# Appendix IX: GHD BSIA Industrial Ecology Strategy

CLIENTS | PEOPLE | PERFORMANCE

# LandCorp

## Report for Boodarie Strategic Industrial Area

### Industrial Ecology Strategy

29 August 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

The estimates provided in this report are indicative estimates based on information to GHD at the time of release of this report (see cover page for date), which does not include specific market research on the types of industries locating to the Boodarie Strategic Industrial Area. The estimates presented here should only be used for the purpose of the Concept Design of the Boodarie Strategic Industrial Area. The data presented in this report should be updated as more detailed information becomes available through the structure plan development process and thereafter (e.g. lot sizes, net developable land, industries locating to Boodarie Strategic Industrial Area, industry locations, industry inputs and outputs).

Limitations and reliance of data provided in this report are presented Section 13 'Limitations and Reliance'.

# Executive Summary

## Overview

Industrial ecology is about smart(er) design and operation of industrial estates from an economic, environmental and community perspective, including optimisation of resource efficiencies through industry collaboration, and ensuring the short and long term viability of the estate from economic, environmental, and social perspective.

This report outlines the industrial ecology opportunities for the Boodarie Strategic Industrial Area (BSIA), and its implications for the BSIA Concept Plan. The work follows a customised industrial ecology methodology developed by GHD for the project.

In this report, GHD has addressed the industrial ecology of the BSIA by examining potential industry inputs and outputs, utility demand forecasting, industrial synergy opportunities, centralised facilities, industry precincts, industry clustering, anchor tenants, benchmarking with other industrial estates, and an implementation plan.

## Industry Input / Output assessment

An industry input/output assessment was undertaken to guide transport (e.g. location and type of transport routes), engineering work (e.g. location and width of service corridors), and planning of the estate. Furthermore, the industry input/output assessment provides the foundation for the utility demand forecasting and the identification of industrial synergy opportunities for the estate.

*Key indicative inputs (when estate is fully developed):*

**Table 1 Summary of BSIA Industry Input / Output Assessment**

| Resource | BSIA Excluding Total BHP Investigation Area (700 ha) | BSIA Excluding BHP Investigation Area North West of Estate (385 ha) | BSIA Including Total BHP Investigation Area (700 ha) |
|---|---|---|---|
| Net developable land for industry | 2,230 ha | 2,545 ha | 2,930 ha |
| INPUTS: | | | |
| Power | 1,207 MW | 1,378 MW | 1,586 MW |
| Gas | 428 PJ/a | 489 PJ/a | 562 PJ/a |
| Domestic use potable water | 257 ML/a | 293 ML/a | 337 ML/a |
| High quality industry feedwater | 23,013 ML/a | 26,264 ML/a | 30,237 ML/a |
| Low(er) quality industry feedwater | 36,792 ML/a | 41,989 ML/a | 48,341 ML/a |
| OUTPUTS: | | | |
| Effluent | 63,306 ML/a | 72,248 ML/a | 83,177 ML/a |
| Products | 93,711 ktpa | 106,948 ktpa | 123,127 ktpa |
| By-products | 4,643 ktpa | 5,299 ktpa | 6,101 ktpa |

## Utility Demand Forecasting

Based on a set of high level assumptions developed from other industrial estates in WA, along with the industry input / output assessment, an utility demand forecasting (power, gas, water) for the BSIA was undertaken to assist utility providers, government, and future industry with the planning and on-time delivery of required infrastructure and services to the estate.

In consultation with LandCorp, the assumptions made in this report are based on heavy industries being established in the BSIA over period of approximately 50 years. The utility demands will develop to their ultimate levels (as summarised above) over this time frame.

The forecasted demands will vary and are approximate estimates only, subject to actual development of the estate and final industry mix that will establish in the BSIA over time.

**Industrial Synergies**

Based on the potential industry mix and industry input / output assessment (Section 3), the great potential for new synergies emerging from the development of Boodarie Strategic Industrial Area was confirmed. As confirmation, this report identified a total of 44 synergy opportunities for the BSIA at this stage, made up of 13 supply chain synergies, 11 utility synergies, 14 by-product synergies, and 6 service synergies.

The types of benefits from industrial synergies often go well beyond the conventional business case benefits. Security of water and energy supply, increased resource efficiency, lower operational costs for resource use, and reduced storage and landfill costs are key benefits from the synergies presented in this report.

The BSIA Concept Plan should allow for the development of promising industrial synergy opportunities identified. This report outlines the potential implications from the industrial synergy opportunities on the BSIA Concept Plan, and to what extent the Concept Plan will be able to facilitate the development of these synergies over time.

**Centralised Water, Energy, By-Product Facilities**

Securing water and energy supply, and storage and processing of large volume industrial by-products and wastes will be critical to the successful development of the Boodarie Strategic Industrial Area. Key industrial ecology initiatives proposed for the BSIA are:

- Centralised industry feedwater facility: The BSIA, when fully developed, will likely require between 60 and 80 GL/yr of industry feedwater (high and low(er) quality). The lack of access to appropriate, well priced industry feed water can be a potential show stopper for new heavy industry wanting to establish in the BSIA. In the BSIA Concept Plan, it is proposed to allocate sufficient land area (about 65 ha) in the Utility Precinct for a centralised facility to produce fit-for-purpose industry feedwater. Such a facility could feed from various sources, including groundwater, industrial effluents generated within the estate, effluent from nearby municipal WWTP, seawater, or a combination of these sources. At this point in time, the BSIA Concept Plan should not lock in one water resource, but rather allow for the use of any of these water resources over time (subject to future feasibility studies, developments, and water availability).
- Centralised energy facility: Given the significant potential energy requirements of the BSIA, it is proposed to allow for the development of a centralised and joint industry energy facility (about 60 ha) in the Utility Precinct of the estate creating economies of scale and potentially avoiding the need for multiple, smaller, and under-utilised facilities throughout the estate. Such facility could produce electricity, steam, chill, hot air to industries in its close proximity. Allowance should be made for the facility to feed from various energy sources, including gas, coal, renewable energy, and industry

waste heat. It is recommended to co-locate the centralised energy facility with the industry feedwater facility to enable the generation of feedwater or seawater desalination with industry waste heat.

- Centralised by-product facility: Significant amounts of industrial by-products (both inorganic and organic) will likely be generated in the BSIA. Rather than stockpiling the large volume industrial by-products in within the strategic core of the estate, there is potential to transfer these by-products to a centralised storage facility in the buffer zone of the estate (subject to environmental, town planning, and land assembly constraints). A centralised facility in the buffer would maximise industrial land use in the strategic core, but would also facilitate and encourage the (co-)processing industrial by-products into valuable materials.

For the proposed centralised facilities to be successful, sufficient corridor access to these facilities must be provided.

**Precincts and Industry Clustering**

The clustering of relevant industries (based on their services and resource inputs and outputs) is at the heart of industrial ecology. Industry clustering is a critical element to allow for the development of regional synergies within the BSIA and with its surrounding regions, as well as a mechanism to reduce the need for utility infrastructure and associated costs.

High level industry clustering is facilitated through the industry precincts identified and their positioning within the Boodarie Strategic Industrial Area. Based on the industry input/output assessment, previous reports on the BSIA, regional synergy opportunities, and discussions with the Concept Plan Design Team, the following precincts were identified and positioned within the estate according to set of defined precinct location criteria:

- Port Dependent and Material Intensive Industries
- Downstream Petroleum / Gas / Coal Processing
- Downstream Iron Ore Processing
- Resource Processing
- General industries
- Noxious industries

Industry clustering within the proposed precincts in the BSIA can be based on various parameters, including water and energy consumption, risk profile, services and support, processing of organic and/or inorganic materials. This report provides guidance on the types of industry clustering which can occur in Boodarie, rather than locking in clustering scenarios at this point in time with limited information on future industries to locate to the BSIA. As industries locate to the BSIA, specific industry clustering scenarios should be assessed.

**Anchor Tenants**

The development of the BSIA will significantly benefit from having anchor tenants to attract associated and synergic businesses and establish regional synergies in the area. These anchor tenants can be existing industries in surrounding areas (such as the Port Hedland port) or new businesses locating in the BSIA. A preliminary review of potential anchor tenants for the BSIA is provided in this report.

**Benchmarking with Other Industrial Areas**

This report includes benchmarking of the results from this BSIA study with the existing Kwinana Industrial Area and the proposed Oakajee Industrial Area in WA. The benchmarking shows that the BSIA may have similar characteristics as Kwinana and Oakajee in terms of water demand, raw materials inputs, products, and effluent discharges (quantities per ha and per industry). BSIA seems to have higher gas and power demands than Kwinana and Oakajee. This can be partly be explained by the Petroleum / Gas

/ Coal Processing Precinct in Boodarie. Furthermore, it is recognised that each industrial estate is unique in terms of industry mix, land assembly, infrastructure, and transportation (e.g. access to port, rail, etc).

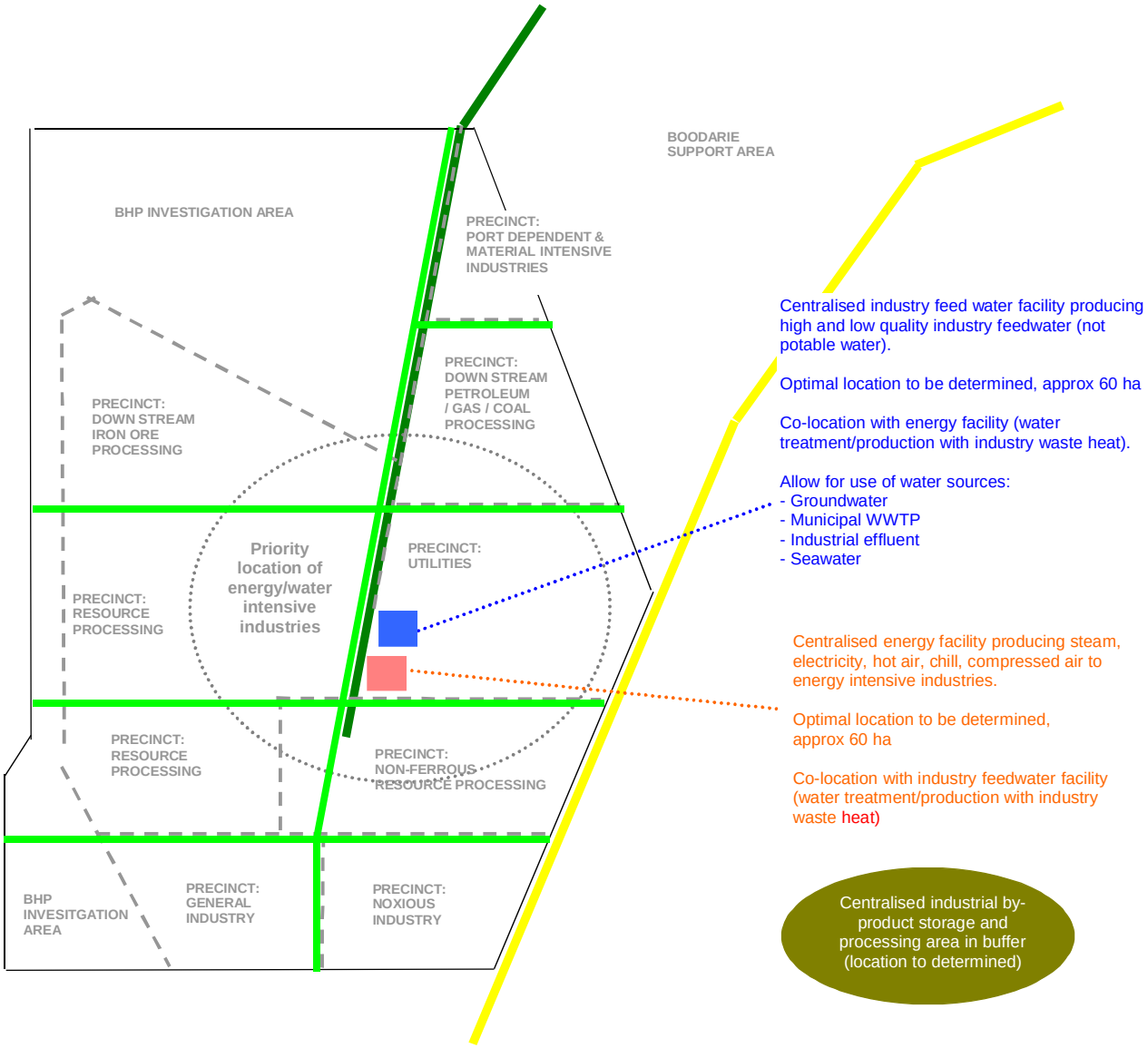
**Implementation Plan**

There is a need for an action plan and operational management model for the estate to assist with the further development and implementation of the industrial ecology (and other engineering and planning initiatives) post concept planning. It is recognised that otherwise key initiatives may not materialise because of a lack of a coordinated approach and upfront commitment from key stakeholders. The implementation plans listed in this report provide suggested leads for actions, listing of infrastructure components which are influenced by the industrial ecology initiatives, and a suggested timing.

**Limitations and Reliance**

Limitations and reliance of data provided in this report are presented Section 13 'Limitations and Reliance'.

## Proposed Precinct Concept for Boodarie Strategic Industrial Area




Notes:

- Alignment shown are only indicative, and subject to assembly of base mapping;
- Plan subject to environmental, town planning, and land assembly constraints;
- Do not scale this plan; and
- Land size and location flexible, subject to industry demand.

# Contents

## Appendices

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# 1. Introduction

## 1.1 Boodarie Industrial Area

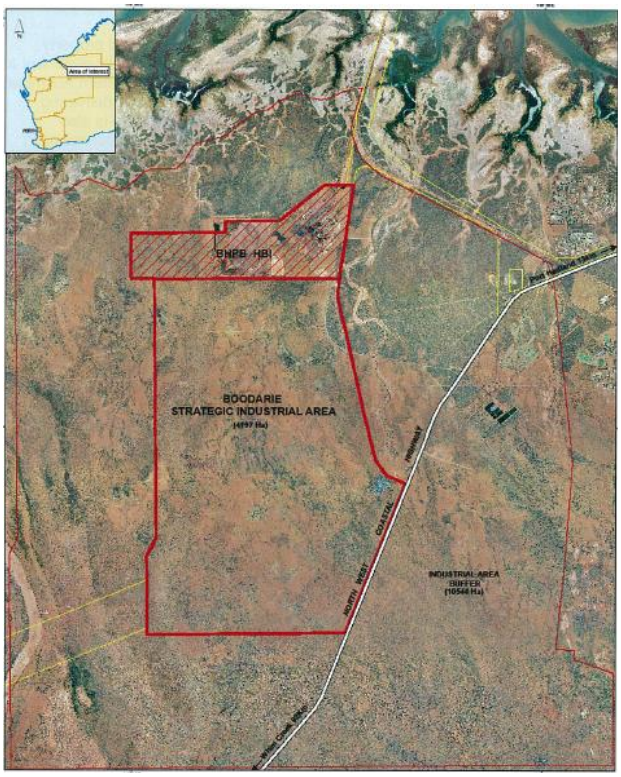
In line with the State Government's Heavy Use Industrial Land Strategy (HUILS), LandCorp is leading the conceptual design and structure planning for the Boodarie Strategic Industrial Area (BSIA).

The overarching vision for the BSIA is to create a benchmark industrial estate demonstrating an effective interface between general/noxious industry and strategic industry uses. This includes efficient use of land and infrastructure while incorporating flexibility to respond to changing market requirements to support a rapidly expanding resource sector.

The BSIA is well located in relation to social infrastructure and has large amounts of land available fronting Great Northern Highway. BSIA is approximately 25 km south west of Port Hedland township, and 5 km west of South Hedland.

An aerial map of the estate is provided below.

**Figure 1 Aerial Map of Boodarie Strategic Industrial Area**




BSIA provides approximately 4,000 ha of core heavy industry land zoned for Strategic Industry with an estimated minimum 2 km buffer in the Town of Port Hedland Planning Scheme No. 5.

The BSIA was established to provide opportunities for the development of downstream processing of local resources and waste planned with service corridor connections to the port. The types of industries likely to establish in the BSIA are those based on the local resources of iron ore, base metals, steel alloy, precious metals, salt, and gas. Land areas in the order of 45 ha to 150 ha would be likely be required for major processors.

There is a growing urgency in the Town of Port Hedland for the release of General Industry / Noxious Use land to accommodate new industries and to allow for inappropriately located existing industries to relocate into the BSIA. An indicative area within which to locate a 200 ha general industrial / noxious use area has been identified over the southern portion of the BSIA.

## 1.2 Industrial Ecology

Industrial Ecology is both 'industrial' and 'ecological'[1]. It is industrial in that it focuses on product design and manufacturing processes. Industry is therefore viewed as the primary agent for environmental improvement, as it possesses the technological expertise, management capability and financial and other resources necessary for successful execution of environmentally informed design of products and processes. Industrial Ecology is ecological in at least two senses. Firstly, it looks to non-human 'natural' systems as models for industrial activity. Mature ecosystems are extremely effective in recycling of resources and therefore promoted as exemplary models for effective recycling in industry and society. Secondly, Industrial Ecology places industry – or technological activity – in the context of the larger ecosystems that support it. This focuses Industrial Ecology on examining the sources of resources used in industrial activity and the sinks that absorb and detoxify the wastes discharged by society.

In the context of industrial land planning and development of the Boodarie Strategic Industrial Area, an industrial ecology approach involves the following elements:

- Qualify and quantify industry inputs and outputs over time;
- Provide input into the identification and establishment of appropriate infrastructure to support the development of the industrial estate (e.g. service and utility corridors, transportation routes, facilities for water, energy, and waste processing and supply);
- Identify industrial synergy opportunities (supply chain, utility, by-product, and service synergies), and ensure that the industrial estate concept plan allows for the development of promising opportunities;
- Identify and locate appropriate industry precincts within the estate, and subsequent clustering of industries within these precincts based on their services, resource inputs and outputs, and potential synergy opportunities;
- Identify anchor tenants to attract further synergistic industries to the estate;
- Delivery of implementation plans to assist with the post concept plan development of the industrial ecology initiatives highlighted in this report.

In short, industrial ecology is about smart(er) design and operation of industrial estates from an economic, environmental and community perspective, including optimisation of resource efficiencies through industry collaboration, and ensuring the short and long term viability of the estate from economic, environmental, and social perspective.

[1] Lifset, R. and T. Graedel. 2002. Industrial Ecology: goals and definitions. In Handbook of Industrial Ecology, edited by R. Ayres and L. Ayres. Cheltenham, UK: Edward Elgar Publications.

## 1.3 Scope of Work

As part of the Engineering brief for the BSIA, LandCorp commissioned GHD to undertake the following industrial ecology study:

- Qualification and quantification of indicative inputs and outputs of potential industry types locating to the BSIA;
- Undertake high level and indicative utility demand forecasting;
- Review of potential industrial synergy opportunities;
- Identification of industry precincts and industry clustering opportunities;
- Development of implementation plans for promising industrial ecology opportunities.

The above items have been incorporated into the methodology presented in Section 2 'Methodology' of this report.

## 1.4 This Report

This report is structured as follows:

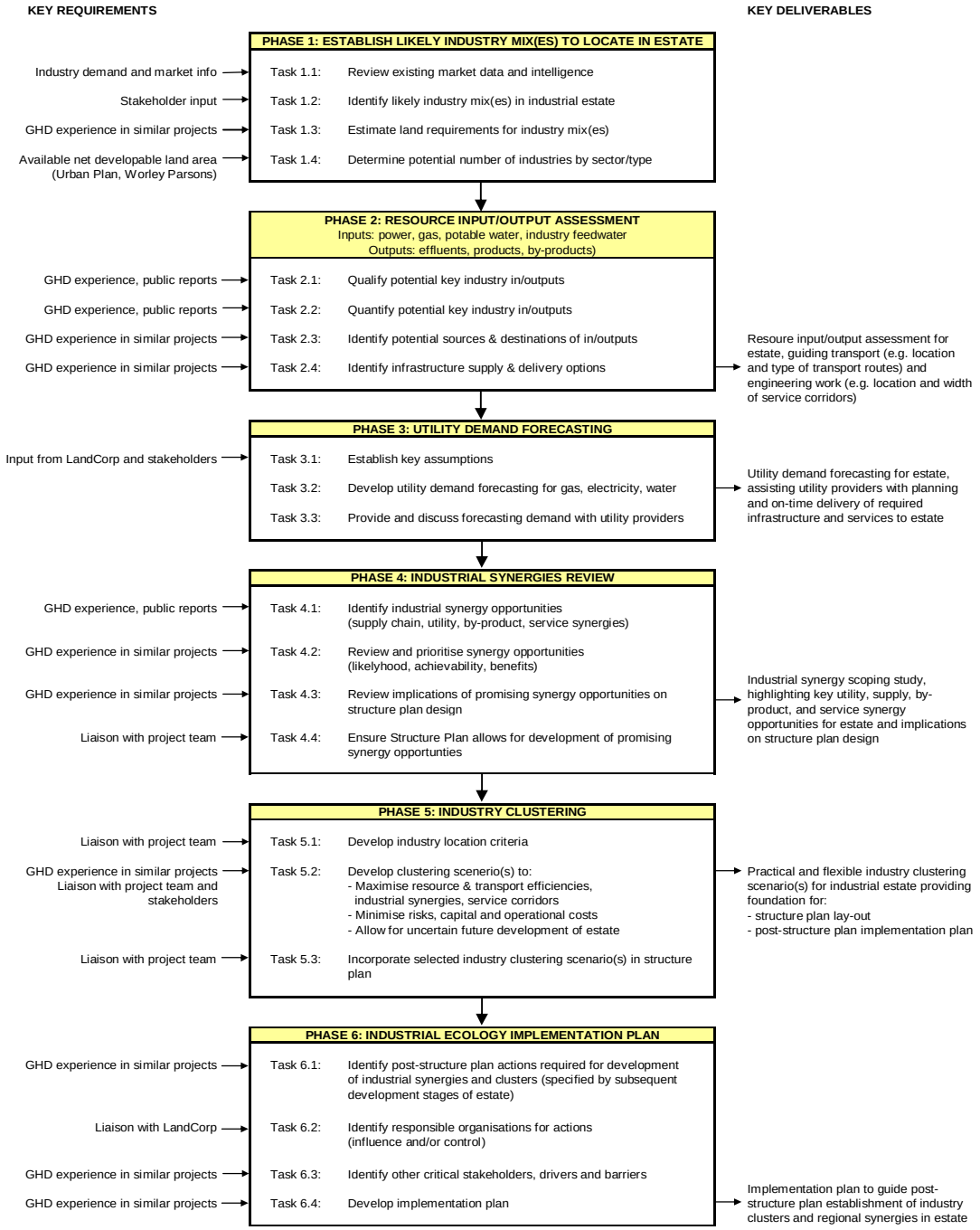
- Section 1 'Introduction' introduces the project and industrial ecology, including limitations and reliance of this report;
- The industrial ecology methodology applied as part of the BSIA Concept Planning process is provided in Section 2 'Methodology';
- Section 3 'Industry Input / Output Assessment' outlines the review of the inputs (e.g. power, gas, water, raw materials) and outputs (e.g. effluent, products, by-products, wastes) of potential industry types locating to the BSIA;
- The forecasting of utility demand (power, gas, water) is presented in Section 4 'Utility Demand Forecasting';
- Section 5 'Industrial Synergies' outlines the potential industrial synergy opportunities (supply chain, utility, by-product, and service synergies) for the estate, including implications for the BSIA Concept Plan;
- Introduction to the business case and the concepts of centralised facilities in the BSIA for industry feedwater, energy, and industrial by-products are provided in Section 6 'Centralised Water, Energy and By-Product Facilities';
- Based on the assessment of industry inputs and outputs and industrial synergies, Section 7 'Industrial Area Precincts' identifies appropriate industry precincts for the estate, including recommended locations of the precincts and a precinct concept plan;
- Potential location of industries within the precincts and potential opportunities for industry clustering are outlined in Section 8 'Industry Clustering';
- Section 9 'Anchor Tenants' provides a summary of potential industries to attract to BSIA. This information will assist LandCorp and DSD with the successful development of the estate;
- Benchmarking of the results from this BSIA study with the Kwinana and Oakajee Industrial Areas is provided in Section 10 'Benchmarking with Other Industrial Areas';

- Section 11 'Implementation Plan' presents an implementation and action plan to assist LandCorp, DSD and other stakeholders with the way forward towards implementation of promising industrial ecology initiatives post concept planning;
- Recommendations from this report are provided in Section 12 'Recommendations';
- Limitations and reliance of data provided in this report are presented in Section 13 'Limitations and Reliance'.

# 2. Methodology

The industrial ecology methodology developed by GHD and applied as part of the BSIA Concept Planning process is provided in the figure below, including key input requirements and deliverables.

**Figure 2 BSIA – GHD's Industrial Ecology Methodology**



# 3. Industry Input / Output Assessment

The estimates provided in this report are indicative estimates based on information to GHD at the time of release of this report (see cover page for date), which does not include specific market research on the types of industries locating to the Boodarie Strategic Industrial Area. The estimates presented here should only be used for the purpose of the Concept Design of the Boodarie Strategic Industrial Area. The data presented in this report should be updated as more detailed information becomes available through the structure plan development process and thereafter (e.g. lot sizes, net developable land, industries locating to Boodarie Strategic Industrial Area, industry locations, industry inputs and outputs).

An industry input/output assessment is presented in this section to guide transport (e.g. location and type of transport routes), engineering work (e.g. location and width of service corridors), and concept planning of the estate.

Furthermore, the industry input/output assessment for the BSIA outlined in this section provides the foundation for the utility demand forecasting (Section 3.4.2), and the identification of industrial synergy opportunities for the estate (Section 5).

## 3.1 Notes and Limitations

The industry input and output assessment presented in this section is subject to following uncertainties and limitations:

- Underlying assumptions and references are included in Appendix A;
- These are indicative and high level estimates based on limited information available at this point in time, and therefore subject to change;
- Estimates are subject to the industry mix to be located in BSIA (still unknown);
- There is no certainty about date/year when the BSIA will be fully developed;
- Estimates do not take into account ongoing industry expansions and increasing efficiencies and technology developments over time;
- These estimates cover the operation of industries. Estimates do not cover potential higher demands during construction period.

## 3.2 Net Developable Areas

Table 2 shows the estimated total land areas and Net Developable Area (NDA) of the identified industry precincts of the Boodarie estate. As shown in the table, it is been estimated (by Urban Plan and Worley Parsons, May 2011) that about 490 ha and 80 ha will be consumed by service corridors and landscape drainage respectively.

It is likely that a proportion of the BSIA will be taken up by BHP Billiton for their future iron ore operations and facilities (this land area is referred to in this report as “BHP Investigation Area”). This report takes into account two land take scenarios for the BHP investigation area, namely 700 ha (total BHP investigation area) and 385 ha (BHP investigation area in the north west of the estate.

## Table 2 BSIA – Land Uses and Estimated Net Developable Land

| Land uses | ha |
|---|---|
| **Total gross area of BSIA** | **3,500** |
| Estimated area required for corridors | 490 |
| Estimated area required for landscape drainage | 80 |
| **Total estimated net developable area BSIA - incl total BHP investigation area** | **2,930** |
| BHP investigation area north west of estate | 385 |
| Total BHP investigation area | 700 |
| **Total estimated net developable area BSIA - excl BHP investigation area north west of estate (385 ha)** | **2,545** |
| **Total estimated net developable area BSIA - excl total BHP investigation area (700 ha)** | **2,230** |

| Net developable areas per land use | ha |
|---|---|
| Downstream iron ore processing | 520 |
| Downstream non-ferrous resource processing | 600 |
| Downstream petroleum / gas / coal processing | 300 |
| Port dependant (not specific to industry sector at this stage) | 240 |
| Utilities and resource recovery | 310 |
| General industry | 160 |
| Noxious industry | 100 |
| **Total estimated net developable area BSIA - excl total BHP investigation area (700 ha)** | **2,230** |

## 3.3 Summary of Estimated Industry Inputs and Outputs

### 3.3.1 BSIA – Excluding Total BHP Investigation Area (700 Ha)

The table below provides the estimated industry inputs and outputs for the Boodarie Estate with a net developable land of 2,230 ha which excludes the total BHP investigation area (700 ha). The assessment is based on assumptions and references provided in Appendix A.

**Table 3 Summary Indicative Industry Inputs and Outputs for BSIA - Excluding Total BHP Investigation Area**

| | | | | | | POTENTIAL KEY INPUTS | | | | | | POTENTIAL KEY OUTPUTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Potential industry types | Total area | Direct employment | | | Power | Gas | Domestic use of potable water | High quality industry feed water | Process & cooling water (lower quality) | Raw / source materials | Water discharge | Products | By-products / wastes |
| | | | Total | 'White collar' | 'Blue Collar' | | | | | | | | | |
| | | Ha | persons | persons | persons | MW | TJ/a | ML/a (ktpa) | ML/a (ktpa) | ML/a (ktpa) | ktpa | ML/a (ktpa) | ktpa | ktpa |
| **DOWNSTREAM IRON ORE PROCESSING** | | | | | | | | | | | | | | |
| 1 | Sintered iron plant | 80 | 400 | 120 | 280 | 25 | 200 | 11 | 2,600 | 0 | 6,210 | 2,340 | 5,000 | 311 |
| 1 | Iron ore pelletising plant | 80 | 400 | 120 | 280 | 10 | 2,000 | 11 | 1,050 | 1,950 | 5,250 | 2,408 | 5,000 | 250 |
| 1 | DRI / alternative smelting iron plant | 140 | 400 | 120 | 280 | 60 | 50,000 | 11 | 2,100 | 3,900 | 5,250 | 4,815 | 2,000 | 726 |
| 1 | Integrated steel making plant | 120 | 400 | 120 | 280 | 80 | 50,000 | 11 | 3,500 | 6,500 | 6,072 | 8,025 | 2,000 | 730 |
| 1 | Ferromanganese production plant | 40 | 400 | 120 | 280 | 50 | 25,000 | 11 | 525 | 975 | 28 | 1,204 | 10 | 6 |
| 1 | Ferrosilicon production plant | 40 | 400 | 120 | 280 | 80 | 10,000 | 11 | 525 | 975 | 88 | 1,204 | 23 | 8 |
| 1 | Iron carbide plant | 20 | 400 | 120 | 280 | 20 | 10,000 | 11 | 1,400 | 1,100 | 2,000 | 2,085 | 1,000 | 500 |
| **Subtotal** | | **520** | **2,800** | **840** | **1,960** | **325** | **147,200** | **76** | **11,700** | **15,400** | **24,898** | **22,080** | **15,033** | **2,531** |
| **DOWNSTREAM NON-FERROUS RESOURCE PROCESSING** | | | | | | | | | | | | | | |
| 1 | Magnesium production plant | 50 | 400 | 120 | 280 | 8 | 10,000 | 11 | 700 | 1,300 | 262 | 1,605 | 100 | 16 |
| 1 | Titanium production plant | 60 | 400 | 120 | 280 | 145 | 1,000 | 11 | 1,400 | 2,600 | 112 | 3,210 | 50 | 11 |
| 1 | Copper smelter | 120 | 400 | 120 | 280 | 50 | 10,000 | 11 | 525 | 975 | 624 | 1,204 | 150 | 474 |
| 1 | Silicon manganese production plant | 50 | 400 | 120 | 280 | 25 | 10,000 | 11 | 525 | 975 | 115 | 1,204 | 38 | 24 |
| 1 | Silicon metal production plant | 50 | 400 | 120 | 280 | 25 | 10,000 | 11 | 525 | 975 | 77 | 1,204 | 15 | 9 |
| 1 | Chlor-alkali plant | 50 | 100 | 30 | 70 | 90 | 0 | 3 | 70 | 130 | 400 | 161 | 460 | 39 |
| 1 | Aluminium smelter | 120 | 400 | 120 | 280 | 170 | 10,000 | 11 | 1,050 | 1,950 | 281 | 2,408 | 100 | 17 |
| 1 | Chromite processing plant (ferro-chromium production) | 100 | 400 | 120 | 280 | 80 | 10,000 | 11 | 525 | 975 | 630 | 1,204 | 315 | 144 |
| **Subtotal** | | **600** | **2,900** | **870** | **2,030** | **593** | **61,000** | **79** | **5,320** | **9,880** | **2,502** | **12,198** | **1,228** | **733** |
| **DOWNSTREAM PETROLEUM / GAS / COAL PROCESSING** | | | | | | | | | | | | | | |
| 1 | Methanol plant | 50 | 100 | 30 | 70 | 1 | 28,000 | 3 | 875 | 1,625 | 595 | 2,006 | 800 | 125 |
| 1 | Ammonia / urea plant | 65 | 250 | 75 | 175 | 2 | 22,400 | 7 | 500 | 2,500 | 448 | 2,325 | 650 | 477 |
| 1 | Ethane extraction | 60 | 150 | 45 | 105 | 30 | 100,000 | 4 | 88 | 163 | 2,000 | 201 | 2,650 | 100 |
| 1 | Ethane cracker | 50 | 250 | 75 | 175 | 10 | 8,750 | 7 | 51 | 94 | 175 | 116 | 145 | 20 |
| 1 | Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant | 50 | 400 | 120 | 280 | 8 | 10,000 | 11 | 525 | 975 | 365 | 1,204 | 340 | 200 |
| 1 | Sodium cyanide plant | 25 | 100 | 30 | 70 | 1 | 10,000 | 3 | 525 | 975 | 34 | 1,204 | 15 | 2 |
| **Subtotal** | | **300** | **1,250** | **375** | **875** | **52** | **179,150** | **34** | **2,563** | **6,332** | **3,617** | **7,056** | **4,600** | **924** |
| **PORT DEPENDANT** | | | | | | | | | | | | | | |
| 1 | Large scale processing plant (liquids - not defined) | 120 | 400 | 120 | 280 | 80 | 10,000 | 11 | 350 | 650 | 3,413 | 803 | 3,250 | 163 |
| 1 | Large scale processing plant (conveyors - not defined) | 120 | 400 | 120 | 280 | 80 | 10,000 | 11 | 350 | 650 | 2,100 | 803 | 2,000 | 100 |
| **Subtotal** | | **240** | **800** | **240** | **560** | **160** | **20,000** | **22** | **700** | **1,300** | **5,513** | **1,605** | **5,250** | **263** |
| **UTILITIES AND RESOURCE RECOVERY** | | | | | | | | | | | | | | |
| 1 | Gas fired power station (250 MW) | 50 | 75 | 23 | 53 | 0 | 10,000 | 2 | 200 | 0 | 0 | 180 | 0 | 0 |
| 1 | Gas fired power station (120MW) | 25 | 50 | 15 | 35 | 0 | 5,000 | 1 | 100 | 0 | 0 | 90 | 0 | 0 |
| 1 | Coal fired power station (800 MW) | 100 | 200 | 60 | 140 | 0 | 0 | 5 | 450 | 2,000 | 802 | 1,905 | 0 | 30 |
| 1 | Waste-to-energy and material recovery facility | 10 | 25 | 8 | 18 | 0 | 2,500 | 1 | 100 | 0 | 252 | 90 | Double counting | 32 |
| 1 | Industry feedwater facility | 65 | 15 | 5 | 11 | 36 | 0 | 0.4 | 0 | 0 | 80,000 | 15,000 | 65,000 | 2 |
| 1 | Energy facility (electricity, steam, heat, chill) | 60 | 25 | 8 | 18 | 0 | Double counting | 1 | Double counting | Double counting | 0 | Double counting | Double counting | 0 |
| **Subtotal** | | **310** | **390** | **117** | **273** | **36** | **17,500** | **11** | **850** | **2,000** | **81,054** | **17,265** | **65,000** | **63** |
| **GENERAL INDUSTRY** | | | | | | | | | | | | | | |
| 64 | General industries | 160 | 960 | 288 | 672 | 26 | 2,080 | 26 | 1,280 | 1,280 | 1,680 | 2,112 | 1,600 | 80 |
| **Subtotal** | | **160** | **960** | **288** | **672** | **26** | **2,080** | **26** | **1,280** | **1,280** | **1,680** | **2,112** | **1,600** | **80** |
| **NOXIOUS INDUSTRY** | | | | | | | | | | | | | | |
| 20 | Noxious industries | 100 | 300 | 90 | 210 | 16 | 1,300 | 8 | 600 | 600 | 1,050 | 990 | 1,000 | 50 |
| **Subtotal** | | **100** | **300** | **90** | **210** | **16** | **1,300** | **8** | **600** | **600** | **1,050** | **990** | **1,000** | **50** |
| **Total Boodarie Strategic Industrial Area - excl total BHP area** | | **2,230** | **9,400** | **2,820** | **6,580** | **1,207** | **428,230** | **257** | **23,013** | **36,792** | **120,313** | **63,306** | **93,711** | **4,643** |

### 3.3.2 BSIA - Excluding BHP Investigation Area North West of Estate (385 Ha)

The table below provides the estimated industry inputs and outputs for the Boodarie Estate with a total net developable area of 2,545 ha which excludes the BHP investigation area north west of the estate. The estimates are based on per ha proxies derived from the detailed input/output assessment undertaken for the BSIA excluding total BHP investigation area (Table 3).

**Table 4 Summary Indicative Industry Inputs and Outputs for BSIA - Excluding BHP Investigation Area North West of Estate**

| | | | | | POTENTIAL KEY INPUTS | | | | | | POTENTIAL KEY OUTPUTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total area | Direct employment | | | Power | Gas | Domestic use of potable water | High quality industry feed water | Process & cooling water (lower quality) | Raw / source materials | Water discharge | Products | By-products / wastes |
| | | Total | 'White collar' | 'Blue Collar' | | | | | | | | | |
| | Ha | persons | persons | persons | MW | TJ/a | ML/a (ktpa) | ML/a (ktpa) | ML/a (ktpa) | ktpa | ML/a (ktpa) | ktpa | ktpa |
| Total BSIA - excl total BHP investigation area | 2,230 | 9,400 | 2,820 | 6,580 | 1,207 | 428,230 | 257 | 23,013 | 36,792 | 120,313 | 63,306 | 93,711 | 4,643 |
| | Ha/ha | persons/ha | persons/ha | persons/ha | MW/ha | (TJ/a)/ha | (ML/a)/ha | (ML/a)/ha | (ML/a)/ha | ktpa/ha | (ML/a)/ha | ktpa/ha | ktpa/ha |
| Industry input/output proxy per ha based on detailed input/output assessme | 1.0 | 4.2 | 1.3 | 3.0 | 0.5 | 192.0 | 0.1 | 10.3 | 16.5 | 54.0 | 28.4 | 42.0 | 2.1 |
| | Ha | | | | | | | | | | | | |
| Difference BHP investigation area to be added (700 ha - 385 ha) | 315 | | | | | | | | | | | | |
| | **Ha** | **persons** | **persons** | **persons** | **MW** | **TJ/a** | **ML/a (ktpa)** | **ML/a (ktpa)** | **ML/a (ktpa)** | **ktpa** | **ML/a (ktpa)** | **ktpa** | **ktpa** |
| **Total BSIA - excl BHP area (385 ha)** | **2,545** | **10,728** | **3,218** | **7,509** | **1,378** | **488,720** | **293** | **26,264** | **41,989** | **137,308** | **72,248** | **106,948** | **5,299** |

### 3.3.1 BSIA - Including Total BHP Investigation Area North West of Estate (700 Ha)

The table below provides the estimated industry inputs and outputs for the Boodarie Estate with a total net developable area of 2,930 ha which includes the total BHP investigation area. The estimates are based on per ha proxies derived from the detailed input/output assessment undertaken for the BSIA excluding total BHP investigation area (Table 3).

**Table 5 Summary Indicative Industry Inputs and Outputs for BSIA - Including Total BHP Investigation Area**

| | | | | | POTENTIAL KEY INPUTS | | | | | | POTENTIAL KEY OUTPUTS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total area | Direct employment | | | Power | Gas | Domestic use of potable water | High quality industry feed water | Process & cooling water (lower quality) | Raw / source materials | Water discharge | Products | By-products / wastes |
| | | Total | 'White collar' | 'Blue Collar' | | | | | | | | | |
| | Ha | persons | persons | persons | MW | TJ/a | ML/a (ktpa) | ML/a (ktpa) | ML/a (ktpa) | ktpa | ML/a (ktpa) | ktpa | ktpa |
| Total BSIA - excl total BHP investigation area | 2,230 | 9,400 | 2,820 | 6,580 | 1,207 | 428,230 | 257 | 23,013 | 36,792 | 120,313 | 63,306 | 93,711 | 4,643 |
| | Ha/ha | persons/ha | persons/ha | persons/ha | MW/ha | (TJ/a)/ha | (ML/a)/ha | (ML/a)/ha | (ML/a)/ha | ktpa/ha | (ML/a)/ha | ktpa/ha | ktpa/ha |
| Industry input/output proxy per ha based on detailed input/output assessme | 1.0 | 4.2 | 1.3 | 3.0 | 0.5 | 192.0 | 0.1 | 10.3 | 16.5 | 54.0 | 28.4 | 42.0 | 2.1 |
| | Ha | | | | | | | | | | | | |
| Total BHP investigation area | 700 | | | | | | | | | | | | |
| | **Ha** | **persons** | **persons** | **persons** | **MW** | **TJ/a** | **ML/a (ktpa)** | **ML/a (ktpa)** | **ML/a (ktpa)** | **ktpa** | **ML/a (ktpa)** | **ktpa** | **ktpa** |
| **Total BSIA - incl BHP area (700 ha)** | **2,930** | **12,351** | **3,705** | **8,645** | **1,586** | **562,652** | **337** | **30,237** | **48,341** | **158,080** | **83,177** | **123,127** | **6,101** |

## 3.4 Boodarie Strategic Industrial Area and Port

Sufficient and efficient access to the Port Hedland port is critical to the development of the BSIA. Based on the industry input / output assessment undertaken for the BSIA, the tables below provide a summary of the potential corridor and trade requirements between the industrial estate and the port.

### 3.4.1 BSIA – Excluding Total BHP Investigation Area (700 Ha)

**Table 6 Potential Corridor and Trade Requirements between BSIA and Port - Excluding Total BHP Investigation Area (700 Ha)**

| BOODARIE STRATEGIC INDUSTRIAL AREA | | | | | | | PORT RELATED TRADE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Land uses | Potential industry types | Area [ha] | Resource type | Resource name | Bulk or break bulk | Total BSIA quantity [ktpa] | Import or export from port | Estimated trade quantity with port (import & export) [ktpa] | Transportation between port andestate | Number of corridors [number] | Comments / assumptions |
| Downstream iron ore processing | Sintered iron plant | 80 | Raw material | Dolomite | Bulk | 200 | Import | 200 | Road | | Assumed that 100% of total dolomite demand is imported from port |
| | | | Raw material | Coke breeze | Bulk | 350 | Import | 175 | Road | | Assumed that 50% of total coke breeze demand is imported from elsewhere |
| | | | Product | Sintered products | Bulk | 5,000 | Export | 3,750 | Conveyor (or road) | 1 | Assumed that 75% of produced sintered products is exported through port |
| | Iron ore pelletising plant | 80 | Product | Iron ore pellets | Bulk | 5,000 | Export | 3,750 | Conveyor (or road) | 1 | Assumed that 75% of produced iron ore pellets is exported through port |
| | DRI / alternative smelting iron plant | 140 | Raw material | Dolomite | Bulk | 175 | Import | 175 | Road | | Assumed that 100% of total dolomite demand is imported through port |
| | | | Raw material | Coal (reductant) | Bulk | 700 | Import | 700 | Conveyor | 1 | Assumed that 100% of total coal demand is imported through port |
| | | | Product | Direct reduced iron | Breakbulk | 2,000 | Export | 2,000 | Road | | Assumed that all products are exported |
| | Integrated steel making plant | 120 | Raw material | Coal | Bulk | 940 | Import | 940 | Conveyor | 1 | Assumed that 100% of total coal demand is imported through port |
| | | | Product | Steel products | Breakbulk | 2,000 | Export | 2,000 | Road | | Assumed that all products are exported through port |
| | Ferromanganese production plant | 40 | Raw material | Coke | Bulk | 4 | Import | 2 | Road | | Assumed that 50% of total coke demand is imported from elsewhere |
| | | | Raw material | Coal | Bulk | 2 | Import | 2 | Road | | Assumed that 100% of total coal demand is imported through port |
| | | | Product | Fe/Mn HC/LS | Breakbulk | 10 | Export | 10 | Road | | Assumed that all products are exported through port |
| | Ferrosilicon production plant | 40 | Raw material | Coke | Bulk | 9 | Import | 4 | Road | | Assumed that 100% of total coal demand is imported through port |
| | | | Raw material | Coal | Bulk | 13 | Import | 13 | Road | | Assumed that 100% of total coal demand is imported through port |
| | | | Product | FeSi | Breakbulk | 23 | Export | 23 | Road | | Assumed that all products are exported through port |
| | Iron carbide plant | 20 | Product | Iron carbide | Bulk | 1,000 | Export | 1,000 | Road | | Assumed that all products are exported through port |
| Downstream non-ferrous resource processing | Magnesium production plant | 50 | Raw material | Petcoke | Bulk | 2 | Import | 1 | Road | | Assumed that 50% of total petcoke demand is imported from elsewhere |
| | | | Product | Deod burned MgO | Breakbulk | 80 | Export | 80 | Road | | Assumed that all products are exported through port |
| | | | Product | Electrofused MgO | Breakbulk | 20 | Export | 20 | Road | | Assumed that all products are exported through port |
| | Titanium production plant | 60 | Product | Titanium sponge | Breakbulk | 50 | Export | 50 | Road | | Assumed that all products are exported through port |
| | Copper smelter | 120 | Raw material | Copper concentrate | Bulk | 624 | Import | 624 | Conveyor | 1 | Asumed that all copper concentrate is imported through port |
| | | | Product | Blister copper | Breakbulk | 150 | Export | 150 | Road | | Assumed that all products are exported through port |
| | Silicon manganese production plant | 50 | Raw material | Coke | Bulk | 16 | Import | 8 | Road | | Assumed that 50% of total coke demand is imported from elsewhere |
| | | | Raw material | Coal | Bulk | 10 | Import | 10 | Road | | Assumed that 100% of total coal demand is imported through port |
| | | | Product | SiMn | Breakbulk | 38 | Export | 38 | Road | | Assumed that all products are exported through port |
| | Silicon metal production plant | 50 | Raw material | Coke | Bulk | 2 | Import | 1 | Road | | Assumed that 50% of total coke demand is imported from elsewhere |
| | | | Raw material | Coal | Bulk | 20 | Import | 20 | Road | | Assumed that 100% of total coal demand is imported through port |
| | | | Product | Silicon metal | Breakbulk | 15 | Export | 15 | Road | | Assumed that all products are exported through port |
| | Chlor-alkali plant | 50 | Raw material | Sodium chloride | Breakbulk | 400 | Import | 400 | Pipeline | 1 | Assumed that all sodiu chloride is imported through port |
| | Aluminium smelter | 120 | Raw material | Alumina | Bulk | 190 | Import | 95 | Road | | Assumed that 50% of total alumina demand is imported through port |
| | | | Raw material | Petcoke | Bulk | 75 | Import | 38 | Road | | Assumed that 50% of total coke demand is imported from elsewhere |
| | | | Raw material | Fluorides | Breakbulk | 3 | Import | 3 | Road | | Assumed that all fluorides are imported through port |
| | | | Product | Aluminium ingots | Breakbulk | 100 | Export | 100 | Road | | Assumed that all products are exported through port |
| | Chromite processing plant (ferro-chromium production) | 100 | Raw material | Coke | Bulk | 90 | Import | 45 | Road | | Assumed that 50% of total coke demand is imported from elsewhere |
| | | | Raw material | Coal | Bulk | 90 | Import | 90 | Road | | Assumed that 100% of total coal demand is imported through port |
| | | | Product | Ferro-chromium | Breakbulk | 315 | Export | 315 | Road | | Assumed that all products are exported through port |

| BOODARIE STRATEGIC INDUSTRIAL AREA | | | | | | | PORT RELATED TRADE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Land uses | Potential industry types | Area [ha] | Resource type | Resource name | Bulk or break bulk | Total BSIA quantity [ktpa] | Import or export from port | Estimated trade quantity with port (import & export) [ktpa] | Transportation between port andestate | Number of corridors [number] | Comments / assumptions |
| Downstream petroleum / gas / coal processing | Methanol plant | 50 | Raw material | Natural gas | Bulk | 595 | Import | 595 | Pipeline | 1 | Assumed that methanol plant will process natural gas from North West Shelf, imported through port |
| | | | Product | Methanol | Bulk | 800 | Export | 400 | Pipeline | 1 | Assumed that 50% of methanol product will be exported through port |
| | Ammonia / urea plant | 65 | Raw material | Natural gas | Bulk | 448 | Import | 448 | Pipeline | 1 | Assumed that ammonium/urea plant will process natural gas from North West Shelf, imported through port |
| | | | Product | Ammonia | Bulk | 250 | Export | 125 | Pipeline | 1 | Assumed that 50% of ammonia product will be exported through port |
| | | | Product | Urea | Bulk | 400 | Export | 200 | Road | | Assumed that 50% of urea product will be exported through port |
| | Ethane extraction | 60 | Raw material | Natural gas | Bulk | 2,000 | Import | 2,000 | Pipeline | 1 | Assumed that ethane extraction plant will process natural gas from North West Shelf, imported through port |
| | | | Product | Ethane | Bulk | 200 | Export | 100 | Pipeline | 1 | Assumed that 50% of ethane product will be exported through port |
| | | | Product | LPG | Bulk | 2,450 | Export | 1,225 | Pipeline | 1 | Assumed that 50% of LPG product will be exported through port |
| | Ethane cracker | 50 | Product | Ethylene | Bulk | 145 | Export | 73 | Pipeline (or road) | 1 | Assumed that 50% of ethylene product will be exported through port |
| | Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant | 50 | Product | Ethylene dichloride (EDC) | Bulk | 100 | Export | 50 | Pipeline (or road) | 1 | Assumed that 50% of EDC product will be exported through port |
| | | | Product | Vinyl chloride monomer (VCM) | Bulk | 240 | Export | 120 | Pipeline | 1 | Assumed that 50% of VCM product will be exported through port |
| | Sodium cyanide plant | 25 | Product | Sodium cyanide | Breakbulk | 15 | Export | 8 | Road | | Assumed that 50% of sodium cyanide product will be exported through port |
| Port dependant | Large scale processing plant (liquids - not defined) | 120 | Raw material | Raw materials | Bulk | 3,313 | Import | 3,313 | Pipeline | 1 | Assumed that 100% of raw materials are imported through port |
| | | | Raw material | Process chemicals | Breakbulk | 100 | Import | 50 | Road | | Assumed that 50% of process chemicals are imported through port |
| | | | Product | Liquid product 1 | Bulk | 2,500 | Export | 1,250 | Pipeline | 1 | Assumed that 50% of products are exported through port |
| | | | Product | Liquid product 2 | Bulk | 500 | Export | 250 | Pipeline | 1 | Assumed that 50% of products are exported through port |
| | | | Product | Liquid product 3 | Bulk | 250 | Export | 125 | Pipeline | 1 | Assumed that 50% of products are exported through port |
| | Large scale processing plant (conveyors - not defined) | 120 | Raw material | Raw materials | Bulk | 2,000 | Import | 2,000 | Pipeline | 1 | Assumed that 100% of raw materials are imported through port |
| | | | Raw material | Process chemicals | Breakbulk | 100 | Import | 50 | Road | | Assumed that 50% of process chemicals are imported through port |
| | | | Product | Solid product 1 | Bulk | 1,500 | Export | 1,500 | Conveyor | 1 | Assumed that 100% of product 1 will be exported |
| | | | Product | Solid product 2 | Bulk | 500 | Export | 500 | Conveyor | 1 | Assumed that 100% of product 2 will be exported |
| Utilities and resource recovery | Gas fired power station (250 MW) | 50 | No imports/exports for port | N/A | N/A | N/A | N/A | N/A | N/A | | |
| | Gas fired power station (120MW) | 25 | No imports/exports for port | N/A | N/A | N/A | N/A | N/A | N/A | | |
| | Coal fired power station (800 MW) | 100 | Raw material | Coal | Bulk | 800 | Import | 400 | Conveyor | 1 | Assumed that 50% of coal will be imported through the port |
| | Waste-to-energy and material recovery facility | 10 | No imports/exports for port | N/A | N/A | N/A | N/A | N/A | N/A | | |
| | Industry feedwater facility | 65 | Raw material | Groundwater or seawater | Bulk | 40,000 | Import | 0 | Pipeline | 1 | Assumed that industry feedwater facility will take seawater as a water source |
| | | | Water discharge | Brine | Bulk | 15,000 | Export | 0 | Pipeline | 1 | Assumed that brine from facility will discharged back to port area for ocean disposal |
| | Energy facility (electricity, steam, heat, chill) | 60 | No imports/exports for port | N/A | N/A | N/A | N/A | N/A | N/A | | |
| General industry | General industries | 160 | Raw material | Various | Breakbulk | 1,680 | Import | 554 | Road | | Assumed that 33% of all raw materials are imported through port |
| | | | Product | Various products | Breakbulk | 1,000 | Export | 528 | Road | | Assumed that 33% of all products are exported through port |
| Noxious industry | Noxious industries | 100 | Raw material | Various | Breakbulk | 1,050 | Import | 347 | Road | | Assumed that 33% of all raw materials are imported through port |
| | | | Product | Various products | Breakbulk | 1,000 | Export | 330 | Road | | Assumed that 33% of all products are exported through port |
| | **Total** | **2,230** | | | | | | **33,387** | | **26** | |

### 3.4.2 BSIA - Excluding BHP Investigation Area North West of Estate (385 Ha)

The service corridor and trade forecast between port and BSIA excluding BHP investigation area north west of estate is presented in table below. The indicative estimates are based on per ha proxies derived from the detailed input/output assessment undertaken for the BSIA excluding total BHP investigation area (Table 3).

**Table 7 Potential Corridor and Trade Requirements between BSIA and Port - Excluding BHP Investigation Area North West of Estate (385 Ha)**

| | Area | Estimated Trade Quantity with Port | Number of Corridors |
|---|---|---|---|
| Total BSIA - excl total BHP investigation area | 2,230 ha | 33,387 ktpa | 26 |
| Trade/corridor proxy per ha based on detailed input/output assessment (Table 6) | 1.0 ha/ha | 15.0 ktpa/ha | 0.0117 corridors/ha |
| Difference BHP investigation area to be added (700 ha - 385 ha) | 315 ha | | |
| Total BSIA - excl BHP area (385 ha) | 2,545 ha | 38,103 ktpa | 30 |

### 3.4.1 BSIA - Including Total BHP Investigation Area (700 Ha)

The service corridor and trade forecast between port and BSIA including total BHP investigation area is presented in table below. The indicative estimates are based on per ha proxies derived from the detailed input/output assessment undertaken for the BSIA excluding total BHP investigation area (Table 3).

**Table 8 Potential Corridor and Trade Requirements between BSIA and Port - Including Total BHP Investigation Area**

| | Area | Estimated Trade Quantity with Port | Number of Corridors |
|---|---|---|---|
| Total BSIA - excl total BHP investigation area | 2,230 ha | 33,387 ktpa | 26 |
| Trade/corridor proxy per ha based on detailed input/output assessment (Table 6) | 1.0 ha/ha | 15.0 ktpa/ha | 0.0117 corridors/ha |
| Difference BHP investigation area to be added (700 ha) | 700 ha | | |
| Total BSIA - incl total BHP area (700 ha) | 2,930 ha | 43,867 ktpa | 34 |

# 4. Utility Demand Forecasting

The estimates provided in this report are indicative estimates based on information to GHD at the time of release of this report (see cover page for date), which does not include specific market research on the types of industries locating to the Boodarie Strategic Industrial Area. The estimates presented here should only be used for the purpose of the Concept Design of the Boodarie Strategic Industrial Area. The data presented in this report should be updated as more detailed information becomes available through the structure plan development process and thereafter (e.g. lot sizes, net developable land, industries locating to Boodarie Strategic Industrial Area, industry locations, industry inputs and outputs).

The purpose of the utility demand forecasting for estate is to assist utility providers with the planning and on-time delivery of required infrastructure and services to the Boodarie Strategic Industrial Area.

Based on a set of high level assumptions developed from other industrial estates in WA, along with the industry input / output assessment, an utility demand forecasting (power, gas, water) for the BSIA was undertaken to assist utility providers, government, and future industry with the planning and on-time delivery of required infrastructure and services to the estate.

## 4.1 Notes and Limitations

The utility demand forecasting presented in this section is subject to following uncertainties and limitations:

- In consultation with LandCorp, the assumptions made in this report are based on heavy industries being established in the BSIA over period of approximately 50 to 60 years. The utility demands will develop to their ultimate levels over this time frame.
- Forecasting demands have been provided for the BSIA with a net developable land of 2,230 ha which excludes total BHP investigation (700 ha);
- The forecasted demands will vary and are approximate estimates only, subject to actual development of the estate and final industry mix that will establish in the BSIA over time.
- Information on estimated industry mix, industry specific utility demands is provided in Section 3 of this report;
- These are indicative and high level estimates based on limited information available at this point in time, and therefore subject to change;
- Estimates are subject to industry mix to be located in BSIA (still unknown);
- There is no certainty about date/year when the BSIA will be fully developed;
- Estimates do not take into account ongoing industry expansions and increasing efficiencies and technology developments over time;
- These estimates cover operation of industries. Estimates do not cover potential higher demands during construction period.

## 4.2 Assumptions

**Table 9 BSIA Utility Demand Forecasting – Key Assumptions**

| Industry Type | Assumptions |
|---|---|
| Heavy industry | ◗ First heavy industry establishes in 2015<br>◗ One heavy industry establishes every 2 years thereafter (average estimate based on historical development in the Kwinana Industrial Area)<br>◗ Estimated total of 30 potential heavy industries in BSIA<br>◗ Above assumptions imply that heavy industries establish in BSIA over period of approximately 60 years (by 2075)<br>◗ Utility demands averaged over total 30 heavy industries<br>◗ Sequence of industries establishing in BSIA is not known, but it is likely that a ferrous processing company will be first to establish in BSIA |
| General and noxious industry | ◗ First general industry establishes in 2014<br>◗ Estimated Net Developable Area (NDA) for General and Noxious Industries = 260 ha<br>◗ General and noxious industries establish in BSIA over period of approximately 50 years (by 2064)<br>◗ Above assumptions imply development of 5.2 ha per annum for General and Noxious Industries Precincts |
| Iron ore stockpiling areas | ◗ Assumed that iron stockpiling areas (e.g. BHPB, Hancock) will be outside of Boodarie Strategic Industrial Area. Therefore, utility forecasting for iron ore stockpiling areas have not been included in this forecasting. |

## 4.3 Gas

**Table 10 BSIA Gas Demand Forecasting – Proxy Indicators**

| Industry Type | Proxy Indicator | Value |
|---|---|---|
| Heavy industry | Total estimated heavy industries in BSIA | 30 |
| | Total estimated gas use heavy industries | 425 PJ/a |
| | Average gas use per heavy industry | 14.2 PJ/a |
| General and noxious industry | Estimated NDA general and noxious industries | 260 ha |
| | Total estimated gas use general and noxious industries | 3.4 PJ/a |
| | Average gas use per ha | 0.013 PJ/ha |

**Table 11 BSIA Gas Demand Forecast**

| Industry Types | Indicative Forecast - Gas Demand (PJ/a) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 | 2055 | 2060 | 2065 | 2070 | 2075 |
| Heavy industry | 14 | 50 | 85 | 120 | 156 | 191 | 227 | 262 | 297 | 326 | 354 | 389 | 425 |
| General & noxious industry | 0.1 | 0.5 | 0.8 | 1.1 | 1.5 | 1.8 | 2.2 | 2.5 | 2.8 | 3.2 | 3.4 | 3.4 | 3.4 |
| Total – Excl BHP Investigation Area (700 ha) | 14 | 50 | 86 | 122 | 157 | 193 | 229 | 264 | 300 | 329 | 357 | 393 | 428 |

## 4.4 Power

**Table 12 BSIA Power Demand Forecasting – Proxy Indicators**

| Industry Type | Proxy Indicator | Value |
|---|---|---|
| Heavy industry | Total estimated heavy industries in BSIA | 30 |
| | Total estimated electricity use heavy industries | 1,166 MW |
| | Average electricity use per heavy industry | 39 MW/ha |
| General and noxious industry | Estimated NDA general and noxious industries | 260 ha |
| | Total estimated electricity use general and noxious industries | 42 MW |
| | Average electricity use per ha | 0.16 MW/ha |

**Table 13 BSIA Power Demand Forecast**

| Industry Types | Indicative Forecast - Power Demand (MW) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 | 2055 | 2060 | 2065 | 2070 | 2075 |
| Heavy industry | 39 | 136 | 233 | 330 | 427 | 525 | 622 | 719 | 816 | 894 | 971 | 1,068 | 1,166 |
| General & noxious industry | 2 | 6 | 10 | 14 | 18 | 22 | 27 | 31 | 35 | 39 | 42 | 41.6 | 42 |
| Total – Excl BHP Investigation Area (700 ha) | 41 | 142 | 243 | 344 | 446 | 547 | 648 | 750 | 851 | 933 | 1,013 | 1,110 | 1,207 |

## 4.5 Water

### 4.5.1 High Quality Industry Feedwater

Quality: ~ 100 to 200 mg/L TDS (subject to detailed options / pre-feasibility studies)

Targeted to be suitable for following applications:

- Boiler feedwater / steam production;
- High quality process water.

**Table 14 BSIA High Quality Industry Feedwater Demand Forecasting – Proxy Indicators**

| Industry Type | Proxy Indicator | Value |
|---|---|---|
| Heavy industry | Total estimated heavy industries in BSIA | 30 |

| Industry Type | Proxy Indicator | Value |
|---|---|---|
| | Total estimated high quality industry feedwater use heavy industries | 21 GL/a |
| | Average high quality industry feedwater use per heavy industry | 0.70 GL/a |
| General and noxious industry | Estimated NDA general and noxious industries | 260 ha |
| | Total estimated high quality industry feedwater use general and noxious industries | 1.88 GL/a |
| | Average high quality industry feedwater use per ha | 0.0072 GL/ha |

**Table 15 BSIA High Quality Industry Feedwater Demand Forecast**

| Industry Types | Indicative Forecast - High Quality Industry Feedwater Demand (GL/a) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 | 2055 | 2060 | 2065 | 2070 | 2075 |
| Heavy industry | 0.7 | 2.5 | 4.2 | 6.0 | 7.7 | 9.5 | 11.3 | 13.0 | 14.8 | 16.2 | 17.6 | 19.4 | 21.1 |
| General & noxious industry | 0.1 | 0.3 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 1.9 | 1.9 | 1.9 |
| Total – Excl BHP Investigation Area (700 ha) | 0.8 | 2.7 | 4.7 | 6.6 | 8.6 | 10.5 | 12.5 | 14.4 | 16.4 | 18.0 | 19.5 | 21.3 | 23.0 |

### 4.5.2 Low(er) Quality Industry Feedwater

Quality: ~ 800 to 1000 mg/L TDS (subject to detailed options / pre-feasibility studies)

Targeted to be suitable for following applications:

- Cooling water
- Process water
- Dust suppression
- Wash water
- Slurry water
- Irrigation

**Table 16 BSIA Low(er) Quality Industry Feedwater Demand Forecasting – Proxy Indicators**

| Industry Type | Proxy Indicator | Value |
|---|---|---|
| Heavy industry | Total estimated heavy industries in BSIA | 30 |
| | Total estimated low quality industry feedwater heavy industries | 35 GL/a |
| | Average low quality industry feedwater use per heavy industry | 1.2 GL/a |
| General and noxious industry | Estimated NDA general and noxious industries | 260 ha |
| | Total estimated low quality industry feedwater use general and noxious industries | 1.88 GL/a |
| | Average low quality industry feedwater use per ha | 0.0072 GL/ha |

**Table 17 BSIA Low(er) Quality Industry Feedwater Demand Forecast**

| Industry Types | Indicative Forecast – Low(er) Quality Industry Feedwater Demand (GL/a) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 | 2055 | 2060 | 2065 | 2070 | 2075 |
| Heavy industry | 1.2 | 4.1 | 7.0 | 9.9 | 12.8 | 15.7 | 18.6 | 21.5 | 24.4 | 26.8 | 29.1 | 32.0 | 34.9 |
| General & noxious industry | 0.1 | 0.3 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 1.9 | 1.9 | 1.9 |
| Total – Excl BHP Investigation | 1.2 | 4.3 | 7.4 | 10.5 | 13.6 | 16.7 | 19.8 | 22.9 | 26.0 | 28.5 | 31.0 | 33.9 | 36.8 |

| Industry Types | Indicative Forecast – Low(er) Quality Industry Feedwater Demand (GL/a) |
|---|---|
| Area (700 ha) | |

### 4.5.3 Industry Feedwater – Total

**Table 18 BSIA Total Industry Feedwater Demand Forecast (High and Low Quality)**

| Industry Types | Indicative Forecast - Total Industry Feedwater Demand (GL/a) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 | 2055 | 2060 | 2065 | 2070 | 2075 |
| Heavy industry | 1.9 | 6.5 | 11.2 | 15.9 | 20.5 | 25.2 | 29.9 | 34.6 | 39.2 | 43.0 | 46.7 | 51.4 | 56.0 |
| General & noxious industry | 0.2 | 0.5 | 0.9 | 1.3 | 1.7 | 2.0 | 2.4 | 2.8 | 3.2 | 3.5 | 3.8 | 3.8 | 3.8 |
| Total – Excl BHP Investigation Area (700 ha) | 2.0 | 7.1 | 12.1 | 17.2 | 22.2 | 27.3 | 32.3 | 37.3 | 42.4 | 46.5 | 50.5 | 55.1 | 59.8 |

### 4.5.4 Potable Water for Domestic Use

Assessment includes domestic use of potable water in:

- Toilets;
- Hand basins;
- Showers;
- Commercial kitchens;
- 10% for other various.

Water demand for irrigation and industry feedwater are not included.

Assumptions and calculations for estimating potable water use for domestic purposes in the Boodarie Industrial Area are provided in Appendix B.

**Table 19 BSIA Potable Water for Domestic Use Forecasting – Proxy Indicators**

| Industry Type | Proxy Indicator | Value |
|---|---|---|
| Heavy industry | Total estimated heavy industries in BSIA | 25 |
| | Total estimated domestic use of potable water | 222 ML/a |
| | Average domestic use of potable water per heavy industry | 7.4 ML/a |
| General and noxious industry | Estimated NDA general and noxious industries | 260 ha |
| | Total estimated domestic use of potable water general and noxious industries | 34 ML/a |
| | Average domestic use of potable water per ha | 0.13 ML/ha |

**Table 20 BSIA Potable Water for Domestic Use Forecast**

| Industry Types | Indicative Forecast Potable Water for Domestic Use (ML/a) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 | 2055 | 2060 | 2065 | 2070 | 2075 |
| Heavy industry | 7 | 26 | 44 | 63 | 81 | 100 | 119 | 137 | 156 | 170 | 185 | 204 | 222 |
| General & noxious industry | 1.4 | 4.8 | 8.3 | 11.7 | 15.1 | 18.6 | 22.0 | 25.5 | 28.9 | 32.3 | 34.4 | 34.4 | 34.4 |
| Total – Excl BHP Investigation Area (700 ha) | 9 | 31 | 53 | 75 | 97 | 119 | 141 | 162 | 184 | 203 | 220 | 238 | 257 |

# 5. Industrial Synergies

## 5.1 Introduction

Regional synergies are perhaps the best-known application of the principles of industrial ecology. They deal with the exchange of by-products, energy, and water, and sharing of services between closely situated firms. Because of the links between the firms, an industrial area is transformed into an 'industrial ecosystem' through 'industrial symbiosis'. Chertow (2000) defines industrial symbiosis as a process that "engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity".

As part of the project, GHD explored the following types of regional synergies for the Boodarie Industrial Area:

- Supply synergies: featuring local manufacturers and dedicated suppliers of principal reagents for core process industries (e.g. production of ammonia and chlorine for industrial use);
- Utility synergies: shared use of utility infrastructure, and mainly revolving around water and energy (e.g. water recovery and energy cogeneration);
- By-product synergies: the use of a previously disposed by-product (as solid, liquid, or gas) from one facility by another facility to produce a valuable by-product; and
- Service synergies: sharing of services and activities between industries in an industrial area (e.g. joint training of staff and sharing of maintenance contractors).

## 5.2 Summary of Synergy Opportunities Identified

Based on the identified industry mix and industry input / output assessment (Section 3), a total of 44 synergy opportunities have been identified for the BSIA at this stage, including 13 supply chain synergies, 11 utility synergies, 14 by-product synergies, and 6 service synergies. A summary of the industrial synergy opportunities identified for the potential types of industries to be located in the BSIA are presented in Table 21.

A high level assessment of their overall benefits and achievability (low, medium, high) has been included in the table below. A more detailed analysis of the benefits and achievability can be undertaken if required.

**Table 21 Summary of Synergy Opportunities for Boodarie Strategic Industrial Area**

| Potential Synergies | | Overall Benefits | Overall Achievability | Overall Priority |
|---|---|---|---|---|
| SUPPLY SYNERGIES: | | | | |
| 1 | Supply of stockpiled iron ore to ferrous processing plants | High | High | High |
| 2 | Supply of produced steel products (e.g. finished shapes) from BSIA steel plant to local heavy construction companies | High | Medium | Medium |
| 3 | Supply of logistical and transportation services by transport companies and warehouses to BSIA industries (e.g. road, rail, port) | High | High | High |
| 4 | Supply of beneficiated iron fines from pelletising and/or sinter plant to iron carbide plant | High | High | High |

| Potential Synergies | | Overall Benefits | Overall Achievability | Overall Priority |
|---|---|---|---|---|
| 5 | Supply of Fe-chips to ferrosilicon plant by steel plant | Medium | Medium | Medium |
| 6 | Supply of chlorine from chlor-alkali plant to resource processing plants | High | High | High |
| 7 | Supply of caustic soda from chlor-alkali plant to resource processing plants | High | High | High |
| 8 | Supply of magnesium by magnesium production plant to titanium production plant | Medium | Medium | Medium |
| 9 | Supply of sodium chloride from salt mine to chlor-alkali plant | High | High | High |
| 10 | Supply of ethane from ethane extraction to ethane cracker | High | High | High |
| 11 | Supply of ethylene from ethane cracker to EDC / VCM plant | High | High | High |
| 12 | Supply of ammonia from ammonia/urea plant to sodium cyanide plant and fertiliser production plant | High | High | High |
| 13 | BSIA non-ferrous smelter (e.g. nickel, aluminium, copper, zinc, lead) supplying intermediate product (e.g. nickel-in-matte, alumina, blister copper, zinc, lead) to non-ferrous refinery in BSIA | High | High | High |
| UTILITY SYNERGIES: | | | | |
| 1 | Energy factory supplying electricity, steam, and hot/cold air to surrounding BSIA industries. Potential feeds:<br>◗ Gas<br>◗ Electricity<br>◗ Biofuels<br>◗ Renewables<br>◗ Off-gases and waste heat from BSIA industries | High | Medium | Medium |
| 2 | Water factory supplying high and low quality industry feedwater to BSIA industries. Potential feeds:<br>◗ Groundwater<br>◗ Industrial effluents<br>◗ WWTP effluent<br>◗ Seawater<br>◗ Waste heat from BSIA industries | High | High | High |
| 3 | Direct use of WWTP treated effluent by selected BSIA industries (potential for on-site treatment to suit requirements) | High | High | High |
| 4 | Reuse of effluent stream (segregated or not) from one BSIA industry by other BSIA industry | Medium | Medium | Medium |
| 5 | Centralised production and supply of pressurised air to BSIA industries | Medium | Low / medium | Low |
| 6 | Centralised production, supply, and recovery of utility gases to BSIA industries (nitrogen, hydrogen, oxygen) | High | Medium | Medium |
| 7 | Managed aquifer recharge of treated effluents, and indirect industrial reuse | Medium | Low | Low |
| 8 | Centralised storage and processing facility for large volume inorganic by-products produced in BSIA | High | High | High |
| 9 | Centralised treatment facility for industry off-gases (e.g. SOx, NOx) | Medium | Medium | Medium |
| 10 | Joint industry production of demineralised water for specialised applications (boiler feedwater) | Medium | Medium | Medium |

| Potential Synergies | | Overall Benefits | Overall Achievability | Overall Priority |
|---|---|---|---|---|
| 11 | Centralised storage and processing facility for selected (smaller volume) waste streams (e.g. hazardous wastes, oils, pallets, metals) | Medium | High | Medium |
| BY-PRODUCT SYNERGIES: | | | | |
| 1 | Use of industry waste heat for drying or concentrating wet products and by-products. Potential products:<br>◗ Sludges<br>◗ Filtercakes<br>◗ Acids | Medium | Medium | Medium |
| 2 | Use of pelletising wastes from iron ore pelletising plant (e.g. cement plant) | Medium | Medium | Medium |
| 3 | Use of ammonium sulphate from nickel processing in fertiliser production | High | High | High |
| 4 | Processing and use of slag from ferrous mineral processing.<br>Potential uses:<br>◗ Aggregate in construction<br>◗ Substitute for clinker in cement manufacturing<br>◗ Soil conditioning | High | Medium | Medium |
| 5 | Processing and use of gypsum from resource processing<br>Potential uses:<br>◗ Use in construction materials (e.g. plasterboard and blended in bricks)<br>◗ As feedstock for chemical processing (e.g. ammonium sulphate, sulphuric acid, nitric fertiliser, and lime) | Medium | Medium | Medium |
| 6 | Re-processing of scrap steel from BSIA industries by BSIA steel plant | Medium | High | Medium |
| 7 | Co-processing of organic by-products from BSIA industries at large scale organic processing plant (e.g. ethanol, biofuels). Potential feeds:<br>◗ Biosolids from WWTP<br>◗ Residues from organic based processing plants<br>◗ Waste grain<br>◗ Organic residues from alternative waste technologies | High | Medium | Medium |
| 8 | Co-processing of inorganic by-products from BSIA industries and other alternative materials. Potential feeds:<br>◗ Slags from ferrous mineral processing<br>◗ Process residues from non-ferrous mineral processing (e.g. nickel)<br>◗ Process residues from industrial processing (manufacturing)<br>◗ Inorganic residues from alternative waste technologies<br>◗ Tyres<br>◗ Gypsum | High | Medium | Medium |
| 9 | Use of alternative fuels at selected BSIA industries (e.g. waste oils, tyres, shredded wood, coke dust from steel making) | High | Medium | Medium |
| 10 | Use of alternative lime sources in ferrous and non-ferrous mineral processing. Potential alternatives:<br>◗ Lime kiln dust from cement manufacturing<br>◗ Lime dust from steel making | High | High | High |

| Potential Synergies | | Overall Benefits | Overall Achievability | Overall Priority |
|---|---|---|---|---|
| 11 | Conversion of process carbon dioxide in commercial gases by utility gas company | High | Medium | Medium |
| 12 | Conversion of process by-product hydrogen into commercial gases by utility gas company | High | High | High |
| 13 | Conversion of process by-product nitrogen into commercial gases by utility gas company | High | High | High |
| 14 | Use of charcoal (from plantations) as alternative to (petroleum) coke as reductant in steel sintering and mineral processing | High | Medium | Medium |
| SERVICE SYNERGIES: | | | | |
| 1 | Joint industry training and education facilities (regional industry training centre), including shared staffing (e.g. maintenance support) | High | High | High |
| 2 | Joint logistic and transportation facilities covering:<br>◗ Centralised storage<br>◗ Shared transportation of incoming and outgoing goods<br>◗ Common vehicle maintenance | High | Medium | Medium |
| 3 | Joint industry agreement for collection and handling of selected industry wastes.<br>Potential waste streams:<br>◗ Waste metals<br>◗ Waste oil and greases<br>◗ Packaging materials (e.g. pallets, cardboard, plastics, drums)<br>◗ Construction and demolition wastes<br>◗ "Small volume" process residues | Medium | Medium | Medium |
| 4 | BSIA interpretive centre which aims:<br>◗ Communication, education, and awaresss of industry processes, resource recovery<br>◗ Facilitate stakeholder discussions re BSIA (e.g. industries, government, community)<br>◗ Facilitate community involvement in BSIA | Medium | Medium | Medium |
| 5 | Joint industry monitoring and control of odour and air quality footprint | Medium | High | Medium |
| 6 | Joint industry incident and accident prevention and response | High | High | High |

## 5.3 Benefits of Industrial Synergies

The potential synergies for the BSIA, if implemented, can provide a range of economic, environmental, and social benefits to the companies involved, the region as a whole, and the local community. Appendix C shows that the types of benefits can vary greatly and often go well beyond the conventional business case benefits. Security of water and energy supply, increased resource efficiency, lower operational costs for resource use, and reduced storage and landfill costs are key benefits from the synergies presented here. In addition, all of these synergies had environmental and community benefits. The benefits from regional synergies are not just commercial but also strategic, leading to reduced exposure to risk and improved reputation. The full range of benefits needs to be communicated clearly to the stakeholders (industries, government, community) involved in the synergy development process.

The information on synergy benefits allows for the selection of opportunities that target specific benefits or outcomes (e.g. creation of employment or search for cheaper raw materials).

## 5.4 Success Factors on Industrial Synergies

The realisation of successful synergies is dependent on three main aspects: proven technology, convincing business case, and license to operate (see Figure 3)[2]. For a synergy to be successful all involved parties must benefit in one way or another. In fact, it is unlikely that a synergy would be implemented unless all involved parties at least perceive some business benefit (direct or indirect). When developing synergy opportunities for the Boodarie Strategic Industrial Area, it is most important to maintain a focus on these three key success factors.

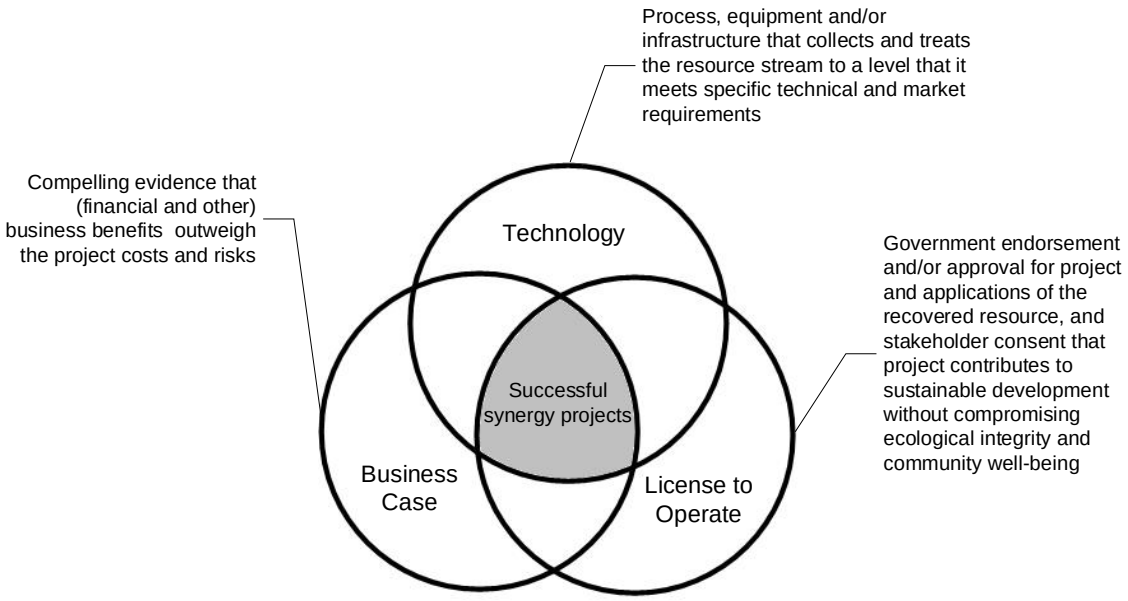



**Figure 3 Success Factors for Regional Resource Synergies (van Berkel 2006)**

## 5.5 Industrial Synergies and BSIA Concept Plan

The BSIA Concept Plan should allow for the development of promising industrial synergy opportunities identified. The table below outlines the potential implications from the industrial synergy opportunities on the BSIA Concept Plan, and to what extent the Concept Plan will be able to facilitate the development of these synergies over time.

[2] van Berkel, R. 2006. Regional Resource Synergies for Sustainable Development in Heavy Industrial Areas: An Overview of Opportunities and Experiences. Perth, WA, Australia: Curtin University of Technology.

**Table 22 Potential Implication of Industrial Synergies on BSIA Concept Plan**

| # | Industrial Synergy Opportunity | Implications for BSIA Concept Design Plan |
|---|---|---|
| SUPPLY SYNERGIES: | | |
| 1 | Supply of stockpiled iron ore to ferrous processing plants | ◗ Allow for location ferrous processing plants adjacent to iron ore stockpiling areas<br>◗ Service corridors and transportation nodes to allow for potential material movements between estate and iron ore stockpiling area west of estate |
| 2 | Supply of produced steel products (e.g. finished shapes) from BSIA steel plant to local heavy construction companies | ◗ Allow for location of heavy construction companies in General Industry Precincts, and possibly in strategic core of estate<br>◗ Transportation nodes to allow for potential steel products movements within strategic core of estate and General Industry Precinct |
| 3 | Supply of logistical and transportation services by transport companies and warehouses to BSIA industries (e.g. road, rail, port) | ◗ Allow for location of logistical and transportation industries in General Industry Precincts and areas adjacent to BSIA<br>◗ Transportation nodes to allow for potential material movements between and within strategic core, General Industry Precinct, Port, and BSIA surrounding regions |
| 4 | Supply of beneficiated iron fines from pelletising and/or sinter plant to iron carbide plant | ◗ Allow for co-location of iron pelletising plant, sinter plant, and iron carbide plant<br>◗ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries |
| 5 | Supply of Fe-chips to ferrosilicon plant by steel plant | ◗ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries |
| 6 | Supply of chlorine from chlor-alkali plant to resource processing plants | ◗ Allow for co-location of chlor-alkali plant and resource processing plants<br>◗ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries |
| 7 | Supply of caustic soda from chlor-alkali plant to resource processing plants | ◗ Allow for co-location of chlor-alkali plant and resource processing plants<br>◗ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries |
| 8 | Supply of magnesium by magnesium production plant to titanium production plant | ◗ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries |
| 9 | Supply of sodium chloride from salt mine to chlor-alkali plant | ◗ Allow for location of chlor-alkaline plant in Port Dependent and Material Intensive Industries Precinct<br>◗ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries |
| 10 | Supply of ethane from ethane extraction to ethane cracker | ◗ Allow for location of ethane extraction and ethane cracker<br>◗ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries |
| 11 | Supply of ethylene from ethane cracker to EDC / VCM plant | ◗ Allow for location of ethane cracker and EDC / VCM plant<br>◗ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries |
| 12 | Supply of ammonia from ammonia/urea plant to sodium cyanide plant and fertiliser production plant | ◗ Allow for location of ammonia/urea plant, sodium cyanide plant and/or fertiliser plant<br>◗ Service corridors and transportation nodes to allow for potential material movements between these synergistic industries |

| # | Industrial Synergy Opportunity | Implications for BSIA Concept Design Plan |
|---|---|---|
| 13 | BSIA non-ferrous smelter supplying intermediate product to non-ferrous refinery in BSIA | ◗ Allow for co-location of non-ferrous smelter and refinery<br>◗ Service corridors and transportation nodes to allow for potential material movements between non-ferrous smelter and refinery |
| UTILITY SYNERGIES: | | |
| 1 | Energy factory supplying electricity, steam, and hot/cold air to surrounding BSIA industries. | ◗ Allow for location of energy facility in Utility Precinct<br>◗ Allow for co-location of energy intensive industries in close proximity of energy facility<br>◗ Service corridors to allow for potential energy exchanges between energy facility and energy intensive industries |
| 2 | Water factory supplying high and low quality industry feedwater to BSIA industries. | ◗ Allow for location of industry feedwater facility in Utility Precinct<br>◗ Allow for co-location of water intensive industries in close proximity of water facility<br>◗ Allow for co-location of energy facility with industry feedwater facility<br>◗ Service corridors to allow for potential water exchanges between industry feedwater facility, water/energy intensive industries, ocean, municipal WWTP, groundwater access point |
| 3 | Direct use of WWTP treated effluent by selected BSIA industries (potential for on-site treatment to suit requirements) | ◗ Service corridors to allow for potential water exchanges between water intensive industries and municipal WWTP |
| 4 | Reuse of effluent stream (segregated or not) from one BSIA industry by other BSIA industry | ◗ Allow for co-location of water intensive industries<br>◗ Service corridors to allow for potential water exchanges between water intensive industries |
| 5 | Centralised production and supply of pressurised air to BSIA industries | ◗ Allow for location of centralised pressurised air facility in Utility Precinct<br>◗ Service corridors to allow for potential pressurised air supply from facility to key industries in strategic core |
| 6 | Centralised production, supply, and recovery of utility gases to BSIA industries (nitrogen, hydrogen, oxygen) | ◗ Allow for location of centralised utility gas facility in Utility Precinct<br>◗ Service corridors to allow for potential utility gas movements between facility and key industries in strategic core |
| 7 | Managed aquifer recharge of treated effluents, and indirect industrial reuse | ◗ To be confirmed in later studies |
| 8 | Centralised storage and processing facility for large volume inorganic by-products produced in BSIA | ◗ Allow for location of centralised storage and processing facility for large volume inorganic by-products (if possible in buffer zone)<br>◗ Service corridors and transportation nodes to allow potential material movements between centralised storage and processing facility and industries in strategic core of BSIA |
| 9 | Centralised treatment facility for industry off-gases (e.g. SOx, NOx) | ◗ Allow for location of centralised treatment facility for industry off-gases in Utility Precinct<br>◗ Service corridors to allow for potential off-gas movements between facility and key industries in Utility Precinct |
| 10 | Joint industry production of demineralised water for specialised applications (boiler feedwater) | ◗ Allow for location of joint industry demin plant in Utility Precinct<br>◗ Service corridors to allow for potential demin water exchanges between key industries in Utility Precinct |

| # | Industrial Synergy Opportunity | Implications for BSIA Concept Design Plan |
|---|---|---|
| 11 | Centralised storage and processing facility for selected (smaller volume) waste streams (e.g.hazardous wastes, oils, pallets, metals) | ◗ Allow for location of centralised storage and processing facility for smaller volume wastes in BSIA<br>◗ Transportation nodes to allow for potential waste movements within BSIA Precincts and surrounding regions |
| BY-PRODUCT SYNERGIES: | | |
| 1 | Use of industry waste heat for drying or concentrating wet products and by-products. | ◗ Allow for co-location of energy intensive industries and potential users of waste heat<br>◗ Service corridors to allow for potential waste heat exchanges industries in close proximity |
| 2 | Use of pelletising wastes from iron ore pelletising plant (e.g. cement plant) | ◗ Transportation nodes to allow for potential pelletising waste movements between pelletising plant and industrial/commercial users |
| 3 | Use of ammonium sulphate from nickel processing in fertiliser production | ◗ Allow for co-location of fertiliser plant with nickel refinery in Resource Processing Precincts<br>◗ Service corridors and transportation nodes to allow for potential material movements |
| 4 | Processing and use of slag from ferrous mineral processing | ◗ Transportation nodes to allow for potential material movements |
| 5 | Processing and use of gypsum from resource processing | ◗ Transportation nodes to allow for potential material movements |
| 6 | Re-processing of scrap steel from BSIA industries by BSIA steel plant | ◗ Transportation nodes to allow for potential material movements |
| 7 | Co-processing of organic by-products from BSIA industries at large scale organic processing plant (e.g. ethanol, biofuels) | ◗ Transportation nodes to allow for potential material movements |
| 8 | Co-processing of inorganic by-products from BSIA industries and other alternative materials. | ◗ Transportation nodes to allow for potential material movements |
| 9 | Use of alternative fuels at selected BSIA industries (e.g. waste oils, tyres, shredded wood, coke dust from steel making) | ◗ Transportation nodes to allow for potential material movements |
| 10 | Use of alternative lime sources in ferrous and non-ferrous mineral processing. | ◗ Transportation nodes to allow for potential material movements |
| 11 | Conversion of process carbon dioxide in commercial gases by utility gas company | ◗ Allow for co-location of utility gas plant with key industries<br>◗ Service corridors to allow for potential utility gas movements between facility and key industries in strategic core of BSIA |
| 12 | Conversion of process by-product hydrogen into commercial gases by utility gas company | ◗ Allow for co-location of utility gas plant with key industries<br>◗ Service corridors to allow for potential utility gas movements between facility and key industries in strategic core of BSIA |

| # | Industrial Synergy Opportunity | Implications for BSIA Concept Design Plan |
|---|---|---|
| 13 | Conversion of process by-product nitrogen into commercial gases by utility gas company | ◗ Allow for co-location of utility gas plant with key industries<br>◗ Service corridors to allow for potential utility gas movements between facility and key industries in strategic core of BSIA |
| 14 | Use of charcoal (from plantations) as alternative to (petroleum) coke as reductant in steel sintering and mineral processing | ◗ Transportation nodes to allow for potential material movements |
| SERVICE SYNERGIES: | | |
| 1 | Joint industry training and education facilities (regional industry training centre), including shared staffing (e.g. maintenance support) | ◗ Identify potential location(s) of training and education facility in BSIA |
| 2 | Joint logistic and transportation facilities | ◗ Allow for location of logistic and transporation companies in General Industry Precinct or BSIA surrounding areas<br>◗ Transportation nodes to allow for potential material movements between BSIE strategic core, General Industry Precinct, Port, and BSIA surrouding regions |
| 3 | Joint industry agreement for collection and handling of selected industry wastes | ◗ Transportation nodes to allow for potential material movements |
| 4 | BSIA interpretive centre | ◗ Identify potential location(s) of BSIA interpretive centre (e.g. in General Industry Precinct or BSIA surrounding area) |
| 5 | Joint industry monitoring and control of odour and air quality footprint | ◗ Identify optimal locations for odour intensive industries<br>◗ Allow for co-location of odour intensive industries with minimum impact on community (e.g. close to BSIA Buffer Zone) |
| 6 | Joint industry incident and accident prevention and response | ◗ Identify optimal locations for high(er) risk industries<br>◗ Allow for co-location of high(er) risk industries (e.g. close to BSIA Buffer Zone) |

# 6. Centralised Water, Energy and By-Product Facilities

Industrial ecology focuses on industry collaboration to address common needs and to increase resource efficiencies. Securing water and energy supply, and efficient and effective storage and processing of large volume industrial by-products and wastes are critical to the successful development of the Boodarie Strategic Industrial Area. Each item is discussed below from an industrial ecology perspective.

## 6.1 Centralised Industry Feedwater Facility

### 6.1.1 Business Case

Over the past 30 years Australia, including Western Australia, has experienced significantly decreased rainfall, most probably as a result of climate change. Due to declining levels of stored water in dams and underground aquifers, fresh water will be a more scarce resource over the next decades and the cost of water is likely to increase over time. Runoff into dams has reduced by 40-50 percent since 1975 due to decreased rainfall. This has impacted industrial water users by directly reducing the available fresh water resources and indirectly restricting potable scheme water available to industry. This trend is most likely to increase in the future.

The industry input / output assessment (Section 3) indicated that the BSIA, when fully developed, will potentially require between 60 and 80 GL/yr of industry feedwater, including 23 to 30 GL/yr of high quality feedwater (e.g. boilers, process), and about 36 to 48 GL/yr of lower quality feedwater (e.g. cooling, dust suppression). The lack of access to appropriate, well priced (industry feed) water can be a potential show stopper for new heavy industry wanting to establish in the BSIA.

The Water Corporation plan (Water Forever - Towards Climate Resilience, October 2009) has set a target of 30% for recycling of wastewater by 2030, with recycling to industry being a focus area. Of relevance to the Boodarie Strategic Industrial Area, the plan also refers to the need to influence land planning and development by initiatives such as planning for use of recycled water, increasing the application of water sensitive urban design, and helping business and industry to make better use of fit for purpose water.

### 6.1.2 Proposed Concept

In the BSIA Concept Plan, it is proposed to allocate sufficient land area (about 65 ha) in the Utility Precinct for a centralised facility to produce fit-for-purpose industry feedwater. Proposed approximate location of the facility is shown in Figure 4 in Section 7.

Such a facility could feed from various sources, including groundwater, industrial effluents generated within the estate, effluent from nearby municipal WWTP, seawater, or a combination of these sources. At this point in time, the BSIA Concept Plan should not lock in one water resource, but rather allow for the use of any of these water resources over time (subject to future feasibility studies, developments, and water availability).

It may be that an alternative industry feedwater arrangement and/or system is set up outside the boundaries of the BSIA. This is subject to future feasibility studies, and initiatives undertaken by other

organisations and/or utility providers in the region. In this case, the allocated land use for feedwater facility can be used for alternative land uses.

Overall, it is aimed to produce a fit-for-purpose industry feedwater for the BSIA at a cost competitive with potable water, given the likely price increases for potable water in the future. It is recognised that the development of an alternative industry feedwater system in the BSIA may occur additional capital costs over and above a business-as-usual approach (e.g. third pipe, recycling and storage facility). However, anticipated increasing price of potable water and government/community pressures will have positive effect on the economic feasibility of alternative industry feedwater concept. Having an alternative industry feedwater system in BSIA has the potential to attract water intensive industries to the area. Furthermore, it is important to consider the environmental cost of potable water (e.g. from seawater desalination plant) when evaluating the business case of an alternative water supply for industry.

A modular approach to the design of the water facility is recommended to allow the facility to expand over time as more industries require their services.

Future industries in the BSIA will likely generate significant amounts of waste heat, in particular flue gases. For example, the total energy release from flue gases in the Kwinana Industrial Area is estimated at approximate 6,300 TJ/yr, with up to 3,000 TJ/yr over 300$^{o}$C[3]. The industry feedwater facility has potential to feed from the waste heat generated in the BSIA. Evaporative water treatment or desalination systems (e.g. multi-effect distillation) are proven technologies for regions and industries without readily access to fresh water. These technologies are normally driven by fossil fuels, but could be driven by industry waste heat as well. As a result, it is recommended to co-locate the feedwater facility with an energy facility (discussed in Subsection 6.2). The co-location of these two facilities is shown in Figure 4 in Section 7.

## 6.2 Centralised Energy Facility

### 6.2.1 Business Case

The industries in the BSIA will have significant energy requirements. The industry input / output assessment (Section 3) estimated, when estate is fully developed, power requirements between 1,200 to 1,500 MW and gas requirements between 425 and 560 PJ/yr. On the other hand, significant amounts of waste heat will likely be generated by the future BSIA industries resulting in opportunities for energy recovery and efficiencies.

There are numerous ways in which the industry can source these energy requirements, including conventional power stations, gas pipeline, co and/or trigeneration facilities, and renewable energy (e.g. wind, solar, wave, geothermal). Their application to power the BSIA over time will depend on specific industry energy demands, economic and technical feasibility, government (dis)incentives (e.g. carbon tax), community pressures, energy source availability, land assembly, and environmental constraints. The BSIA will most likely be driven by a combination of various energy supply options.

[3] Van Beers (2008). 2008 Status Report of the CSRP Kwinana Synergies Project, Report for Centre for Sustainable Resource Processing.

Given the current uncertainties impacting of the estate development, it is key for the BSIA Concept Plan to allow for the development of multiple energy supply options over time.

### 6.2.2 Proposed Concept

It is proposed to allow for the development of a centralised and joint industry energy facility (about 60 ha) in the Utility Precinct of the estate creating economies of scale and potentially avoiding the need for multiple, smaller, and under-utilised facilities throughout the estate. Such facility could produce electricity, steam, chill, hot air to industries in its close proximity. Allowance should be made for the facility to feed from various energy sources, including gas, coal, renewable energy, and industry waste heat.

As for the industry feedwater facility, a modular approach to the design of the energy facility is recommended to allow the facility to expand over time as more industries require their services.

It is noted that heat losses over longer distances (e.g. over 500 meters) can be significant. Therefore it is recommended to locate the energy facility in the strategic core of the estate, close to industries producing significant amounts of waste heat.

Furthermore, as noted in Subsection 6.1, it is recommended to co-locate the centralised energy facility with the industry feedwater facility to enable the generation of feedwater or seawater desalination with industry waste heat. The co-location of these two facilities is shown in Figure 4 in Section 7.

## 6.3 Centralised Industrial By-Product Storage and Processing Facility

### 6.3.1 Business Case

Significant amounts of industrial by-products (both inorganic and organic) will likely be generated in the BSIA. Subject to specific types of industries locating to the BSIA, these could include slags, tailings, gypsum, cement, ashes, lime and cement kiln dusts.

The industry input / output assessment undertaken (Section 3) estimates that a total between 4.6 and 6.1 Mtpa (4,600,000 tpa to 6,100,000 tpa) of industrial by-products could be generated in the estate once fully developed. It is noted that the quantities could be significant higher if, for example, an alumina refinery would establish in the estate.

Many industrial by-products have significant potential to be reused in building and construction materials, sustainable agriculture, minerals and metals production and other applications. The opportunity exists to replace virgin materials with recovered inorganic by-products from industrial operations in BSIA, either directly or after beneficiation to improve properties. Their utilisation as valuable by-products have the potential to reduce liabilities associated with current management and storage practices. Overall, the reuse of industrial by-products can make a significant contribution to the sustainability of the Boodarie Strategic Industrial Area.

### 6.3.2 Proposed Concept

Rather than stockpiling the large volume industrial by-products within the strategic core of the estate, there is potential to transfer these by-products to a centralised storage facility in the buffer zone of the estate (subject to environmental, town planning, and land assembly constraints). A centralised facility in the buffer would maximise industrial land use in the strategic core, but would also facilitate and encourage the (co-)processing industrial by-products into valuable materials.

The concept of inorganic by-product storage and processing facility is shown in Figure 4 in Section 7.

It is noted that industry will need to ensure that their by-products are of suitable standard for long-term storage and re-processing. Quality standards and protocols should be developed for the facility, including commercial reprocessing agreements between industries to enable co-processing of different by-products into material with enhanced properties (e.g. mixing of gypsum and cement kiln dust as sustainable agricultural product).

It is envisaged that the different industrial by-products will be stored in separate areas to avoid cross contamination, and enable re- and co-processing of by-products into valuable products over time.

The preferred location and size of the centralised industrial by-product facility are yet to be determined.

Key criteria for the determining the location of the facility:

- Service corridor and road access (e.g. transferring materials in and out of storage facility);
- Town planning approval;
- Environmental constraints (e.g. flora, fauna, water bodies, soil type); and
- Land assembly (e.g. other planned uses and existing infrastructure and facilities in the buffer).

# 7. Industrial Area Precincts

In the first instance and at a high order, industry clustering is facilitated through the development of appropriate industry precincts within the BSIA. This section outlines the precincts identified, their preferred location, and proposed precinct concept for the estate.

Industry location and clustering within the precincts are discussed in Section 8.

## 7.1 Identification of Precincts

Based on the industry input/output assessment (Section 3), previous reports on the BSIA, and discussions with the Concept Plan Design Team (LandCorp, DSD, and appointed consultants), the following precincts were identified:

- Port Dependent and Material Intensive Industries;
- Downstream Petroleum / Gas / Coal Processing;
- Downstream Iron Ore Processing;
- Resource Processing;
- General industries;
- Noxious industries.

## 7.2 Precincts Location Criteria

Based on industry input/output assessment and industrial synergy opportunities identified, appropriate and relevant location criteria (requirements) for each precinct are summarised in Table 23.

**Table 23 Precinct Location Criteria for Boodarie Strategic Industrial Area**

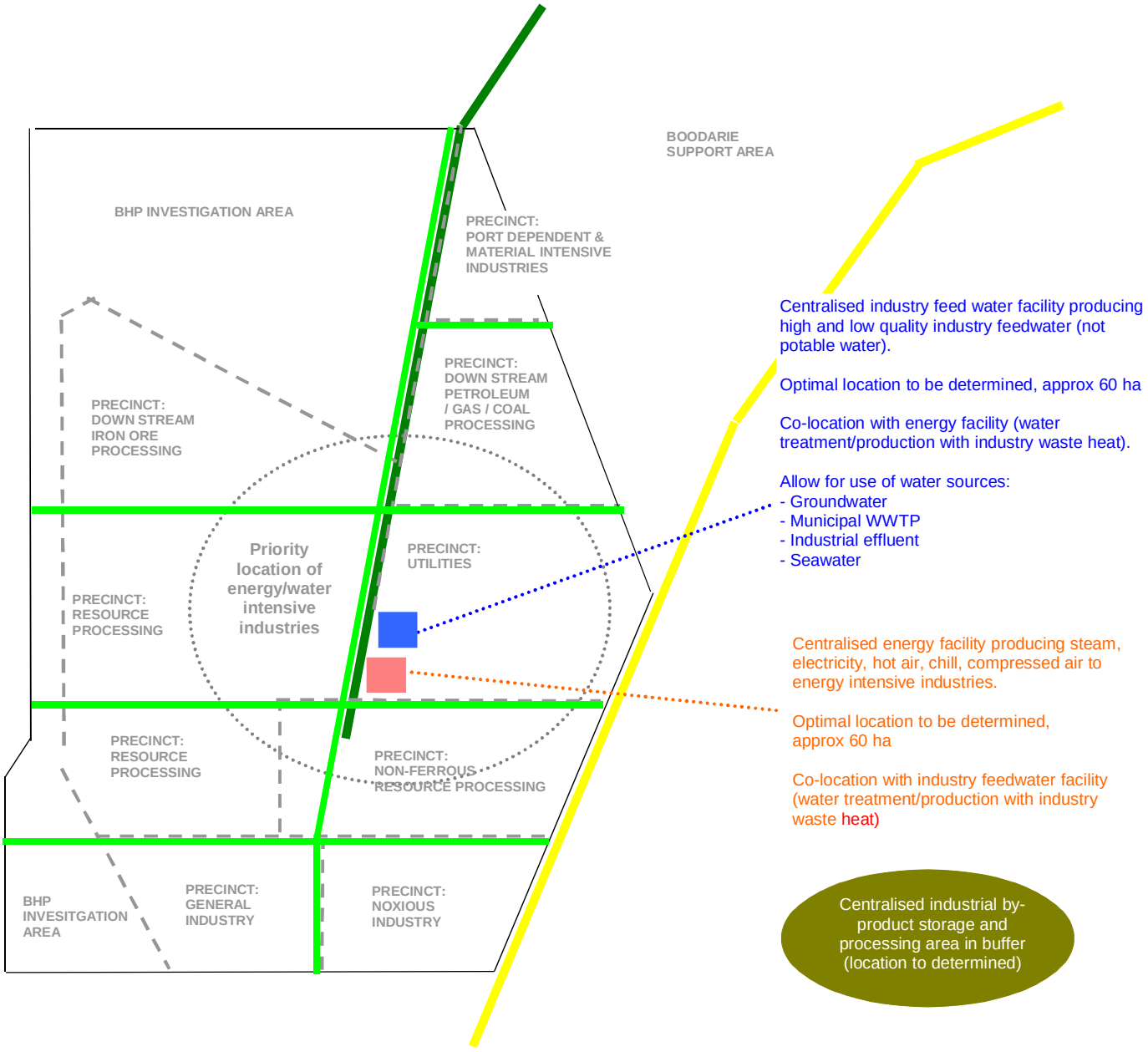
| Precinct | Precinct Location Criteria | Recommended Precinct Location |
|---|---|---|
| Port Dependent and Material Intensive Industries | ◗ Access to port (service corridor, road, rail)<br>◗ Access to bulk commodity rail<br>◗ Access to multi-product rail<br>◗ Access to road<br>◗ Access to conveyor systems | Far north eastern part of estate (closest to port)<br><br>Adjacent to main BSIA service corridor |
| Downstream Iron Ore Processing | ◗ Access to port (service corridor, road, rail)<br>◗ Access to bulk commodity rail<br>◗ Access to multi-product rail<br>◗ Access to road<br>◗ Access to gas pipelines<br>◗ Access to conveyor systems<br>◗ Access to HV power supply<br>◗ Access to industry feedwater supply<br>◗ Buffer zone<br>◗ Adjacent to Iron Ore Stockpiling Area (raw material supply)<br>◗ Adjacent to Resource Processing Precinct (industrial synergies) | Western part of estate<br><br>Adjacent east of Iron Ore Stockpiling Precinct<br><br>Proximity and access of General and Noxious Industries Precincts<br><br>Adjacent to main BSIA service corridor |

| Precinct | Precinct Location Criteria | Recommended Precinct Location |
|---|---|---|
| | ◗ Proximity and access to Noxious Industries Precincts (support and synergies) | |
| Downstream Petroleum / Gas / Coal Processing | ◗ Access to gas pipeline supply<br>◗ Access to port (service corridor, road, rail)<br>◗ Access to pipelines in service corridors<br>◗ Buffer zone<br>◗ Appropriate distance to Turner River Aquifer Groundwater Control Area south of BSIA (spillage risks) | North eastern part of estate (close access to port and away from Turner River Aquifer Groundwater Control Area)<br><br>Adjacent to main BSIA service corridor |
| Resource Processing | ◗ Access to port (service corridor, road, rail)<br>◗ Access to bulk commodity rail<br>◗ Access to multi-product rail<br>◗ Access to road<br>◗ Access to gas pipelines<br>◗ Access to HV power supply<br>◗ Access to industry feedwater supply<br>◗ Buffer zone<br>◗ Adjacent to Down Stream Iron Ore Processing Precinct (industrial synergies)<br>◗ Proximity and access to General and Noxious Industries Precincts (support and synergies) | North eastern part of estate<br><br>Adjacent to Downstream Iron Ore Processing Precinct<br><br>Proximity and access of General and Noxious Industries Precincts<br><br>Adjacent to main BSIA service corridor |
| General industries | ◗ Access to road<br>◗ Proximity and access to Resource Processing Precinct (industrial synergies)<br>◗ Proximity and access to Down Stream Iron Ore Processing Precinct (industrial synergies) | Subject to environmental assessment (e.g. Turner River Aquifer Groundwater Control Area of BSIA) and connection to sewer<br><br>Southern part of estate<br><br>Proximity and access to Resource Processing Precinct<br><br>Proximity and access to Down Stream Iron Ore Processing Precinct |
| Noxious industries | ◗ Buffer zone<br>◗ Access to road<br>◗ Adjacent to Resource Processing Precinct (industrial synergies)<br>◗ Adjacent to Down Stream Iron Ore Processing Precincts (industrial synergies) | Subject to environmental assessment (e.g. Turner River Aquifer Groundwater Control Area south of BSIA) and connection to sewer<br><br>Southern part of estate<br><br>Adjacent south of Resource Processing Precinct<br><br>Adjacent south of Down Stream Iron Ore Processing Precinct |

## 7.3 Precinct Concept

Following the review of location criteria and subsequent recommended precinct location, Figure 4 presents a precinct concept for the Boodarie Strategic Industrial Area. This precinct plan will allow for the development of promising industry synergies identified and subsequent industry clustering.

Figure 4 Proposed Precinct Concept for Boodarie Strategic Industrial Area




Notes:

- Alignment shown are only indicative, and subject to assembly of base mapping;
- Plan subject to environmental, town planning, and land assembly constraints;
- Do not scale this plan; and
- Land size and location flexible, subject to industry demand.

# 8. Industry Clustering

High level industry clustering is facilitated through the industry precincts identified and their positioning within the Boodarie Strategic Industrial Area (Section 7). This section discusses the potential for industry clustering within the precincts.

It is noted that the specific industry types locating to the BSIA are still largely unknown. Therefore, this section provides guidance on the types of clustering which can occur in Boodarie, rather than locking in clustering scenarios at this point in time.

The implementation plans in Section 11 provide guidance on actions to be taken to facilitate industry clustering post concept planning.

## 8.1 Industry Clustering

The clustering of relevant industries (based on their services and resource inputs and outputs) is at the heart of industrial ecology. Industry clustering is a critical element to allow for the development of regional synergies within the BSIA and with its surrounding regions as well as a mechanism to reduce the need for utility infrastructure and associated costs.

Firms and organisations involved in clusters are able to achieve synergies and leverage economic advantage from shared access to information and knowledge networks, supplier and distribution chains, markets and marketing intelligence, special competencies, resources and support institutions available in a specific locality. The cluster concept focuses on the functional linkages and interdependencies among actors in value chains.

*In summary, the benefits of industry clustering include[4]:*

- Attracting businesses to the industrial estate because of the cost benefits associated with co-location and security of resource supply;
- Proximity generates externality savings and economies of scale, which reduce operational costs for companies sharing common suppliers or services;
- Encourages innovation, which leads to opportunities for the development of new industries especially firms capable of using wastes and by-products;
- The more intense the agglomeration, the greater are the prospects for innovation and synergies.

Table 24 presents a preliminary overview of industry clustering options for the Boodarie Industrial Area.

**Table 24 Preliminary Review of Industry Clustering Options**

| Clustering Options | Comments / Illustrative Examples |
|---|---|
| Water cluster | Water intensive industries (demand and discharges) |
| Energy cluster | Energy intensive industries (demand and discharges) |

[4] Planning for Sustainable Industry" by Roberts and Wadley, Royal Australian Planning Institute. 2004.

| Clustering Options | Comments / Illustrative Examples |
|---|---|
| Anchor tenant clusters | Clusters around power station, cement plant, chemical plant (see next section) |
| High risk industry cluster | Clusters of high risk industries to enhance accident prevention and emergency response |
| Service and support cluster | Logistics, maintenance, storage , buying, training |
| Inorganics cluster | Processing and recovery of inorganic materials, including acids, process chemicals, construction materials, industrial inorganic by-products |
| Organics cluster | Processing and recovery of organic materials, including grains, wood, food waste |
| By-product / waste exchange cluster | By-product / waste intensive and processing industries |
| "Green products" cluster | Manufacturers of water/energy saving products, business utilising semi-products from resource recovery operations |
| Post-consumer waste cluster | Processing and recovery of end-of-life household appliances, plastics, paper, glass, waste oil, tyres |
| Intermodal cluster | Industries servicing inter-modal facility |
| Industry type clusters | Engineering, manufacturing, chemical, utility providers |
| Industry size clusters | Locate small, medium, large enterprises in different clusters |

## 8.2 Locating Industries within the Estate and Precincts

The tables on the next pages provide guidance on locating potential industry types within the BSIA precincts.

Given the uncertainties regarding potential industry types locating to BSIA and the need to incorporate maximum flexibility in the development of the industrial estate, the assessment is based on relevant industry groups from the Australian and New Zealand Standard Industry Codes (ANSZIC).

Each potential industry type is assessed against a set of industry location criteria. These location criteria provide the basis for determining preferred location of the industries within the identified precincts.

The industry location criteria cover the following:

- Risk:
  - High risk profile: Industries with the risk of high impact (noise, odour, air emissions) industries;
  - Industry co-location risk: Separate industries that may increase the risk profile within the estate if they were located next to each other;
- Transport:
  - Access to port: Industries with high import/export volumes requiring access to port;
  - Access to bulk commodity rail: Industries with high input/output volumes requiring access to bulk commodity rail;
  - Access to multi-product rail: Industries with high input/output volumes requiring access to multi-product rail;
  - High wide loads: Industries with high and/or wide inputs/outputs;

- Access to conveyors:
- Access to other materials handling services: Industries with other significant materials handling requirements needing access to multi-purpose corridors;

- Water:
  - High water requirements: Industries with significant industry feedwater requirements;
- Energy:
  - High energy requirements: Industries with high energy use requirements;
- Waste:
  - Access to by-product/waste storage and processing area;
- Lot size:
  - Large lots: Industries which require large, generally flat areas for their operations.

## Table 25 Guidance for Locating Industries within the Estate and Precincts

| ANZSIC - Short-listed industries | | | Industry location criteria | | | | | | | | | | | | Recommended location within BSIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Industry type | Potential to locate to BSIA (Low, Medium, High) | Risk | | Transport | | | | | | Water | Energy | Waste | Lot size | | | | | | | | | | | |
| | | | High risk profile | Industry co-location risk | Access to port | Access to bulk commodity rail | Access to multi-product rail | High wide loads | Access to conveyors | materials handling services | High water requirements | High energy requirements | Access to by-product/waste storage and processing | Large lots | Port Related and Material Intensive | Downstream Iron Ore Processing Precinct | Downstream Petroleum / Coal / Gas Processing Precinct | Resource Processing Precinct | Utilities | Non-Ferrous Resource Processing | General Industry Precinct | Noxious Industry Precinct | Buffer zone | Boodarie Support Area (east of BSIE boundary) | Priority location in selected precinct (if applicable) |
| Division A | Agriculture, Forestry and Fishing | | | | | | | | | | | | | | | | | | | | | | | | |
| 011 | Nursery and Floriculture Production | Low | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 013 | Fruit and Tree Nut Growing | Low | | | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 014 | Sheep, Beef Cattle and Grain Farming | Medium | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 0143 | Beef Cattle Feedlots (Specialised) | Medium | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 016 | Dairy Cattle Farming | Medium | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 017 | Poulty Farming | Medium | | X | | | | | | | | | | | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 0203 | Onshore Aquaculture | Low | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 051 | Forestry Support Services | Low | | | | | | | | | | | | | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 052 | Agriculture and Fishing Support Services | Low | | | | | | | | | | | | | | | | | | | | | O | | Sufficient distance to nearest industry development |
| Division B | Mining | | | | | | | | | | | | | | | | | | | | | | | | |
| 091 | Construction Material Mining | High | | | | | | | | | | | | XX | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | Subject to mining/extraction leases |
| 099 | Other Non-Metallic Mineral Mining and Quarrying | High | | | | | | | | | | | | XX | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | Subject to mining/extraction leases |
| 109 | Other Mining Support Services (includes ore stockpiling) | High | | | XX | XX | | | XX | | | | | XX | | | | | | | | | | | As per current arrangements |
| Division C | Manufacturing | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Textile, Leather, Clothing, and Footwear Manufacturing | Low | | | | | | | | | XX | X | | | | | | | | | O | | | | Proximity / access to industry feedwater facility<br><br>Synergistic industries close and/or good access to appropriate precinct |
| 14 | Wood Product Manufacturing | Low | | X | | | | | | | X | X | | | | | | | | | O | O | | | Synergistic industries close and/or good access to appropriate precinct |
| 15 | Pulp, Paper, and Converted Paper Product Manufacturing | Low | | X | | | | | | | XX | X | | | | | | | | | O | | | | Proximity / access to industry feedwater facility<br><br>Synergistic industries close and/or good access to appropriate precinct |

| ANZSIC - Short-listed industries | | | Industry location criteria | | | | | | | | | | | | Recommended location within BSIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Industry type | Potential to locate to BSIA (Low, Medium, High) | Risk | | Transport | | | | | | Water | Energy | Waste | Lot size | | | | | | | | | | | |
| | | | High risk profile | Industry co-location risk | Access to port | Access to bulk commodity rail | Access to multi-product rail | High wide loads | Access to conveyors | materials handling services | High water requirements | High energy requirements | Access to by-product/waste storage and processing | Large lots | Port Related and Material Intensive | Downstream Iron Ore Processing Precinct | Downstream Petroleum / Coal / Gas Processing Precinct | Resource Processing Precinct | Utilities | Non-Ferrous Resource Processing | General Industry Precinct | Noxious Industry Precinct | Buffer zone | Boodarie Support Area (east of BSIE boundary) | Priority location in selected precinct (if applicable) |
| Division A | Agriculture, Forestry and Fishing | | | | | | | | | | | | | | | | | | | | | | | | |
| 011 | Nursery and Floriculture Production | Low | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 013 | Fruit and Tree Nut Growing | Low | | | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 014 | Sheep, Beef Cattle and Grain Farming | Medium | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 0143 | Beef Cattle Feedlots (Specialised) | Medium | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 016 | Dairy Cattle Farming | Medium | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 017 | Poulty Farming | Medium | | X | | | | | | | | | | | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 0203 | Onshore Aquaculture | Low | | X | | | | | | | | | | X | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 051 | Forestry Support Services | Low | | | | | | | | | | | | | | | | | | | | | O | | Sufficient distance to nearest industry development |
| 052 | Agriculture and Fishing Support Services | Low | | | | | | | | | | | | | | | | | | | | | O | | Sufficient distance to nearest industry development |
| Division B | Mining | | | | | | | | | | | | | | | | | | | | | | | | |
| 091 | Construction Material Mining | High | | | | | | | | | | | | XX | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | Subject to mining/extraction leases |
| 099 | Other Non-Metallic Mineral Mining and Quarrying | High | | | | | | | | | | | | XX | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | TBC | Subject to mining/extraction leases |
| 109 | Other Mining Support Services (includes ore stockpiling) | High | | | XX | XX | | | XX | | | | | XX | | | | | | | | | | | As per current arrangements |
| Division C | Manufacturing | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Textile, Leather, Clothing, and Footwear Manufacturing | Low | | | | | | | | | XX | X | | | | | | | | | O | | | | Proximity / access to industry feedwater facility<br><br>Synergistic industries close and/or good access to appropriate precinct |
| 14 | Wood Product Manufacturing | Low | | X | | | | | | | X | X | | | | | | | | | O | O | | | Synergistic industries close and/or good access to appropriate precinct |
| 15 | Pulp, Paper, and Converted Paper Product Manufacturing | Low | | X | | | | | | | XX | X | | | | | | | | | O | | | | Proximity / access to industry feedwater facility<br><br>Synergistic industries close and/or good access to appropriate precinct |
| 17 | Petroleum and Coal Product Manufacturing | High | XX | XX | XX | XX | X | | | XX | XX | XX | X | XX | O | | O | | | | | | | | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries |

| ANZSIC - Short-listed industries | | | Industry location criteria | | | | | | | | | | | | Recommended location within BSIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Industry type | Potential to locate to BSIA (Low, Medium, High) | Risk | | Transport | | | | | | Water | Energy | Waste | Lot size | | | | | | | | | | | |
| | | | High risk profile | Industry co-location risk | Access to port | Access to bulk commodity rail | Access to multi-product rail | High wide loads | Access to conveyors | materials handling services | High water requirements | High energy requirements | Access to by-product/waste storage and processing | Large lots | Port Related and Material Intensive | Downstream Iron Ore Processing Precinct | Downstream Petroleum / Coal / Gas Processing Precinct | Resource Processing Precinct | Utilities | Non-Ferrous Resource Processing | General Industry Precinct | Noxious Industry Precinct | Buffer zone | Boodarie Support Area (east of BSIE boundary) | Priority location in selected precinct (if applicable) |
| 18 | Basic Chemical and Chemical Product Manufacturing | High | XX | XX | XX | X | X | | | XX | XX | XX | X | XX | O | | | O | | | | | | | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries |
| 19 | Polymer Product and Rubber Product Manufacturing | Medium | X | X | | | X | | | X | X | X | | X | | | O | | | | O | O | | | Synergistic industries close and/or good access to appropriate precinct |
| 201 | Glass and Glass Product Manufacturing | Low | | | | | | | | | | | | | | | | | | | O | | | | Synergistic industries close and/or good access to appropriate precinct |
| 202 | Ceramic Product Manufacturing | Medium | | | | | | | | | | | | | | | | O | | | O | | | | Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General and Noxious Industry Precinct<br><br>General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 203 | Cement, Lime, Plaster and Concrete Product Manufacturing | Medium | | XX | X | X | | | | X | XX | XX | X | XX | O | | | O | | O | O | O | | | Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General or Noxious Industry Precincts<br><br>General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries<br><br>If required: proximity to centralised industrial by-products storage and processing area |
| 209 | Other Non-Metallic Mineral Product Manufacturing | High | | X | | X | | | | X | X | X | X | X | O | | | O | | O | O | O | | | Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General or Noxious Industry Precincts<br><br>General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 211 | Basic Ferrous Metal Manufacturing | High | X | XX | XX | XX | XX | | | XX | XX | XX | XX | XX | O | O | | O | | | | | | | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries<br><br>Proximity to centralised industrial by-products storage and processing area |

| ANZSIC - Short-listed industries | | | Industry location criteria | | | | | | | | | | | | Recommended location within BSIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Industry type | Potential to locate to BSIA (Low, Medium, High) | Risk | | Transport | | | | | | Water | Energy | Waste | Lot size | | | | | | | | | | | |
| | | | High risk profile | Industry co-location risk | Access to port | Access to bulk commodity rail | Access to multi-product rail | High wide loads | Access to conveyors | materials handling services | High water requirements | High energy requirements | Access to by-product/waste storage and processing | Large lots | Port Related and Material Intensive | Downstream Iron Ore Processing Precinct | Downstream Petroleum / Coal / Gas Processing Precinct | Resource Processing Precinct | Utilities | Non-Ferrous Resource Processing | General Industry Precinct | Noxious Industry Precinct | Buffer zone | Boodarie Support Area (east of BSIE boundary) | Priority location in selected precinct (if applicable) |
| 212 | Basic Ferrous Metal Product Manufacturing | High | | X | XX | | XX | XX | | XX | X | X | | X | O | O | | | | O | O | O | | | Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General or Noxious Industry Precincts<br><br>General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 2131 | Alumina Production | Medium | X | XX | XX | XX | X | | | XX | XX | XX | XX | XX | O | | | O | | O | | | | | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries<br><br>Proximity to centralised industrial by-products storage and processing area |
| 2132 | Aluminium Smelting | High | X | XX | XX | X | X | | | XX | XX | XX | X | XX | O | | | O | | O | | | | | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries<br><br>Proximity to centralised industrial by-products storage and processing area |
| 2133 | Copper, Silver, Lead and Zinc Smelting and Refining | Medium | XX | XX | XX | XX | X | | | XX | XX | XX | XX | XX | O | | | O | | O | | | | | Access to water and energy facility<br><br>Co-location with synergistic industries<br><br>Access to centralised industrial by-products storage and processing area |
| 2139 | Other Basic Non-Ferrous Metal Manufacturing | High | X | XX | XX | XX | XX | | | XX | XX | XX | XX | XX | O | | | O | | | | | | | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries<br><br>Proximity to centralised industrial by-products storage and processing area |
| 214 | Basic Non-Ferrous Metal Product Manufacturing | Medium | | X | X | X | X | XX | | X | X | X | | X | O | | | O | | O | O | O | | | Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General and Noxious Industry Precinct<br><br>General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |

| ANZSIC - Short-listed industries | | | Industry location criteria | | | | | | | | | | | | Recommended location within BSIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Industry type | Potential to locate to BSIA (Low, Medium, High) | Risk | | Transport | | | | | | Water | Energy | Waste | Lot size | | | | | | | | | | | |
| | | | High risk profile | Industry co-location risk | Access to port | Access to bulk commodity rail | Access to multi-product rail | High wide loads | Access to conveyors | materials handling services | High water requirements | High energy requirements | Access to by-product/waste storage and processing | Large lots | Port Related and Material Intensive | Downstream Iron Ore Processing Precinct | Downstream Petroleum / Coal / Gas Processing Precinct | Resource Processing Precinct | Utilities | Non-Ferrous Resource Processing | General Industry Precinct | Noxious Industry Precinct | Buffer zone | Boodarie Support Area (east of BSIE boundary) | Priority location in selected precinct (if applicable) |
| 22 | Fabricated Metal Product Manufacturing | Medium | | X | X | X | X | XX | | X | X | X | | X | | | | O | | O | O | O | | | Energy, water, material intensive companies in Resource Processing Precinct, in proximity to water and energy facility. Otherwise in General and Noxious Industry Precinct<br><br>General or Noxious Industry Precincts: Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 23 | Transport Equipment Manufacturing | Medium | | | X | | X | X | | X | | | | X | | | | | | | O | | | | Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 24 | Machinery and Equipment Manufacturing | Medium | | | X | | X | X | | X | | | | X | | | | | | | O | | | | Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 25 | Furniture and Other Manufacturing | Low | | | | | | | | | | | | | | | | | | | O | | | | Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| Division D | Electricity, Gas, Water, and Waste Services | | | | | | | | | | | | | | | | | | | | | | | | |
| 2611 | Fossil Fuel Electricity Generation | High | | XX | XX | X | | | | XX | XX | XX | X | X | | | | | O | | | | | | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries<br><br>If required: proximity to centralised industrial by-products storage and processing area |
| 2612 | Hydro-Electricity Generation | Low | | | | | | | | X | XX | X | | XX | | | | | | | | | O | | Proximity to ocean<br><br>Access to service corridor |
| 2619 | Other Electricity Generation | High | | X | | | | | | | XX | XX | | X | | | | | O | | | | | | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries |
| 2811 | Water Supply | High | | X | | | | | | XX | XX | X | | X | | | | | O | | | | | | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries |
| 2812 | Sewerage and Drainage Services | High | | X | | | | | | XX | | | | X | | | | | O | | | | O | O | Proximity / access to water and energy facility<br><br>Co-location with synergistic industries |

| ANZSIC - Short-listed industries | | Potential to locate to BSIA (Low, Medium, High) | Industry location criteria | | | | | | | | | | | | Recommended location within BSIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Industry type | | Risk | | Transport | | | | | | Water | Energy | Waste | Lot size | | | | | | | | | | | |
| | | | High risk profile | Industry co-location risk | Access to port | Access to bulk commodity rail | Access to multi-product rail | High wide loads | Access to conveyors | materials handling services | High water requirements | High energy requirements | Access to by-product/waste storage and processing | Large lots | Port Related and Material Intensive | Downstream Iron Ore Processing Precinct | Downstream Petroleum / Coal / Gas Processing Precinct | Resource Processing Precinct | Utilities | Non-Ferrous Resource Processing | General Industry Precinct | Noxious Industry Precinct | Buffer zone | Boodarie Support Area (east of BSIE boundary) | Priority location in selected precinct (if applicable) |
| 291 | Waste Collection Services | High | | X | | | | | | | | | XX | | | | | | | | O | O | | | Synergistic industries close and/or good access to appropriate precinct<br><br>Proximity to centralised industrial by-product storage/processing area<br><br>Co-location with synergistic industries |
| 2921 | Waste Treatment and Disposal Services | High | X | X | | | | | | XX | X | X | XX | X | | | | | O | | O | O | | | Synergistic industries close and/or good access to appropriate precinct<br><br>Proximity to centralised industrial by-product storage/processing area<br><br>Co-location with synergistic industries |
| 2922 | Waste Remediation and Materials Recovery Services | High | X | X | | | | | | XX | X | X | XX | X | | | | O | | O | O | O | | | Synergistic industries close and/or good access to appropriate precinct<br><br>Proximity to centralised industrial by-product storage/processing area<br><br>Co-location with synergistic industries |
| Division E | Construction | | | | | | | | | | | | | | | | | | | | | | | | |
| 31 | Heavy and Civil Engineering Construction | High | | | | | | X | | X | | | | X | | | | | | | O | | | O | Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 32 | Construction Services | High | | | | | | | | | | | | | | | | | | | O | | | O | Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| Division F | Whole Trade | | | | | | | | | | | | | | | | | | | | | | | | |
| 33 | Basic Material Wholesaling | High | | | | | | | | | | | | | | | | | | | O | | | O | Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 34 | Machinery and Equipment Wholesaling | High | | | | | | X | | | | | | | | | | | | | O | | | O | Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| Division G | Retail Trade | | | | | | | | | | | | | | | | | | | | | | | | |
| - | None are suitable for location in OIE | - | - | - | - | - | - | - | | - | - | - | | - | | - | - | - | - | - | - | - | - | - | - |

| ANZSIC - Short-listed industries | | | Industry location criteria | | | | | | | | | | | | Recommended location within BSIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Industry type | Potential to locate to BSIA (Low, Medium, High) | Risk | | Transport | | | | | | Water | Energy | Waste | Lot size | | | | | | | | | | | |
| | | | High risk profile | Industry co-location risk | Access to port | Access to bulk commodity rail | Access to multi-product rail | High wide loads | Access to conveyors | materials handling services | High water requirements | High energy requirements | Access to by-product/waste storage and processing | Large lots | Port Related and Material Intensive | Downstream Iron Ore Processing Precinct | Downstream Petroleum / Coal / Gas Processing Precinct | Resource Processing Precinct | Utilities | Non-Ferrous Resource Processing | General Industry Precinct | Noxious Industry Precinct | Buffer zone | Boodarie Support Area (east of BSIE boundary) | Priority location in selected precinct (if applicable) |
| Division H | Accommodation and Food Services | | | | | | | | | | | | | | | | | | | | | | | | |
| 451 | Cafes, Restaurants, and Takeaway Food Services | High | | | | | | | | | | | | | | | | | | | O | | O | O | As required to service BSIE<br><br>Sufficient distance to industries with high(er) risk profile |
| Division I | Transport, Postal and Warehousing | | | | | | | | | | | | | | | | | | | | | | | | |
| 461 | Road Freight Transport | High | | X | | XX | XX | | | X | | | | X | | | | | | | O | | O | O | Proximity / access to road and rail<br><br>Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 471 | Rail Freight Transport | High | | X | | XX | XX | | | X | | | | X | | | | | | | O | | O | O | Proximity/access to road and rail<br><br>Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 52 | Transport Support Services | High | | | | | | | | | | | | X | | | | | | | O | | O | O | Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| 53 | Warehousing and Storage Services | High | | | X | X | X | | | X | | | | XX | | | | | | | O | | O | O | Synergistic industries close and/or good access to appropriate precinct<br><br>Co-location with synergistic industries |
| Division J | Information Media and Telecommunications | | | | | | | | | | | | | | | | | | | | | | | | |
| 580 | Telecommunications Services | High | | | | | | | | X | | | | | | | | | | | O | | | O | |
| 592 | Data Processing, Web Hosting and Electronic Information Storage Services | High | | | | | | | | | | | | | | | | | | | O | | | O | |
| 602 | Other Information Services | High | | | | | | | | | | | | | | | | | | | O | | | O | |
| Division K | Financial and Insurance Services | | | | | | | | | | | | | | | | | | | | | | | | |
| - | None are suitable for location in OIE | - | - | - | - | - | - | - | | - | - | - | | - | | - | - | - | - | - | - | - | - | - | - |
| Division L | Rental, Hiring, and Real Estate Services | | | | | | | | | | | | | | | | | | | | | | | | |
| - | None are suitable for location in OIE | - | - | - | - | - | - | - | | - | - | - | | - | | - | - | - | - | - | - | - | - | - | - |
| Division M | Professional, Scientific and Technical Services | | | | | | | | | | | | | | | | | | | | | | | | |
| 691 | Scientific Research Services | Medium | | | | | | | | | | | | | | | | | | | O | | O | O | Sufficient distance to industries with high(er) risk profile |
| Division N | Administrative and Support Services | | | | | | | | | | | | | | | | | | | | | | | | |
| 721 | Employment Services | Medium | | | | | | | | | | | | | | | | | | | | | | O | Sufficient distance to industries with high(er) risk profile |

| ANZSIC - Short-listed industries | | | Industry location criteria | | | | | | | | | | | | Recommended location within BSIA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Industry type | Potential to locate to BSIA (Low, Medium, High) | Risk | | Transport | | | | | | Water | Energy | Waste | Lot size | | | | | | | | | | | |
| | | | High risk profile | Industry co-location risk | Access to port | Access to bulk commodity rail | Access to multi-product rail | High wide loads | Access to conveyors | materials handling services | High water requirements | High energy requirements | Access to by-product/waste storage and processing | Large lots | Port Related and Material Intensive | Downstream Iron Ore Processing Precinct | Downstream Petroleum / Coal / Gas Processing Precinct | Resource Processing Precinct | Utilities | Non-Ferrous Resource Processing | General Industry Precinct | Noxious Industry Precinct | Buffer zone | Boodarie Support Area (east of BSIE boundary) | Priority location in selected precinct (if applicable) |
| 722 | Travel Agency and Tour Arrangement Services | Medium | | | | | | | | | | | | | | | | | | | | | | O | Sufficient distance to industries with high(er) risk profile |
| 729 | Other Administrative Services | High | | | | | | | | | | | | | | | | | | | | | | O | Sufficient distance to industries with high(er) risk profile |
| 731 | Building Cleaning, Pest Control, and Gardening Services | Medium | | | | | | | | | | | | | | | | | | | | | | O | Sufficient distance to industries with high(er) risk profile |
| 732 | Packaging Services | Medium | | | | | | | | | | | | | | | | | | | O | | | O | Sufficient distance to industries with high(er) risk profile |
| Division O | Public Administration and Safety | | | | | | | | | | | | | | | | | | | | | | | | |
| - | None are suitable for location in OIE | - | - | - | - | - | - | - | | - | - | - | | - | | - | - | - | - | - | - | - | - | - | - |
| Division P | Education and Training | | | | | | | | | | | | | | | | | | | | | | | | |
| 8219 | Adult, Community and Other Education n.e.c. | High | | | | | | | | | | | | | | | | | | | | | | O | Sufficient distance to industries with high(er) risk profile |
| 822 | Educational Support Services | High | | | | | | | | | | | | | | | | | | | | | | O | Sufficient distance to industries with high(er) risk profile |
| Division Q | Health Care and Social Assistance | | | | | | | | | | | | | | | | | | | | | | | | |
| 851 | Medical Services | High | | | | | | | | | | | | | | | | | | | | | | O | Sufficient distance to industries with high(er) risk profile |
| 871 | Child Care Services | High | | | | | | | | | | | | | | | | | | | | | | O | Sufficient distance to industries with high(er) risk profile |
| 879 | Other Social Assistance Services | Medium | | | | | | | | | | | | | | | | | | | | | | O | Sufficient distance to industries with high(er) risk profile |
| Division R | Arts and Recreation Services | | | | | | | | | | | | | | | | | | | | | | | | |
| 892 | Parks and Gardens Operations | Medium | | | | | | | | | | | | | | | | | | | | | O | O | Sufficient distance to industries with high(er) risk profile |
| Division S | Other Services | | | | | | | | | | | | | | | | | | | | | | | | |
| 94 | Repair and Maintenance | High | | | | | | | | | | | | | | | | | | | O | O | O | O | Sufficient distance to industries with high(er) risk profile |

# 9. Anchor Tenants

An anchor tenant can act as a central feature of an industrial estate and a step towards establishing regional synergies. Having an anchor tenant helps to define potential sources of exchanges (e.g. the use of steam from a power plant). Furthermore, the availability of a specific resource (e.g. inorganic and organic by-product, waste energy, wastewater stream) may serve as an attraction for potential tenants. The major inputs and outputs of an anchor will help define the search for the next round of companies, those capable of using its outputs or supplying it with theirs.

The development of Boodarie Strategic Industrial Area will significantly benefit from having anchor tenants to attract associated businesses and establish regional synergies in the area. These anchor tenants can be existing industries in surrounding areas (such as the Port Hedland port) or new businesses locating in the BSIA. A preliminary review of existing and potential new anchor tenants is provided in the table below.

**Table 26 Preliminary Review of Anchor Tenants for BSIA**

*Most significant* — Overall significance for development BIE — *Less significant*

| # | Potential Anchor Tenants | Trigger or Contribute to Attracting Industries | | | |
|---|---|---|---|---|---|
| | | **Supply Synergies** | **Utility Synergies** | **By-Product Synergies** | **Service Synergies** |
| 1 | Steel plant | Iron ore pelletising plant | industry feedwater facility supplying low and/or high quality industry feedwater | Company processing and/or reusing slag (aggregrate, soil conditioner, cement clinker) | Joint industry training and education facility |
| | | Heavy construction companies | energy facility supplying steam, electricity, hot/cold air | Company processing and/or reusing gypsum (plasterboard, bricks, chemical processing) | Joint industry logistic and transporation facility |
| | | Producers or local suppliers of process chemicals and raw materials | Producer of utility gases | Company co-processing large volume inorganic by-products from BIE industries into valuable products | Waste management company collecting small(er) volume wastes in BIE |
| | | Warehouses | Treatment facility for industry off-gases | Company processing and supplying alternative fuels | |
| | | Transport companies | | Company processing and supplying lime sources (e.g. cement plant) | |
| | | Commercial businesses | | Utility company converting process $CO_2$, $N_2$, $H_2$ into commercial gases | |
| 2 | Non-ferrous industries | Non-ferrous smelter or refinery | industry feedwater facility supplying low and/or high quality industry feedwater | Fertiliser company processing ammonium sulphate (from nickel refinery) | Joint industry training and education facility |
| | | Producers or local suppliers of process chemicals and raw materials | energy facility supplying steam, electricity, hot/cold air | Company co-processing large volume inorganic by-products from BIE industries into valuable products | Joint industry logistic and transporation facility |
| | | Warehouses | Producer of utility gases | Company processing and supplying alternative fuels | Waste management company collecting small(er) volume wastes in BIE |
| | | Transport companies | Treatment facility for industry off-gases | Utility company converting process CO2, N2, H2 into commercial gases | |
| | | Commercial businesses | | | |
| 2 | Chemical and/or commercial fertiliser plant | Nickel refinery supplying ammonium sulphate | industry feedwater facility supplying low and/or high quality industry feedwater | Company co-processing large volume organic materials (products, by-products, wastes) into valuable products | Joint industry training and education facility |
| | | Producers or local suppliers of process chemicals and raw materials | energy facility supplying steam, electricity, hot/cold air | Company co-processing large volume inorganic by-products from BIE industries into valuable products | Joint industry logistic and transporation facility |
| | | Warehouses | Producer of utility gases | Company processing and supplying alternative fuels | Waste management company collecting small(er) volume wastes in BIE |
| | | Transport companies | Treatment facility for industry off-gases | Utility company converting process $CO_2$, N2, $H_2$ into commercial gases | |
| | | Commercial businesses | | | |

*Most significant* Overall significance for development BIE *Less significant*

| # | Potential Anchor Tenants | Trigger or Contribute to Attracting Industries | | | |
|---|---|---|---|---|---|
| | | **Supply Synergies** | **Utility Synergies** | **By-Product Synergies** | **Service Synergies** |
| 3 | Power station | Producers or local suppliers of process chemicals and raw materials | industry feedwater facility supplying low and/or high quality industry feedwater | Company co-processing large volume inorganic by-products from BIE industries into valuable products | Joint industry training and education facility |
| | | Transport companies | Producer of utility gases | Company processing and supplying alternative fuels | Joint industry logistic and transporation facility |
| | | Commercial businesses | Treatment facility for industry off-gases | Utility company converting process CO2, N2, H2 into commercial gases | Waste management company collecting small(er) volume wastes in BIE |
| 4 | Cement plant | Producers or local suppliers of process chemicals and raw materials | industry feedwater facility supplying low and/or high quality industry feedwater | Company co-processing large volume inorganic by-products from BIE industries into valuable products | Joint industry training and education facility |
| | | Ferrous and non-ferrous mineral processing industries using lime as raw material | energy facility supplying steam, electricity, hot/cold air | Company processing and supplying alternative fuels | Joint industry logistic and transporation facility |
| | | Ferrous and non-ferrous mineral processing industries supplying raw materials (e.g. iron oxide, gypsum, overburden, bauxite) | Treatment facility for industry off-gases | Utility company converting process CO2, N2, H2 into commercial gases | Waste management company collecting small(er) volume wastes in BIE |
| | | Warehouses | | | |
| | | Transport companies | | | |
| | | Commercial businesses | | | |
| 5 | Organic-based processing plant | Producers or local suppliers of process chemicals and raw materials | industry feedwater facility supplying low and/or high quality industry feedwater | Company co-processing large volume organic by-products into valuable products | Joint industry training and education facility |
| | | Grain and other organic material handling facilities | energy facility supplying steam, electricity, hot/cold air | Company processing and supplying alternative fuels | Joint industry logistic and transporation facility |
| | | Warehouses | Producer of utility gases | Utility company converting process CO2, N2, H2 into commercial gases | Waste management company collecting small(er) volume wastes in BIE |
| | | Transport companies | | | |
| | | Commercial businesses | | | |
| 6 | Solid waste industrial processing plant | Pre-treatment and local suppliers of solid wastes | industry feedwater facility supplying low and/or high quality industry feedwater | Company co-processing large volume inorganic and organic by-products into valuable products | Joint industry training and education facility |
| | | Producers or local suppliers of process chemicals | energy facility supplying steam, electricity, hot/cold air | Company processing and supplying alternative fuels | Joint industry logistic and transporation facility |
| | | Warehouses | Producer of utility gases | Utility company converting process CO2, N2, H2 into commercial gases | Waste management company collecting small(er) volume wastes in BIE |
| | | Transport companies | | | |
| | | Commercial businesses | | | |
| 7 | Municipal WWTP | industry feedwater facility supplying low and/or high quality industry feedwater (with Oakajee WWTP as one of more potential water sources) | energy facility supplying electricity, hot/cold air | Company co-processing large volume organic materials (e.g. biosolids) into valuable products | Waste management company collecting small(er) volume wastes in BIE |
| | | BIE industries using Oakajee WWTP effluent as industry feedwater directly | | | |
| | | Producer or local supplier of water treatment chemicals | | | |
| 8 | Industry feedwater facility | Water intensive industries requiring high and/or low quality industry feedwater | energy facility supplying electricity, hot/cold air | Company co-processing large volume organic materials (e.g. biosolids) into valuable products | Waste management company collecting small(er) volume wastes in BIE |
| | | Oakajee WTTP supplying source water | BIE industries supplying waste heat (for advanced treatment such as multi-effect evaporation) | | |
| | | Producer or local supplier of water treatment chemicals | | | |
| 9 | Energy facility | Energy intensive industries requiring steam, electricity, hot/cold air | industry feedwater facility supplying low and/or high quality industry feedwater | Company processing and supplying alternative fuels | Waste management company collecting small(er) volume wastes in BIE |
| | | Producer or local supplier of process chemicals | Treatment facility for industry off-gases | | |
| 10 | Centralised storage and processing facility for large volume inorganic by- | Large scale ferrous and non-ferrous minerals processing plants | None identified | Companies (co-)processing large volume inorganic by-products from BIE industries into valuable products | Waste management company servicing storage and processing facility, and associated handling of by-products |
| | | Large scale industrial processing plants | | | |

# 10. Benchmarking with Other Industrial Areas

The estimates provided in this report are indicative estimates based on information to GHD at the time of release of this report (see cover page for date), which does not include specific market research on the types of industries locating to the Boodarie Strategic Industrial Area. The estimates presented here should only be used for the purpose of the Concept Design of the Boodarie Strategic Industrial Area. The data presented in this report should be updated as more detailed information becomes available through the structure plan development process and thereafter (e.g. lot sizes, net developable land, industries locating to Boodarie Strategic Industrial Area, industry locations, industry inputs and outputs).

This section benchmarks of the results from this BSIA study with the existing Kwinana Industrial Area and the proposed Oakajee Industrial Area in WA. An introduction to both industrial estates is provided first.

## 10.1 Introduction to Kwinana and Oakajee Industrial Areas

### 10.1.1 Kwinana Industrial Area (Existing)

Heavy process industry is concentrated in a few industrial areas in WA, of which the Kwinana Industrial Area is by far the largest and most diverse. The industrial area was established in the 1950's following a special Act of Parliament, which secured an area of about 120 square km to accommodate the development of major resource processing industries in Western Australia. Kwinana is located 40 km south of the capital city of Perth on the shores of the Cockburn Sound, a sensitive marine environment. It has a deep-water port, and is therefore strategically placed for export markets in Asia. About 3,600 people work in the area's core industries, and many more in related sectors and service jobs. The total economic output of the area exceeds A$4.3 billion annually. Overall, the Kwinana Industrial Area plays a very important role in the economy of Western Australia, and in the local community. The region has long been recognised as a cornerstone of the Western Australia's economy.

The Kwinana Industrial Area is dominated by heavy process industries. These include[5]: 2,000 kt/yr alumina refinery (Alcoa), 70 kt/yr nickel refinery (Kwinana Nickel Refinery), 105 kt/yr titanium dioxide pigment plant (Tiwest), 850 kt/yr lime and cement kilns (Cockburn Cement), 135,000 barrels/day oil refinery (BP), and 800 kt/yr pig iron plant (HIsmelt). These are complemented with a variety of chemical producers, including CSBP (ammonia, ammonia nitrate, cyanide, chlor-alkali and fertiliser plants), Coogee Chemicals (inorganic chemicals), Nufarm (herbicides and other agricultural chemicals), Nufarm Coogee (chlor-alkali plant), Bayer (agricultural chemicals), Chemeq (veterinary products), and Ciba and Nalco (water treatment and process chemicals). Moreover, there are important utility operations, including two power stations (900 MW coal, oil and gas fired, and 240 MW combined cycle gas) both Verve Energy, two cogeneration plants (respectively 116 MW (Kwinana

[5] SKM. 2002. Kwinana Industrial Area Economic Impact Study: an example of industrial interaction. Perth, Australia: Sinclair Knight and Merz for Kwinana Industries Council.

Cogeneration Plant) and 40 MW (Verve Energy)), two air separation plants (Air Liquide and BOC Gases), a grain handling and export terminal (CBH), port facilities (Fremantle Port Authority), and water and wastewater treatment and recycling plants (Water Corporation). There is historically considerable supply chain integration between these industries in the area. A number of companies produce essential raw materials for the manufacturing and refining processes or other nearby enterprises. Figure 1 provides an overview of the location of companies in Kwinana.

In 1991 the core industries established the Kwinana Industries Council (KIC, www.kic.org.au). Until then there was no formal industry association for the Kwinana Industrial Area. The original purpose of the KIC was to organise the required air and water monitoring collectively for the industries in the area. This was in response to increased government and community pressure to manage the air- and watersheds, and protect the sensitive marine environment in the adjacent Cockburn Sound. The KIC now addresses a broad range of issues common to Kwinana's major industries, and seeks to foster positive interactions between member companies, government, and the broader community.

### 10.1.2 Oakajee Industrial Area (Planned)[6]

Oakajee is currently farmland used for cropping and grazing. It was selected by the State Government in 1992 as a site for future processing industry and a deep water port. Over the ensuing years the State acquired and zoned approximately 6,400 ha of land for this purpose (approx 2,300 ha excluding buffer zones).

Early 2000, prospective mining developments in the Mid-West and Murchison began generating interest from various proponents in railing iron ore to Oakajee for export through a deep water port. The ultimate outcome was the signing in March 2009 of a Development Agreement between the State Government and Oakajee Port and Rail (OPR) to construct a rail line from the mines to Oakajee and to develop a deep water port at the mouth of the Oakajee River. OPR has prepared and submitted concept plans for the port, rail and related infrastructure. These concept plans have taken account of LandCorp's requirements that the port and rail design do not constrain but instead complement the Oakajee Industrial Area.

The vision for the Oakajee Industrial Area is to be globally competitive with access to excellent local, national and international transport links by sea, road and rail. Access to skilled labour, support industries and competitively priced energy is also available. Renewable energy and commercial plantations help industry meet carbon management requirements and clusters of synergistic industries provide efficiencies which attract others. Streamlined approvals processes speed development and ensure timely service provision through ample service corridors.

Under LandCorp and DSD leadership, a Concept Plan for the BSIA is being developed which will:

- Fulfil the statutory requirements of the Shire of Chapman Valley Town Planning Scheme No 1 (Note that the gazettal of TPS No.2 is imminent);
- Take account of, and seek to maximise the benefit to the estate from OPR's planned port, rail and related infrastructure;
- Identify and take account of relevant features of the physical and social environment of the site;

[6] Extracted from LandCorp documents

- Plan for long term servicing and infrastructure requirements of the estate beyond what will be provided by OPR in developing its port and rail;
- Provide a guide for locating and developing future industry within the estate, for bringing infrastructure and services to that industry, and for management and land use of the surrounding buffer; and
- Provide guidance on staging of development within the two support industry precincts and, to such extent as may be practical, within the strategic industry core.

## 10.2 Industrial Area Base Data

Table 27 presents the base data for the Boodarie Strategic Industrial Area, existing Kwinana Industrial Area, and the proposed Oakajee Industrial Area. These data provide the basis for the benchmarking in the following subsection.

**Table 27 Industrial Areas – Base Data**

| Base Data | Unit | Boodarie Industrial Area (Planned)[7] | Kwinana Industrial Area (Existing)[8] | Oakajee Industrial Area (Planned)[9] |
|---|---|---|---|---|
| Total area (excluding buffer zones) | ha | 2,800[10] | 2,400 | 2,333 |
| Key heavy industries | No. | 30 | 14 | 14 |
| Total power demand | MW | 1,207 | - | 365 |
| Total gas/coal demand | TJ/yr | 428,230 | 88,750 | 154,000 |
| Total industry feedwater use | ML/yr | 59,805 | 35,000 | 38,000 |
| Total effluent | ML/yr | 63,306 | 20,000 | 34,000 |
| Total raw material input | ktpa | 40,313 | 26,800 | 33,000 |
| Total product output | ktpa | 28,711 | 20,700 | 23,000 |
| Total industrial by-products/wastes | ktpa | 4,643 | 7,500 | 2,700 |
| Existing industrial synergies | No. | 0 | 47 | 0 |
| Potential industrial synergies | No. | 44 | 127 | 39 |
| Direct employment | No. | 9,400 | 4,804 | 5,500 |

## 10.3 Industrial Area Benchmarking

Table 28 presents the benchmarking of the results from this BSIA study with the existing Kwinana Industrial Area and the proposed Oakajee Industrial Area in WA. The benchmarking shows that the BSIA may have similar characteristics (quantities per ha and per industry) as Kwinana and Oakajee in

[7] Values extracted from BSIA industry input and output assessment (Section 3 of this report).

[8] Values extracted from: Van Beers (2008). 2008 Status Report of the Kwinana Synergies Project. Report for Centre for Sustainable Resource Processing.

[9] Values extracted from industry input / output assessment for Oakajee Industrial Area (GHD, 2008).

[10] BSIA excluding total BHP investigation area (700 Ha).

terms of water demand, raw materials inputs, products, and effluent discharges. BSIA seems to have high gas and power demands than Kwinana and Oakajee. This can be partly be explained by the proposed Petroleum / Gas / Coal Processing Precinct in Boodarie. Furthermore, it is recognised that each industrial estate is unique in terms of industry mix, land assembly, infrastructure, and transportation (e.g. access to port, rail, etc).

**Table 28 Industrial Areas – Benchmarking**

| Base Data | Unit | Boodarie Industrial Area (Planned) | Kwinana Industrial Area (Existing) | Oakajee Industrial Area (Planned) |
|---|---|---|---|---|
| PER HECTARE: | | | | |
| Heavy industry | ha per industry | 93 | 171 | 167 |
| Power demand | MW per ha | 0.43 | - | 0.16 |
| Gas/coal demand | TJ/yr per ha | 153 | 37 | 66 |
| Industry feedwater | ML/yr per ha | 21.4 | 14.6 | 16.3 |
| Effluent | ML/yr per ha | 22.6 | 8.3 | 14.6 |
| Raw material input | ktpa per ha | 14.4 | 11.2 | 14.1 |
| Product output | ktpa per ha | 10.3 | 8.6 | 9.9 |
| Industrial by-products/wastes | ktpa per ha | 1.7 | 3.1 | 1.2 |
| Direct employment | No. per ha | 3.4 | 2.0 | 2.4 |
| PER HEAVY INDUSTRY: | | | | |
| Power demand | MW per industry | 40.2 | - | 26.1 |
| Gas/coal demand | TJ/yr per industry | 14,274 | 6,339 | 11,000 |
| Industry feedwater | ML/yr per industry | 1,994 | 2,500 | 2,714 |
| Effluent | ML/yr per industry | 2,110 | 1,429 | 2,429 |
| Raw material input | ktpa per industry | 1,344 | 1,914 | 2,357 |
| Product output | ktpa per industry | 957 | 1,479 | 1,643 |
| Industrial by-products/wastes | ktpa per industry | 155 | 536 | 193 |
| Existing industrial synergies | No. per industry | 0 | 3.4 | 0 |
| Potential industrial synergies | No. per industry | 1.5 | 9.1 | 2.8 |
| Direct employment | No. per industry | 313 | 343 | 393 |

# 11. Implementation Plan and Operational Management Model

## 11.1 Implementation Plan

There is a need for an action plan and operational management model for the estate to assist with the further development and implementation of the industrial ecology in the BSIA post concept planning. It is recognised that otherwise key initiatives may not materialise because of a lack of coordinated approach and upfront commitment from key stakeholders. Table 29 present the implementation plan for the industrial ecology initiatives with suggested leads for actions, listing of infrastructure components which are influenced by the industrial synergies, clustering and industrial ecology initiatives, and a suggested timing.

**Table 29 Industrial Ecology Opportunities – Proposed Implementation Plans**

| Industrial Ecology Initiative | Suggested Actions / Studies | Suggested Lead for Action | Stakeholder Support Required | Infrastructure Components in BSIA which may be Influenced by Suggested Actions | Suggested Timing |
|---|---|---|---|---|---|
| Centralised industry feedwater facility | Engage with potential service providers and existing/proponent BSIA industries to build up the business case, including detailed technical review of industry feedwater concept | LandCorp | ◗ Water Corporation<br>◗ Service provider<br>◗ Existing/proponent industries | ◗ Location and size of service corridors<br>◗ Land requirements for industry feed water production and storage | Post concept / precinct planning |
| | Assess available financial incentive schemes with State and Federal Government | LandCorp | State and Federal Government Departments | Not applicable | Post concept / precinct planning |
| | Conduct key studies in conjunction with the service provider(s) and existing/proponent BSIE industries, including water balance calculations, water supply options (e.g. groundwater, seawater, municipal WWTP, industrial effluents) | Water Corporation and/or service provider | ◗ Existing/proponent industries<br>◗ Service provider<br>◗ Department of Water | ◗ Location and size of service corridors<br>◗ Land requirements for industry feed water production and storage | Post concept / precinct planning |
| | Secure water supply and disposal (e.g. groundwater, seawater, municipal WWTP, industrial effluents) | Water Corporation and/or service provider | ◗ Water Corporation<br>◗ Department of Water<br>◗ Existing/proponent industries | ◗ Location and size of service corridors | Post concept / precinct planning |
| | Require installation of third pipe infrastructure for land parcels with water intensive industries | LandCorp | ◗ DSD<br>◗ WAPC | ◗ Location and size of service corridors | Post concept / precinct planning |

| Industrial Ecology Initiative | Suggested Actions / Studies | Suggested Lead for Action | Stakeholder Support Required | Infrastructure Components in BSIA which may be Influenced by Suggested Actions | Suggested Timing |
|---|---|---|---|---|---|
| | Assess use of centralised industry feedwater facility for each new industry establishing in the BSIA | LandCorp | ◗ Water Corporation<br>◗ Service provider<br>◗ Proponent industries | ◗ Location and size of service corridors<br>◗ Land requirements for industry feed water production and storage | Subdivision design |
| | Develop and implement centralised industry feedwater facility as required | Water Corporation and/or service provider | ◗ Existing/proponent industries<br>◗ Department of Water<br>◗ LandCorp / DSD | ◗ Location and size of service corridors<br>◗ Land requirements for industry feed water production and storage | Subdivision design<br>Lots/facilities design |
| Centralised energy facility | Engage with potential service providers and existing/proponent BSIA industries to build up the business case, including detailed technical review of centralised energy facility concept, including renewable energy opportunities | LandCorp | ◗ Service provider<br>◗ Existing/proponent industries | ◗ Location and size of service corridors<br>◗ Land requirements for centralised energy facility | Post concept / precinct planning |
| | Assess available financial incentive schemes with State and Federal government | LandCorp | State and Federal Government Departments | Not applicable | Post concept / precinct planning |
| | Conduct key studies in conjunction with the service provider(s) and existing/proponent BSIE industries, including energy balance calculations, energy supply and recovery options (e.g. gas, renewables, industry off-gases and waste heat) | LandCorp | ◗ Existing/proponent industries<br>◗ Service provider | ◗ Location and size of service corridors<br>◗ Land requirements for centralised energy facility | Post concept / precinct planning |
| | Secure energy supply and contracts | Service provider | ◗ Existing/proponent industries | ◗ Location and size of service corridors | Post concept / precinct planning |
| | Consider installation of energy supply/recovery infrastructure for land parcels with energy intensive industries | LandCorp | ◗ Existing/proponent industries | ◗ Location and size of service corridors | Post concept / precinct planning |
| | Assess use of centralised energy facility for each new industry establishing in the BSIA | LandCorp | ◗ Service provider<br>◗ Proponent industries | ◗ Location and size of service corridors<br>◗ Land requirements for centralised energy facility | Subdivision |
| | Develop and implement centralised energy facility as required | Service provider | ◗ Existing/proponent industries<br>◗ LandCorp / DSD | ◗ Location and size of service corridors<br>◗ Land requirements for centralised energy facility | Subdivision design<br>Lots/facilities design |

| Industrial Ecology Initiative | Suggested Actions / Studies | Suggested Lead for Action | Stakeholder Support Required | Infrastructure Components in BSIA which may be Influenced by Suggested Actions | Suggested Timing |
|---|---|---|---|---|---|
| Centralised industrial by-product storage and processing facility | Confirm optimal location of centralised storage and processing facility, preferably outside boundaries of strategic core of estate (subject to environmental, town planning, and land assembly constraints) | LandCorp | ◗ Existing/proponent industries<br>◗ Service providers<br>◗ DEC and EPA | ◗ Location and size of service corridors<br>◗ Land requirements for centralised industrial by-product facility | Post concept / precinct planning |
| | Conduct key studies in conjunction with the existing/proponent BSIE industries and potential service provider(s), including by-product transportation to/from facility, storage and management options, environmental issues, and land assembly | LandCorp | ◗ Existing/proponent industries<br>◗ Service provider | ◗ Location and size of service corridors<br>◗ Land requirements for centralised industrial by-product facility | Post concept / precinct planning |
| | Identify and develop viable markets for (re- and/or co-processed) industrial by-products | Service provider | ◗ Existing/proponent industries | Not applicable | Subdivision |
| | Assess use of centralised industrial by-product facility for each new industry establishing in the BSIA | LandCorp | ◗ Service provider<br>◗ Proponent industries | ◗ Location and size of service corridors<br>◗ Land requirements for centralised industrial by-product facility | Subdivision |
| | Develop and implement centralised industrial by-product storage/processing facility as required | Service provider | ◗ Existing/proponent industries<br>◗ LandCorp / DSD | ◗ Location and size of service corridors<br>◗ Land requirements for centralised industrial by-product facility | Subdivision design<br>Lots/facilities design |
| Industrial synergies and industry clustering | Undertake detailed industrial synergy assessment for each new industry locating to BSIA, covering supply, utility, by-product, and service synergies | LandCorp | ◗ Existing/proponent industries<br>◗ Service provider | ◗ Location and size of service corridors (subject to synergy opportunity)<br>◗ Transportation routes | Subdivision design<br>Lots/facilities design |
| | Assess preferred location with BSIA for industry proponent according to industry location criteria outlined in Table 25 (page 37), and synergy opportunities with existing industries | LandCorp | ◗ Existing/proponent industries | ◗ Location and size of service corridors (subject to synergy opportunity)<br>◗ Transportation routes | Subdivision design<br>Lots/facilities design |
| | Undertake feasibility studies into promising synergy opportunities identified, including triple bottom line assessment and short/long-term benefits | Existing/proponent industries | ◗ Service provider<br>◗ LandCorp / DSD | ◗ Location and size of service corridors (subject to synergy opportunity)<br>◗ Transportation routes | Subdivision design<br>Lots/facilities design |
| | Develop and implement feasible industrial synergies as required | Existing/proponent industries | ◗ Service provider<br>◗ LandCorp / DSD | ◗ Location and size of service corridors (subject to synergy opportunity)<br>◗ Transportation routes | Subdivision design<br>Lots/facilities design |

| Industrial Ecology Initiative | Suggested Actions / Studies | Suggested Lead for Action | Stakeholder Support Required | Infrastructure Components in BSIA which may be Influenced by Suggested Actions | Suggested Timing |
|---|---|---|---|---|---|
| Anchor tenants | Develop economic development strategy for BSIA, including strategies to attract key anchor tenants to the estate | LandCorp / DSD | ◗ Existing/proponent industries<br>◗ Local, State and Federal Government Departments | ◗ Location and size of service corridors (subject to synergy opportunity)<br>◗ Transportation routes<br>◗ Overall land assembly | Post concept planning |
| | Implement economic development strategy as required | LandCorp / DSD | ◗ Existing/proponent industries<br>◗ Local, State and Federal Government Departments | ◗ Location and size of service corridors (subject to synergy opportunity)<br>◗ Transportation routes<br>◗ Overall land assembly | Post concept planning<br>Subdivision planning |

## 11.2 Operational Management Model

After completion of the the BSIA Concept Plan, there is a strong need for the establishment of an ongoing operational management model to ensure BSIA's ongoing viability, maximise resource efficiencies, and enable the development of industrial synergies (service, utility, supply, and by-products). This operational model would require the wide-spread support and participation from a range of stakeholders (industry, government, community).

The possible functions and development process of such an operational model are presented in Subsections 11.2.1 and 11.2.2 respectively.

### 11.2.1 Potential Functions of Operational Management Model

The potential functions of an ongoing operational management model are summarised in the table below, including the key stakeholders that should be involved for the different functions of the management model.

**Table 30 Operational Management Model – Possible Functions and Stakeholders**

| Possible Functions | Development Element | Key Stakeholder(s) ("Make or break" support) | Other Relevant Stakeholders |
|---|---|---|---|
| Enforcement | ◗ Design requirements (built form and civil works)<br>◗ Landscaping requirements | ◗ DEC and EPA<br>◗ WAPC | ◗ Industries/businesses<br>◗ LandCorp<br>◗ Land developers<br>◗ Local government |
| Facilitate | ◗ Community engagement | ◗ Community groups | ◗ Industries/businesses<br>◗ KIC and members<br>◗ LandCorp and DSD<br>◗ DEC and EPA |
| | ◗ Regional development options | - | ◗ CCI and DSD<br>◗ Industries/businesses<br>◗ LandCorp and DoP<br>◗ Synergy facilitator |
| | ◗ Recruitment of new industries | ◗ LandCorp and DSD<br>◗ Industries/businesses | ◗ CCI<br>◗ Synergy facilitator |
| | ◗ Cogeneration and energy cascading developments | ◗ Industries/businesses<br>◗ Service/technology provider | ◗ CCI and DSD<br>◗ LandCorp<br>◗ Synergy facilitator |
| | ◗ Development of integrated and shared (waste)water systems | ◗ Industries/businesses<br>◗ Water Corporation | ◗ LandCorp and DSD<br>◗ DEC and EPA<br>◗ Synergy facilitator<br>◗ WAPC |

| Possible Functions | Development Element | Key Stakeholder(s) ("Make or break" support) | Other Relevant Stakeholders |
|---|---|---|---|
| | ◗ Development of waste management and recycling systems | ◗ Industries/businesses<br>◗ LandCorp | ◗ Local Government<br>◗ DEC and EPA<br>◗ Waste Authority |
| | ◗ Technology innovation, sharing and integration | ◗ Industries/businesses | ◗ CCI and DSD<br>◗ LandCorp and DoP |
| | ◗ Identification and development of by-product and supply synergies | ◗ Industries/businesses | ◗ Synergy facilitator<br>◗ LandCorp and DSD |
| | ◗ Identification and development of new markets | ◗ Industries/businesses | ◗ LandCorp<br>◗ CCI and DSD<br>◗ Synergy facilitator |
| | ◗ Identification and development of industry relocation opportunities | ◗ Industries/businesses<br>◗ LandCorp and DSD | ◗ CCI and DSD<br>◗ LandCorp<br>◗ Synergy facilitator |
| Manage | ◗ Estate wide management system | ◗ Industries/businesses | ◗ LandCorp<br>◗ DEC and EPA<br>◗ WAPC |
| Encourage and assist | ◗ Industry uptake of cleaner production practices | ◗ Cleaner production experts/ practitioners<br>◗ Industries/businesses | ◗ CCI and DSD<br>◗ DEC and EPA |
| | ◗ Development of regulatory framework to encourage reuse of alternative fuels | ◗ DEC and EPA | ◗ Industries/businesses |
| | ◗ Development of regulatory framework to encourage reuse of large volume inorganic by-products in infrastructure projects | ◗ DEC and EPA | ◗ Industries/businesses<br>◗ LandCorp / DoP<br>◗ Research providers |
| Coordinate | ◗ Shared buying | ◗ Industries/businesses | ◗ Synergy facilitator |
| | ◗ Shared logistics | ◗ Industries/businesses | ◗ Synergy facilitator |
| | ◗ Shared marketing | ◗ Industries/businesses | ◗ Synergy facilitator |
| | ◗ Benefit/wellness packages | ◗ Industries/businesses | ◗ Synergy facilitator |
| | ◗ Shared training | ◗ CCI<br>◗ Industries/businesses | ◗ Synergy facilitator |
| | ◗ Shared human resources | ◗ Industries/businesses | ◗ Synergy facilitator |

| Possible Functions | Development Element | Key Stakeholder(s) ("Make or break" support) | Other Relevant Stakeholders |
|---|---|---|---|
| | ◗ Volunteer/community programs | ◗ Industries/businesses | ◗ Synergy facilitator |
| | ◗ Emergency response | ◗ DEC and EPA<br>◗ Industries/businesses | ◗ Synergy facilitator |
| | ◗ Common sub-contractors | ◗ Industries/businesses | ◗ Synergy facilitator |

### 11.2.2 Development of Operational Management Model

A possible pathway for the development of the operational management model is presented in Figure 5. The figure shows that LandCorp and DSD could have a larger involvement in the initial stages of the operational management model, with their role declining over time as new occupiers and other interest groups increase their participation. LandCorp and DSD's involvement is expected to cease at the end of the development phases. By this stage the management model is expected to be self-sufficient and driven by the land occupants.

This pathway has not yet been discussed with any external stakeholders so there is not yet an indication for their level of support and commitment.

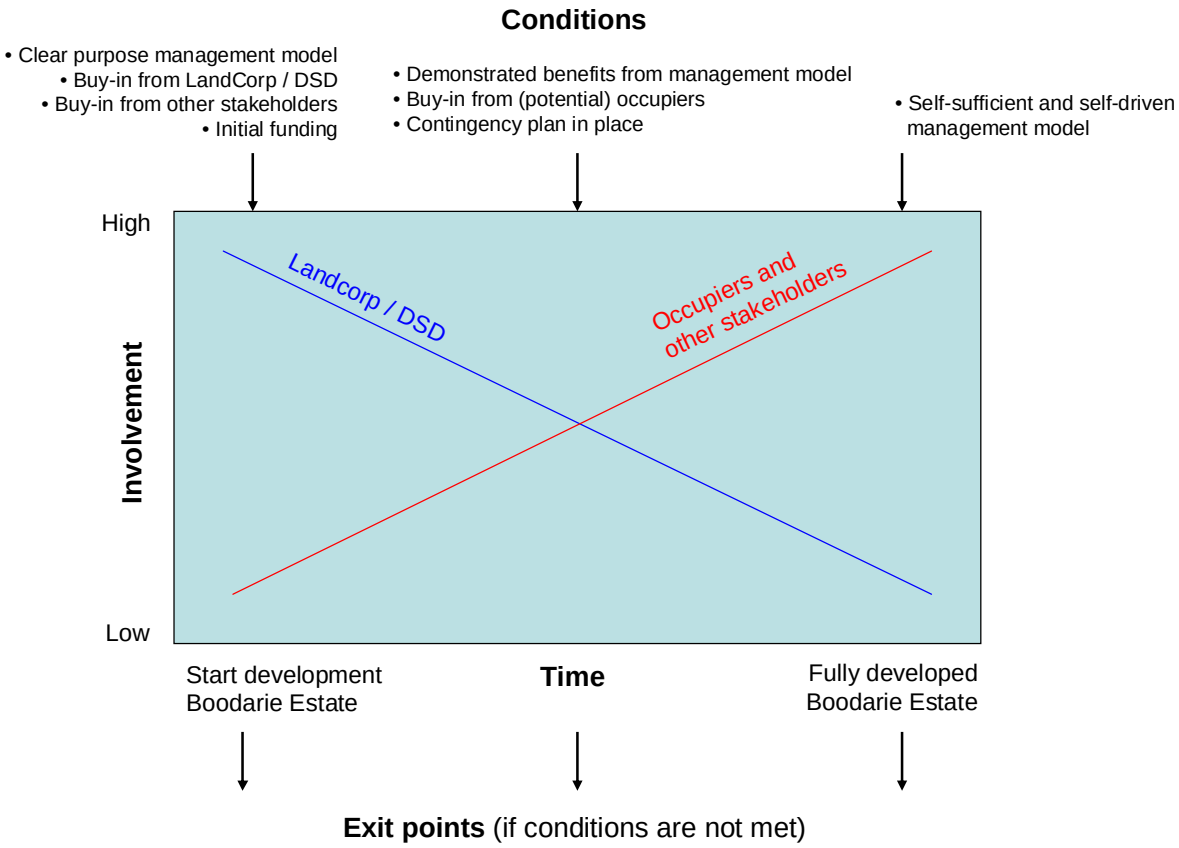
The development of the operational management model would be subject to a number of conditions, such as buy-in from LandCorp/DSD and other relevant key stakeholders, defined purpose, and demonstrated benefits. Exit points for LandCorp/DSD (and the other stakeholders) should be incorporated if these conditions are not met.

As expected, variations and different scenarios exist for Boodarie Estate's operational management model. It is envisaged that these will be subjected to further discussions with LandCorp, DSD and other stakeholders. Scenarios for discussion with LandCorp, DSD and other stakeholders include:

- Whether or not a management model becomes a part of the wider initiative for the Port Hedland industrial region;
- Structure of the Operational Management Model;
    - For example, Management Committee with (topic specific) sub-committees;
    - Expanding structure as development of the Boodarie Etstate progresses;
- Level of stakeholder involvement and engagement;
- The potential mentor role of the Kwinana Industries Council.

Given the success and experience of the Kwinana Industries Council (KIC), it is recommended to learn from KIC's practical experiences as a member based industry organisation. In the initial stages the KIC could have a mentor role to assist with setting up appropriate management structures (e.g. (sub)committees), stakeholder engagement, business networks, and achieving the desired outcomes.

**Figure 5 Possible Pathway for Operational Management Model Development**



# 12. Recommendations

It is suggested to review the recommendations made here with the detailed implementation plans provided in Section 11 'Implementation Plan'. In summary of the results and learnings of this study, the following recommendations are made to further develop industrial ecology in the Boodarie Strategic Industrial Area:

- The development of the BSIA is still subject to many uncertainties (e.g. potential industry mix, development timeframe, development front). As the BSIE develops and industries locate to the estate, it is recommended to review and update the content of this report on a period basis (e.g. every 5 years) to reflect estate developments into the industry input / output assessment and utility demand forecasting. This will assist with the efficient and effective roll-out of the estate over time.
- This study showcases that there is significant potential for the development of industrial synergies and industry clusters within the BSIA providing economic, environmental, and social benefits to the industries and region as a whole. Industry clustering within the proposed precincts in the BSIA can be based on various parameters, including water and energy consumption, risk profile, services and support, processing of organic and/or inorganic materials. This report provides guidance on the types of industry clustering and industrial synergies which can occur in Boodarie, and is reflected in the Precinct Concept Plan presented in this report (Figure 4, subject to environmental, town planning, and land assembly constraints). As industries locate to the BSIA, specific industry clustering and industrial synergy scenarios should be assessed on a case-by-case basis.
- Securing water and energy supply, and efficient and effective storage and processing of large volume industrial by-products and wastes are critical to the successful development of the Boodarie Strategic Industrial Area. There appears to be significant potential for the development of centralised facilities for industry feedwater, energy supply, and industrial by-product storage and processing. It is recommended to initiate detailed scoping and/or pre-feasibility studies into the proposed centralised industry feedwater, energy, and industrial by-product storage/processing facilities. It is strongly recommended to undertake these follow-up studies through a collaborative approach with state and local government, industry, and service providers. The follow-up work can involve follow-up discussions and/or additional studies with relevant parties to further evaluate the technical, economic, environmental, and social potential of these facilities.
- It is recommended to co-locate the proposed industry feedwater facility with an energy facility in the proposed Utility Precinct to enable synergies between these two facilities (e.g. use of waste heat for evaporative water treatment of desalination).
- Subject to environmental, town planning, and land assembly constraints, it is recommended to assess the feasibility of establishing a centralised storage facility in the buffer zone of the estate. A centralised facility in the buffer would maximise industrial land use in the strategic core, but would also facilitate and encourage the (co-)processing industrial by-products into valuable materials.
- There is significant potential for anchor tenants to locate to BSIA (e.g. power generation, cement plant, chemical producers, recycling facilities), and thereby attracting additional industries to Boodarie estate. Furthermore, existing anchor tenants in the region (e.g. power stations, iron ore facilities, port, Wedgefield) could attract synergistic industries to the BSIA. An industrial ecology

study for the entire Port Hedland region is recommended, taking into account the full range of existing and potential anchor tenants in region.

- Implementation of synergistic and industrial ecology opportunities in the BSIA requires long-term participation of various stakeholders (e.g. industry, government, and the community). There is a need for a coordinated effort and long-term operational management model to ensure and encourage:
  - Boodarie's ongoing and future economic, environment, and social viability;
  - Ensure that industrial synergies and key industrial ecology initiatives (such as the industry feedwater, energy, and industrial by-product storage and processing facilities) are incorporated into the development of the estate;
  - Boodarie will become a world class industrial development.

# 13. Limitations and Reliance

This Report:

a) has been prepared by GHD for LandCorp and DSD;

b) may only be used and relied on by LandCorp and DSD;

c) may only be used for the specific purpose of the concept design of the Boodarie Strategic Industrial Area (and must not be used for any other purpose).

GHD and its servants, employees and officers expressly disclaim responsibility to any person other than LandCorp and DSD arising from or in connection with this Report.

This Report must not be altered, amended or abbreviated, issued in part or issued incomplete in any manner whatsoever without prior checking and approval by GHD which GHD may provide or withhold in its absolute discretion. GHD expressly disclaims responsibility for any liability which may arise from circumstances of issue of this Report in part or incomplete or its modification in any way whatsoever.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and this Report are expressly excluded.

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in Section 1.3 (Scope of Work) of this Report; and

GHD prepared this Report on the basis of information provided by external parties which GHD has not independently verified or checked (*Unverified Information*). GHD expressly disclaims responsibility in connection with the Unverified Information, including (but not limited to) errors in, or omissions from this Report which are caused or contributed to by errors in, or omissions from, the Unverified Information.

GHD accepts no obligation to update this Report for events subsequent to the date that this Report is signed by GHD.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing this Report (*Assumptions*), including (but not limited to) those identified in this Report and GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

GHD has prepared the Industry Input and Output Estimates set out in this Report:

a) using information available to the GHD employee(s) who prepared this Report (as referenced and listed in this report); and

b) based on assumptions made by GHD (as listed throughout report).

The Industry Input and Output Estimates have been prepared for the purpose of the concept design of the Boodarie Strategic Industrial Area, and assisting with the planning of required infrastructure to service the estate, and must not be used for any other purpose.

The industry inputs and outputs are estimates only. Actual industry inputs and outputs are dependent on, and directly affected by, many factors and may be different to those used to prepare the Industry Input and Output Estimates. The Industry Input and Output Estimates may need to be reviewed and revised if any of the assumptions made by GHD change. GHD does not represent, warrant or

guarantee that the development of the Boodarie Strategic Industrial Area over time can or will be undertaken according to the Industry Input and Output Estimate.

If LandCorp or DSD wishes to provide this Report to a third party recipient to use and rely upon, then GHD's prior written consent will be required. Before this Report is released to the third party recipient, the recipient will be required to execute a GHD prepared deed poll under which the recipient agrees:

a) to acknowledge that the basis on which this Report may be relied upon is consistent with the above principles; and

b) to the maximum extent permitted by law, GHD shall not have, and the recipient forever releases GHD from, any liability to the recipient for loss or damage howsoever in connection with, arising from or in respect of this Report whether such liability arises in contract, tort (including negligence), under statute or otherwise and whether arising from or in connection with one or more events.

Appendix A

# Industry Input / Output Assessment – Assumptions and References

| | | | | | | | POTENTIAL KEY INPUTS | | | | | | | | | | | | POTENTIAL KEY OUTPUTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Potential industry types | Production process info | Total area | Reference / comments / assumptions | Direct employ-ment | Reference / comments / assumptions | Power | Reference / comments / assumptions | Gas | Reference / comments / assumptions | Domestic use of potable water | Reference / comments / assumptions | High quality industry feed water | Reference / comments / assumptions | Process & cooling water (lower quality) | Reference / comments / assumptions | Raw / source materials | Reference / comments / assumptions | Water discharge | Reference / comments / assumptions | Products | Reference / comments / assumptions | By-products / waste | Reference / comments / assumptions |
| | | | Ha | | persons | | MW | | TJ/a | | ML/a (ktpa) | | ML/a (ktpa) | | ML/a (ktpa) | | ktpa | | ML/a (ktpa) | | ktpa | | ktpa | |
| **DOWNSTREAM IRON ORE PROCESSING** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Sintered iron plant | Thermal treatments, sintering furnace | 80 | Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 25 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 200 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 11 | - See estimated breakdown and assumptions in worksheet 'BIE Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 2,600 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 0 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 4,700 | Iron ore fines (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 2,340 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 5,000 | Sinter (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 311 | Assumed that process waste accounts for 5% of raw material input |
| | | | | | | | | | | | | | | | | | 900 | Limestone (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |
| | | | | | | | | | | | | | | | | | 200 | Dolomite (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |
| | | | | | | | | | | | | | | | | | 350 | Coke breeze (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |
| | | | | | | | | | | | | | | | | | 60 | Other (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |
| 1 | Iron ore pelletising plant | Grinding, concentration, and slurry transport, pelletising furnace | 80 | Estimated based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated | 10 | Oakajee Market Analysis (ACIL Tasman, 2009) | 2,000 | Oakajee Market Analysis (ACIL Tasman, 2009) | 11 | - See estimated breakdown and assumptions in worksheet 'BIE Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 1,050 | - Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 1,950 | - Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 5,250 | - Assumed that material input (iron ore) accounts for 105% of product output<br>- Raw material input includes product (95%) + waste (5%) | 2,408 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 5,000 | Iron ore pellets (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 250 | - Pelletising wastes include scale, fines, off-spec products<br>- Assumed that pelletising waste accounts for 5% of raw material input |
| 1 | DRI / alternative smelting iron plant | Alternative technologies include Hismelt, Corex, Finex, ITmk3 and gas based Direct Reduced Iron (DRI) | 140 | Average from Oakajee Market Analysis (ACIL Tasman, 2009) and Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 60 | Oakajee Market Analysis (ACIL Tasman, 2009) | 50,000 | Oakajee Market Analysis (ACIL Tasman, 2009) | 11 | - See estimated breakdown and assumptions in worksheet 'BIE Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 2,100 | - Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 3,900 | - Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 175 | Lime source: Assumed 5% of ore input (estimate based on CSRP Kwinana | 4,815 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 2,000 | Assumed that similar capacity Hismelt plant in Kwinana | 700 | Slag to product ratio (0.35) based on Hismelt plant in Kwinana |
| | | | | | | | | | | | | | | | | | 175 | Dolomite: Assumed 5% of ore input (estimate based on CSRP Kwinana | | | | | 26 | Gypsum to product ratio (0.0.13) based on Hismelt plant in Kwinana |
| | | | | | | | | | | | | | | | | | 700 | Coal (reductant): Assumed 20% of ore input (estimate based on CSRP Kwinana | | | | | | |
| | | | | | | | | | | | | | | | | | 700 | Utility gases (e.g. nitrogen, oxygen): Assumed 20% of ore input (estimate based on CSRP Kwinana | | | | | | |
| | | | | | | | | | | | | | | | | | 3,500 | Iron ore to product ratio (0.75) based on Hismelt plant in Kwinana | | | | | | |
| 1 | Integrated steel making plant | Basic Oxygen Furnace or Electric Arc | 120 | CIL Tasman Oakajee Market Analysis and Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 80 | Oakajee Market Analysis (ACIL Tasman, 2009) | 50,000 | Oakajee Market Analysis (ACIL Tasman, 2009) | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 3,500 | - Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 6,500 | - Total estimated water use taken from Oakajee Market Analysis (ACIL Tasman, 2009)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 3,160 | Iron ore: Assumed 1.58 kg iron ore to 1 kg steel product (Simapro LCA software) | 8,025 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 2,000 | Steel products: Assumed that similar capacity as a possible DRI plant | 700 | Slag: Assumed slag to product ratio (0.35) |
| | | | | | | | | | | | | | | | | | 1,340 | Limestone: Assumed 0.67 kg limestone to 1 kg steel product (Simapro LCA | | | | | 30 | Gypsum: Assumed gypsum to product ratio (0.015) |
| | | | | | | | | | | | | | | | | | 632 | Utility gases (e.g. nitrogen, oxygen): Assumed 20% of ore | | | | | | |
| | | | | | | | | | | | | | | | | | 940 | Coal: Assumed 0.47 kg coal to 1 kg steel product (Simapro LCA software) | | | | | | |
| 1 | Ferromanganese production plant | Production of ferromanganese from iron-containing manganese ores (blast furnace) | 40 | Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 50 | - Assumed FeMg production through blast furnace<br>- GHD guestimate | 25,000 | - Assumed FeMg production through blast furnace<br>- GHD guestimate | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 525 | - Total estimated water use is GHD guestimate<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 975 | - Total estimated water use is GHD guestimate<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 18.4 | Manganese ore (Boodarie Resource Processing Estate - Environmental Report | 1,204 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 10 | Fe/Mn HC/LS (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 5 | Slag (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 2.4 | Limestone (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| | | | | | | | | | | | | | | | | | 1.2 | Quartz (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | 1.2 | Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 3.8 | Coke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| | | | | | | | | | | | | | | | | | 2.4 | Coal (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |

| | | | | | | | POTENTIAL KEY INPUTS | | | | | | | | | | | | POTENTIAL KEY OUTPUTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Potential industry types | Production process info | Total area | Reference / comments / assumptions | Direct employ-ment | Reference / comments / assumptions | Power | Reference / comments / assumptions | Gas | Reference / comments / assumptions | Domestic use of potable water | Reference / comments / assumptions | High quality industry feed water | Reference / comments / assumptions | Process & cooling water (lower quality) | Reference / comments / assumptions | Raw / source materials | Reference / comments / assumptions | Water discharge | Reference / comments / assumptions | Products | Reference / comments / assumptions | By-products / waste | Reference / comments / assumptions |
| | | | Ha | | persons | | MW | | TJ/a | | ML/a (ktpa) | | ML/a (ktpa) | | ML/a (ktpa) | | ktpa | | ML/a (ktpa) | | ktpa | | ktpa | |
| 1 | Ferrosilicon production plant | Reduction of silica or sand with coke in presence of scrap iron, millscale, or other source of iron. Electric arc furnace | 40 | Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 80 | - Guestimate by GHD<br>- Literature suggested 9 MW/ton product | 10,000 | GHD guestimate | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 525 | - Total estimated water use is GHD guestimate<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 975 | - Total estimated water use is GHD guestimate<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 45 | Quartz (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | 1,204 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 23 | FeSi (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 0.9 | Slag (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 8.5 | Coke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| | | | | | | | | | | | | | | | | | 13.1 | Coal (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | 6.9 | Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 5.5 | Fe-chips (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| | | | | | | | | | | | | | | | | | 16.1 | Woodchips (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| 1 | Iron carbide plant | Reduction of iron oxide in the presence of carbon monoxide | 20 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated | 20 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 10,000 | GHD guestimate | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 1,400 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 1,100 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 2,000 | Beneficiated iron ore fines (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 2,085 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 1,000 | Iron carbide (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 500 | Tailings (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| **Subtotal** | | | **520** | | **2,800** | | **325** | | **147,200** | | **76** | | **11,700** | | **15,400** | | **24,898** | | **22,080** | | **15,033** | | **2,531** | |
| **DOWNSTREAM NON-FERROUS RESOURCE PROCESSING** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Magnesium production plant | Electrowinning of magnesium or chemical reduction of magnesium compounds at high temperatures with carbon, calcium carbide, or ferrosilicon | 50 | Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 8 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 10,000 | GHD guestimate | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 700 | - Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 1,300 | - Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 250 | Magnesium ore (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 1,605 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 80 | Deod burned MgO (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 13 | Assumed that process waste accounts for 5% of raw material input |
| | | | | | | | | | | | | | | | | | 5.0 | Chloride (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | 20 | Electrofused MgO (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 3.2 | Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 2.0 | Petcoke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| | | | | | | | | | | | | | | | | | 5.4 | Fuel oil/gas (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| 1 | Titanium production plant | Purification, sponge production | 60 | GHD estimate based on other projects | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 145 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 1,000 | GHD estimate based on other projects | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 1,400 | - Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 2,600 | - Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 105 | Ilmenite (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | 3,210 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 50 | Titanium sponge (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 6 | Assumed that process waste accounts for 5% of raw material input |
| | | | | | | | | | | | | | | | | | 4.5 | Chlorine (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| | | | | | | | | | | | | | | | | | 2.0 | HCl (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | 5 | Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 1.0 | Magnesium (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| 1 | Copper smelter | Furnaces | 120 | Guestimate by GHD | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated | 50 | GHD guestimate | 10,000 | GHD guestimate | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA | 525 | - Total estimated water use is GHD guestimate<br>- Assumed high quality water comprises 35% of | 975 | - Total estimated water use is GHD guestimate<br>- Assumed lower quality water demand | 624 | Assumed raw material input (copper concentrate) is sum of product and slag | 1,204 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use | 150 | - Assumed capacity by GHD<br>- Olympic Dam production is about 175 | 474 | Slag formula developed by Yale Stocks and Flows Project (2001) |
| 1 | Silicon manganese production plant | Electric furnace | 50 | Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 25 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 10,000 | GHD guestimate | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 525 | - Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 975 | - Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 63.5 | Manganese ore (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 1,204 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 38 | SiMn (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 19 | Slag (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 2.7 | Limestone (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |
| | | | | | | | | | | | | | | | | | 22.0 | Quartz (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | 4.5 | Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 16.3 | Coke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| | | | | | | | | | | | | | | | | | 10.3 | Coal (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |

| | | | | | | | POTENTIAL KEY INPUTS | | | | | | | | | | | | POTENTIAL KEY OUTPUTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Potential industry types | Production process info | Total area | Reference / comments / assumptions | Direct employ-ment | Reference / comments / assumptions | Power | Reference / comments / assumptions | Gas | Reference / comments / assumptions | Domestic use of potable water | Reference / comments / assumptions | High quality industry feed water | Reference / comments / assumptions | Process & cooling water (lower quality) | Reference / comments / assumptions | Raw / source materials | Reference / comments / assumptions | Water discharge | Reference / comments / assumptions | Products | Reference / comments / assumptions | By-products / waste | Reference / comments / assumptions |
| | | | Ha | | persons | | MW | | TJ/a | | ML/a (ktpa) | | ML/a (ktpa) | | ML/a (ktpa) | | ktpa | | ML/a (ktpa) | | ktpa | | ktpa | |
| 1 | Silicon metal production plant | Carbothermic reaction of silica (quartz) in an electric arc furnace | 50 | Estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 25 | Assumed same power demand as silicon manganese production plant | 10,000 | Assumed same power demand as silicon manganese production plant | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 525 | - Total estimated water use is GHD guestimate<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 975 | - Total estimated water use is GHD guestimate<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 40.1 | Quartz (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 1,204 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 15 | Silicon metal (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 0.7 | Slag (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 2.3 | Coke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde | | | | | | |
| | | | | | | | | | | | | | | | | | 20.1 | Coal (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | 8.6 | Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 15.0 | Woodchips (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |
| 1 | Chlor-alkali plant | Electrolysis of sodium chloride with chlorine and sodium hydroxide as products | 50 | Guestimate by GHD | 100 | GHD guestimate | 90 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 0 | Chlor-alkali plant does not consume significant amounts of gas | 3 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 70 | - Total estimated water use based on CSRP Kwinana Synergies Project (Van Beers, 2008)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 130 | - Total estimated water use based on CSRP Kwinana Synergies Project (Van Beers, 2008)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 400 | Sodium chloride (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 161 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 220 | Chlorine (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 35 | Contaminated water (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | | | | | 240 | Caustic soda (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 3.6 | Brine sludge (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| 1 | Aluminium smelter | Hall-Héroult process (electrolytic process) | 120 | Guestimate by GHD | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 170 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 10,000 | GHD guestimate | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 1,050 | - Estimated water use (lower) based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 1,950 | - Estimated water use (lower) based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 190 | Alumina (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 2,408 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 100 | Aluminium ingots (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 1 | Spent pot (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 13 | Pitch (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | 2 | Dust (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 75 | Petcoke (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | 14 | Assumed that other process waste accounts for 5% of raw material input |
| | | | | | | | | | | | | | | | | | 2.5 | Fluorides (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |
| 1 | Chromite processing plant (ferro-chromium production) | Electric arc melting of chromite (FeCr2O4). Carbothermic reduction operation taking place at high temperatures. Cr Ore (an oxide of chromium and iron) is reduced by coal and coke to form the iron-chromium alloy | 100 | - Guestimate by GHD<br>- Assumed same as integrated steel plant | 400 | - Average of 400 employee per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 80 | - GHD guestimate<br>- Electric arc furnace is energy intensive process | 10,000 | GHD guestimate | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 525 | - Total estimated water use is GHD guestimate<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 975 | - Total estimated water use is GHD guestimate<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 450 | Concentrated chromite ore:<br>Assumed same as planned production of Coobina chromite mine | 1,204 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 315 | Ferro-chromium:<br>Assumed 70% of chromite ore input | 113 | Assumed that slag accounts for 25% of ore input |
| | | | | | | | | | | | | | | | | | 90 | Coke:<br>Assumed to account for 20% of chromite ore input | | | | | 32 | Assumed that other process waste accounts for 5% of raw material input |
| | | | | | | | | | | | | | | | | | 90 | Coal:<br>Assumed to account for 20% of chromite ore input | | | | | | |
| **Subtotal** | | | **600** | | **2,900** | | **593** | | **61,000** | | **79** | | **5,320** | | **9,880** | | **2,502** | | **12,198** | | **1,228** | | **733** | |
| **DOWNSTREAM PETROLEUM / GAS / COAL PROCESSING** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Methanol plant | Steam-methane reforming, water-gas shift reaction, catalylic reactions | 50 | Increased estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 100 | - Estimate based on GHD experience | 0.5 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 28,000 | Estimated 35GJ/ton product based on SimaPro LCA database | 3 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 875 | - Estimate (lower) based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 1,625 | - Estimate (lower) based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 595 | - Natural gas use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed conversion factor of 20 tonnes/TJ | 2,006 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 800 | Methanol (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 125 | Assumed that oily and saline water accounts for 5% of total industry feedwater use |
| 1 | Ammonia / urea plant | Ammonia is synthesised from hydrogen (from natural gas) and nitrogen (from the air) Urea is made from ammonia and carbon dioxide | 65 | GHD estimate based on other projects (Perdaman) and Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 250 | - Estimate based on GHD experience | 2 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 22,400 | Natural gas use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 7 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 500 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 2,500 | Estimate (lower) based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 448 | - Natural gas use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed 20 tonnes/GJ | 2,325 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 250 | Ammonia (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 4 | - Assumed catalyst waste accounts for 1% of raw material (gas) input<br>- Assumed gas conversion factor of 20 tonnes/TJ |
| | | | | | | | | | | | | | | | | | | | | | 400 | Urea (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 450 | Contaminated water (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | | | | | | | 22 | Assumed that other process waste accounts for 5% of raw material (gas) input |

| | | | | | | | POTENTIAL KEY INPUTS | | | | | | | | | | | | POTENTIAL KEY OUTPUTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Potential industry types | Production process info | Total area | Reference / comments / assumptions | Direct employ-ment | Reference / comments / assumptions | Power | Reference / comments / assumptions | Gas | Reference / comments / assumptions | Domestic use of potable water | Reference / comments / assumptions | High quality industry feed water | Reference / comments / assumptions | Process & cooling water (lower quality) | Reference / comments / assumptions | Raw / source materials | Reference / comments / assumptions | Water discharge | Reference / comments / assumptions | Products | Reference / comments / assumptions | By-products / waste | Reference / comments / assumptions |
| | | | Ha | | persons | | MW | | TJ/a | | ML/a (ktpa) | | ML/a (ktpa) | | ML/a (ktpa) | | ktpa | | ML/a (ktpa) | | ktpa | | ktpa | |
| 1 | Ethane extraction | Isolation from natural gas, or as a byproduct of petroleum refining. | 60 | Increased estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 150 | GHD guestimate | 30 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 100,000 | - Natural gas estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed conversion factor of 20 tonnes/TJ | 4 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 88 | - Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 163 | - Total estimated water use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 2,000 | Natural gas (estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 201 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 200 | Ethane (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 100 | Assumed that process waste accounts for 5% of raw material input |
| | | | | | | | | | | | | | | | | | | | | | 2,450 | LPG (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | |
| 1 | Ethane cracker | Production of ethylene from ethane in steam cracking | 50 | Increased estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 250 | GHD guestimate | 10 | GHD guestimate | 8,750 | - Natural gas use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed conversion factor of 20 tonnes/TJ | 7 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 51 | - Assumed 1 kL/ton product based on http://sustainability.bhpbiliton.com/2003/additional/appendix_f.html<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 94 | - Assumed 1 kL/ton product based on http://sustainability.bhpbiliton.com/2003/additional/appendix_f.html<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 175 | Ethane (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 116 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 145 | Ethylene (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 20 | Various liquid wastes (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| 1 | Ethylene dichloride (EDC) / Vinyl chloride monomer (VCM) plant | EDC = Iron(III) chloride-catalysed reaction of ethene (ethylene) and chlorine | 50 | Increased estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 400 | - Average of 400 employees per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC | 8 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 10,000 | GHD guestimate | 11 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 525 | - Total estimated water use is GHD guestimate<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 975 | - Total estimated water use is GHD guestimate<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 145 | Ethylene (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 1,204 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 100 | Ethylene dichloride (EDC) (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 200 | Various liquid wastes (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) |
| | | | | | | | | | | | | | | | | | 220 | Chlorine (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | 240 | Vinyl chloride monomer (VCM) (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | |
| 1 | Sodium cyanide plant | Treating hydrogen cyanide with sodium hydroxide | 25 | Increased estimate based on Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 100 | GHD guestimate | 1 | Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996) | 10,000 | GHD guestimate | 3 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 525 | - Total estimated water use is GHD guestimate<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 975 | - Total estimated water use is GHD guestimate<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 14 | - Natural gas use taken from Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)<br>- Assumed conversion factor of 20 tonnes/TJ | 1,204 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 15 | Sodium cyanide (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | 2 | Assumed that process waste accounts for 5% of raw material input |
| | | | | | | | | | | | | | | | | | 10 | Caustic soda (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |
| | | | | | | | | | | | | | | | | | 10 | Ammonia (Boodarie Resource Processing Estate - Environmental Report (Woodward-Clyde 1996)) | | | | | | |
| **Subtotal** | | | **300** | | **1,250** | | **52** | | **179,150** | | **34** | | **2,563** | | **6,332** | | **3,617** | | **7,056** | | **4,600** | | **924** | |
| **PORT DEPENDANT** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Large scale processing plant (liquids - not defined) | Subject to specific industry type | 120 | - Assumed average lot size of 1 large scale processing plant = 100 ha | 400 | - Average of 400 employees per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 80 | - Guestimate based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers) | 10,000 | - Guestimate based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers) | 10.9 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 350 | - Total water use estimated based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 650 | - Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 3,313 | - Raw materials<br>- Subject to specific types of large scale processing plant | 803 | - Assumed discharge = 90% potable water use + 75% of process/cooling water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 2,500 | - Liquid product 1<br>- Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers) | 163 | - Assumed that process residues account to 5% of total product output<br>- Various process wastes<br>- Specific types of large scale manufacturing plants are unknown |
| | | | | | | | | | | | | | | | | | 100 | - Process chemicals<br>- Subject to specific types of large scale processing plant | | | 500 | - Liquid product 2<br>- Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers) | | |
| | | | | | | | | | | | | | | | | | | | | | 250 | - Liquid product 3<br>- Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers) | | |
| 1 | Large scale processing plant (conveyors - not defined) | Subject to specific industry type | 120 | - Assumed average lot size of 1 large scale processing plant = 100 ha | 400 | - Average of 400 employees per major industry (estimate based on Kwinana Integrated Assessment Study (KIC 2007))<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 80 | - Guestimate based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers) | 10,000 | - Guestimate based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers) | 10.9 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 350 | - Total water use estimated based on CSRP Kwinana Industrial Area Regional Synergies Project (2007 Status Report, Van Beers)<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006))<br>- Assumed high quality water comprises 35% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 650 | - Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers)<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006))<br>- Assumed lower quality water demand comprises 65% of total water use (based on Kwinana Water Planning Study (KIC 2006)) | 2,000 | - Raw materials<br>- Subject to specific types of large scale processing plant | 803 | - Assumed discharge = 90% potable water use + 75% of process/cooling water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 1,500 | - Solid product 1<br>- Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers) | 100 | - Assumed that process residues account to 5% of total product output<br>- Various process wastes<br>- Specific types of large scale manufacturing plants are unknown |
| | | | | | | | | | | | | | | | | | 100 | - Process chemicals<br>- Subject to specific types of large scale processing plant | | | 500 | - Solid product 1<br>- Guestimate based on CSRP Kwinana Industrial Area Synergies Project (2007 Status Report, Van Beers)<br>- Subject to specific type of large scale processing plant - currently unknown | | |
| **Subtotal** | | | **240** | | **800** | | **160** | | **20,000** | | **22** | | **700** | | **1,300** | | **5,513** | | **1,605** | | **5,250** | | **263** | |

| | | | | | | | POTENTIAL KEY INPUTS | | | | | | | | | | | | POTENTIAL KEY OUTPUTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Potential industry types | Production process info | Total area | Reference / comments / assumptions | Direct employ-ment | Reference / comments / assumptions | Power | Reference / comments / assumptions | Gas | Reference / comments / assumptions | Domestic use of potable water | Reference / comments / assumptions | High quality industry feed water | Reference / comments / assumptions | Process & cooling water (lower quality) | Reference / comments / assumptions | Raw / source materials | Reference / comments / assumptions | Water discharge | Reference / comments / assumptions | Products | Reference / comments / assumptions | By-products / waste | Reference / comments / assumptions |
| **UTILITIES AND RESOURCE RECOVERY** | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Gas fired power station (250 MW) | Gas fired power generation (assumed 250 MW) | 50 | Guestimate by GHD | 75 | GHD guestimate | 0 | - Power requirements for power station will substitute power demands for industries listed above<br>- Potential power requirements not included in here to avoid double counting | 10,000 | Estimate based on CSRP Kwinana Synergies Project | 2.0 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 200 | - Boiler feedwater<br>- Estimate based on CSRP Kwinana Synergies Project | 0 | - Assumed that gas fired power generation does not need cooling water<br>- Estimate based on CSRP Kwinana Synergies Project | 0 | Assumed that power station does not consume significant amounts of raw materials (other than fuel captured in gas demand) | 180 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 0 | Other than electricity, assumed no significant product outputs | 0 | - Assumed no significant by-products/waste from gas fired power generation<br>- Waste heat will be significant but not quantified |
| 1 | Gas fired power station (120MW) | Gas fired power generation (120 MW) | 25 | Paul Schneider note at SRG workshop on 9-Nov-10, and preliminary plan 'Lots 600, 601 & Easement' (Whelans) | 50 | GHD guestimate | 0 | - Power requirements for power station will substitute power demands for industries listed above<br>- Power station will produce its own power<br>- Potential power requirements not included in here to avoid double counting | 5,000 | Estimate based on CSRP Kwinana Synergies Project | 1.4 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | 100 | - Boiler feedwater<br>- Estimate based on CSRP Kwinana Synergies Project | 0 | - Assumed that gas fired power generation does not need cooling water<br>- Estimate based on CSRP Kwinana Synergies Project | 0 | Assumed that power station does not consume significant amounts of raw materials (other than fuel captured in gas demand) | 90 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 0 | Other than electricity, assumed no significant product outputs | 0 | - Assumed no significant by-products/waste from gas fired power generation<br>- Waste heat will be significant but not quantified |
| 1 | Coal fired power station (800 MW) | Coal fired power station (assumed 800 MW) | 100 | Guestimate based on GHD experience | 200 | GHD guestimate | 0 | - Power requirements for power station will substitute power demands for industries listed above<br>- Power station will produce its own power<br>- Potential power requirements not included in here to avoid double | 0 | Assumed no use of gas for coal-fired power station | 5.5 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial | 450 | - Boiler feedwater (approx 60 tph of boiler feedwater)<br>- Estimate based on CSRP Kwinana Synergies Project | 2,000 | - Ashing, dust suppression water<br>- Assumed air cooling<br>- Estimate based on CSRP Kwinana Synergies Project | 800 | Coal: estimate based on CSRP Kwinana Synergies Project | 1,905 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | 0 | Other than electricity, assumed no significant product outputs | 25 | Fly ash: estimate based on CSRP Kwinana Synergies Project |
| | | | | | | | | | | | | | | | | | 2 | Process chemicals (e.g. water treatment, oils and greases): estimate based on CSRP Kwinana Synergies Project | | | | | 5 | Bottom ash: estimate based on CSRP Kwinana Synergies Project |
| 1 | Waste-to-energy and material recovery facility | Waste to gas thermal conversion technology, including material recovery facility (MRF) | 10 | Waste To Gas Renewable Energy proposal, New Energy, September 2010 | 25 | - Guestimate<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 0 | - Power requirements for energy factory will substitute power demands for industries listed above<br>- Potential power requirements not included in here to avoid double counting | 2,500 | Guestimate for back-up gas use | 0.7 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial | 100 | - Boiler feedwater<br>- Estimate based on Waste To Gas Renewable Energy proposal, New Energy, September 2010 | 0 | - Assumed that waste to enery plant does not need cooling water<br>- Estimate based on Waste To Gas Renewable Energy proposal, New Energy, September 2010 | 126 | - Initial capacity of plant will be 360 tonnes/day<br>'- Waste To Gas Renewable Energy proposal, New Energy, September 2010 | 90 | - Assumed discharge = 90% high quality water use + 75% of lower quality water use<br>- Assumed that 25% of lower quality water use is lost (e.g. evaporation, product) | Double counting | Steam, electricity, heat/chill to selected industries | 32 | Slag production: assumed 25% of total raw material input into gasifier |
| | | | | | | | | | | | | | | | | | 126 | Guestimate for various waste streams recycled through material recycling facility | | | | | | |
| 1 | Industry feedwater facility | Production of industry feedwater at different qualities, feeding from range of potential water sources (e.g. ground water, seawater, treated effluents) | 65 | Guestimate based on GHD experience and land area estimate for industry feedwater facility in Oakajee Industrial Estate | 15 | - Guestimate based on GHD experience<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 36 | - Power requirement = 0.2 MW/(ML/day water production) (Proxy based on Kwinana Desalination Plant) | 0 | Water recycling plant is not likely to use significant amounts of gas | 0.4 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial | 0 | Assumed Water factory does not require significant amount of high quality industry feedwater | 0 | Assumed Water factory does not require significant amount of high quality industry feedwater | 40,000 | Processing of industrial effluents | 15,000 | Assumed that proportion of water (e.g. brine) needs to be discharged | 25,000 | - High quality industry feedwater<br>- Sufficient capacity to supply water demand BIE industries | 2.0 | Sludge production = 0.03 tonnes/day per ML/day potable water production (Proxy based on Kwinana Desalination Plant) |
| | | | | | | | | | | | | | | | | | 40,000 | Use of groundwater and/or seawater | | | 40,000 | - Lower quality industry feedwater<br>- Sufficient capacity to supply water demand BIE industries | | |
| 1 | Energy facility (electricity, steam, heat, chill) | Potential joint-industry cogen or tri-generation plant, potential to feed from industry waste heat | 60 | Guestimate based on GHD experience | 25 | - Guestimate based on GHD experience<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 0 | - Power requirements for energy factory will substitute power demands for industries listed above<br>- Potential power requirements not included in here to avoid double counting | Double counting | - Gas requirements for energy factory will substitute gas demands for industries listed above<br>- Potential gas requirements not included in here to avoid double counting | 0.7 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 78 l/employee/day for domestic use of potable water in industrial operations | Double counting | - Water requirements for energy factory will substitute water demands for industries listed above<br>- Potential water requirements not included in here to avoid double counting | Double counting | - Water requirements for energy factory will substitute water demands for industries listed above<br>- Potential water requirements not included in here to avoid double counting | 0 | Other than energy sources (e.g. gas, coal, waste heat) and water, energy factory is not likely to consume large large of raw materials | Double counting | - Water discharges from energy factory will substitute water discharges from industries listed above<br>- Potential water requirements not included in here to avoid double counting | Double counting | Steam, electricity, heat/chill to selected industries | 0 | No significant solid or liquid by-products from energy factory |
| **Subtotal** | | | **310** | | **390** | | **36** | | **17,500** | | **11** | | **850** | | **2,000** | | **81,054** | | **17,265** | | **65,000** | | **63** | |
| **GENERAL INDUSTRY** | | | | | | | | | | | | | | | | | | | | | | | | |
| 64 | General industries | Subject to specific industry type | 160 | - Assumed average lot size of 1 general industry = 2.5 ha | 960 | - Assumed 15 employees per general industry<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 26 | - Assumed 200 KVA per ha for general industrial area (Western Power standard)<br>- Assumed that 200 kVA/ha = 160 kW/ha = 0.16 MW/ha | 2,080 | Estimated gas demand proxy general industry = 13 TJ/ha (based on Latitude 32 Alternative Energy Study (GHD) | 26 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 64 l/employee/day for domestic use of potable water in non-industrial operations | 1,280 | - Estimated water use per general industry = 40 ML/yr (based on Latitude 32 Alternative Industry Feedwater Study (GHD)<br>- Assumed high quality water demand comprises 50% of total water use (based on Latitude 32 Alternative Industry Feedwater Study (GHD) | 1,280 | - Estimated water use per general industry = 40 ML/yr (based on Latitude 32 Alternative Industry Feedwater Study (GHD)<br>- Assumed lower quality water demand comprises 50% of total water use (based on Latitude 32 Alternative Industry Feedwater Study (GHD) | 1,680 | - Assumed that raw materials is sum of products + by-products/wastes<br>- Specific types of general industries have not yet been identified | 2,112 | - Assumed discharge = 90% potable water use + 75% of lower quality water use<br>- Assumed that 25% of process/cooling water use is lost (e.g. evaporation, product) | 1,600 | - Assumed 25 ktpa of produced product per general industry<br>- Specific types of general industries have not yet been identified | 80 | - Assumed that wastes from general industry accounts to 5% of total product output |
| **Subtotal** | | | **160** | | **960** | | **26** | | **2,080** | | **26** | | **1,280** | | **1,280** | | **1,680** | | **2,112** | | **1,600** | | **80** | |
| **NOXIOUS INDUSTRY** | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | Noxious industries | Subject to specific industry type | 100 | - Assumed average lot size of 1 noxious industry = 5 ha | 300 | - Assumed 25 employees per noxious industry<br>- 30% white collar employees, 70% blue collar employees (estimate based on Kwinana Integrated Assessment Study (KIC 2007)) | 16 | - Assumed 200 KVA per ha for general industrial area (Western Power standard)<br>- Assumed that 200 kVA/ha = 160 kW/ha = 0.16 MW/ha | 1,300 | Estimated gas demand proxy general industry = 13 TJ/ha (based on Latitude 32 Alternative Energy Study (GHD) | 8 | - See estimated breakdown and assumptions in worksheet 'BSIA Domestic Use Potable Water'<br>- Estimated 64 l/employee/day for domestic use of potable water in non-industrial operations | 600 | - Estimated water use per noxious industry = 60 ML/yr<br>- Assumed high quality water demand comprises 50% of total water use (based on Latitude 32 Alternative Industry Feedwater Study (GHD) | 600 | - Estimated water use per noxious industry = 60 ML/yr<br>- Assumed lower quality water demand comprises 50% of total water use (based on Latitude 32 Alternative Industry Feedwater Study (GHD) | 1,050 | - Assumed that raw materials is sum of products + by-products/wastes<br>- Specific types of general industries have not yet been identified | 990 | - Assumed discharge = 90% potable water use + 75% of lower quality water use<br>- Assumed that 25% of process/cooling water use is lost (e.g. evaporation, product) | 1,000 | - Assumed 50 ktpa of produced product per noxious industry<br>- Specific types of general industries have not yet been identified | 50 | - Assumed that wastes from general industry accounts to 5% of total product output |
| **Subtotal** | | | **100** | | **300** | | **16** | | **1,300** | | **8** | | **600** | | **600** | | **1,050** | | **990** | | **1,000** | | **50** | |
| **Total Boodarie Industrial Estate** | | | **2,230** | | **9,400** | | **1,207** | | **428,230** | | **257** | | **23,013** | | **36,792** | | **120,313** | | **63,306** | | **93,711** | | **4,643** | |

Appendix B

# Potable Water for Domestic Use – Assumptions

**INDUSTRIAL OPERATIONS**

| Applications | Indicative water use (ltr/employee/day) | % of total water use | Assumptions | Comments / Data sources |
|---|---|---|---|---|
| Toilets | 25.0 | 32% | 5 * 3 ltr half flushes per employee per day<br>2 * 5 ltr full flushes per employee per day | |
| Hand basins | 20.0 | 26% | Basin water use = 10 L/min<br>Standard basin use per employee is 6 uses per day for 20 seconds. | |
| Showers | 20.0 | 26% | Shower water use = avg 10 L/min<br>Average time per shower = 10 min<br>20% of employees take one shower per day | |
| Commercial kitchen | 5.0 | 6% | Kitchen water consumption: 10.0 L/meal<br>50% of employees consume 1 kitchen meal per day | |
| Other various | 8.0 | 10% | Assume 10% of total domestic use of potable water | |
| Irrigation | 0.0 | 0% | Assumed that irrigation will not be supplied by potable water | |
| **Total** | 78.0 | 100% | | |

**NON-INDUSTRIAL OPERATIONS**

| Applications | Indicative water use (ltr/employee/day) | % of total water use | Assumptions | Comments / Data sources |
|---|---|---|---|---|
| Toilets | 25.0 | 39% | 5 * 3 ltr half flushes per employee per day<br>2 * 5 ltr full flushes per employee per day | |
| Hand basins | 20.0 | 31% | Basin water use = 10 L/min<br>Standard basin use per employee is 6 uses per day for 20 seconds. | |
| Showers | 10.0 | 16% | Shower water use = avg 10 L/min<br>Average time per shower = 10 min<br>10% of employees take one shower per day | |
| Commercial kitchen | 2.5 | 4% | Kitchen water consumption: 10.0 L/meal<br>25% of employees consume 1 kitchen meal per day | |
| Other various | 6.5 | 10% | Assume 10% of total domestic use of potable water | |
| Irrigation | 0.0 | 0% | Assumed that irrigation will not be supplied by potable water | |
| **Total** | 64.0 | 100% | | |

Appendix C

# Potential Economic, Environmental, and Social Benefits of Industrial Synergy Opportunities

| # | Opportunity | Potential economic benefits | | | | | Potential environment and community benefits | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lower operational / capital costs | Increased business revenue | Increased transportation efficiencies | Increased resource security | Increased resource efficiency | Reduced impact of disposal | Reduced impact of extraction | Employment creation | Reduced risk | Improved living / work conditions |
| **SUPPLY CHAIN SYNERGIES** | | | | | | | | | | | |
| 1 | Supply of stockpiled iron ore to ferrous processing plants | X | | X | X | | | | X | | |
| 2 | Supply of produced steel products (e.g. finished shapes) from BIE steel plant to local heavy construction companies | X | | X | X | | | | X | | |
| 3 | Supply of logistical and transportation services by transport companies and warehouses to BIE industries (e.g. road, rail, port) | X | | X | | X | | | X | | |
| 4 | Supply of beneficiated iron fines from pelletising and/or sinter plant to iron carbide plant | X | | X | X | | | | X | | |
| 5 | Supply of Fe-chips to ferrosilicon plant by steel plant | X | | X | X | | | | X | | |
| 6 | Supply of chlorine from chlor-alkali plant to resource processing plants | X | | X | X | | | | X | X | |
| 7 | Supply of caustic soda from chlor-alkali plant to resource processing plants | X | | X | X | | | | X | X | |
| 8 | Supply of magnesium by magnesium production plant to titanium production plant | X | | X | X | | | | X | | |
| 9 | Supply of sodium chloride from salt mine to chlor-alkali plant | X | | X | X | | | | X | | |
| 10 | Supply of ethane from ethane extraction to ethane cracker | X | | X | X | X | | | X | X | |
| 11 | Supply of ethylene from ethane cracker to EDC / VCM plant | X | | X | X | X | | | X | X | |
| 12 | Supply of ammonia from ammonia/urea plant to sodium cyanide plant and fertiliser production plant | X | | X | X | X | | | X | X | |
| 13 | BIE non-ferrous smelter (e.g. nickel, aluminium, copper, zinc, lead) supplying intermediate product (e.g. nickel-in-matte, alumina, blister copper, zinc, lead) to non-ferrious refinery in BIE | X | | X | X | | | | X | | |
| **UTILITY SYNERGIES** | | | | | | | | | | | |
| 1 | Energy factory supplying electricity, steam, and hot/cold air to surrounding BIE industries. | X | | | X | X | | X | X | | |
| 2 | Water factory supplying high and low quality industry feedwater to BIE industries | (X) | | | X | X | | X | X | | X |
| 3 | Direct use of WWTP treated effluent by selected BIE industries (potential for on-site treatment to suit requirements) | X | | | X | | | | | | |
| 4 | Reuse of effluent stream (segregated or not) from one BIE industry by other BIE industry | (X) | | | X | X | X | X | | | |
| 5 | Centralised production and supply of pressurised air to BIE industries | X | | | (X) | X | | | | | |
| 6 | Centralised production, supply, and recovery of utility gases to BIE industries (nitrogen, hydrogen, oxygen) | (X) | | X | (X) | X | | | X | | |
| 7 | Managed aquifer recharge of treated effluents, and indirect industrial reuse | | | | X | X | | | | | |
| 8 | Centralised storage and processing facility for large volume inorganic by-products produced in BIE | (X) | | X | | | X | | | X | |
| 9 | Centralised treatment facility for industry off-gases (e.g. SOx, NOx) | (X) | | | | | X | | X | X | X |
| 10 | Joint industry production of demineralised water for specialised applications (boiler feedwater) | X | | | X | | | | X | | |
| 11 | Centralised storage and processing facility for selected (smaller volume) waste streams (e.g.hazardous wastes, oils, pallets, metals) | X | | | | X | X | | X | X | |
| **BY-PRODUCT SYNERGIES** | | | | | | | | | | | |
| 1 | Use of industry waste heat for drying or concentrating wet products and by-products | (X) | | | | X | | | | | |
| 2 | Use of pelletising wastes from iron ore pelletising plant (e.g. cement plant) | X | | | X | X | X | | | | |
| 3 | Use of ammonium sulphate from nickel processing in fertiliser production | X | | | | X | X | | X | | |
| 4 | Processing and use of slag from ferrous mineral processing | X | X | | | X | X | | X | | |
| 5 | Processing and use of gypsum from resource processing | X | X | | | X | X | | X | | |
| 6 | Re-processing of scrap steel from BIE industries by BIE steel plant | (X) | X | | | X | X | X | | | |
| 7 | Co-processing of organic by-products from BIE industries at large scale organic processing plant (e.g. ethanol, biofuels) | (X) | | | (X) | X | X | | X | | |
| 8 | Co-processing of inorganic by-products from BIE industries and other alternative materials | (X) | | | (X) | X | X | | X | | |
| 9 | Use of alternative fuels at selected BIE industries (e.g. waste oils, tyres, shredded wood, coke dust from steel making) | X | | | X | X | | X | | | |
| 10 | Use of alternative lime sources in ferrous and non-ferrous mineral processing | X | | | X | X | X | X | | | |
| 11 | Conversion of process carbon dioxide in commercial gases by utility gas company | X | | | | X | X | X | X | | |
| 12 | Conversion of process by-product hydrogen into commercial gases by utility gas company | X | | | | X | X | X | X | | |
| 13 | Conversion of process by-product nitrogen into commercial gases by utility gas company | X | | | | X | X | X | X | | |
| 14 | Use of charcoal (from plantations) as alternative to (petroleum) coke as reductant in steel sintering and mineral processing | (X) | | | | X | | X | | | |
| **SERVICE SYNERGIES** | | | | | | | | | | | |
| 1 | Joint industry training and education facilities (regional industry training centre), including shared staffing (e.g. maintenance) | X | | | | X | | | X | X | X |
| 2 | Joint logistic and transportation facilities | X | | | | X | | | | | |
| 3 | Joint industry agreement for collection and handling of selected industry wastes | X | | X | | X | X | | X | X | X |
| 4 | BIE interpretive centre | | | | | | | | X | | X |
| 5 | Joint industry monitoring and control of odour and air quality footprint | | | | | | X | | | X | X |
| 6 | Joint industry incident and accident prevention and response | | | | | | | | | X | X |

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**Document Status**

| Rev No. | Author | Reviewer | | Approved for Issue | | |
|---|---|---|---|---|---|---|
| | | Name | Signature | Name | Signature | Date |
| Draft 1 | D. van Beers | J.A.L. Kotula | | J.A.L. Kotula | | 1st December 2010 |
| Draft 2 | D. van Beers | J.A.L. Kotula | | J.A.L. Kotula | | 1st December 2010 |
| Final | D. van Beers | J.A.L. Kotula | | J.A.L. Kotula | | 29th August 2011 |
| | | | | | | |