APPENDIX 29

ARROW LNG PLANT

Waste Impact Assessment

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SPECIALISTS IN ENVIRONMENTAL, SOCIAL AND SAFETY PERFORMANCE

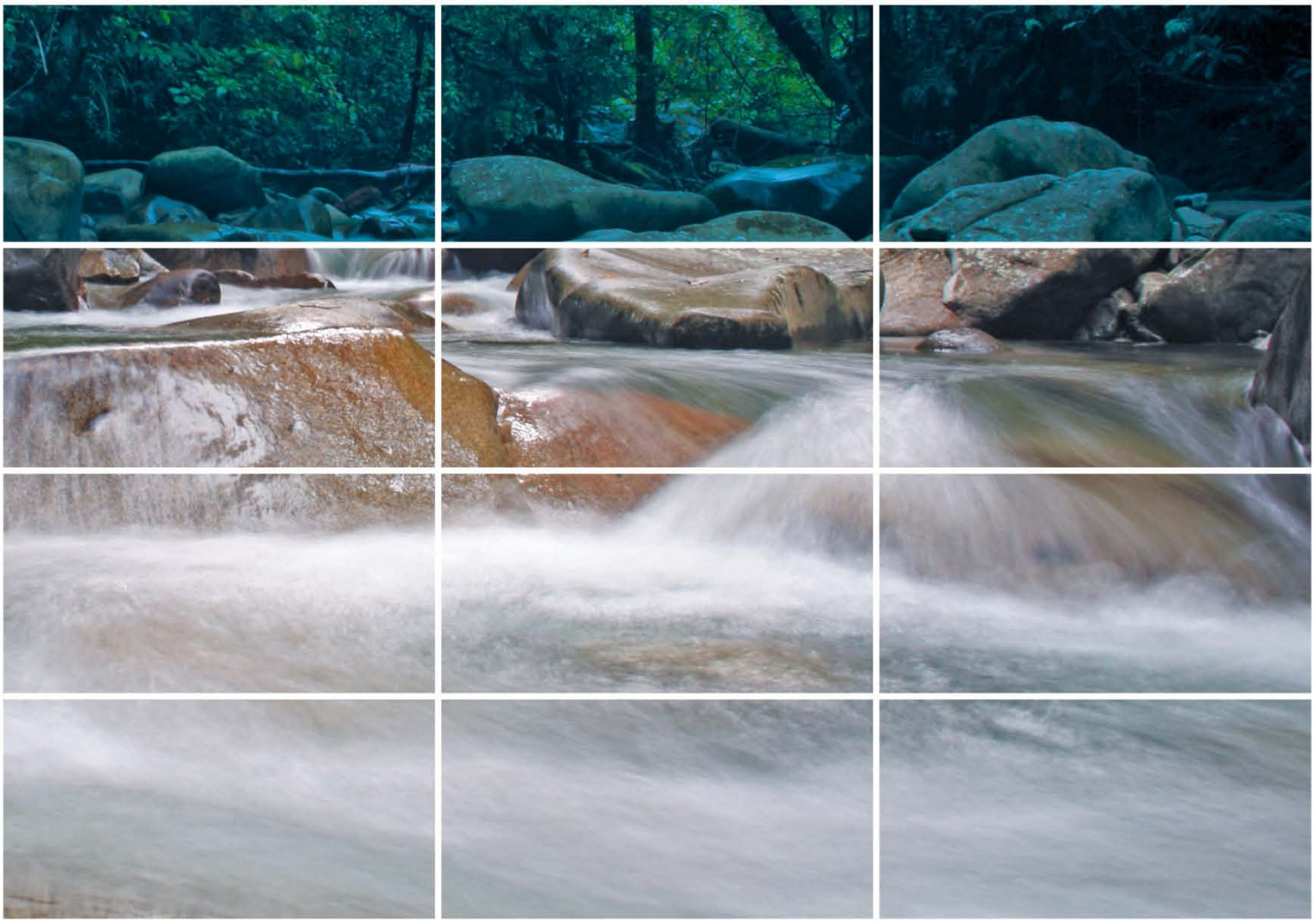
WASTE IMPACT ASSESSMENT

Arrow CSG (Australia) Pty Ltd and Coffey Environments Australia Pty Ltd

Gladstone, Queensland

ENAUBRIS107033CA (Rev 6)

12 AUGUST 2011



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WASTE IMPACT ASSESSMENT

Prepared for:

Arrow CSG (Australia) Pty Ltd and Coffey Environments Australia Pty Ltd

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CONTENTS

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY **VII**

1. INTRODUCTION **1-1**

2. PROJECT DESCRIPTION **2-1**

2.1 Proponent 2-1

2.2 Arrow LNG Plant 2-1

2.2.1 LNG Plant 2-1

LNG Plant Power 2-2

Liquefaction Process 2-3

Workforce Accommodation 2-3

Marine Infrastructure 2-4

2.2.2 Feed Gas Pipeline 2-5

2.2.3 Dredging 2-6

2.3 Waste Sources 2-7

2.3.1 Construction 2-7

Feed Gas Pipeline 2-7

LNG Plant and Associated Facilities 2-8

2.3.2 Operation 2-8

Feed Gas Pipeline 2-8

LNG Plant 2-9

Marine Operations 2-9

2.3.3 Decommissioning Waste 2-10

2.3.4. Abnormal Operating Conditions or Unplanned Events 2-11

Plant Shutdown, Start-Up and Upset Conditions 2-11

Fire 2-11

Storm Events 2-11

3. LEGISLATIVE CONTEXT **3-1**

3.1 Commonwealth Framework 3-1

3.1.1 National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 2004 3-1

3.1.2 Quarantine Act 1908 3-1

3.2 Queensland Framework 3-1

3.2.1 Environmental Protection Act 1994 3-1

3.2.2 Environmental Protection Regulation 2008 3-2

3.2.3 Environmental Protection (Waste Management) Policy 2000 3-2

3.2.4 Environmental Protection (Waste Management) Regulation 2000 3-3

3.2.5 Queensland Waste Management Strategy 3-3

4. STUDY METHOD **4-1**

4.1 Overview 4-1

4.2 Existing Waste Management Infrastructure 4-1
4.3 Waste Streams and Quantities 4-1
4.4 Waste Management Strategies 4-2
4.5 Impact Assessment 4-2
4.5.1 Residual Risk Assessment 4-3
4.5.2 Cumulative Impact Assessment 4-5

5. EXISTING ENVIRONMENT 5-1
5.1 Natural Environment 5-1
5.2 Waste Management Infrastructure 5-1
5.2.1 Landfills 5-1
5.2.2 Recycling Facilities 5-2
5.2.3 Wastewater Treatment Facilities 5-3
5.2.4 Licensed Waste Management Contractors 5-4

6. WASTE QUANTITIES 6-1
6.1 Construction and Operational Wastes 6-1
6.2 Sewage 6-3
6.3 Accommodation Waste 6-4
6.4 Reverse Osmosis Brine 6-5
6.5 Effluent Treatment Plant Wastewater 6-5

7. ISSUES AND POTENTIAL IMPACTS 7-1
7.1 Discharges to Land and Water 7-1
7.2 Discharges to Air 7-1
7.3 Poor Management Practices 7-2

8. AVOIDANCE, MITIGATION AND MANAGEMENT MEASURES 8-1
8.1 General Principles 8-1
8.2 Waste Avoidance 8-6
8.3 Waste Recycling 8-7
8.4 Storage and Handling 8-8
8.5 Waste Treatment 8-9
8.6 Waste Transportation 8-9
8.7 Waste Disposal 8-10
8.7.1 Waste Disposal on Curtis Island 8-10
8.7.1.1 Liquid Waste to Land 8-10
Liquid Waste to the Marine Environment 8-11
8.7.1.3 Solid Waste to Land 8-11
8.7.2 Waste Disposal Off-Site 8-12
8.7.2.1 Liquid Waste 8-12
Solid Waste 8-12
8.8 Specific Waste Management 8-12
8.8.1 Stormwater 8-12
8.8.2 Sewage 8-13
8.8.3 Brine 8-13
8.8.4 Marine Wastes 8-13
8.8.5 Dredging Spoil 8-13
8.8.6 Tunnel Spoil 8-13
8.8.7 Acid Sulfate Soils 8-13

8.8.8 Hydrotest Water 8-14
8.8.9 Regulated Wastes 8-14
8.8.10 Wastes from Abnormal Operating Conditions or Unplanned Events 8-14
Plant Start-Up and Shutdown 8-14
Spills 8-15
Fire 8-15
Storm Events 8-16
8.9 Health, Safety and Environmental Management System 8-16
8.9.1 Incidents and Emergency Response 8-17
8.9.2 Training 8-17
8.9.3 Auditing and Monitoring 8-17
Auditing 8-17
Monitoring 8-18
8.9.4 Reporting 8-18
Regulated Waste Tracking 8-18
National Greenhouse and Energy Reporting System 8-19
National Pollutant Inventory 8-19
Compliance Reporting 8-19

9. RESIDUAL IMPACTS 9-1

10. MONITORING 10-1

11. CUMULATIVE IMPACT ASSESSMENT 11-1
11.1 Impacts on the Receiving Environment 11-1
11.2 Utilisation of Regional Infrastructure 11-2
11.2.1 Solid Waste to Landfill 11-6
11.2.2 Recycled Waste 11-6
11.2.3 Waste to Licensed Waste Contractors 11-7
11.2.4 Waste to Liquid Waste Treatment Plants 11-7

12. CONCLUSIONS 12-1

13. REFERENCES 13-1

14. GLOSSARY AND ABBREVIATIONS 14-1

Tables

Table 4.1: Descriptors to classify likelihood and consequence 4-4
Table 4.2 Risk evaluation matrix 4-4
Table 5.1: Recyclables and market potential 5-2
Table 5.2 Wastewater treatment plant capacities 5-3
Table 6.1: LNG Plant and associated infrastructure construction and operation solid wastes and quantities 6-1
Table 6.2: LNG plant and associated infrastructure construction and operation liquid wastes and quantities 6-3
Table 6.3: Estimated sewage generation rates 6-4
Table 6.4: Accommodation waste type and estimated quantities 6-4
Table 6.5: Indicative brine characteristics 6-5

Table 6.6: Recommended water quality specifications for class A recycled water 6-7
Table 8.1: Summary of wastes and management 8-2
Table 9.1: Results of residual impact assessment 9-2
Table 11.1: Baseline projects 11-2
Table 11.2: Baseline impacts from construction and operation over life of projects 11-3
Table 11.3: Projects (not yet constructed) considered for cumulative impact assessment 11-3
Table 11.4: Approximate minimum waste disposal quantities from proposed projects over life of projects 11-4
Table 11.5: Cumulative waste management quantities 11-6

Figures

Figure 2.1: Regional context
Figure 2.2: Site locality
Figure 2.3: Arrow LNG Plant and associated infrastructure
Figure 2.4: Arrow LNG Plant process flow diagram
Figure 6.1: Effluent treatment plant and site drainage system
Figure 6.2: Effluent treatment plant process flow diagram

Attachments

Attachment A: Terms of Reference Cross Reference Table for the Waste Technical Study

EXECUTIVE SUMMARY

Arrow CSG (Australia) Pty Ltd (Arrow Energy) proposes to develop a liquefied natural gas (LNG) facility on Curtis Island off the central Queensland coast, near Gladstone. The project known as the Arrow LNG Plant, is a component of the larger Arrow LNG Project. Coffey Environments Australia Pty Ltd (Coffey Environments) has been commissioned by Arrow Energy to undertake a waste impact assessment as part of the development of an Environmental Impact Statement (EIS) for the proposed Arrow LNG Plant. The LNG plant will have a base-case capacity of 16 Mtpa, with a total plant capacity of up to 18 Mtpa. The plant will consist of four LNG trains, each with a nominal capacity of 4 Mtpa.

Operations infrastructure associated with the LNG plant includes the LNG trains (where liquefaction occurs, LNG storage tanks, cryogenic pipelines, seawater inlet for desalination and stormwater outlet pipelines, water and wastewater treatment, a 110 m high flare stack, power generators, administrative buildings and workshops.

Construction infrastructure associated with the LNG plant includes construction camps, concrete batching plant and laydown areas. The plant will also require marine infrastructure for the transport of materials, personnel and product (LNG) during construction and operations.

Solid, liquid and gaseous waste will be generated throughout the construction, operation and decommissioning phases of the project. The main gaseous wastes to be produced from the project during operation are primarily associated with the combustion of carbon based fuels. Consequently, the gaseous wastes produced include oxides of nitrogen (NO_X), carbon monoxide (CO), carbon dioxide (CO_2), particulate matter of 10 micrometres (PM_{10}) or 2.5 micrometres ($PM_{2.5}$) or less and various hydrocarbon species (Katestone, 2011a and PAEHolmes, 2011). A complete description and estimated quantities of gaseous wastes produced at the project can be found in Katestone (2011a) and PAEHolmes (2011).

The potential impacts of waste generated from the project include:

- Loss of containment of fuels and chemicals during abnormal operating conditions or emergency situations.
- Solid or liquid effluent discharge from vehicles during transportation of wastes on and off site.
- Leachate generation from solid waste storage facilities such as greenwaste or recycling materials lay down areas.
- Discharge of untreated liquid wastes such as brine to the marine environment during normal operations.
- Discharge of untreated liquid wastes such as used fire-water or contaminated run-off from abnormal operating conditions or emergency situations such as effluent treatment plant (ETP) malfunction or a fire.
- Discharge of treated liquid wastes from the ETP to the land environment via irrigation.
- Waste being generated that could be avoided or waste not being segregated for re-use or recycling. Higher quantities of waste than predicted may result in larger quantities being

disposed of at regional waste management facilities. These facilities may not have the resources to cope with the unforseen increased rate of disposal.

- Litter may be released from storage areas where lids have not been replaced or fencing is inadequate.
- Odours may be generated if putrescibles wastes such as that from kitchens or accommodation facilities are not collected at a regular frequency.
- Vermin and diseases may establish, reproduce and disperse if waste is not stored, handled or transported in accordance with designated procedures on site. Vermin such as the house mouse (*Mus musculus*) are attracted to waste storage areas as they provide an easy food source. Diseases may be propagated by an increased presence of vermin such as the house mouse. Quarantine waste (solid and liquid) may contain potentially dangerous pests and diseases that may have a serious impact on natural systems, nature conservation values and the economic industry of Australia if not appropriately managed (treatment or disposal).
- Poor housekeeping of waste can result in spills (liquid or solid) which may alter the characteristics of the soil (by adding nutrients) and encourages the growth of opportunistic weed species. Weeds have potential to and have a serious impact on natural systems and nature conservation values.
- Inappropriate location of combustible waste (such as paper and cardboard, waste hydrocarbons and tyres) near ignition sources may result in a fire. Ignition of a fire and its subsequent spread may present a significant threat to the environmental values of the project area. Fire fighting water that is used to suppress fires may be contaminated with residues and may impact on the land and water if not managed appropriately.
- Emissions to air from normal operations at the LNG Plant and through vehicles and shipping movements, largely from the combustion of fuel.

The proposed management methods for waste produced from the project include:

- Collecting and transporting solid wastes that cannot be re-used off Curtis Island for disposal at a recycling facility or licensed waste management facility. Arrow Energy does not propose to construct a landfill or other final disposal facility on Curtis Island nor will any local landfills on the island be utilised for waste disposal.
- Discharging liquid wastes such as uncontaminated stormwater, brine from the RO plant and hydrotest water to the marine environment via an outflow pipe located at Boatshed Point. Discharges from the LNG facility to the marine environment will be monitored to ensure that they meet discharge criteria. Additionally, a marine monitoring program will be implemented to monitor the quality of the marine waters within Port Curtis, particularly in and around the brine and ETP discharge location.
- Managing all potentially contaminated or contaminated run-off by a controlled discharge facility.
- Collecting and treating sewage (from the LNG plant and accommodation camp) on Curtis Island through an effluent treatment facility. Treated wastewater will be re-used on site or irrigated to land in accordance with the Queensland Water Recycling Guidelines (EPA, 2005). The treatment plant will be designed to treat the wastewater to Class A quality.
- Collecting, transporting and disposing liquid wastes such as solvents and oils, off-specification chemicals at a licensed waste facility by a licensed waste contractor.

- Collecting sewage and greywater from the pioneer camp on Curtis Island in portable disposal units or other mobile collection facilities and using licensed waste contractors to service the sewage facilities and dispose of effluent at a licensed waste management facility.
- Collecting sewage from the TWAF by local sewerage network or in portable disposal units or other mobile collection facilities.
- Treating gaseous air emissions during abnormal operating conditions (start-up, shutdown, upset and emergency conditions) by a flaring system. Collection headers will collect various gaseous and liquid hydrocarbons streams and direct these to a common knock out drum and flare stack.
- Collecting boil-off gas and return vapours from LNG carriers using an appropriate vapour recovery system (e.g., compressor system) and not releasing vapours directly to the atmosphere.

An assessment of residual impacts of the proposed waste management system on the environment was undertaken by examining the likelihood of an impact occurring and the potential consequences (i.e., a measure of severity) should the impact occur. The residual risk to the environmental values of the Arrow LNG Plant area for the majority of the proposed waste management strategies were categorised as ‘low’ when control measures are considered.

A moderate residual risk was highlighted for the potential contamination of Port Curtis as a result of discharge of RO brine. The moderate risk ranking was achieved as a result of the discharge being of a continuous nature rather than due to the consequences of the impact being significant. Implementation of a marine monitoring program will ensure the potential impact of the discharge on Port Curtis will be quantified and that additional management measures can be implemented if the need is indicated.

The impact on soils from irrigation of treated effluent was categorised as a moderate risk also largely as a result of the discharge being of a continuous nature, rather than the impact having significant consequences. Impacts to the soil from repeated irrigation of treated effluent will occur gradually and regular monitoring of the treated effluent and the soils in the irrigated areas will ensure that any impacts to the soil will be detected before any long term damage occurs.

The environmental impacts resulting from unexpected events, such as LNG spills and contaminated firewater run-off, was assessed as a low risk, due to the improbability of an event, the facility design and spill and emergency response plans proposed to mitigate any impacts.

The overall residual risk to the environmental values of the project area as a result of the waste management activities for the proposed Arrow LNG Plant is considered to be minimal in view of the comprehensive control measures proposed to prevent adverse environmental outcomes.

Assessment of the cumulative impacts relating to wastes focussed on potential impacts on waste management infrastructure, resources and services.

A minimum of 1,364,084 tonnes of solid waste will be generated in the Gladstone region by existing and proposed domestic and commercial generators over a period of 30 years that will require disposal at local landfills in or near to Gladstone. Of this figure, approximately 1.64% is predicted to be generated by the Arrow LNG Plant.

The increase in the volume of solid waste is unlikely to impact significantly on the lifespan of the Benaraby Regional Landfill as the current licensed capacity is 1,500,000 tonnes over a 30 year period.

A minimum of approximately 41,646 tonnes of recyclable waste will be generated over a period of 30 years from new projects (including GLNG and Queensland Curtis LNG projects) and will require management by specialist recyclers in Queensland. Of this figure, approximately 11.9% is predicted to be generated by the Arrow LNG Plant.

A minimum of approximately 563,203 tonnes of waste requiring disposal by licensed waste management contractors will be generated over a period of 30 years from new projects (including GLNG and Queensland Curtis LNG projects). Of this figure, approximately 1.3% is predicted to be generated by the Arrow LNG Plant.

It is anticipated that other large national waste management companies operating in Gladstone would also be able to adequately plan for the increase demands for services provided by their companies, largely as a result of long lead up times to new projects commencing and the availability of waste management data in publicly available documents (i.e., EISs).

It is estimated that in the Gladstone region a minimum of approximately 6,120 megalitres per annum (ML/a) liquid (sewage) waste will require treatment and disposal over an initial period of 5 years, during the construction of the Arrow LNG Plant, and 5,983 ML/a thereafter for an additional 25 years. Of the waste requiring treatment and disposal in the first 5 years, approximately 2.2% is predicted to be generated by the Arrow LNG Plant.

The current capacity of the Calliope River and South Trees Sewage Treatment Plants is 6,789 ML/a, indicating that between the two treatment plants, there is sufficient capacity to cope with increased supply of sewage from proposed new projects in the Gladstone region. These figures do not include increased supply of sewage and wastewater from expansion of housing in Gladstone. Planned upgrades for both the treatment plants to cater for 97,000 people (approximately 10,622 ML/a) would provide sufficient capacity to accommodate an increase in demand for services from population growth and increase in new projects in the area.

1. INTRODUCTION

Arrow CSG (Australia) Pty Ltd (Arrow Energy) proposes to develop a liquefied natural gas (LNG) facility on Curtis Island off the central Queensland coast, near Gladstone.

The Arrow LNG Plant will have a maximum design capacity of nominally 18 million tonnes per annum (Mtpa), involving phased modular construction of up to four trains, each with a nominal 4 Mtpa capacity The LNG plant will utilise gas resources supplied from coal seam gas (CSG) developments in the Surat and Bowen basins in Central Queensland. The Arrow LNG Plant will process, cool and store the CSG in LNG storage tanks for subsequent loading onto LNG carriers via a jetty and export to international markets.

The Coordinator-General of the state of Queensland (Coordinator-General) declared the Arrow LNG Plant (then referred to as the Shell Australia LNG Project) to be a significant project for which an EIS is required in accordance with Part 4 of the *State Development and Public Works Organisation Act 1971*.

Coffey Environments Australia Pty Ltd (Coffey Environments) has been commissioned by Arrow Energy to undertake a waste impact assessment as part of the development of an Environmental Impact Statement (EIS) for the proposed Arrow LNG Plant.

There are two main objectives for the waste impact assessment. The first objective is to identify, characterise and quantify where possible the waste associated with construction, operation and decommissioning phases of the project. The second objective is to assess the proposed waste management strategies and identify any residual risks to the environment.

In fulfilling the objectives of the study, consideration has also been given to the following:

- The management of wastes in accordance with local, state and federal government regulations.
- Minimising pollution and potential damage to the environment as a result of waste management practices on site.
- Cumulative impacts of waste management from existing and proposed operations on Curtis Island and the Gladstone area.
- Residual impacts of proposed waste management strategies to the environment.
- The requirements of the Terms of Reference for the Arrow LNG Plant EIS, as issued by the Coordinator-General, January 2010.

2. PROJECT DESCRIPTION

2.1 Proponent

Arrow CSG (Australia) Pty Ltd (Arrow Energy) proposes to develop a liquefied natural gas (LNG) facility on Curtis Island off the central Queensland coast, near Gladstone. The project, known as the Arrow LNG Plant, is a component of the larger Arrow LNG Project.

The proponent is a subsidiary of Arrow Energy Holdings Pty Ltd which is wholly owned by a joint venture between Royal Dutch Shell plc and PetroChina Company Limited.

2.2 Arrow LNG Plant

Arrow Energy proposes to construct the Arrow LNG Plant in the Curtis Island Industry Precinct at the southwestern end of Curtis Island, approximately 6 km north of Gladstone and 85 km southeast of Rockhampton, off Queensland's central coast (see Figure 2.1). In 2008, approximately 10% of the southern part of the island was added to the Gladstone State Development Area to be administered by the Queensland Department of Local Government and Planning. Of that area, approximately 1,500 ha (25%) has been designated as the Curtis Island Industry Precinct and is set aside for LNG development. The balance of the Gladstone State Development Area on Curtis Island has been allocated to the Curtis Island Environmental Management Precinct, a flora and fauna conservation area.

The Arrow LNG Plant will be supplied with coal seam gas from gas fields in the Surat and Bowen basins via high-pressure gas pipelines to Gladstone, from which a feed gas pipeline will provide gas to the LNG plant on Curtis Island. A tunnel is proposed for the feed gas pipeline crossing of Port Curtis. The location of the LNG plant and associated infrastructure is shown in Figure 2.2.

The project is described below in terms of key infrastructure components: LNG plant, feed gas pipeline and dredging.

2.2.1 LNG Plant

Overview. The LNG plant will have a base-case capacity of 16 Mtpa, with a total plant capacity of up to 18 Mtpa. The plant will consist of four LNG trains, each with a nominal capacity of 4 Mtpa. The project will be undertaken in two phases of two trains (nominally 8 Mtpa), with a financial investment decision taken for each phase.

Operations infrastructure associated with the LNG plant includes the LNG trains (where liquefaction occurs; see 'Liquefaction Process' below), LNG storage tanks, cryogenic pipelines, seawater inlet for desalination and stormwater outlet pipelines, water and wastewater treatment, a 110 m high flare stack, power generators (see 'LNG Plant Power' below), administrative buildings and workshops.

Construction infrastructure associated with the LNG plant includes construction camps (see 'Workforce Accommodation' below), a concrete batching plant and lay down areas.

The plant will also require marine infrastructure for the transport of materials, personnel and product (LNG) during construction and operations (see 'Marine Infrastructure' below).

The proposed site layout of the LNG plant and associated infrastructure is shown in Figure 2.3.

Construction Schedule. The plant will be constructed in two phases. Phase 1 will involve the construction of LNG trains 1 and 2, two LNG storage tanks (each with a capacity of between 120,000 m^3 and 180,000 m^3), Curtis Island construction camp and, if additional capacity is required, a mainland workforce accommodation camp. Associated marine infrastructure will also be required as part of Phase 1. Phase 2 will involve the construction of LNG trains 3 and 4 and potentially a third LNG storage tank. Construction of Phase 1 is scheduled to commence in 2014 with train 1 producing the first LNG cargo in 2017. Construction of Phase 2 is anticipated to commence approximately five years after the completion of Phase 1 but will be guided by market conditions and a financial investment decision at that time.

Construction Method. The LNG plant will generally be constructed using a modular construction method, with preassembled modules being transported to Curtis Island from an offshore fabrication facility. There will also be a substantial stick-built component of construction for associated infrastructure such as LNG storage tanks, buildings, underground cabling, piping and foundations. Where possible, aggregate for civil works will be sourced from suitable material excavated and crushed on site as part of the bulk earthworks. Aggregate will also be sourced from mainland quarries and transported from the mainland launch site to the plant site by roll-on, roll-off vessels. A concrete batching plant will be established on the plant site. Bulk cement requirements will be sourced outside of the batching plant and will be delivered to the site by roll-on roll-off ferries or barges from the mainland launch site.

LNG Plant Power

Power for the LNG plant and associated site utilities may be supplied from the electricity grid (mains power), gas turbine generators, or a combination of both, leading to four configuration options that will be assessed:

- Base case (mechanical drive): The mechanical drive configuration uses gas turbines to drive the LNG train refrigerant compressors, which is the traditional powering option for LNG facilities. This configuration would use coal seam gas and end flash gas (produced in the liquefaction process) to fuel the gas turbines that drive the LNG refrigerant compressors and the gas turbine generators that supply electricity to power the site utilities. Construction power for this option would be provided by diesel generators.
- Option 1 (mechanical/electrical – construction and site utilities only): This configuration uses gas turbines to drive the refrigerant compressors in the LNG trains. During construction, mains power would provide power to the site via a cable (30 MW capacity) from the mainland. The proposed capacity of the cable is equivalent to the output of one gas turbine generator. The mains power cable would be retained to power the site utilities during operations, resulting in one less gas turbine generator being required than the proposed base case.
- Option 2 (mechanical/electrical): This configuration uses gas turbines to drive the refrigerant compressors in the LNG trains and mains power to power site utilities. Under this option, construction power would be supplied by mains power or diesel generators.
- Option 3 (all electrical): Under this configuration mains power would be used to supply electricity for operation of the LNG train refrigerant compressors and the site utilities. A

switchyard would be required. High speed electric motors would be used to drive the LNG train refrigerant compressors. Construction power would be supplied by mains power or diesel generators.

Liquefaction Process

The coal seam gas enters the LNG plant where it is metered and split into two pipe headers which feed the two LNG trains. With the expansion to four trains the gas will be split into four LNG trains.

For each LNG train, the coal seam gas is first treated in the acid gas removal unit where the carbon dioxide and any other acid gases are removed. The gas is then routed to the dehydration unit where any water is removed and then passed through a mercury guard bed to remove mercury. The coal seam gas is then ready for further cooling and liquefaction.

A propane, pre-cooled, mixed refrigerant process will be used by each LNG train to liquefy the predominantly methane coal seam gas. The liquefaction process begins with the propane cycle. The propane cycle involves three pressure stages of chilling to pre-cool the coal seam gas to - 33°C and to compress and condense the mixed refrigerant, which is a mixture of nitrogen, methane, ethylene and propane. The condensed mixed refrigerant and precooled coal seam gas are then separately routed to the main cryogenic heat exchanger, where the coal seam gas is further cooled and liquefied by the mixed refrigerant. Expansion of the mixed refrigerant gases within the heat exchanger removes heat from the coal seam gas. This process cools the coal seam gas from - 33°C to approximately - 157°C. At this temperature the coal seam gas is liquefied (LNG) and becomes 1/600th of its original volume. The expanded mixed refrigerant is continually cycled to the propane pre-cooler and reused.

LNG is then routed from the end flash gas system to a nitrogen stripper column which is used to separate nitrogen from the methane, reducing the nitrogen content of the LNG to less than 1 mole per cent (mol%). LNG separated in the nitrogen stripper column is pumped for storage on site in full containment storage tanks where it is maintained at a temperature of minus 163°C.

A small amount of off-gas is generated from the LNG during the process. This regasified coal seam gas is routed to an end flash gas compressor where it is prepared for use as fuel gas.

Finally, the LNG is transferred from the storage tanks onto LNG carriers via cryogenic pipelines and loading arms for transportation to export markets. The LNG will be regasified back into sales specification gas on shore at its destination location.

A flow diagram of the liquefaction process is provided in Figure 2.4.

Workforce Accommodation

The LNG plant (Phase 1), tunnel, feed gas pipeline, and dredging components of the project each have their own workforces with peaks occurring at different stages during construction. The following peak workforces are estimated for the project:

- LNG plant Phase 1 peak workforce of 3,500, comprising 3,000 construction workers: 350 engineering, procurement and construction (EPC) management workers and 150 Arrow Energy employees.
- Tunnel peak workforce of up to 100.

- Feed gas pipeline (from the mainland to Curtis Island) peak workforce of up to 75.
- A dredging peak workforce of between 20 and 40.

Two workforce construction camp locations are proposed: the main construction camp at Boatshed Point on Curtis Island, and a possible mainland overflow construction camp, referred to as a temporary workers accommodation facility (TWAF). Two potential locations are currently being considered for the mainland TWAF; in the vicinity of Gladstone city on the former Gladstone Power Station ash pond No.7 (TWAF7) or in the vicinity of Targinnie on a primarily cleared pastoral grazing lot (TWAF8). Both potential TWAF sites include sufficient space to accommodate camp infrastructure and construction laydown areas. The TWAF and its associated construction laydown areas will be decommissioned on completion of the Phase 1 works.

Of the 3,000 construction workers for the LNG plant, it is estimated that between 5% and 20% will be from the local community (and thus will not require accommodation) and that the remaining fly-in, fly-out workers will be accommodated in construction camps. The 350 EPC management and 150 Arrow Energy employees are expected to relocate to Gladstone with the majority housed in company facilitated accommodation.

The tunnel workforce of 100 people and gas pipeline workforce of 75 people are anticipated to be accommodated in the mainland in company facilitated accommodation. The dredging workforce of 20 to 40 workers will be housed onboard the dredge vessel.

Up to 2,500 people will be housed at the Boatshed Point construction camp. Its establishment will be preceded by a pioneer camp at the same locality which will evolve into the completed construction camp.

Marine Infrastructure

Marine facilities include the LNG jetty, materials offloading facility (MOF), personnel jetty and mainland launch site.

LNG Jetty. LNG will be transferred from the storage tanks on the site to the LNG jetty via above ground cryogenic loading pipelines. Loading arms on the LNG jetty will deliver the product to an LNG carrier. The LNG jetty will be located in North China Bay, adjacent to the northwest corner of Hamilton Point.

MOF. Delivery of materials to the site on Curtis Island during the construction and operations phases will be facilitated by a MOF where roll-on / roll-off or lift-on / lift-off vessels will dock to unload preassembled modules, equipment, supplies and construction aggregate. The MOF will be connected to the LNG plant site via a heavy-haul road.

Boatshed Point (MOF 1) is the base-case MOF option and would be located at the southern tip of Boatshed Point. The haul road would be routed along the western coastline of Boatshed Point (abutting the construction camp to the east) and enters the LNG Plant site at the southern boundary. A quarantine area will be located south of the LNG plant and will be accessed via the northern end of the haul road.

Two alternative options are being assessed, should the Boatshed Point option be determined to be not technically feasible:

- South Hamilton Point (MOF 2): This MOF option would be located at the southern tip of Hamilton Point. The haul road from this site would traverse the saddle between the hills of Hamilton Point to the southwest boundary of the LNG plant site. The quarantine area for this option will be located southwest of the LNG plant near the LNG storage tanks.
- North Hamilton Point (MOF 3): This option involves shared use of the MOF being constructed for the Santos Gladstone LNG Project (GLNG Project) on the northwest side of Hamilton Point (south of Arrow Energy's proposed LNG jetty). The GLNG Project is also constructing a passenger terminal at this site, but it will not be available to Arrow Energy contractors and staff. The quarantine area for this option would be located to the north of the MOF. The impacts of construction and operation of this MOF option and its associated haul road were assessed as part of the GLNG Project and will not be assessed in this EIS.

Personnel Jetty. During the peak of construction, base case of up to 1,500 people may require transport to Curtis Island from the mainland on a daily basis. A personnel jetty will be constructed at the southern tip of Boatshed Point to enable the transfer of workers from the mainland launch site to Curtis Island by high-speed vehicle catamarans (Fastcats) and vehicle or passenger ferries (ROPAX). This facility will be adjacent to the MOF constructed at Boatshed Point. The haul road will be used to transport workers to and from the personnel jetty to the construction camp and LNG plant site. A secondary access for pedestrians will be provided between the personnel jetty and the construction camp.

Mainland Launch Site. Materials and workers will be transported to Curtis Island via the mainland launch site. The mainland launch site will contain both a passenger terminal and a roll-on, roll-off facility. The passenger terminal will include a jetty and transit infrastructure, such as amenities, waiting areas and car parking. The barge or roll-on, roll-off facility will have a jetty, associated laydown areas, workshops and storage sheds.

The two location options for the mainland launch site are:

- Launch site 1: This site is located north of Gladstone city near the mouth of the Calliope River, adjacent to the existing RG Tanna coal export terminal.
- Launch site 4N: This site is located at the northern end of the proposed reclamation area for the Fishermans Landing Northern Expansion Project, which is part of the Port of Gladstone Western Basin Master Plan. The availability of this site will depend on how far progressed the Western Basin Dredging and Disposal Project is at the time of construction.

2.2.2 Feed Gas Pipeline

An approximately 8 km long feed gas pipeline will supply gas to the LNG plant from its connection to the Arrow Surat Pipeline (formerly the Surat Gladstone Pipeline) on the mainland adjacent to Rio Tinto's Yarwun alumina refinery. The feed gas pipeline will be constructed in three sections:

- A short length of feed gas pipeline will run from the proposed Arrow Surat Pipeline to the tunnel launch shaft, which will be located on a mudflat south of Fishermans Landing, just south of Boat Creek. This section of pipeline will be constructed using conventional open-cut trenching methods within a 40 m wide construction right of way.
- The next section of the feed gas pipeline will traverse Port Curtis harbour in a tunnel to be bored under the harbour from the mainland tunnel launch shaft to a receival shaft on Hamilton Point. The tunnel under Port Curtis will have an excavated diameter of up to approximately 6 m

and will be constructed by a tunnel boring machine that will begin work at the mainland launch shaft. Tunnel spoil material will be processed through a de-sanding plant to remove the bentonite and water and will comprise mainly a finely graded fill material, which will be deposited in a spoil placement area established within bund walls constructed adjacent to the launch shaft. Based on the excavated diameter, approximately 223,000 m3 of spoil will be treated as required for acid sulfate soil and disposed of at this location.

- From the tunnel receival shaft on Hamilton Point, the remaining section of the feed gas pipeline will run underground to the LNG plant, parallel to the above ground cryogenic pipelines. This section will be constructed using conventional open-cut trenching methods within a 30 m wide construction right of way. A permanent easement up to 30 m wide will be negotiated with the relevant land manager or owner.

Should one of the electrical plant power options be chosen, it is intended that a power connection will be provided by a third party to the tunnel launch shaft, whereby Arrow Energy would construct a power cable within the tunnel to the LNG plant.

Other infrastructure, such as communication cables, water and wastewater pipelines, may also be accommodated within the tunnel.

2.2.3 Dredging

Dredging required for LNG shipping access and swing basins has been assessed under the Gladstone Ports Corporation's Port of Gladstone Western Basin Dredging and Disposal Project. Additional dredging within the marine environment of Port Curtis may be required to accommodate the construction and operation of the marine facilities. Up to five sites may require dredging including:

- Dredge site 1 (dredge footprint for launch site 1): The dredging of this site would facilitate the construction and operation of launch site 1. This dredge site is located in the Calliope River and extends from the intertidal area abutting launch site 1, past Mud Island to the main shipping channel. The worst-case dredge volume estimated at this site is approximately 900,000 m^3.
- Dredge site 2 (dredge footprint for launch site 4N): The dredging of this site would facilitate the construction and operation of launch site 4N. This dredge site would abut launch site 4N and extend east from the launch site to the shipping channel. The worst-case dredge volume identified at this site is approximately 2,500 m^3.
- Dredge site 3 (dredge footprint for Boatshed Point MOF 1): The dredging of this site would facilitate the construction and operation of the personnel jetty and MOF at Boatshed Point. This dredge site would encompass the area around the marine facilities, providing adequate depth for docking and navigation. The worst-case dredge volume identified at this site is approximately 50,000 m^3.
- Dredge site 4 (dredge footprint for Hamilton Point South MOF 2): The dredging of this site would facilitate the construction and operation of the MOF at Hamilton Point South. This dredge site would encompass the area around the marine facilities, providing adequate depth for docking and navigation. The worst-case dredge volume identified at this site is approximately 50,000 m^3.
- Dredge site 5 (dredge footprint for LNG jetty): The dredging of this site will facilitate the construction of the LNG jetty at Hamilton Point. This dredge site extends from the berth pocket

to be dredged as part of the Western Basin Strategic Dredging and Disposal Project to the shoreline and is required to enable a work barge to assist with construction of the jetty. The worst-case dredge volume identified is approximately 120,000 m^3.

The spoil generated by dredging activities will be placed and treated for acid sulfate soils (as required) in the Port of Gladstone Western Basin Dredging and Disposal Project reclamation area.

2.3 Waste Sources

Solid, liquid and gaseous waste including general and regulated waste will be generated throughout the construction, operation and decommissioning phases of the project. Details of waste produced from each phase of the project are summarised in the following sections.

2.3.1 Construction

Waste will be generated through the construction of the LNG plant, feed gas pipelines, water supply facilities, waste treatment facilities and other infrastructure including workshops, accommodation facilities and marine infrastructure. Construction waste is largely comprised of waste from vegetation clearing and site preparation activities, left over, off-specification or quarantined construction materials, and domestic waste associated with the presence of a workforce on site. Construction activities will take place in two phases including:

- Trains 1 – 2 and supporting infrastructure such as the effluent treatment plant, marine facilities, workshops and accommodation facilities.
- Trains 3 – 4 will commence after completion of Trains 1 and 2 depending on market conditions.

Feed Gas Pipeline

Feed gas pipeline construction from mainland Australia under Port Curtis comprises a number of stages. This includes right of way (ROW) clearing and grading, access track construction, trenching, thrust boring, horizontal directional drilling or tunnelling, pipeline installation, backfilling and rehabilitation of disturbed areas. The construction of the pipeline will involve earthworks resulting in relatively small quantities of waste. The main wastes that will be generated from the construction and commissioning of the pipeline include:

- Greenwaste, timber, topsoil, spoil and acid sulfate soil from site preparation works.
- Scrap metal (pipe off-cuts).
- General waste including putrescible wastes from portable offices and crib rooms.
- Waste chemicals, paints and adhesives.
- Oil and chemical containers.
- Recyclable wastes (aluminium, cardboard, glass, paper, plastics and tin).
- Waste oils and sludges.
- Sewage and greywater.
- Hydrotest water (containing biocides and corrosion inhibitors) from testing of pipelines during commissioning of the pipeline.

- Gaseous and particulate emissions from earthworks and vehicular movements.
- Drill cuttings from horizontal directional drilling.

LNG Plant and Associated Facilities

During the construction of the LNG plant, associated marine infrastructure and accommodation facilities, the wastes expected to be generated include:

- Greenwaste, timber, topsoil and acid sulfate soil from site preparation works.
- Timber packaging.
- Scrap metal.
- General waste including putrescible wastes from offices and crib rooms.
- Recyclable wastes (aluminium, cardboard, glass, paper, plastics and tin).
- Waste concrete.
- Batteries.
- Hydrotest water from integrity testing of pipelines and LNG tanks.
- Vehicle and equipment washdown water.
- Sewage and greywater.
- Stormwater run-off.
- Effluent treatment plant discharge.
- Waste oils, sludges and oily water.
- Brine from the reverse osmosis (RO) water treatment plant.
- Paint, chemical residues and containers.
- Quarantine wastes (including washwater, clinical and biohazard wastes).
- Dredging material from construction of the pipeline crossing, a MOF, LNG jetty and a ferry passenger terminal (if required).

2.3.2 Operation

Waste will be generated through the operation of the LNG plant, feed gas pipelines, water supply facilities, waste treatment facilities and other infrastructure including workshops, accommodation facilities and marine infrastructure. Operational waste is largely comprised of waste from maintenance of plant and equipment, wastes from liquefaction of feed gas, wastewater from drainage of potentially contaminated areas around the plant, waste from abnormal operating conditions and domestic waste associated with the presence of a workforce on site.

Feed Gas Pipeline

Low quantities of waste will be generated from the operation of the feed gas pipeline. Waste generated during operation of the feed gas pipeline is limited to sludge that will be produced when

the pipeline is pigged. Sludge will be collected by a licensed waste contractor and disposed of at a licensed waste management facility.

LNG Plant

The major solid waste streams likely to be generated during the operation of the LNG plant and associated infrastructure include:

- General wastes (domestic, putrescible, clothing etc.).
- Sludges from pigging operations and tank cleaning.
- Paper, cardboard and timber packaging.
- Ceramic balls, molecular sieve and activated carbon adsorbents.
- Ferrous and non-ferrous metals from maintenance activities.
- Spent batteries.
- Contaminated soil from accidental spillages.

The LNG process produces minor quantities of liquid wastes. The liquid streams generated at the LNG facility include:

- Potentially contaminated run-off from facility process areas which will be routed to the controlled discharge facility where the quality is monitored and either discharged with the uncontaminated stormwater run-off to the sea or diverted to the ETP for treatment.
- Oil contaminated water from the slops tank bottom.
- Waste triethylene glycol (TEG) from the dehumidifying process.
- Sewage and greywater from office buildings and the canteen.
- Brine from RO facility.
- Hydrotest water from testing of LNG storage tanks and pipelines.
- Waste oils, coolants and sump fluids from maintenance activities.

The main gaseous wastes to be produced from the project during operation are primarily associated with the combustion of carbon based fuels. Consequently, the gaseous wastes produced include NO_X, CO, CO_2, PM_{10}, $PM_{2.5}$ and various hydrocarbon species (Katestone, 2011a and PAEHolmes, 2011). Other sources include the venting of process units used for the removal of impurities such as CO_2 and N_2.

Reduced sulphur compounds such as hydrogen sulfide (H_2S) are not expected to be present in the CSG resource. H_2S will be removed, if required, during the pre-treatment phase of the gas liquefaction process in order to meet LNG specifications. The removal of H_2S means there is a minimal amount of H_2S in the gas turbine fuel and hence SO_2 emissions will be negligible.

A complete description and estimated quantities of gaseous wastes produced at the project can be found in Katestone (2011a) and PAEHolmes (2011).

Marine Operations

Solid and liquid wastes likely to be produced from the marine operations associated with the LNG plant include the following:

- General waste including food waste.

- Recyclables such as glass, paper and cardboard from office facilities.
- Sewage and greywater.
- Quarantine wastes.
- Gaseous waste.
- Ballast water from shipping activities.

The largest gaseous waste stream from marine operations is boil-off gas from LNG ship tanks. Boil-off gas originating from stored LNG (including return vapours from the LNG carrier) will be collected using an appropriate vapour recovery system (e.g., compressor system) and not be released to air.

Similarly, a CO_2 rich gas from LNG ship loading arm purging will also be collected and returned to the shore low pressure tank flare. Foreign ballast water will be managed in accordance with the *Australian Ballast Water Management Requirements* (DAFF, 2008) before its discharge will be permitted by the Australian Quarantine Inspection Service (AQIS) in Australian waters.

2.3.3 Decommissioning Waste

General and regulated wastes will be produced during the decommissioning of the gas pipeline and LNG facility, but as the project is in the early phases of development, a detailed assessment of the type and quantity of waste generated has yet to be investigated. In the future a detailed decommissioning plan will be developed to ensure that the site does not pose an ongoing risk to public safety or the quality of the environment and fulfils community expectations.

Minimal wastes will be produced during the decommissioning of the gas pipeline if the pipeline is decommissioned in place. It is expected that all aboveground facilities and equipment will be dismantled and removed.

The material and equipment from decommissioning likely to be suitable for re-use or recycling includes:

- Process and chemical pumps.
- Aboveground storage tanks.
- Compressors and process equipment.
- Gas and diesel engine power generators.
- Demountable and modular buildings.
- Building steel frames and cladding.
- Electrical switchgear and cables.
- Control systems equipment.
- Above ground pipelines, flow-lines and manifolds.
- Fencing and miscellaneous steelwork.

The material and equipment likely to be unsuitable for either re-use or recycling and likely to require disposal includes:

- Plastic and glass fibre reinforced plastic tanks.
- Sludge from pipelines and equipment.
- Contaminated soil generated from spills or leaks during dismantling of equipment.

2.3.4. Abnormal Operating Conditions or Unplanned Events

Atypical or abnormal operating conditions are considered to be events that could potentially occur that are not part of normal and expected operations. These include events such as shutdown or start-up of plant (planned or unplanned), upset conditions such as equipment failure, interruption to feed gas / power supply and abnormal weather conditions such as extreme storm events.

Plant Shutdown, Start-Up and Upset Conditions

During abnormal operating conditions (start-up, shutdown, upset and emergency conditions) gaseous and liquid hydrocarbon waste streams will be generated at the LNG plant. Abnormal operating conditions will occur on an intermittent and occasional basis for a short duration and may be planned or unplanned.

Typical abnormal operating events include:

- Plant shutdown for maintenance followed by cold start up.
- Upset or emergency conditions due to the need to depressurise a liquefaction train or the feed gas pipeline entering the plant.
- Upset or emergency conditions from equipment malfunction or human error.

Wastes produced by abnormal operating conditions potentially include emissions to air from flares, and releases of liquid wastes such as contaminated bund water, liquefied LNG, waste oil or potentially contaminated run-off.

Fire

In the event of a fire at the LNG plant the following wastes may potentially be generated:

- Air emissions from combustion of flammable material. The toxicity of the emissions will vary depending on the material that is combusting.
- Firewater used in sprinkler systems and for the flooding and cooling of tanks.
- Waste water generated from use in extinguishing fires.
- Combusted waste residue.

Storm Events

In the event of a storm, bunded areas that are not roofed may collect stormwater and overflow, potentially releasing contaminated water. The volume of the releases depends on the size of the rainfall event and the capacity of the bunds.

3. LEGISLATIVE CONTEXT

3.1 Commonwealth Framework

3.1.1 National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 2004

The National Environment Protection (Movement of Controlled Waste between States and Territories) Measure (NEPM) 2004 aims to minimise the potential for harm to human health and the environment from the transport of waste around Australia.

To achieve this, the NEPM establishes a national system to track transport movements. The system ensures that controlled waste being moved between States and Territories are properly identified, transported and handled in an environmentally sound manner, and that it reaches licensed or approved receiving facilities for storage, treatment, recycling and/or disposal.

It is unlikely that waste produced at the Arrow LNG Plant will be transported outside of Queensland to other Australian states, but if it were to occur, management and tracking of wastes would be required to be in accordance with the NEPM.

3.1.2 Quarantine Act 1908

The *Quarantine Act 1908* establishes a basis for human, plant and animal quarantine activities to minimise the risk of exotic pests and diseases entering Australia and impacting the human health, the agricultural industry or the natural environment.

The Australian Quarantine and Inspection Service (AQIS) is the lead agency for the regulation of the *Quarantine Act 1908* and have inspection and quarantine services at Australia's seaports, airports, international mail centres and cargo centres.

AQIS will be involved with the Arrow LNG Plant in relation to the use of imported building materials (used during construction) being transported to Curtis Island from an offshore fabrication facility.

Foreign ballast water will also required to be managed in accordance with the *Australian Ballast Water Management Requirements* (DAFF, 2008) before its discharge will be permitted (by AQIS) in Australian waters.

3.2 Queensland Framework

3.2.1 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) establishes a duty of care on all persons to take reasonable and practicable measures to prevent environmental harm. The EP Act allows for the establishment of Environmental Protection Policies (EPPs) which detail the Queensland Government's objectives in relation to environmental protection. The EP Act and EPPs are administered by the Department of Environment and Resources Management (DERM).

Various regulations made under the EP Act deal with specific aspects of waste management, including licensing of specified waste management activities and tracking of regulated wastes.

There are two main definitions of waste in Queensland statutes; ‘waste’ and ‘regulated waste’. The EP Act defines ‘waste’ as anything that is:

- Left over or an unwanted by-product from an industrial, commercial, domestic or other activity.
- Surplus to the industrial, commercial, domestic or other activity generating the waste.

A definition of regulated waste is contained in the *Environmental Protection Regulation 2008* and is provided Section 3.2.2.

3.2.2 Environmental Protection Regulation 2008

The objective of the *Environmental Protection Regulation 2008* (EP Regulation) is to provide the basis for effective and efficient administration and enforcement of the object and provisions of the EP Act. The EP Regulation defines 'general waste' as waste other than regulated waste. Regulated waste’ is defined as waste that is:

- A commercial or industrial waste, whether or not it has been immobilised or treated.
- Of a type, or contains a constituent of a type, mentioned in schedule 7 of the Regulation.

3.2.3 Environmental Protection (Waste Management) Policy 2000

The *Environmental Protection (Waste Management) Policy 2000* (EPP Waste) provides a strategic framework for managing waste in Queensland and establishes management principles as the basis for waste management. The principles relevant to the project are:

- Polluter pays principle.
- Product stewardship principle.

The EPP (Waste) also outlines the waste management hierarchy as an optimal waste management tool, which moves from most preferred to least preferred:

- Waste avoidance.
- Waste re-use.
- Waste recycling.
- Energy recovery.
- Waste disposal.

The EPP (Waste) also:

- Identifies environmental values to be enhanced or protected.
- Sets criteria for administering authorities (usually DERM or local government) to follow when making management decisions concerning waste.
- Specifies the content of waste management programs which may be required as part of a development approval or environmental authority.
- Outlines requirements for voluntary industry waste reduction programs.

- Requires state government departments and local governments to undertake strategic waste management planning.

3.2.4 Environmental Protection (Waste Management) Regulation 2000

The *Environmental Protection (Waste Management) Regulation 2000* (EP Regulation (Waste)) contains the requirements for handling specific waste streams with the objective being to minimise the impact of waste on the environment, particularly the impact of waste so far as it directly affects human health.

The EP Regulation (Waste) specifically provides for:

- Offences for littering and waste dumping.
- A waste tracking and reporting system.
- Clinical and relate waste management planning, segregation of infectious wastes, appropriate onsite storage and proper disposal.
- Managing and ultimately phasing out certain polychlorinated biphenyls.
- Design rules for waste equipment and toilets.

The EP Regulation (Waste) regulation is particularly of relevance to the Arrow LNG Plant in relation to the transportation and disposal of regulated wastes, which must be tracked and reported to DERM.

3.2.5 Queensland Waste Management Strategy

In December 2010, *Queensland's Waste Strategy 2010 – 2020 – Waste Avoidance and Recycling* was released by DERM. The Strategy is a ten year plan to achieve the government's vision of a low waste Queensland and replaces the 1996 Waste Management Strategy for Queensland. The Strategy outlines a substantial waste reform program comprising the following elements:

- New legislation dealing with waste avoidance and resource efficiency.
- Introduction of a landfill levy.
- Identification of priority products and product stewardship arrangements, including voluntary or mandatory take-back schemes and landfill disposal bans.
- Resource recovery requirements, including investing in design-for-environment to increase recyclability or reduce toxicity of inputs, support for collection programs or reprocessing infrastructure and education and awareness campaigns to target reduced generation and enhanced recovery.
- Strengthened reporting requirements.

The strategy discusses proposed new legislation to support the goals of the strategy in promoting waste reduction and resource recovery and developing sustainable waste and resource recovery industries. New regulations will support the proposed act, strengthening and co-ordinating compliance and enforcement. Stronger regulation of illegal activities will ensure fairness and encourage industry investment.

The proposed landfill levy payment will apply to the disposal of commercial and industrial waste, construction and demolition waste, contaminated soils and acid sulfate soils. From the 1 December 2011, a $35 per tonne levy is proposed for these wastes when disposed of to landfill. Other waste types, such as lower hazard regulated waste including tyres, food processing wastes and stabilised regulated wastes will incur a fee of $50 per tonne; while higher hazard regulated waste from industries such as foundries, chemical or fertiliser manufacturing etc. will attract a $150 per tonne levy.

The new waste strategy has potential future implications for the Arrow LNG Plant, largely relating to the cost of disposal of waste to landfill. There may also be future benefits from the establishment of recycling and resource recovery facilities in regional Queensland, increasing the opportunities for resource recovery for the project.

4. STUDY METHOD

4.1 Overview

This section outlines the methodology and assumptions used to assess the following tasks in the waste impact assessment including:

- Assessment of the existing waste management infrastructure in the greater Gladstone region that may be able to be used by Arrow Energy during the life of the project.
- Assessment of waste streams and quantities associated with the construction, operation, and decommissioning of the LNG plant and associated infrastructure on Curtis Island, mainland and marine infrastructure, tunnel, feed gas pipeline and power supply.
- Assessment of Arrow Energy's proposed waste management strategies for the project.
- Assessment potential baseline and cumulative impacts of the waste streams on the environment.

4.2 Existing Waste Management Infrastructure

To identify existing waste management infrastructure the following tasks were undertaken:

- Meetings and correspondence with infrastructure providers including the Gladstone Regional Council and J.J. Richards & Sons Pty Ltd (JJ Richards).
- Desktop study of facilities listed in current phone directories and on the world-wide-web.
- Review of existing EIS documents for other LNG facilities including:
  - Queensland Curtis LNG: Environmental Impact Statement (QGC, 2009).
  - Australia Pacific LNG Project: Environmental Impact Statement (APLNG, 2010).
  - Gladstone LNG: Environmental Impact Statement (URS, 2009).
- Site visit to view existing facilities including Benaraby Regional Landfill and JJ Richards facility.

4.3 Waste Streams and Quantities

Types and quantities of wastes were identified using data from the following sources:

- Arrow Energy.
- Air Quality Impact Assessment (Katestone, 2011a).
- Queensland Curtis LNG: Environmental Impact Statement (QGC, 2009).
- Australia Pacific LNG Project: Environmental Impact Statement (APLNG, 2010).
- Gladstone LNG: Environmental Impact Statement (URS, 2009).

Limited information has also been obtained from infrastructure providers including the Gladstone Regional Council.

The following assumptions were made in the estimation of waste generation rates:

- Construction activities will take approximately five years for trains 1 and 2, and an additional four years for trains 3 and 4.
- Construction workforce would ramp up to a peak workforce and then decline towards commissioning and handover to operators.

Waste quantities are reported as tonnes per annum (tpa) wherever possible. The annual waste quantities for operations can be utilised to calculate weekly or monthly statistics with a high degree of accuracy as waste is produced on a consistent and regular basis except through scheduled shutdown or maintenance periods. The annual waste quantities for construction periods cannot be utilised with the same degree of accuracy due to the varying activities and changing population numbers during this time. Whilst annual average quantities are provided, it is anticipated that waste production rates will be lower in years 1 and 4 of construction with a peak during years 2 and 3.

4.4 Waste Management Strategies

Management strategies for the various waste streams are based on the principles of the waste management hierarchy and cleaner production initiatives, with consideration given to existing and proposed waste management infrastructure in the Gladstone and greater Queensland region.

Where feasible, Arrow Energy has engineering design measures to avoid impacts, however, where these are not feasible, mitigation and management measures for each impact are proposed to reduce impacts as far as practicable.

Waste management strategies have been identified from a number of sources including the following:

- Arrow Energy.
- AS 1940–2004: The Storage and Handling of Flammable and Combustible Liquids (Standards Australia, 2004a).
- AS 3780–2008: **The** S**torage and** H**andling of** C**orrosive** S**ubstances** (Standards Australia, 2008).

4.5 Impact Assessment

The general approach to impact assessment includes:

- Identification of existing resources and/or receptors that may be impacted by waste generation and management both on and off site.
- Consideration of the estimated waste types and quantities likely to require management on site or off site and the potential impact on the existing resources and/or receptors.
- Assessment of the potential impacts using a risk assessment matrix.
- Identification of appropriate management and mitigation measures.
- Assessment of the significance of any residual impacts taking into account the management or mitigation measures.

Impact assessments have not been conducted for wastes that have been assessed by other technical experts. These wastes include:

- Brine effluent and stormwater run-off discharged to Port Curtis.
- Gaseous and particulate emissions to air.
- Contaminated soil.
- Acid sulfate soil.
- Dredging spoil.

The following reports provide more details on impact assessments on the natural environment:

- Contaminated Land Impact Assessment (Coffey Environments, 2011a).
- Acid Sulfate Soil Impact Assessment (Coffey Geotechnics, 2011).
- Coastal Processes, Hydrodynamics and Marine Water Quality Impact Assessment (WBM, 2011).
- Aquatic Ecology Impact Assessment (Aquateco, 2011).
- Air Quality Impact Assessment (Katestone, 2011a).
- Plume Rise Impact Assessment (Katestone, 2011b).
- Marine and Estuarine Ecology Impact Assessment (Coffey Environments, 2011b).

4.5.1 Residual Risk Assessment

The assessment of the residual impacts to the environment (after proposed mitigation/management measures are taken into consideration) is undertaken by examining the likelihood of an impact occurring and the potential consequences (i.e., a measure of severity) of the potential impact. The risk is assessed post mitigation/management to determine how effective the proposed strategy is in reducing the potential impacts of the proposed development. The result of the post mitigation risk assessment of the impact is the residual impact of the project. Table 4.1 contains the descriptors used to classify the likelihood and consequence.

Table 4.1: Descriptors to classify likelihood and consequence

Descriptor	Description
Likelihood	
Almost certain	Will occur, or is of a continuous nature. There is likely to be an event at least once a year or greater (up to 10 times per year). It often occurs in similar environments. The event is expected to occur in most circumstances.
Likely	There is likely to be an event on average every one to five years. Likely to have been a similar incident occurring in similar environments. The event will probably occur in most circumstances.
Possible	The event could occur. There is likely to be an event on average every five to 20 years.
Unlikely	The event could occur but is not expected. May have heard it discussed as a possibility, but an extremely unusual one. A rare occurrence (once per 100 years).
Rare	The event may only occur in exceptional circumstances. Rare occurrence (once per 1,000 years). Unlikely that it has occurred elsewhere; and if it has occurred, it is regarded as extremely unique.
Consequence	
Insignificant	Possible impacts but without noticeable consequence. Temporary or short-term reversible environmental, social or economic impact, localised event, location of little environmental value.
Minor	Some limited consequence but no significant long-term changes, may be easily rehabilitated.
Medium	Significant changes may be rehabilitated with difficulty. Direct or indirect environmental, social or economic impacts beyond location (on site or off site). Repeated public concern. Reportable to the government.
Major	Substantial and significant changes will attract public concern, only partially able to be rehabilitated or uncertain if it can be successfully rehabilitated. Actual or potential environmental, social or economic harm either temporary or permanent, requiring immediate attention. Possible prosecution by regulatory authorities.
Catastrophic	Extreme permanent changes to the environment, society or the economy, major public outrage, or the consequences are unknown. Serious environmental, social or economic harm that causes actual or potential environmental, social or economic impacts that are irreversible or of high impact or widespread. Likely prosecution by regulatory authorities.

Source: Adapted from AS/NZS 14001:2004 (Standards Australia, 2004b).

The matrix shown in Table 4.2 was used as a guide to address each residual impact, drawing a conclusion about its significance in the context of the values to be protected and the activities proposed.

Table 4.2 Risk evaluation matrix

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Medium**	**Major**	**Catastrophic**
Almost certain	Moderate	Moderate	High	Extreme	Extreme
Likely	Low	Moderate	Moderate	High	Extreme
Possible	Low	Low	Moderate	High	High
Unlikely	Negligible	Low	Low	Moderate	High
Rare	Negligible	Negligible	Low	Moderate	Moderate

Source: Adapted from AS/NZS 14001:2004 (Standards Australia, 2004b).

4.5.2 Cumulative Impact Assessment

The cumulative impact assessment quantifies the potential impact on local waste management infrastructure including landfills, wastewater treatment plants, recycling facilities and local waste management contractors.

In order to ascertain the cumulative impact of waste on existing local waste management infrastructure, a baseline case has been developed that includes the following:

- The quantities of waste currently being disposed of at waste management facilities by existing domestic and commercial sectors.
- The quantities of waste likely to be disposed of at these facilities by projects that have taken a financial investment decision at the date of this report.

The cumulative impact assessment on the baseline case has been developed by incorporating the potential waste disposal quantities from the Arrow LNG Plant and other projects that have been approved by the Queensland Coordinator-General or have sufficient information in the public domain (i.e., EIS) to enable an assessment of the potential impacts.

Waste types and quantities reported vary in units of weight or volume and have been converted to a consistent unit of measure (i.e., tonnes) to enable comparison of data in the cumulative impact assessment. For example, where waste figures were reported in cubic metres, a conversion to tonnes was made using the specific weight or density of the material. For the purpose of this study typical specific weights for residential, commercial, industrial and agricultural wastes outlined in Tchobanoglous *et. al.*, (1993) have been applied to all waste volumes that required conversion to tonnes.

5. EXISTING ENVIRONMENT

The existing conditions relating to waste management include an assessment of the following:

- The existing natural environment that may be impacted by waste generation and management.
- The existing socio-economic environment that may be impacted by storage, handling, transport and disposal (including re-use, recycling, energy recovery and disposal) of waste both on site and off site.

5.1 Natural Environment

The following reports provide more details on the existing environment in the study area:

- Contaminated Land Impact Assessment (Coffey Environments, 2011a).
- Acid Sulfate Soil Impact Assessment (Coffey Geotechnics, 2011).
- Coastal Processes, Hydrodynamics and Marine Water Quality Impact Assessment (WBM, 2011).
- Aquatic Ecology Impact Assessment (Aquateco, 2011).
- Air Quality Impact Assessment (Katestone, 2011a).
- Plume Rise Impact Assessment (Katestone, 2011b).
- Marine and Estuarine Ecology Impact Assessment (Coffey Environments, 2011b).

5.2 Waste Management Infrastructure

Waste management infrastructure in the Gladstone region is well established, having serviced the local domestic (residential kerbside collections) and commercial (waste from all non-residential sources) markets for decades. There are many commercial enterprises operating in or nearby to Gladstone that utilise the services of local waste management facilities and contractors. These include small businesses, the health industry, schools, industrial facilities (including mining and manufacturing), port and rail facilities and the construction and demolition industry.

5.2.1 Landfills

There are several landfills within or near to the project area that may be used for the disposal of solid waste, however the Gladstone Regional Council has indicated (R. Doherty, pers. comm., 10 June 2010) it is unlikely to accept commercial wastes at any of the council run facilities except the Benaraby Regional Landfill, located on the Bruce Highway, Benaraby. The Benaraby Regional Landfill has an operating life of approximately 30 years plus a potential for an additional 30 years at the current disposal rate of 50,000 tonnes per annum (tpa) (R. Doherty, pers. comm., 10 June 2010). The Benaraby Regional Landfill is licensed to accept some regulated wastes, however acceptance is at the discretion of the Gladstone Regional Council. Regulated waste disposal is assessed on a case by case basis (R. Doherty, pers. comm., 10 June 2010). Disposal of large commercial loads and regulated waste at the Benaraby Regional Landfill will have to be co-ordinated with the operations staff at the landfill.

5.2.2 Recycling Facilities

Recycling facilities exist within the Gladstone region for limited wastes generated from the project, including waste oils; construction materials such as concrete; tyres; scrap ferrous and non-ferrous metal; paper and cardboard; glass; and some plastics.

A majority of the recyclables are transported to south-east Queensland for re-processing or export to international markets as limited opportunities exist for re-processing in regional areas. Table 5.1 summarises recyclable material, marketability and opportunities for recycling in Gladstone.

Table 5.1: Recyclables and market potential

Waste Material	Marketability	Opportunity for Recycling in Gladstone
Waste oil	Waste oil has a high marketability in Queensland and is reprocessed in two locations; Brisbane or Townsville.	There are several licensed waste contractors in Gladstone that are available to collect waste oil and transport to reprocessing facilities.
Construction and demolition waste such as earthen spoil, concrete, bricks/pavers, timber and plaster board.	Construction and demolition waste has limited marketability in regional areas of Queensland due to distance from reprocessing facilities located largely in Southeast Queensland.	Limited opportunities available in Gladstone. Most wastes would have to be collected and transported to Southeast Queensland by third part contractors.
Paper and cardboard	Moderate marketability	Queensland has two paper mills that receive and process the paper and cardboard collected within the state; both located in Brisbane. The Gladstone region is currently serviced by a waste contractor that collects recyclable materials and transports to a recycling facility in Brisbane.
Glass	Moderate to low marketability	Some opportunity may exist for recycling in Rockhampton as part of road base trial. Glass would otherwise need to be transported to Southeast Queensland for reprocessing.
Ferrous metals	High marketability with high global demand.	Steel and other scrap metals are collected from across the state for processing in Southeast Queensland. There are several local scrap metal merchants in Gladstone that could service the needs of the LNG facility.
Non-ferrous metals	High marketability with high global demand.	Steel and other scrap metals are collected from across the state for processing in Southeast Queensland. There are several local scrap metal merchants in Gladstone that could service the needs of the LNG plant.

Table 5.1 (Cont'd): Recyclables and market potential

Waste Material	Marketability	Opportunity for Recycling in Gladstone
Tyres	Moderate to low marketability.	Limited opportunities available in Gladstone. Used tyres are currently collected and transported to Southeast Queensland where they are shredded. Some of the shredded material is recovered for processing; however the majority of used tyres are landfilled. Most wastes would have to be collected and transported to south-east Queensland by third part contractors.
Plastics	Moderate to low marketability.	Mixed plastics are transported to Southeast Queensland and exported[1].

1. EPA (2007)

A regional materials recovery facility was opened in Rockhampton in November 2010 which accepts and processes recyclable materials. The bailed recyclable material is shipped to Brisbane for re-processing or export to international markets. This may provide Arrow Energy with the opportunity to maximise recycling potential of wastes produced from the project

5.2.3 Wastewater Treatment Facilities

There are two main wastewater treatment facilities located in Gladstone; the Calliope River Sewage Treatment Plant and the South Trees Sewage Treatment Plant, both operated by the Gladstone Regional Council. The Calliope River Sewage Treatment Plant treats approximately 97% of Gladstone's wastewater. There are several smaller facilities including Yarwun, Aldoga, Boyne Island, Tannum Sands and Calliope Town, however these are almost at operating capacity or are located outside the Gladstone town-ship.

Both the Calliope River Sewage Treatment Plant and the South Trees Sewage Treatment Plant have capacity available for the discharge of trade waste and are planning upgrades to increase capacity (see Table 5.2).

Use of the any of the wastewater treatment facilities would require a trade waste agreement between the Gladstone Regional Council and the proponent or a contractor. Specified discharge limits would need to be met prior to any disposal at any wastewater treatment plant (GRC, 2009).

Table 5.2 Wastewater treatment plant capacities

Wastewater Treatment Plant	Current Loading (People)	Current Capacity (People)	Planned Upgrade (People)
Calliope River	43,000	57,000	87,000
South Trees	2,500	5,000	10,000

Source: QCG (2009)

5.2.4 Licensed Waste Management Contractors

There are several large commercial waste management contractors located in Gladstone that currently service the needs of large industrial operations located in and around Gladstone. These are described below.

JJ Richards is the largest privately owned waste management company in Australia. It currently has the contract with the Gladstone Regional Council for the local kerbside collection of domestic waste and recyclables. The main activities conducted by JJ Richards in Gladstone include:

- Grease trap cleaning.
- Septic tank cleaning.
- Commercial waste collection.
- Collection and processing of recyclables (oil, batteries, glass, paper and cardboard).

Transpacific Industries Group Pty Ltd (TPI) is a large multinational organisation that provides waste collection and disposal to the commercial sector. In Gladstone, TPI operates Gladstone Mini Bins.

Veolia Environmental Services (Veolia) is a national leader in resource recovery and waste management and currently provide the following services in Gladstone:

- Disposal of industrial waste including hazardous waste, construction and industrial waste.
- On site waste facility management.
- Industrial cleaning.

One Steel Recycling and Simsmetal Ltd both offer ferrous and non-ferrous recycling service in Gladstone.

There are several other companies based outside of Gladstone but within Queensland that service the Gladstone area. These include:

- SteriHealth, based in Brisbane, which specialise in the management of clinical, medical or biohazardous waste and also offer a recycling service for fluorescent tubes and alkaline and rechargeable batteries.
- ToxFree is one of the largest waste management companies in Australia and is based in North Rockhampton and provides a range of services including hazardous waste disposal, liquid waste treatment and integrated on site industrial services such as contaminated site remediation, drain and tank cleaning, pigging etc.
- All Hours Vac Truck in Rockhampton provides a liquid waste collection and disposal.
- Filter and Drum Crushers in Rockhampton provides a filter and drum crushing service.
- Flat Filters in Biloela provides a filter crushing service.
- Tannum/Boyne Liquid Waste provides a liquid waste collection and disposal service.
- Nationwide Oil in North Rockhampton provides a liquid waste collection and disposal service.

6. WASTE QUANTITIES

Waste generation will occur throughout construction, operation and decommissioning of the Arrow LNG Plant. This section provided a summary of waste types and estimated quantities. Quantities are provided as tonnes per annum (tpa) wherever possible, however these figures are typically average figures and do not reflect variations that may occur on a daily, weekly or monthly basis. This is particularly the case during the construction periods where activities and population numbers vary considerably.

6.1 Construction and Operational Wastes

Tables 6.1 and 6.2 present a summary of the indicative wastes generated annually from the construction and operation of the Arrow LNG plant and associated infrastructure.

Table 6.1: LNG Plant and associated infrastructure construction and operation solid wastes and quantities

Waste Type	Generation Point / Source	Construction Trains 1 & 2 (tpa)	Construction Trains 3 & 4 (tpa)	Operation Trains 1 to 4 (tpa)
Green waste[1]	Site preparation activities	16,186 t	Minimal	Minimal
General waste (including food waste)[2,3]	Offices and workshops, accommodation village and canteen	1200	781.3	76.3
Medical wastes[2]	LNG Plant and accommodation	0.75	0.625	Minimal
Waste clothes and fabric[2,3]	Personal protective equipment	3.75	3.125	0.75
Waste polyethylene lining[2]	Construction of pipelines and storage vessels.	20	18.75	12
Waste photographic and x-ray film[2]	Construction of pipelines and storage vessels.	8	8	Minimal
Process wastes (molecular sieve, ceramic balls, spent activated carbon, silica gel filters, waste zeolite etc) [2]	Dehydration unit, acid gas removal unit and mercury removal unit	Minimal	Minimal	154
Paint and adhesive wastes[2]	Construction and general maintenance of plant and equipment	1.2	1.25	2
Concrete wastes[2]	Construction of infrastructure	2000	1000	30

Table 6.1 (Cont'd): LNG Plant and associated infrastructure construction and operation solid wastes and quantities

Waste Type	Generation Point / Source	Construction Trains 1 & 2 (tpa)	Construction Trains 3 & 4 (tpa)	Operation Trains 1 to 4 (tpa)
Glass[2]	Offices, workshops, accommodation village	4	3	0.6
Dust	Mercury removal unit	Minimal	Minimal	Minimal
Oily rags and filters	General maintenance of plant and equipment	Minimal	Minimal	3
Ferrous and non-ferrous metal[2,4]	Maintenance activities	37.8	26.2	151.3
Tyres[2]	Vehicles	20	12.5	7.5
Batteries (lead acid cells, dry charged, rechargeable) [2]	Plant and equipment	2.2	1.25	4.1
Timber[2]	Packaging and carpentry off-cuts	40	24	36
Oil contaminated steel drums[2]	Packaging	2	1.25	Minimal
Insulation and slag wool[2]		0.75	0.5	Minimal
Paper and cardboard[2]	Offices, workshops and accommodation village	80	50	30
Biosolid sludge (dewatered)[5]	Effluent Treatment Plant	812 - 1280	812 - 1280	147 - 230
Topsoil[6]	Site preparation activities	867,000 m^3	86,000 m^3	Minimal
Overburden[7]	Site preparation activities	43,000 m^3	Minimal	Minimal

1. Calculated on biomass load of 50.9 t/ha for dry schlerophyll forest (Freudenberger *et. al.*, 2004) assuming disturbance of 250 ha of land on Curtis Island and 68 ha in Gladstone.

2. Arrow Energy.

3. Scaled up from 2000 people to 2500 people.

4. Includes aluminium cans from accommodation village.

5. Figures based on 2500 construction workers and 450 operations workers. Assumes all solids in the wastewater are from sewage and treatment efficiency of sludge thickener is between 80 and 94%.

6. Assumes 300mm topsoil over 221 ha of land on Curtis Island and 68 ha in Gladstone cleared during construction of Trains 1 and 2, 28.7 ha to be cleared on Curtis Island during construction of Trains 3 and 4.

7. Source: Arrow Energy Cut and Fill Study (2010).

Table 6.2: LNG plant and associated infrastructure construction and operation liquid wastes and quantities

Waste Type	Generation Point / Source	Construction Trains 1 & 2 (tpa)	Construction Trains 3 & 4 (tpa)	Operation Trains 1 to 4 (tpa)
Used grease, lubricants and oils	Maintenance activities	80(1)	40(1)	42.3(2)
Grease trap waste	Accommodation facilities	57.4	57.4	10.3
Sulfuric acid[1]	Batteries	1.6	1	0.4
Dry weather flow		137 m3/d	137 m3/d	274 m3/d
Demineralisation regeneration effluent	Demineralisation plant	108 m3/d	108 m3/d	216 m3/d
Spent TEG, engine coolant, waste paint, cleaning agents, developing solutions and water treatment chemicals	Vehicle, plant and equipment maintenance and operation	40	32	111.6
ETP effluent for irrigation (design flow rate)[1]	ETP (dry weather flow, sanitary waste water, drips & drains)	1246 m^3/day	1246 m^3/day	1246 m^3/day
Brine	Reverse osmosis facility	1,872 m^3/d	3,744 m^3/d	3,744 m^3/d
Hydrotest water[2]	Testing LNG storage tanks and pipeline	97,000 m^3 per tank	97,000 m^3 per tank	Nil
Gas turbine wash water[2]	Gas turbine washing	365 m3/d	365 m3/d	730 m3/d

1. Arrow Energy.

2. Periodic generation.

6.2 Sewage

Sewage generation will be at its peak during construction of trains 1 and 2 and associated pipeline and marine infrastructure. During this time, there will be up to 2500 people staying on Curtis Island and an additional 1000 permanently housed in Gladstone.

Tunnel, gas pipeline and dredging workforce (maximum population of 215) and excess LNG construction workforce will not be housed on Curtis Island so will not contribute to sewage generation rates on the island. Sewage generated from this component of the workforce will be collected and disposed of at a sewage treatment plant by a licensed waste contractor.

It is anticipated that during the operation of the Arrow LNG Plant on Curtis Island, sewage production will be at an average rate of 135 kL/d and a maximum rate of 180 kL/d (based on an average population of 450 and a maximum population of 600.

Estimated sewage generation rates are shown in Table 6.3.

Table 6.3: Estimated sewage generation rates

Workforce	Number[1]	Sewage[1] (kL/d)
Pioneer camp on Curtis island[2],[3]	200	60
Peak construction workforce at the LNG plant during project life on Curtis Island[2]	2500	750
Additional construction workforce in Gladstone	1000	300
Peak construction workforce in temporary accommodation (tunnel, feed gas and dredging workforce) [3]	215	64.5
Peak operational workforce on Curtis Island	600	180
Typical operational workforce on Curtis Island	450	135

1. Based on generation rate of 300 L/person/day.
2. Total number of personnel accommodated on Curtis Island per day. Excludes daily commuters.
3. To be disposed of at Calliope River or South Trees Sewage Treatment Plant.

6.3 Accommodation Waste

During construction, the workers' accommodation facility on Curtis Island will house up to 2,500 personnel. Population numbers during construction of trains 1 and 2 will range from 250 to 2,500.

Construction of trains 3 and 4 will commence when trains 1 and 2 are operating and a combination of construction and operations staff will be on site during this time. There will still only be a maximum of 2,500 personnel staying in the workers' accommodation during this time.

Table 6.4 summarises the types of waste and estimated quantities that will be generated from the workers' accommodation facility, including kitchen, accommodation units and communal areas.

Sewage generated from the accommodation facility during the construction and operational phases of the project is discussed in Section 6.2.

Table 6.4: Accommodation waste type and estimated quantities

Waste Type	Construction (Trains 1 & 2) Maximum Workforce[1]	Construction (Trains 3 & 4) Maximum Workforce[1]	Operations Typical Workforce[2]
	Quantity (tpa)	Quantity (tpa)	Quantity (tpa)
General waste (not separated)[3]	182.5	182.5	16.4
Food waste[4,5]	160	100	20
Grease trap waste[6]	57.4	57.4	10.3
Aluminium cans[7]	7.4	7.4	1.3

1. Based on 2500 workers.
2. Based on typical workforce of 450 workers.
3. Based on generation rate of 200 kg per worker per annum.
4. Arrow Energy (2011).
5. Includes food waste from LNG Plant canteen and accommodation village.

6. Based on generation rate of 23 kg/person/annum.

7. Based on average rate of 200 cans per person per annum with each can weighing 14.7g.

6.4 Reverse Osmosis Brine

An RO water treatment plant is to be installed to supply potable water for use in the LNG plant. The RO plant will process 130 m^3/h sea water producing 52 m^3/h of freshwater and 78 m^3/hr of brine during construction and operation of trains 1 and 2. A second RO plant will be brought on line during the construction and operation of trains 3 and 4 doubling the output of freshwater and brine.

The sea water is pre-treated (filtering with addition of biocide and anti-scalant) and is then passed through one of two RO unit membranes. The membrane allows fresh water to pass through and rejects the salts, resulting in a brine waste stream containing concentrated dissolved salts. The brine reject is discharged to the marine environment via a pipeline diffuser outlet off Boatshed Point. The indicative characteristics of the brine are detailed in Table 6.5.

Table 6.5: Indicative brine characteristics

Parameter	Concentration
pH	8 – 8.2
Total dissolved solids[1]	56.7 g/kg
Sulfate[2]	4 – 6 g/L
Total suspended solids[2]	20 – 30 mg/L
Anti–scalant[2]	8 mg/L
Flocculant[2]	5 mg/L

Source: Arrow Energy

1. Based on maximum expected salinity level in intake waters 32 and 33 g/L.

2. Estimation only.

6.5 Effluent Treatment Plant Wastewater

The effluent treatment plant (ETP) is a tertiary treatment facility designed to treat the wastewater from the Arrow LNG plant to a quality suitable for discharge to land via irrigation. The ETP will be established early in the construction phase of the project and includes the following components:

- Main equalization tank and off-specification tank.
- Membrane bioreactor package (two modules).
- Granular activated carbon (GAC) filter package.
- Chemical dosing package.
- Ultraviolet (UV) disinfection package.
- Sludge dewatering facilities.

The membrane bioreactor package and granular activated carbon packages are included in the treatment system to treat effluent to a level suitable for irrigation to land (Class A quality). Treated effluent will be re-used on site or irrigated to land in accordance with the Queensland Water Recycling Guidelines (EPA, 2005). The relationship between the ETP and the water management system is shown in Figure 6.1. Figure 6.2 details the ETP process.

Sewage and greywater, oily water from the slops oil tank bottom and effluent from LNG operations such as wastewater, oil from the boil off gas compressor area, flare knock out water and gas turbine washwater will be received in the ETP. Used fire fighting water, potentially contaminated stormwater flow and dry weather flows will be drained to a controlled discharge facility (CDF) where water quality will be analysed using continuous monitoring equipment. If the effluent is uncontaminated, it will be discharged to the marine environment. If the effluent is unsuitable for discharge, it is pumped to the ETP for treatment.

In the ETP, the sewage will be mixed with other process water streams in the main equalisation tank. Intermittent flow generated from the gas turbine wash water, the slops oil tank bottom water and the contaminated CDF water will be routed to either the main equalisation tank or the off-specification tank. The effluent streams are mixed by bubble aeration from the air blower.

The membrane bioreactor package is designed with anoxic and aerobic compartments in the biological tank and a membrane vessel. The mixed effluent is filtered through the membrane system to produce clarified effluent whilst the reject stream with concentrated biological sludge is returned to the anoxic compartment. The clarified water exiting the membrane bioreactor package passes through a granulated activated carbon filter for total suspended solids (TSS) removal followed by UV dosing/treatment for disinfection.

Excess sludge with a typical concentration of 0.8–2 % solids is collected from the biological tank and pumped to the sludge holding tank. The sludge de-watered by a centrifugal system to produce a thick sludge cake with solids content of 12–15 % and then conveyed to a container for off site disposal. Liquid removed from de-watering of the sludge is diverted back to the ETP for treatment.

The final effluent generated from the ETP will be re-used for irrigation, gardening, and toilet flushing purposes. The disinfected water will be routed to the irrigation water tank where it will be monitored for quality before being pumped around the site. If the treated effluent does not meet the required standard for use, the effluent will be returned to the off-spec tank and mixed gradually into the waste water in the main equalisation tank. Excess treated effluent (beyond design capacity) may be discharged to the marine environment through the brine outfall pipe at Boatshed Point in exceptional conditions, such as excessive wet weather.

Treated effluent from the ETP will meet the recommended water quality specifications for Class A recycled water (shown in Table 6.6) as detailed in the Queensland Water Recycling Guidelines (2005), meaning the treated water can be used for a variety of Class A and below (Class B, C and D) uses including:

- Irrigating public open space and golf courses – above ground irrigation or subsurface irrigation.
- Irrigating public open space and golf courses – controlled access.
- Industrial open system use (potential for occasional human contact, with safeguards in place).
- Industrial closed system use (low human contact).
- Irrigation of “no public access” areas.
- Use in fountains and water features (no primary or secondary contact recreation).
- Water features for amenity purposes only (controlled access).
- Natural or artificial wetlands.

Table 6.6: Recommended water quality specifications for class A recycled water

Class	*E. coli* (median colony forming units (CFU) /100 ml)	Turbidity (95th percentile) Nephelometric Turbidity Units (NTU)	Suspended solids (median) mg/L	Total Dissolved Solids (median) mg/L	pH
A	< 10	< 2	5	1000	6.5 – 8.5

Source: EPA (2005).

7. ISSUES AND POTENTIAL IMPACTS

The potential impacts of waste generated from the project on the environment are discussed in the following sections. The potential impacts are those identified from the project description, including proposed mitigation/management measures.

7.1 Discharges to Land and Water

There are several methods by which the land and water (surface, groundwater and marine) may be impacted by waste from the project. These are:

- Spillage of fuels, lubricants and chemicals during abnormal operating conditions or emergency situations.
- Solid or liquid effluent discharge from vehicles during transportation of wastes on and off site.
- Leachate generation from solid waste storage facilities such as greenwaste or recycling lay down areas.
- Discharge of untreated liquid wastes such as brine to the marine environment during normal operations.
- Discharge of untreated liquid wastes such as used fire-water or contaminated run-off from the abnormal operating conditions or emergency situations such as ETP malfunction.
- Discharge of treated liquid wastes from the ETP to the land environment via irrigation.

Controlled discharge of treated wastewater from the ETP to land via irrigation has the potential to impact on human health, soil, water and to a lesser extent, groundwater. Sodium management is a critical issue when using recycled water for irrigation. If present in recycled water used for irrigation, sodium may impact the productive capacity of the land, or significantly degrade surface and ground water quality. The accumulation of sodium in the soil can cause a decline in soil physical properties, especially in porosity and permeability to water.

Direct discharge of brine and other untreated waste streams such as stormwater run-off to the marine environment may impact directly on the water quality in Port Curtis and aquatic fauna and flora through habitat alteration. Brine is the largest contributor to the effluent stream, being disposed at a rate of 78 m^3/h during construction and operation of trains 1 and 2 and 156 m^3/h during construction and operation of trains 3 and 4.

7.2 Discharges to Air

There will be routine emissions to air from normal operations at the LNG plant and through vehicles and shipping movements, largely from the combustion of fuel. Emission sources include:

- Gas turbines to drive the mixed refrigerant and propane compressors (all mechanical).
- Gas turbines for electrical power generation (all mechanical).
- Acid gas removal unit for the removal of carbon dioxide and sulfides from the feed gas.

- Nitrogen removal unit for the removal of nitrogen from the feed gas resource.

The main emissions include nitrous oxides, sulphur dioxide, carbon dioxide, carbon monoxide, particulate matter, hydrocarbons and methane.

Emission to air may also occur during start-up and shutdown operations, minor incidents and emergency events such as large spills, explosions and fires.

The biggest potential impact on the air environment would be from an emergency event such as an explosion, fire or large spill. Emissions may result in ground level concentrations that could impact on the health and wellbeing of humans and fauna. The closest sensitive receptors are the accommodation camps identified for Arrow LNG Plant and the other LNG facilities proposed for Curtis Island.

7.3 Poor Management Practices

The failure to effectively implement and maintain management procedures may result in the following:

- Waste being generated that could be avoided or waste not being segregated for re-use or recycling. Higher quantities of waste than predicted may result in larger quantities being disposed of at regional waste management facilities. These facilities may not have the resources to cope with the unforseen increased rate of disposal.
- Litter may be released from storage areas where lids have not been replaced or fencing is inadequate.
- Odours may be generated if putrescibles wastes such as that from kitchens or accommodation facilities are not collected at a regular frequency.
- Vermin and diseases may establish, reproduce and disperse if waste is not stored, handled or transported in accordance with designated procedures on site. Vermin such as the house mouse (*Mus musculus*) are attracted to waste storage areas as they provide an easy food source. Diseases may be propagated by an increased presence of vermin such as the house mouse. Quarantine waste (solid and liquid) may contain potentially dangerous pests and diseases that may have a serious impact on natural systems, nature conservation values and the economic industry of Australia if not appropriately managed (treatment or disposal).
- Poor housekeeping of waste can result in spills (liquid or solid) which may alter the characteristics of the soil (by adding nutrients) and encourages the growth of opportunistic weed species. Weeds have potential to and have a serious impact on natural systems and nature conservation values.
- Inappropriate location of combustible waste (such as paper and cardboard, waste hydrocarbons and tyres) near ignition sources may result in a fire. Ignition of a fire and its subsequent spread may present a significant threat to the environmental values of the project area. Fire fighting water that is used to suppress fires may be contaminated with residues and may impact on the land and water if not managed appropriately.

8. AVOIDANCE, MITIGATION AND MANAGEMENT MEASURES

8.1 General Principles

During the project construction, operation and decommissioning stages, wastes will be managed to minimise impacts on the existing environment. The principles for sustainable waste management practices for the project include:

- Developing and implementing management and control systems to manage waste through the application of the waste hierarchy (avoid, reduce, re-use, energy recovery/recycle and disposal).
- Minimising the risk of impact to as low as reasonably practicable.
- Minimising contamination of air, land and water.
- Ensuring correct handling, treatment and disposal of all waste.
- Managing waste material as close to source as practicable.
- Maximising the proportion of waste that is reused or recycled.
- Identifying, segregating, storing and managing hazardous and non hazardous wastes appropriately.
- Disposing of waste at appropriately licensed waste management facilities, using licensed contractors.
- Ensuring no solid waste (other than greenwaste) is disposed of on Curtis Island.

A summary of the waste types likely to be generated from the project and their individual management strategies is provided in Table 8.1.

Table 8.1: Summary of wastes and management

Waste	Waste Group	Management Strategy
Solid Waste		
Acid sulfate soils	Regulated	Acid sulfate soils to be managed in accordance with the site acid sulfate soil management plan (prepared in accordance with the *State Planning Policy 2/02 Planning and Managing Development involving Acid Sulfate Soils*) (Coffey Geotechnics, 2011). Stockpile in dedicated bunded area on site for treatment. Re-use as backfill or disposal to a licensed waste disposal facility.
Batteries (wet cell and alkaline)	Regulated	Alkaline batteries to be stored separately from wet cell batteries in lidded and sealed containers in a bunded area. Disposal to a recycling facility.
Biosolids	Regulated	Biosolids will be pumped out periodically and tested to determine if it meets landfill disposal criteria. The biosolids will be transported off site by a licensed contractor for disposal to a licensed waste disposal facility.
Chemical containers and drums	Regulated	Drums to be emptied and stored in a covered bunded area for periodic removal by waste contractor. Disposal to a licensed waste disposal facility.
Clinical waste	Regulated	Stored in clearly labelled sharps and clinical waste containers for periodic removal by a licensed waste contractor. Disposal to a Licensed clinical waste disposal facility.
Concrete	General waste	Stockpile in laydown area until sufficient quantity to mobilise plant to site to crush and screen waste. In order of preference: • Re-use as fill or for road base on site. • Disposal to a recycling facility. • Disposal to landfill
Ferrous and non-ferrous scrap metal	Recyclable	Collected on site and stored in collection bins or at a laydown area (for larger pieces) until sufficient quantity to transport to a scrap metal recycler.
General waste	General waste	Non-recyclable waste will be stored on site in wheelie bins at the accommodation camp and lidded Merrill or skip bins at other locations. Waste will be collected on a weekly basis by a waste contractor and transported to a licensed landfill for disposal.

Table 8.1 (Cont'd): Summary of wastes and management

Waste	Waste Group	Management Strategy
Solid Waste		
Oil contaminated steel drums	Regulated	Drums to be emptied, lidded and stored in a bunded area. Management in order of preference: • Re-use on site. • Return to supplier. • Sold to recycler.
Oily rags and oil filters (drained)	Regulated	Stored in sealed container in a bunded area. Collection and transportation off site by a licensed waste contractor.
Oily sludges	Regulated	Stored in sealed container in a bunded area or will remain in concrete collection pit for vacuum extraction by a licensed waste contractor.
Quarantine waste	Quarantine	Stored and managed in AQIS approved facility. Disposed of by supervised deep burial or incineration.
Recyclable material (tyres, glass, aluminium cans, plastic, paper and cardboard, electronic waste and printer cartridges)	Recyclable	Dedicated collection bins for recyclables will be located at the accommodation camp and the LNG processing facility. Bins will be collected as required by a contractor and transported to a recycling facility in Gladstone or south-east Queensland if feasible.
Spent activated carbon, molecular sieve and ceramic balls	Regulated	Spent filtration/adsorption materials will be changed out from their units periodically. Waste will be collected from units, stored in sealed containers in a bunded area and removed from site by a licensed waste contractor. Analysis of the material may need to be undertaken to ascertain acceptable disposal location.
Timber and greenwaste	General waste	Mulched or chipped for use on-site in landscaping, stabilisation or rehabilitation. Millable timber may be made available to local community if there is a demand. The management of excess timber, in order of preference is: • Removal to mainland for re-use or recycling. • Disposal to landfill (subject to approval).

Table 8.1 (Cont'd): Summary of wastes and management

Waste	Waste Group	Management Strategy
Solid Waste		
Topsoil and overburden	General waste	Topsoil will be stored in stockpiles for use in rehabilitation of operation redundant areas during or at the end of project life. Excess overburden will be stockpiled on site and managed to ensure run-off is controlled and erosion is minimised.
Tyres	Regulated	Stored in dedicated waste management area until sufficient quantity for a licensed waste contractor to remove from site.
White goods	General waste	De-gas refrigerators or air conditioning units. Remove doors and store in a dedicated waste management area. Management in order of preference: • Disposal to reconditioner. • Sell to scrap metal merchant for recycling. • Disposal to a licensed waste disposal facility.
Liquid Waste		
Ballast water	Regulated	The project will comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) and Australian Quarantine and Inspection Service's Australian Ballast Water Management Requirements Version 4.
Brine	Regulated	Discharged to marine environment via a diffuser pipeline. Discharge will be a sufficient distance offshore to promote effective dispersion of effluent.
ETP treated water	Regulated	Stored in a tank and discharged to land via irrigation system and/or used for toilet flushing.
Grease trap waste	Regulated	Grease trap waste will be pumped out of grease trap sump once per month or more regularly if required by a licensed waste contractor and disposed of to a licensed waste disposal facility
Hydrotest water	Potentially regulated	Storage in pipelines or tanks that are being tested. No dedicated storage tank for waste hydrotest water. Water will be re-use on site for additional hydrotesting where necessary and discharged to Port Curtis if water quality meets discharge guidelines or to the ETP for treatment.
Oil contaminated water	Regulated	Collected at a sump and transported with a vacuum truck to a dedicated slops oil tank. Separated water phase at the slops tank bottom will be pumped to the off-specification pit at the CDF for treatment in the ETP

Table 8.1 (Cont'd): Summary of wastes and management

Waste	Waste Group	Management Strategy
Liquid Waste		
Potentially contaminated run-off	Potentially regulated	Run-off directed to a controlled discharge facility where the quality will be monitored and either discharged with the clean run-off stream to the marine environment or diverted to the ETP for treatment.
Quarantine wash down water	Quarantine	Stored in AQIS approved facility. Treated and disposed of by a licensed waste management contractor.
Regeneration effluent	Potentially regulated	Diverted to observation pond where it is monitored regularly and discharged to the marine environment.
Sewage and greywater	Regulated	Pioneer camp and mainland TWAF will be collected for disposal at a licensed wastewater treatment plant. Accommodation village (during construction and operations) and sewage from the LNG Plant and marine infrastructure on Curtis Island will be pumped or gravity fed to the ETP for treatment and subsequently irrigated to land.
Uncontaminated runoff	General waste	Diverted directly to Port Curtis.
Wash down water	Potentially regulated	Diverted to the ETP for treatment
Waste oil	Regulated	Waste oil will be stored on site at the LNG facility in a bunded containment tank. The waste oil will be transported off site by a licensed contractor and recycled
Waste chemicals (water treatment chemicals, TEG, adhesives, paint, cleaning agents etc.)	Regulated	Waste chemicals will be stored on site in clearly labelled sealed containers in bunded areas. Incompatible chemicals will be separated. The chemicals will be transported off site by a licensed contractor and treated if necessary and disposed of at an appropriately licensed waste disposal facility.

8.2 Waste Avoidance

Waste avoidance is a key step in minimising the amount of solid and liquid waste generated by the project. Wherever possible the LNG plant will be designed and engineered to avoid or minimise the generation of waste. During construction of the LNG facility, waste avoidance measures will include:

- Designing the LNG plant drainage system for segregation of the different water streams, including clean run-off, potentially contaminated run-off, dry weather flow and sewage and greywater.
- Designing the LNG plant to maintain integrity during all foreseeable operating conditions (e.g., start-up, shutdown, and normal operation) so that the potential for uncontrolled loss of containment is minimised.
- Designing the LNG plant not to flare or vent hydrocarbons continuously for disposal. During start-up and shutdown controlled flaring is part of the operational procedure.
- Implementing the latest practicable proven stage of development of processes, facilities and methods of operation to minimise fugitive emissions from sources such as pumps, seals, etc. This includes closed draining, minimising the number of flanges, installation of dry gas seals on compressors, vapour recovery systems and where applicable, double seals for hydrocarbon pumps, etc.
- Applying low emissions technology (e.g., dry low-NO_X burners) throughout for significant combustion equipment (e.g., gas turbines). Where combustion techniques cannot be used to reduce NO_X emissions, an end-of-pipe technology such as selective catalytic reduction shall be used.
- Designing and implementing emergency shutdown and detection systems for LNG transfer and tank filling operations.
- Applying the latest proven practicable processes, facilities and methods of operation to minimise fugitive emissions, including closed draining, minimising the number of flanges, installation of dry gas seals on compressors, vapour recovery systems and where applicable, double seals for hydrocarbon pumps.

Where engineering controls cannot be implemented to avoid or minimise waste, management controls will be implemented. Wastes will be minimised through the following actions:

- Clearing the smallest footprint possible for the LNG plant, associated infrastructure and lay down area, thereby reducing the generation of greenwaste, acid sulfate soil, overburden, topsoil and greenhouse gases from avoidable plant and equipment use.
- Using low sulfur diesel (maximum 0.01% sulfur by mass) on site.
- Implementing a procurement policy for goods and services for the project encouraging the following in order of preference:
  - Elimination of hazardous chemicals or other materials that may be difficult to dispose of.
  - Substitution of the goods and services for more environmentally acceptable options.

  - Minimisation of health and environmental risk by the appropriate storage and management system in place to prevent spills.
- Implementing a routine preventative maintenance program to ensure plant and equipment is maintained in good working order, reducing the risk of malfunction and possible releases of waste to the environment.
- Ensuring unsealed roads and stockpiles are watered to minimise dust generation during dry, dusty periods.

8.3 Waste Recycling

Waste recycling is a large component of the waste management strategy used in the project. To maximise the re-use and recycling potential of wastes generated on site during construction, dedicated skip bins for designated wastes will be placed strategically around construction areas. In addition, a dedicated waste sorting/lay down area will be established early in the project. This area will have the necessary equipment to sort, compact, mulch and store waste quickly and safely.

Inert material such as concrete and gravel will be stockpiled in the waste sorting/lay down area and periodically crushed and screened when sufficient quantity has been gathered. The crushed materials will be used as road base and fill or disposed of to landfill.

Leaves, branches and timber will be mulched on site and used for site stabilisation/erosion control and landscaping. Timber and mulch may be made available to the local community if there is a demand for the material. Millable timber will be stored on-site and loaded on to trucks and shipped from Curtis Island to the mainland on ferries on an as needs basis. Timber which is unsuitable for milling or which exceeds the local capacity for timber use may need to be disposed of to landfill as green waste for mulching, subject to agreement with the Gladstone Regional Council. The Benaraby Regional Landfill is not currently in a position to accept commercial volumes of green waste (R. Doherty, pers. comm., 10 June 2010), however the materials recovery facility that opened in Rockhampton in November 2010 may be able to accept some timber for recycling. Other options include developing partnerships with local industry and using the waste timber for energy generation or recycling.

The following materials will be sent to recyclers via waste management contractors whilst markets are viable:

- Ferrous and non-ferrous metals.
- Paper and cardboard.
- Glass.
- Spent sulfuric acid and batteries.
- Waste oil.

All solid wastes that cannot be recycled or re-used will be disposed of to landfill or other disposal locations that are licensed to accept the particular type of waste. Arrow Energy will not be constructing a landfill on Curtis Island.

8.4 Storage and Handling

The following measures will be implemented to minimise risks to the environment from the storage and handling of liquid wastes on site during construction and operation of the LNG plant:

- During construction, waste materials will be transported from the LNG plant to designated waste management facilities regularly to ensure that no spillage or dispersal of wastes occurs within construction working spaces.
- Bunded storage facilities will be provided for fuels and other chemical or hazardous wastes.
- Bunds for liquid hazardous wastes will be designed in accordance with *AS 1940–2004: The Storage and Handling of Flammable and Combustible Liquids* (Standards Australia, 2004a) and *AS 3780-2008: The Storage and Handling of Corrosive Substances* (Standards Australia, 2008).
- Bunded compounds will have drainage and sump systems in place to assist with the drainage and removal of any waste materials or products released into the containment system.
- Bunds will be pumped out as required to remove stormwater to maintain live capacities. Stormwater will be disposed of appropriately, either to the ETP or into a containment facility designed to store that type of waste.
- The oil storage area, fuel filling points, and mechanical repair shop will have a hard stand surface to protect land and water against leakage of chemicals and petroleum products. The hard surfaced areas will be appropriately contoured to ensure drainage to the ETP system.
- Stockpiles of waste materials such as concrete, tyres, waste polyethylene etc. will be located in dedicated laydown areas with drainage that connects to the CDF.
- During construction, all waste storage bins will be inspected regularly to determine the need for additional removals off site to designated waste management facilities.
- Where practicable, all loading and unloading of liquid wastes will take place within a containment area.
- Containers storing liquid hazardous waste will be securely closed.
- All containers will be labelled for clear identification of the contents as per the appropriate regulations.
- Hazardous wastes will not be mixed with non-hazardous wastes, or stored with any non-compatible wastes.
- Spill kits will be located adjacent to liquid waste storage and waste treatment areas.
- Training in spill response will be conducted for all employees.
- Waste storage bins for domestic and food wastes will be covered.
- Waste generated from accommodation quarters will be collected on a regular basis by an appropriately licensed contractor.
- Excess topsoil will be stockpiled for future use in the rehabilitation of the site.
- Excess overburden that is not suitable for hardstand use or site fill will be stockpiled on site and managed to ensure run-off is controlled and erosion is minimised.

8.5 Waste Treatment

The following wastes will be treated on site:

- Contaminated or potentially contaminated stormwater from process areas at the LNG plant.
- Dry weather flow such as water from wash down bays and liquids wastes from the laboratory.
- Effluent from LNG operations such as wastewater and slops oil from boil off gas compressor area or flare knock out water.
- Gas turbine wash water.
- Oily water from the slops oil tank.
- Sewage and greywater from the accommodation facilities and the LNG plant.

All waste streams listed above will be treated by the ETP, with the exception of sewage from the pioneer camp and the TWAF. Sewage and greywater generated from the pioneer camp will be collected in portable disposal units or other mobile collection facilities. A licensed waste contractor will be used to service the sewage facilities and dispose of effluent at a licensed waste management facility. Sewage from the TWAF constructed on the mainland near Gladstone will be connected to the local sewerage network or will be collected in portable disposal units or other mobile collection facilities.

Sewage and other effluent flows from the LNG plant are either gravity fed or pumped to the ETP for treatment. To minimise the risk of impact on the environment from liquid waste treatment, the following management measures will be implemented:

- The ETP package units are sized to meet the final effluent discharge requirement.
- The ETP design is based on the first 30 mins of peak rainfall flow estimation from process areas.
- Treated effluent is monitored and any discharge that is off-specification is re-routed back to the ETP for re-treatment.
- Alternative storage and disposal options will be available during times of system failure and in conditions preventing discharge to land such as rain events. The ETP discharge is distributed to tanks for re-use on site. The tanks can be by-passed and the treated effluent discharged to the marine outfall if necessary.
- Records of inspection, maintenance, sampling, and cleaning of the ETP will be maintained.

8.6 Waste Transportation

The following measures will be implemented to minimise risks to the environment from the transportation of wastes on and off site:

- All waste shall be removed from the LNG plant by a licensed waste contractor. It is anticipated that barges used to deliver materials and personnel to site will be employed to transport vehicles that convey wastes back to the mainland.
- If regulated waste is being transported then vehicles will be licensed to carry the particular type of waste and appropriate waste tracking documentation will be completed.

- All vehicles entering and leaving the island will be clean and loads securely stowed, and covered where practicable.
- All wastes removed from the site will be recorded in a waste register.

8.7 Waste Disposal

8.7.1 Waste Disposal on Curtis Island

There are three streams of waste that will be disposed of on Curtis Island:

- Liquid waste that will be treated on site, stored and discharged to land or re-used.
- Liquid waste that will be untreated and discharged directly to the marine environment.
- Solid inert waste that will be crushed or mulched, stored and re-used on site.

There will be no waste disposed in landfills or by incineration on Curtis Island.

8.7.1.1 Liquid Waste to Land

Treated wastewater from the ETP will be irrigated to land or re-used around site. A recycled water management plan will be developed that will outline the following:

- Areas and vegetation to be irrigated.
- Distribution systems.
- Type of irrigation system/s.
- Monitoring program including data review and reporting.
- Health and safety requirements, including buffer distances and signage.
- Contingency plan for abnormal operations or wet weather conditions.
- Training of staff and contractors.

As a part of the development of the recycled water management plan a site assessment and desktop study will be undertaken to select appropriate sites, vegetation and irrigation method. The study will include an assessment of the following:

- Topography (e.g., slope and runoff potential).
- Local climate (e.g., rainfall and intensity, evaporation and prevailing winds).
- Soils (e.g., permeability and drainage, salinity and sodicity, soil structure and acid sulfate soil status) and potential impacts from nutrients, salts and heavy metals in recycled water.
- Site hydrology and flooding potential.
- Ground water depth and quality and potential impacts from hydraulic loadings and treated wastewater quality.
- Interaction between treated wastewater and vegetation (e.g., evapotranspiration rates, salinity tolerance, nutrient and hydraulic requirements).
- Potential health impacts on employees and site visitors including inadvertent or unauthorised use.
- Location of utilities and infrastructure (e.g., supply of electricity, road access, requirement for easements).

- Surface water proximity and quality and possible impacts on water quality and aquatic flora and fauna from treated wastewater runoff.
- Terrestrial and aquatic flora and fauna that could be affected by the irrigation of treated wastewater.

Liquid Waste to the Marine Environment

The untreated liquid waste streams that will be discharged directly to Port Curtis include:

- Brine from the RO plant.
- Demineralisation plant regenerate effluent.
- Stormwater from clean catchment areas and roof run off.

Brine will be directed from the RO plant into Port Curtis via a diffuser outfall pipe located a sufficient distance offshore to ensure free flowing current conditions to adequately disperse the brine.

The demineralisation plant regenerate effluent generally does not contain contaminants except some minor chemicals (biocides and algaecides) which will be significantly diluted by the large volume of brine in the discharge stream.

The clean catchment run off will be collected through peripheral drains discharging to a marine outfall.

The following management measures are implemented to ensure the untreated liquid waste streams do not adversely impact on the receiving environment:

- The marine outfall pipe will be designed with the diffuser oriented with ports perpendicular to the dominant flood and ebb tide current directions, allowing the diffuser to perform similarly under both conditions.
- An observation basin for the discharge stream through the outfall will be provided for inspecting the quality of the water before being discharged into the marine environment. The quality of the discharge will be monitored and recorded.
- Signs will be installed on site clearly indicating drains that discharge directly to the marine environment.
- Marine water quality impact monitoring will be conducted periodically to ascertain water quality both inside and outside the mixing zone in Port Curtis.

8.7.1.3 Solid Waste to Land

Solid waste that can be re-used around site includes materials such as concrete and timber. The following management measures will be implemented:

- Timber and green waste generated during construction will be mulched, stockpiled and re-used on site wherever possible. Mulch will be used in stabilising batters, controlling erosion, soil conditioning and general landscaping.
- Inert material such as concrete will be stockpiled in dedicated lay down areas and crushed on site and used as road base or fill.
- Excess concrete will be transported to the mainland if there is no use for the material on site.

- The drainage from lay down areas will either be discharged to the marine environment or diverted to the CDF depending on the level of risk of impact posed by each individual lay down area.

8.7.2 Waste Disposal Off-Site

8.7.2.1 Liquid Waste

The liquid waste streams that will be disposed of by licensed waste contractors include:

- Waste solvents.
- Engine coolants.
- Spent TEG.
- Waste chemicals, paints and cleaning agents.
- Off-specification water treatment chemicals.

Liquid wastes such as solvents and spent TEG are likely to be reprocessed for eventual re-use. Waste chemicals, off-specification water treatment chemicals and wastewater from the acid gas removal unit may need to be treated by a licensed waste contractor to ensure suitability for disposal as trade waste at a licensed wastewater treatment facility.

A licensed waste contractor will be engaged to remove liquid wastes from site on an as is required basis.

Solid Waste

All solid waste that cannot be re-processed or recycled on-site will be transported off site by a licensed waste contractor for ultimate disposal at a recycler, re-processor or other waste management facility such as a landfill. The majority of the solid waste will be disposed of at the Benaraby Regional Landfill. Agreement for the disposal of solid waste at the Benaraby Regional Landfill will be obtained from the Gladstone Regional Council.

8.8 Specific Waste Management

8.8.1 Stormwater

Stormwater is generally not considered a waste if it is clean. However stormwater may be contaminated if it has drained through areas that contain contaminants, in which case it is considered waste. The following management measures will be implemented for stormwater:

- Uncontaminated stormwater will be diverted through two systems of vegetated swales and wetlands designed to settle out sediments and filtrate the stormwater prior to being discharged to the marine environment. During construction, a temporary sedimentation basin will treat run-off from the construction camp.
- Potentially contaminated stormwater will be diverted to the CDF where it will be monitored and either diverted to the ETP if contaminated or discharged to the marine environment if it is uncontaminated.
- Water captured in bunds and sumps will be assessed and disposed of as soon as practicable.

- All discharges to the marine environment will pass through an observation basin where the discharge will be monitored.

8.8.2 Sewage

The proposed management measures for sewage are outlined in Section 8.7.1.

8.8.3 Brine

The proposed management measures for brine discharge to the marine environment are outlined in Section 8.7.1.

8.8.4 Marine Wastes

Management of shipping waste such as wastewater discharges from shipping ballast will be regulated by the International Convention of Pollution from Ships (MARPOL) as established by International Maritime Organisation.

The regulation of shipping waste is undertaken by Gladstone Ports Corporation under a certified agreement with the Australian Quarantine Inspection Service. The Australian Quarantine Inspection Service deems all salt water from ports and coastal waters outside Australia's territorial sea to present a high-risk of introducing exotic marine pests into Australia. The discharge of high-risk ballast water from ships is prohibited anywhere inside Australia's territorial sea.

Therefore, ballast water will be required to be exchanged in international waters prior to entering the Great Barrier Reef Marine Park. Other wastes will be collected from the ships by an authorised collector vessel.

8.8.5 Dredging Spoil

Dredging spoil from the initial deepening and widening of existing channels, swing basins, berth pockets and construction and operation of the marine facilities will be treated for acidity if required and disposed of into reclamation areas designated as part of the Western Basin ‘Fishermans Landing Northern Expansion Area’. Tail water will be managed consistently with the measures proposed in the Western Basin EIS and subsequent approval conditions and management plans.

8.8.6 Tunnel Spoil

Tunnel spoil (slurry) from the tunnel boring machine will be dewatered prior to being re-used as fill in the constructed reclamation area adjacent to the tunnel launch shaft. The tail water from the tunnel boring machine will be treated to remove solids and acidity as a result of contamination from acid sulfate soils prior to being discharged to the intertidal area adjacent to the tunnel launch shaft.

8.8.7 Acid Sulfate Soils

Acid sulfate soils to be managed in accordance with the site acid sulfate soil management plan (prepared in accordance with the *State Planning Policy 2/02 Planning and Managing Development involving Acid Sulfate Soils*) (Coffey Geotechnics, 2011). This will include:

- Stockpiling acid sulfate soils in dedicated bunded areas on site for treatment.

- Re-using treated acid sulfate soil as backfill or disposal to a licensed waste disposal facility.
- Staff training requirements.
- Monitoring, reporting and auditing.

8.8.8 Hydrotest Water

Hydrotest water will be either seawater or treated water from the RO plant. The hydrotest water will be re-used on site for additional hydrotesting where necessary or discharged to Port Curtis via the marine outfall diffuser pipe if water quality meets discharge guidelines. If water does not meet discharge criteria it will be diverted to the ETP for treatment.

8.8.9 Regulated Wastes

Regulated wastes include waste oils and associated wastes, molecular sieve waste (generated by the dehydration and mercury removal unit), used batteries, and spent solvents. The following management measures are proposed for regulated wastes:

- All regulated wastes will be disposed of at licensed waste management sites within Queensland, unless a specialised treatment is required that is not available in Queensland at the time treatment and disposal is required.
- All regulated wastes will be transported by a waste transporter with the appropriate DERM authority to collect and dispose of the waste.
- All procedures required by DERM will be followed.

8.8.10 Wastes from Abnormal Operating Conditions or Unplanned Events

Atypical or abnormal operating conditions are considered to be events that could potentially occur that are not part of normal and expected operations and include plant shut down or start-up, spills, fires and storm events.

Plant Start-Up and Shutdown

The main wastes generated during plant start-up and shutdown are gaseous emissions. The gaseous emissions are managed during these times by being directed to a common knock out drum and flare stack. Five stacks and five knock-out drums will be installed including:

- One emergency/operational system for warm, heavy, wet streams from the feed gas inlet facilities and gas metering unit, the acid gas removal unit, the dehydration unit, the mercury removal unit, the liquefaction unit (defrost gas system), the fuel gas unit and the wet hydrocarbon disposal system.
- Two emergency/operational system for cold, light, dry streams (all hydrocarbon streams that can be cold but are without any water content) from the liquefaction unit (except defrost gas system) and the refrigerant storage unit.
- One emergency/operational system for hydrocarbon streams from LNG storage and loading (boil off gas and vapour return from the jetty) that would normally be compressed into plant fuel gas.

- One operational flare for operational releases required to be relieved during start-up of the LNG plant. The flow through the operational flares will be staged through different burners to ensure smokeless operation.

A spare flare will be installed as backup in the event that any of the flares are out of service for maintenance and inspection. There will be no liquid waste disposal burners.

All flare systems are designed without any pump out facilities and as a result any remaining liquids in vessels will be evaporated by an electric heater.

Limited solid or liquid wastes are expected from plant start-up or shutdown operations.

Spills

Spills and emergency conditions may occur from loading/unloading operations, equipment failure or accidents. Spills that occur in process areas will drain to the CDF where the first flush will be monitored and either diverted to the ETP or discharged to the marine outfall depending on the quality of the effluent. There will be no major volumes of liquid stored on site other than LNG so it is anticipated that any spill, other than a sudden failure of an LNG storage tank, will be diverted and contained in the CDF. The CDF is designed to store 30 minutes of peak flow rainfall quantity from the process areas. The preliminary design capacity is 2,100 m^3 but this will be confirmed once FEED has been completed. Small spills will be contained and cleaned up with absorbent materials provided in spill response kits or by vacuum trucks.

In the event of an LNG release, safe dispersion of the released gas will be allowed, maximizing ventilation of areas and minimizing the possibility that gas can accumulate in closed or partially closed spaces. Spilled LNG will be left to evaporate.

For unloading and loading activities involving marine vessels and terminals, Arrow Energy will prepare and implement specific spill prevention procedures according to applicable international standards and guidelines. Spill prevention procedures will specifically address advanced communications and planning with the receiving terminal.

Fire

Fire is considered an extreme safety risk and design for fire prevention and minimisation of risk will be intrinsic to the plant design.

The main waste likely to be produced in the event of a fire is contaminated fire fighting water. The fire fighting water may be contaminated with bi-products of combustion, suspended solids (such as charcoal), fire extinguishing agent such as medium expansion foam for hydrocarbon fires, carbon dioxide or urea based potassium bicarbonate dry chemical.

A majority of the firewater is used to protect equipment against overheating (i.e., such as flooding LNG tanks) thus preventing further escalation of the fire emergency and will be relatively uncontaminated.

Firewater that is used in any process areas or other areas draining to the controlled discharge facility enters the CDF where the first flush is diverted to the ETP. Additional firewater is directly discharged to the marine outfall.

Storm Events

The main risk of impact on the environment from waste during storm events is the generation of contaminated stormwater from contact with hydrocarbon or chemical residues in storage facilities such as bunds. If a storm event is large enough, bunds may overflow, potentially releasing contaminated stormwater. Bunds will be located in areas that drain to the CDF or ETP so contaminated stormwater will be captured for treatment or diverted to the marine discharge outfall if water quality meets specified discharge criteria.

Arrow Energy will conduct a risk assessment of discharges from bunded areas and any bunds considered to be high risk will have instrument protection installed including high level alarms, manual inspection and pump out and automatic valving with drainage to the CDF.

All bunds will be maintained in an empty condition to maximise capacity in the event of a storm or spill.

8.9 Health, Safety and Environmental Management System

Waste will be managed under an integrated site health, safety and environmental management system (HSEMS) that aims to provide a framework for the control, mitigation, and monitoring, reporting and auditing necessary to prevent potential adverse health, safety and environmental effects. The HSEMS is based on the Australia/New Zealand Standard AS/NZS 14001:2004 Environmental Management Systems – Requirements with Guidance for Use and the Australia/New Zealand Standard AS/NZS 4801:2000 Occupational Health and Safety Management Systems – Specification with Guidance for Use and the International Standard OHSAS 18001 and is a tiered management structure of the following levels:

- Site health, safety and environmental policies that contain the documented commitments of Arrow Energy and are signed off by the Arrow Energy Chief Executive Officer.
- The identification of health, safety and environmental attributes of products, activities and services and their effects (impacts) on health, safety and the environment based on all Arrow Energy's activities.
- Management plans that outline site and function specific implementation and operation plans with respect to health, safety and environmental management.
- Procedures, guidelines, forms, checklists and registers associated with all of Arrow Energy's significant health, safety and environmental aspects.
- System review process of the HSEMS structure to ensure its continuing suitability, adequacy and effectiveness (continuous improvement).

The development and implementation of the project HSEMS will be co-ordinated by environmental and health and safety specialists with expertise in the field of health, safety and environmental management systems.

Environmental procedures will be developed outlining actions to be taken in the event of incidents and emergency situations, training requirements, auditing, inspection, monitoring and reporting requirements.

Site specific waste management procedures will be developed for the construction, operational and decommissioning phases of the project. Construction contractors will be required to comply with the Arrow Energy procedures.

8.9.1 Incidents and Emergency Response

Arrow Energy will develop and implement spill/emergency response plans outlining measures to be taken in the event of a spill or emergency situation. These plans will:

- Link to a national or local oil and chemical spill response plan, which includes interfaces with the relevant local authorities.
- Outline prevention and control measures for significant scenarios and magnitude of releases, including events such as LNG leaks, fires, spills from marine vessels and terminals.
- Outline measures to be taken in the event of a gas leak, effluent leak or fire.
- Outline responsibilities for spill/emergency response.
- Detail investigation and reporting procedures.
- Be supported by the necessary resources (such as spill response equipment) and training.

8.9.2 Training

A comprehensive training program will be established and includes the following:

- Site inductions.
- Job and site specific training.
- Incident and emergency response training.

8.9.3 Auditing and Monitoring

Arrow Energy, as part of the HSEMS, will have a rigorous auditing and monitoring program to not only ensure environmental health is maintained, but to also ensure systems and procedures relating to environmental management are being implemented and complied with.

Auditing

Performance and compliance audits and inspections will be conducted regularly during construction and operational phases of the project. The following types of audits and inspections are likely to occur on site:

- Audits of the EMS with results reported to the Chief Executive Officer.
- Waste audits during construction and operation phases of the project.
- Housekeeping inspections of waste management storage and treatment facilities.
- Audits of waste records to identify if additional waste avoidance, reduction, reuse or recycling measures can be achieved.
- Audits of performance data, such as the discharge from the ETP to determine if system improvements can be made.

- Audits of the site environmental management system to ensure that procedures, guidelines and policies are being complied with by staff and contractors.

Monitoring

Regular monitoring of emissions to the environment will be conducted at the Arrow LNG Plant. Monitoring relating to waste management, storage and transport is outlined in detail in Section 10.

8.9.4 Reporting

Information gathered on waste generated at the LNG Plant and associated infrastructure, environmental performance monitoring data and audit and inspection results will be used not only to ensure the waste management system on site is continually improving but will also be used to meet statutory reporting obligations. These reports include the following:

- Tracking of regulated wastes.
- Reporting on greenhouse gas emissions.
- Reporting on National Pollutant Inventory substances.
- Compliance reporting from project approval or license to operate.

Regulated Waste Tracking

The treatment, storage and transport of most regulated wastes is required to be tracked in accordance with the EP Regulation (Waste). As a waste generator, Arrow Energy will report the following information to DERM:

- The generator's name, address, local government area, contact details and identification number.
- The name, address and contact details of the person to whom the waste is to be transported.
- The day and time the generator provides the waste to a transporter for transporting to a regulated disposal facility.
- The load number.
- The consignment number for any load being transported out of Queensland.
- The type and number of containers if the waste is dangerous goods.
- The following details of the waste:
  - Waste type.
  - Quantity in kilograms or litres.
  - Physical nature (solid, liquid, paste or gas).
  - Waste code.
  - Waste UN number found in the Australian Dangerous Goods Code (if any).
- The waste packaging group designator found in the Australian Dangerous Goods Code (if any).
- The waste dangerous good class and any subsidiary risk found in the Australian Dangerous Goods Code (if any).

- The waste origin code for the activity that produced the waste.

National Greenhouse and Energy Reporting System

The *National Greenhouse and Energy Reporting Act 2007* dictates that businesses who are large emitters of greenhouse gases will be required by law to measure and report their emissions to the government. Organisations that exceed either greenhouse gas or energy thresholds must report their:

- Greenhouse gas emissions.
- Energy production.
- Energy consumption.

Reporting on greenhouse emissions and energy use and consumption will be an annual requirement for the project.

National Pollutant Inventory

Australian industrial facilities are required by law to report annually to the National Pollutant Inventory (NPI) if the amount of fuel, electricity or NPI substances they use triggers a “usage threshold”. The project will calculate the emissions and transfers of substances in waste from their site, and provide the results to DERM who review the report for accuracy before forwarding the data to the Department of Sustainability, Environment, Water, Population and Communities who publish the data on the NPI website.

Reporting on emissions and transfers in waste will be an annual requirement for the project.

Compliance Reporting

Compliance reporting will be required as a condition of project approval. Details of the following may be required to be reported on a regular basis (typically annually):

- Environmental incidents.
- Quality and quantity of effluent discharged to the environment.
- Monitoring of the quality of receiving environments.

Arrow Energy will collect and maintain data required to ensure compliance monitoring reporting requirements can be met.

9. RESIDUAL IMPACTS

The results of the residual environment impact assessment (i.e., after management/mitigation has been applied) are shown in Table 9.1.

A majority of the potential residual impacts were assessed as either a low risk as a result of the management and mitigation measures proposed for the project. The contamination of surface water by discharge of RO brine was categorised as a moderate risk, largely as a result of the discharge being of a continuous nature, rather than the impact having significant consequences.

Hydrodynamic dispersion modelling of the brine discharge into Port Curtis by WBM (2011) has indicated that the zone of impact is limited as the brine salinity will reach close to background salinity within 5 to 10 meters of the marine outfall.

The impact on soils from irrigation of treated effluent was categorised as a moderate risk, largely as a result of the discharge being of a continuous nature, rather than the impact having significant consequences. Impacts to the soil from repeated irrigation of treated effluent will occur gradually and regular monitoring of the treated effluent and the soils in the irrigated areas will ensure that any impacts to the soil will be detected before any long term damage occurs.

The environmental impacts resulting from unexpected events, such as LNG spills, contaminated firewater etc. was assessed as a low risk, due to the improbability of such an event and the facility design and spill and emergency response plans proposed to mitigate any impacts.

The overall residual risk to the environmental values of the project area as a result of the waste management activities for the proposed Arrow LNG Plant is considered to be minimal in view of the comprehensive control measures proposed to prevent adverse environmental outcomes.

Table 9.1: Results of residual impact assessment

Potential Impact	Source	Proposed Management Measures	Likelihood	Consequence	Residual Risk	Residual Risk Management
Land and Water	Contamination from run-off from waste storage (inert waste, acid sulfate soils, oily wastes, recyclables, greenwaste etc.)	Storage of all wastes except inert wastes in dedicated impermeable bunded areas. Storage containers sealed or under cover. Bunds designed in accordance with *AS 1940 – 2004: The Storage and Handling of Flammable and Combustible Liquids* and *AS 3780-2008: The Storage and Handling of Corrosive Substances.* Acid sulfate soils managed in accordance with the site acid sulfate soil management plan (prepared in accordance with the *State Planning Policy 2/02 Planning and Managing Development involving Acid Sulfate Soils*) (Coffey Geotechnics, 2011).	Unlikely	Insignificant	Negligible	Monitoring and measurement of receiving environment
Water - Marine	Contamination from discharge of RO brine	Discharge of brine located sufficiently offshore to minimise stagnation close to shore. Outfall designed to maximise dispersion.	Almost certain	Minor	Moderate	Monitoring and measurement of receiving environment
Water - Marine	Contamination from discharge of ballast water.	No discharge of high-risk ballast water in Australian ports or waters. All waste to be collected by an authorised collector vessel. Discharges to comply with the International Convention for the Prevention of Pollution from Ships (MARPOL), and Australian Quarantine and Inspection Service's Australian Ballast Water Management Requirements Version 4.	Possible	Minor	Low	

Table 9.1 (Cont'd): Results of residual impact assessment

Potential Impact	Source	Proposed Management Measures	Likelihood	Consequence	Residual Risk	Residual Risk Management
Land and Water	Contamination by accidental discharge of solid or liquid waste, hazardous materials or firewater.	Spill and emergency response plans and equipment conveniently available to address all types of spills including small spills. Bunds designed in accordance with *AS 1940 – 2004: The Storage and Handling of Flammable and Combustible Liquids and AS 3780-2008: The Storage and Handling of Corrosive Substances.* An emergency shutdown and detection system available to initiate automatic transfer shutdown actions in case of a significant LNG leak. The facility drainage system designed to ensure that accidental releases of hazardous substances are contained on site, including up to a maximum of two hours of fire fighting water from any one process area. The facility drainage and effluent treatment system will have continuous monitoring equipment fitted to monitor quality of effluent and divert non-compliant effluent back to effluent treatment plant. Staff provided with spill and emergency response training.	Possible	Minor	Low	Monitoring and measurement of receiving environment

Table 9.1 (Cont'd): Results of residual impact assessment

Potential Impact	Source	Proposed Management Measures	Likelihood	Consequence	Residual Risk	Residual Risk Management
Land and Water	Discharge of treated wastewater from ETP to land via irrigation	Treated effluent managed in accordance with the Queensland Water Recycling Guidelines (EPA, 2005). Regular monitoring of the treated water prior to discharge. Introduce buffer zones to reduce risk of human contact. Diversion of treated wastewater to marine outfall in the event of wet weather. Train staff regarding the risks and use of treated water, including hygiene practices.	Almost certain	Minor	Moderate	Monitoring and measurement of receiving environment
Local air quality	Dust from concrete crushing plant	Implementation of dust suppression measures on any unsealed waste management storage areas and during crushing and screening of concrete.	Possible	Insignificant	Low	Monitoring and measurement
Local air quality	Odours from biodegradable waste	The storage of biodegradable (putrescible) waste to be limited to one week on site. All biodegradable waste to be stored in covered bins. The effluent treatment plant to be regularly inspected and emptied of sludge.	Possible	Insignificant	Low	

Table 9.1 (Cont'd): Results of residual impact assessment

Potential Impact	Source	Proposed Management Measures	Likelihood	Consequence	Residual Risk	Residual Risk Management
Human health and biodiversity	Pests and diseases from biodegradable and quarantine wastes	The storage of biodegradable (putrescible) waste to be limited to one week on site. All biodegradable waste to be stored in covered bins. Quarantine wastes to be managed in accordance with AQIS requirements.	Possible	Insignificant	Low	Regular site inspections for pests and diseases with control measures undertaken when required.
Landscape and visual amenity	Litter nuisance from general waste storage.	Storage of all potential windblown waste in lidded bins. Regular site inspections and litter clearance. Covering of all delivery vehicles.	Likely	Insignificant	Low	Regular site inspections for litter with control measures to be undertaken when required.
Air quality and human health	Fire from waste stockpiles (paper and cardboard, tyres or timber) and hazardous waste storage.	Hazardous materials to be segregated and stored in dedicated bunded facility. Combustible waste stockpiles to be located sufficiently away from other wastes to minimise spread. Fire suppression equipment located at dedicated lay down areas. Implementation of site fire management plan. Implementation of spill management procedures. Staff provided with spill and emergency response training.	Possible	Minor	Low	Regular inspections to ensure appropriate storage of materials on site.

10. MONITORING

A comprehensive monitoring program will be implemented by Arrow Energy as part of the site environmental management system. Monitoring will be required pre-site development (baseline monitoring), during construction, operations and decommissioning and post-closure.

The monitoring program will include requirements for:

- Monitoring of compliance with approval conditions.
- Assessment of the actual quantities and types of wastes compared to predicted waste streams and quantities, with a view to implementing improvements to waste management practices where required.
- Monitoring of potential impacts from wastes on the receiving environment.
- Ensuring regulated wastes are transported and disposed of appropriately.

Waste management related inclusions in the site environmental monitoring program are:

- Contractors on site during construction or maintenance operations will be required to comply with the Arrow Energy environmental management system and produce and implement a construction waste management plan (to be approved by Arrow Energy).
- During construction, all waste storage bins will be inspected regularly to determine the need for additional removals off site to designated waste management facilities.
- All waste produced on site will be monitored and details recorded in a site register. The register will include details on:
  - Source of waste.
  - Type of waste.
  - Quantity of waste.
  - Storage location and details.
  - Dates of collection.
  - Date of disposal/recycling.
  - Name and details of transporter and facility used to dispose the waste.
- Housekeeping inspections will be undertaken on a weekly basis and will include as a minimum details on:
  - Waste storage and lay down areas.
  - Waste segregation bins/stockpiles.
  - Levels of windblown litter.
- Equipment will be installed to monitor and record emissions for which regulatory limits exist and/or for which performance statistics are required.
- All monitoring and recording will be based on automatic on-line technology, in line with current best practice.
- All emission stacks will be fitted with emissions monitoring ports suitable for continuous monitoring even if continuous monitoring is not recommended/possible, in order to facilitate future monitoring if required.

- Effluent discharge ports will be fitted with continuous monitoring equipment to ensure water quality complies with discharge criteria.
- Treated wastewater from the ETP will be monitored and any wastewater that is off-specification will be re-routed back to the ETP for re-treatment.
- Impacts on the environment from the use of treated wastewater will be monitored. Monitoring will include:
  - Soil.
  - Vegetation being irrigated.
  - Water resources (surface or groundwater) that are near to irrigation areas.
- Discharges to the marine environment will be monitored to ensure they meet discharge criteria. Additionally, a marine monitoring program will be implemented to monitor the quality of the marine waters within Port Curtis, particularly in and around the brine discharge location off Boatshed Point.

11. CUMULATIVE IMPACT ASSESSMENT

Assessment of the cumulative impacts relating to wastes produced by the Arrow LNG Plant has been divided into two distinct assessments; those relating to direct impacts on the environment (land, air and water (marine and terrestrial); and those relating to impacts on waste management infrastructure, resources and services.

11.1 Impacts on the Receiving Environment

The assessment of cumulative impacts of discharges to the marine environment, surface water, and the local air shed have not been considered as part of this study as these impacts are being assessed by the following technical specialists:

- Coastal Processes, Hydrodynamics and Marine Water Quality Impact Assessment (WBM, 2011).
- Aquatic Ecology Impact Assessment (Ecosure, 2011).
- Plume Rise Impact Assessment (Katestone, 2011b).
- Acid Sulfate Soil Impact Assessment (Coffey Geotechnics, 2011).
- Climate Change Impact Assessment (PAEHolmes, 2011).
- Contaminated Land Impact Assessment (Coffey Environments, 2011a).

A summary of the potential cumulative impacts to land from waste handling and storage and wastewater re-use (i.e., irrigation of treated effluent to land) is provided in this report, however these impacts are addressed in detail in the Contaminated Land Study by Coffey Environments (2011a).

The Arrow LNG Plant and any other proposed projects adjacent to or nearby the Arrow LNG Plant will be required to minimise the potential for soil, groundwater and water contamination to the maximum extent practicable by ensuring wastes are stored, handled and disposed of in accordance with applicable legislation. As a result resultant impacts to land are likely to only occur as a result of an abnormal or emergency event. These events are usually of short duration (typically less than a few hours) and low frequency. It would be unlikely that the timing of a discharge at the Arrow LNG Plant would co-incide with a similar discharge at neighbouring premises and be of a quantity significant enough to migrate and impact land off the project site.

Treated wastewater from the ETP at the Arrow LNG Plant will be discharged to land on a daily basis. Excess water may occasionally be discharged through the Boatshed Point marine outfall into Port Curtis. Other neighbouring LNG plants will operate in a similar manner to the Arrow LNG Plant (irrigating treated effluent to land) or alternatively discharge treated effluent to Port Curtis under normal operating conditions and storm events/wet weather.

The wastewater from all sites will need to meet regulatory standards prior to discharging to either the land or marine environments. Maximum application rates, determined after soil assessment, water quality confirmation, irrigation method and vegetation to be irrigated, will need to be adhered to ensure soil is not degraded or run-off is generated. The rigorous management and

monitoring plan that will be implemented by Arrow Energy will ensure that impacts to land will be minimised and run-off or migration of treated effluent will be minimised. Neighbouring LNG plants will also be required to implement a similar level of control on their irrigation systems to minimise potential impacts to human health and the environment.

Given the regulatory standards for discharge and irrigation of treated effluent combined with the rigorous management and monitoring that will be conducted by all projects within the region the cumulative risk of contamination of land from the irrigation of treated effluent or from waste storage and handling activities is therefore low.

11.2 Utilisation of Regional Infrastructure

In order to ascertain the cumulative impact of waste on existing local waste management infrastructure, resources and services, a baseline case has been developed that includes the following:

- The quantities of waste currently being disposed of at waste management facilities by existing domestic, industrial and commercial sectors.
- The quantities of waste likely to be disposed of at these facilities by projects that have taken a financial investment decision at the date of this report (see Table 11.1 for projects).

Table 11.1: Baseline projects

Name of project	Proponent(s)	Waste impacts relevant to the Arrow LNG Plant
GLNG Project	Santos Limited (and partners Petronas, Total and KOGAS)	• EIS and Supplementary EIS complete. Project approved with conditions by the Queensland Coordinator-General. • Project approved with conditions by the Commonwealth Department of Sustainability, Environment, Water, Population and Communities. • Financial investment decision taken 12 January 2011.
Queensland Curtis LNG	QGC Pty Ltd (BG Group business)	• EIS and Supplementary EIS complete. Project approved with conditions by the Queensland Coordinator-General. • Project approved with conditions by the Commonwealth Department of Sustainability, Environment, Water, Population and Communities. • Financial investment decision taken 31 October 2010.

A summary of the baseline case for disposal of solid waste (at Benaraby Regional Landfill), recycling of waste, waste disposed to licensed contractors and liquid waste disposed to Calliope River Sewage Treatment Plant and the South Trees Sewage Treatment Plant over the known operating life of each project is provided in Table 11.2.

Table 11.2: Baseline impacts from construction and operation over life of projects

Name of Project	Life of Project	Total Solid Waste to Benaraby Regional Landfill (t)	Waste Recycled (t)	Waste to Licensed Contractors (t)	Total Liquid Waste (ML per annum)
Benaraby Regional Landfill	30	1,290,000	-	-	-
Recycling Facilities	N/A	-	N/A	-	-
Licensed Waste Management Contractors	N/A	-	-	N/A	-
Calliope River and South Trees Sewage Treatment Plants	N/A	-	-	-	4,982
GLNG Project	25	2,500	198.4	5,491	115*
Queensland Curtis LNG	20	6,061	978	3,932	N/A
TOTAL		1,298,461	1,177	9,422	4,984

N/A Data not available

* Based on 1050 people housed in Gladstone during construction

The assessment of cumulative impacts on the baseline case shown in Table 11.2 has been conducted by:

- Identifying all projects in the Gladstone regions that have been approved by the Queensland Coordinator-General or have sufficient information in the public domain (i.e., EIS).
- Assessing if the project is of relevance to the Arrow LNG Plant (i.e., are they proposing to use the same infrastructure, resources and services as the Arrow LNG Plant).
- Assessing if the quantities of waste produced are of significance to warrant inclusion in the cumulative assessment.
- Assessing if waste data is available or in a format able to be used for comparative purposes.

Table 11.3 details the projects assessed for inclusion in the cumulative impact assessment.

Table 11.3: Projects (not yet constructed) considered for cumulative impact assessment

Name of project	Proponent(s)	Project used in Cumulative Impact Assessment	Comment
Australia Pacific LNG	Australia Pacific LNG Ltd (ConocoPhillips and Origin Energy)	Yes	Will use same waste management infrastructure.
Central Queensland Pipeline Project	Enertrade (AGL Energy and Arrow Energy)	Yes	Will use same waste management infrastructure.
Western Basin Dredging Project	Gladstone Ports Corporation Limited	No	Have limited wastes other than dredging spoil.

Table 11.3 (Cont'd): Projects (not yet constructed) considered for cumulative impact assessment

Name of project	Proponent(s)	Project used in Cumulative Impact Assessment	Comment
Gladstone Nickel Project	Gladstone Pacific Gladstone Pacific Nickel Limited	Yes	Will use same waste management infrastructure.
Boyne Island Aluminium Smelter Extension of Reduction Lines Project	Comalco	No	No data available
Gladstone Steel Plant Project	Boulder Steel Limited	No	Waste management data not available.
Arrow Surat Pipeline Project	Arrow Energy Ltd	Yes	Will use same waste management infrastructure.
Fishermans Landing Northern Expansion Project	Gladstone Ports Corporation Limited	No	Has limited wastes other than dredging spoil.
Moura Link - Aldoga Rail Project	Queensland Rail Limited	Yes	Will use same waste management infrastructure.
Wiggins Island Coal Export Terminal Project	Central Queensland Ports Authority and Queensland Rail	Yes	Will use same waste management infrastructure.
Gladstone – Fitzroy Pipeline Project	Gladstone Area Water Board	No	Waste to be disposed of at Yeppoon therefore will not use same waste management infrastructure as Arrow Energy.
Hummock Hill Island Community Project	Eaton Place Pty Ltd	No	Data not reported in a format able to be transposed for use in assessment.

The approximate quantity of waste disposed of at the Benaraby Regional Landfill, Calliope River or South Trees Sewage Treatment Plants, recycling facilities or licensed waste disposal facilities for each project included in the cumulative waste impact assessment is shown in Table 11.4.

Table 11.4: Approximate minimum waste disposal quantities from proposed projects over life of projects

Name of project	Life of Project	Total solid waste to Benaraby Regional Landfill (t)	Waste Recycled (t)	Waste to Licensed Contractors (t)	Total Liquid Waste to Calliope River or South Trees Sewage Treatment Plant (ML)
Arrow LNG Plant	25	22,328	4,962	7,088	686.5 (#)
Australia Pacific LNG	30	28,378	22,841	46,586	Minimal
Central Queensland Pipeline Project	30	359	122	241,269	49.3
Gladstone Nickel Project	30*	1,358	520	246,063	664.3

Table 11.4 (Cont'd): Approximate minimum waste disposal quantities from proposed projects over life of projects

Name of project	Life of Project	Total solid waste to Benaraby Regional Landfill (t)	Waste Recycled (t)	Waste to Licensed Contractors (t)	Total Liquid Waste to Calliope River or South Trees Sewage Treatment Plant (ML)
Arrow Surat Pipeline Project	30	1,256	376	7,021	Minimal
Moura Link - Aldoga Rail Project	30	10,125	2,117	1,902	Minimal – propose to use Yarwun Sewage Treatment Plant
Wiggins Island Coal Export Terminal Project	30+	1,820	9,532	3,852	285
TOTAL		65,623	40,468	553,781	1,685
Arrow LNG Plant Contribution (%)		34.0	12.3	1.3	40.7

Based on 200 people at pioneer camp for 12 months, 1000 people housed in Gladstone and 215 tunnel, feed gas and dredging workforce (first 5 years of project only).

* Unknown, assumed a 30 year life.

The quality of the waste data provided in Table 11.4 varied considerably from project to project, for example, data was absent for some waste streams or wastes were categorised differently between projects (i.e., waste oil was a recyclable for some projects and for others it was a waste for a licensed contractor to remove). Several projects provided waste data in volumes rather than on a weight basis resulting in data having to be converted and assumptions made as to the specific weight, density and compaction status of the waste. As a result of the variances in the quality of data, the results provided in Table 11.4 are estimates only.

The results indicate that of wastes produced by the projects listed in Table 11.4, the Arrow LNG Plant will contribute approximately 34% of the solid waste requiring disposal to the Benaraby Regional Landfill over a 30 year period, 12% of recyclables, 1.3% of waste requiring management by a licensed waste contractor, and 40.7% of wastewater requiring disposal at either the Calliope River or South Trees Sewage Treatment Plants.

Table 11.5 provides a summary of baseline waste quantities, waste from new proposed projects and Arrow LNG Plant waste.

Table 11.5: Cumulative waste management quantities

Waste Type	Estimated Baseline Waste (t)	Estimated Waste from New Proposed Projects*	Total wastes (t)	Estimated Waste from Arrow LNG Plant	Arrow Energy's Contribution to overall Wastes (%)
Solid waste to Benaraby Regional Landfill	1,298,461	65,623	1,364,084	22,328	1.64
Recycled Waste	1,177(1)	40,468	41,646	4,962	11.9
Waste to licensed waste contractors	9,422	553,781	563,203	7,088	1.3
Waste to liquid waste treatment plants - Calliope River and South Trees	4,982 ML/a	1,136 ML/a for first 5 years, then 999 ML/a thereafter	6,120 ML/a for first 5 years, then 5,983 ML/a thereafter	137 ML/a(#)	2.2% for first 5 years, then 0% thereafter

* Includes Arrow LNG Plant waste.

\# First five years of construction only.

1. Does not include current disposal rates to recyclers

11.2.1 Solid Waste to Landfill

A minimum of approximately 1,364,084 tonnes of solid waste from domestic and commercial (including industrial) sources will be generated over a period of 30 years and will require disposal at a local landfill in or near to Gladstone. Of this figure, approximately 1.64% is predicted to be generated by the Arrow LNG Plant.

Assuming that all solid waste will be disposed of at the Benaraby Regional Landfill which has a current licensed (maximum) disposal rate of 50,000 tpa and a licensed capacity of 1,500,000 tonnes (approximately 30 years operating life) (R. Doherty 2010, pers. comm., 10 June), the landfill life is unlikely to be reduced below the current licensed life span of 30 years. The licensed disposal rate of 50,000 tpa may be compromised if construction of the new proposed projects occurs simultaneously, as a majority of waste from the proposed facilities would occur during construction activities. The increases in these waste quantities may result in Gladstone Regional Council placing restrictions on the volumes they are able to accept and manage at any one time. Any restriction on the volume of waste being accepted by the Gladstone Regional Council may potentially result in waste generators needing to find temporary storage or alternative treatment/disposal options for the management of these wastes. Alternatively, these point source loads may incur additional disposal charges to compensate for the additional resources required to manage the waste.

11.2.2 Recycled Waste

The baseline case disposal figures are incomplete for waste currently being recycled and waste currently being disposed of to licensed waste contractors. Approximate disposal rates are provided for the GLNG and Queensland Curtis LNG project, however these projects are yet to commence construction.

A minimum of approximately 41,646 tonnes of recyclable waste will be generated over a period of 30 years from new projects (including GLNG and Queensland Curtis LNG projects) and will require management by specialist recyclers in Queensland. Of this figure, approximately 11.9% is predicted to be generated by the Arrow LNG Plant.

11.2.3 Waste to Licensed Waste Contractors

A minimum of approximately 563,203 tonnes of waste requiring disposal by a licensed waste management contractor will be generated over a period of 30 years from new projects (including GLNG and Queensland Curtis LNG projects). Of this figure, approximately 1.3% is predicted to be generated by the Arrow LNG Plant.

Waste management contractors, JJ Richards (L. McGraw, pers. comm., 27 September 2010) indicated that the increase in both recyclables and regulated wastes requiring transport and disposal would not impact on their business in a negative manner as they had recently installed new infrastructure designed and constructed with consideration for rapid future expansion.

It is anticipated that other large national waste management companies operating in Gladstone would also be able to adequately plan for the increase demands for services provided by their companies, largely as a result of long lead up times to new projects commencing and the availability of waste management data in publicly available documents (i.e., EISs).

11.2.4 Waste to Liquid Waste Treatment Plants

It is estimated that in the Gladstone region a minimum of approximately 6,120 ML/a liquid (sewage) waste will require treatment and disposal over a period of five years, and 5,983 ML/a thereafter for an additional 25 years. Of the waste requiring treatment and disposal in the first five years, approximately 2.2% is predicted to be generated by the Arrow LNG Plant. The current capacity of the Calliope River and South Trees Sewage Treatment Plants is 6,789 ML/a, indicating that between the two treatment plants, there is sufficient capacity to cope with increased supply of sewage from proposed new projects in the Gladstone region. These figures do not include increased supply of sewage and wastewater from expansion of housing in Gladstone. Planned upgrades for both the treatment plants to cater for 97,000 people (approximately 10,622 ML/a) would provide sufficient capacity to accommodate an increase in demand for services from population growth and increase in new projects in the area.

12. CONCLUSIONS

The waste assessment was undertaken to identify, characterise and quantify (where possible) the wastes likely to be produced from the project and potential impacts of the waste on the environment and local waste management infrastructure. The potential impacts of waste generated from the project include:

- Spillage of fuels, chemicals, firewater during abnormal operating conditions or emergency situations such as fire or ETP malfunction.
- Solid or liquid effluent discharge from vehicles during transportation of wastes on and off site.
- Leachate generation from solid waste storage areas such as greenwaste or recyclable laydown areas.
- Discharge of untreated liquid wastes such as brine to the marine environment.
- Discharge of treated liquid wastes from the ETP to the land or water environments.
- Emissions to air from normal operations at the LNG Plant and through vehicles and shipping movements, largely from the combustion of fuel.
- Release of litter from storage areas where lids have not been replaced or fencing is inadequate.
- Generation of odours from putrescible wastes.
- Growth of opportunistic weed species and the spread of vermin and diseases.
- Fires caused by waste storage and subsequent spread may present a significant threat to the environmental values of the project area.

The proposed management methods for waste produced from the project include:

- All solid wastes that cannot be re-used on site will be collected and transported off Curtis Island for disposal at a recycling facility or licensed waste management facility. Arrow Energy shall not propose to construct a landfill or other final disposal facility on Curtis Island nor will any local landfills on the island be utilised for waste disposal.
- Liquid wastes such as uncontaminated stormwater, brine from the RO plant and hydrotest will be discharged to the marine environment via an outflow pipe located at Boatshed Point. Discharges from the LNG facility to the marine environment will be monitored to ensure they meet discharge criteria. Additionally, a marine monitoring program will be implemented to monitor the quality of the marine waters within Port Curtis, particularly in and around the brine and ETP discharge location.
- All potentially contaminated or contaminated run-off and sewage will be managed on site by a controlled discharge facility and effluent treatment facility. Treated effluent will be re-used on site or irrigated to land in accordance with the Queensland Water Recycling Guidelines (EPA, 2005). The treatment plant will be designed to treat the wastewater to Class A quality.
- Liquid wastes such as solvents and oils, off-specification chemicals and acid gas removal unit wastewater will be collected, transported and disposed of at a licensed waste facility by a licensed waste contractor.

- All waste streams listed above will be treated by the ETP, with the exception of sewage from the pioneer camp and the TWAF. Sewage and greywater generated from the pioneer camp will be collected in portable disposal units or other mobile collection facilities. A licensed waste contractor will be used to service the sewage facilities and dispose of effluent at a licensed waste management facility. Sewage from the TWAF constructed on the mainland near Gladstone may be connected to the local sewerage network if it is available or alternatively portable disposal units or other mobile collection facilities will be utilised.
- During construction, the main emissions to the air environment are from the combustion of hydrocarbons from the operation of plant and equipment (including LNG plant modules, and vehicles). During abnormal operating conditions (start-up, shutdown, upset and emergency conditions) air emissions are generated largely from pipelines and tank air displacement and will be treated by a flaring system. Collection headers will be installed to collect various gaseous and liquid hydrocarbons streams and these will be directed to a common knock out drum and flare stack.
- Gaseous emissions will be produced from a gas turbine facility that will provide power for the project. In addition, a gaseous waste stream from stored LNG in LNG ship tanks, known as boil-off gas will be produced. Boil-off gas and return vapours from LNG carriers will be collected using an appropriate vapour recovery system (e.g., compressor system) and not be released to air.

An assessment of residual impacts of the proposed waste management system on the environment was undertaken by examining the likelihood of an impact occurring and the potential consequences (i.e., a measure of severity) should the impact occur. The residual risk to the environmental values of the Arrow LNG Plant area for the majority of the proposed waste management strategies were categorised as ‘low’ when control measures are considered.

A moderate residual risk was highlighted for the potential contamination of Port Curtis as a result of discharge of RO brine. The moderate risk ranking was determined as a result of the discharge being of a continuous nature rather than the due to the consequences of the impact being significant. Implementation of a marine monitoring program will ensure the potential impact of the discharge on Port Curtis will be quantified and that additional management measures can be implemented if the need is indicated.

The impact on soils from irrigation of treated effluent was categorised as a moderate risk also largely as a result of the discharge being of a continuous nature, rather than the impact having significant consequences. Impacts to the soil from repeated irrigation of treated effluent will occur gradually and regular monitoring of the treated effluent and the soils in the irrigated areas will ensure that any impacts to the soil will be detected before any long term damage occurs.

The environmental impacts resulting from unexpected events, such as LNG spills and contaminated firewater run-off, was assessed as a low risk, due to the improbability of an event, the facility design and spill and emergency response plans proposed to mitigate any impacts.

The overall residual risk to the environmental values of the project area as a result of the waste management activities for the proposed Arrow LNG Plant is considered to be minimal in view of the comprehensive control measures proposed to prevent adverse environmental outcomes.

Assessment of the cumulative impacts relating to wastes focussed on potential impacts on waste management infrastructure, resources and services.

A minimum of approximately 1,364,084 tonnes of solid waste will be generated over a period of 30 years and will require disposal at a local landfill in or near to Gladstone. Of this figure, approximately 1.64% is predicted to be generated by the Arrow LNG Plant.

The increase in the volume of solid waste is unlikely to impact significantly on the lifespan of the Benaraby Regional Landfill as the current licensed capacity is 1,500,000 tonnes over a 30 year period.

A minimum of approximately 41,646 tonnes of recyclable waste will be generated over a period of 30 years from new projects (including GLNG and Queensland Curtis LNG projects) and will require management by specialist recyclers in Queensland. Of this figure, approximately 11.9% is predicted to be generated by the Arrow LNG Plant.

A minimum of approximately 563,203 tonnes of waste requiring disposal by licensed waste management contractors will be generated over a period of 30 years from new projects (including GLNG and Queensland Curtis LNG projects). Of this figure, approximately 1.3% is predicted to be generated by the Arrow LNG Plant.

It is anticipated that other large national waste management companies operating in Gladstone would also be able to adequately plan for the increase demands for services provided by their companies, largely as a result of long lead up times to new projects commencing and the availability of waste management data in publicly available documents (i.e., EISs).

It is estimated that in the Gladstone region a minimum of approximately 6,120 ML/a liquid (sewage) waste will require treatment and disposal over a period of 5 years, and 5,983 ML/a thereafter for an additional 25 years. Of the waste requiring treatment and disposal in the first 5 years, approximately 2.2% is predicted to be generated by the Arrow LNG Plant.

The current capacity of the Calliope River and South Trees Sewage Treatment Plants is 6,789 ML/a, indicating that between the two treatment plants, there is sufficient capacity to cope with increased supply of sewage from proposed new projects in the Gladstone region. These figures do not include increased supply of sewage and wastewater from expansion of housing in Gladstone. Planned upgrades for both the treatment plants to cater for 97,000 people (approximately 10,622 ML/a) would provide sufficient capacity to accommodate an increase in demand for services from population growth and increase in new projects in the area.

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14. GLOSSARY AND ABBREVIATIONS

The following words and abbreviations are defined in the context of their use in this report. Some definitions have been adapted from the Macquarie dictionary, online dictionaries and encyclopaedias, and relevant specialist studies.

Units

°C *abbr.* degree Celsius.

ha *abbr.* hectare.

kg/day *abbr.* kilogram per day.

kL/day *abbr.* kilolitre per day.

km *abbr.* kilometre.

km/h *abbr.* kilometre per hour.

km² *abbr.* square kilometre.

L *abbr.* litre.

L/week *abbr.* litres per week.

m *abbr.* metre.

mm *abbr.* millimetre.

m^3 *abbr.* cubic metre.

m^3/a *abbr.* cubic metre per annum.

mg/L *abbr.* milligram per litre.

mg/m³ *abbr.* milligram per cubic metre.

ML *abbr.* megalitre.

ML/a *abbr.* megalitre per annum.

ML/day *abbr.* megalitre per day.

mm *abbr.* millimeter.

Mtpa *abbr*. million tonnes per annum.

MW *abbr.* megawatt.

t *abbr.* tonne.

tpa *abbr*. tonnes per annum.

t/day *abbr.* tonnes per day.

t/m *abbr.* tonnes per month.

t/week *abbr.* tonnes per week.

A

AHD *abbr.* Australian Height Datum; a geodetic reference from which altitude measurements are made in Australia.

AQIS *abbr.* Australian Quarantine Inspection Service.

Arrow Energy *abbr*. Arrow CSG (Australia) Pty Ltd.

AS *abbr.* Australian Standard.

AS/NZS *abbr.* Australian/New Zealand Standard.

ASS *abbr.* acid sulfate soils.

B

brine *n.* the concentrated waste product of reverse osmosis water treatment.

C

CDF *abbr.* controlled discharge facility.

CFU *abbr.* colony forming unit.

CO *abbr.* carbon monoxide.

CO_2 *abbr.* carbon dioxide.

$CO_{2\text{-}e}$ *abbr.* carbon dioxide equivalent.

Coffey Environments *abbr.* Coffey Environments Pty Ltd.

controlled action *n.* an action deemed likely to have a significant impact on matters of national environmental significance under the terms of the EPBC Act.

controlled waste *n.* waste types listed in the Commonwealth National Environment Protection (Movement of Controlled Waste between States and Territories) Measure, where wastes in List 1 possess one or more of the characteristics in List 2.

CSG *abbr.* coal seam gas.

Cwlth *abbr.* Commonwealth.

D

dangerous goods *n.* goods specified as dangerous goods under the Australian Dangerous Goods Code (6th edition) as reflected in the Queensland *Dangerous Goods Safety Management Act 2001*.

DERM *abbr.* Department of Environment and Resource Management.

DSEWPC *abbr.* Department of Sustainability, Environment, Water, Population and Communities.

E

EIS *abbr.* Environmental Impact Statement.

environmental risk assessment *n.* the systematic identification, assessment, estimation and characterisation of risks to or from the environment from a particular event, activity, operation, process or design. Environmental risk assessments are carried out and reported by suitably qualified or competent persons, to a defined scope, using recognised tools and techniques.

EPA *abbr.* Environmental Protection Agency.

EP Act *abbr*. *Environmental Protection Act 1994* (QLD).

EPBC Act *abbr. Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

EPC *abbr.* engineering, procurement and construction.

EPPs *abbr.* environmental protection policies.

EP Regulation *abbr. Environmental Protection Regulation 2008.*

EP Regulation (Waste) *abbr. Environmental Protection (Waste Management) Regulation 2000.*

EPP (Air) *abbr. Environmental Protection (Air) Policy 2008.*

EPP (Waste) *abbr. Environmental Protection (Waste Management) Policy 2000*.

ETP *abbr.* effluent treatment plant.

F

FEED *abbr.* front end engineering design.

G

GAC *abbr.* granular activated carbon.

general waste *n.* wastes other than regulated wastes as defined in the Queensland E*nvironmental Protection (Waste Management) Regulation 2000*.

GPC *abbr.* Gladstone Ports Corporation Pty Ltd.

GSDA *abbr.* Gladstone State Development Area.

groundwater *n.* water stored below the ground surface within pore spaces of soils or fractures of a rock mass.

H

hazardous waste *n.* waste that contains significant quantities of any substance that is toxic, poisonous, infectious, explosive, flammable, corrosive, radio-active or reactive; which may pose a threat to human health or the environment when improperly managed or disposed.

HSEMS *abbr.* Health, safety, environmental management system.

HSSE *abbr.* health, safety, security and environment.

hydrostatic testing *n.* pressurising a pipeline to and above its normal maximum allowable operating pressure for a specified period of time to detect any loss of pressure resulting from a failed weld or flaw in the pipeline wall.

hydrotest water *n.* the water used in hydrostatic testing of pipelines or tanks.

H_2O *abbr.* water.

H_2S *abbr.* hydrogen sulfide.

I

ISO *abbr.* International Organization for Standardization.

JKL

JJ Richards *abbr.* J.J. Richards and Sons Pty Ltd.

liquefaction *n., adj.* the process of transforming gas into a liquid by cooling it to approximately -160°C followed by flashing to a low pressure.

LNG *abbr.* liquefied natural gas.

M

MARPOL *abbr.* International Convention for the Prevention of Pollution from Ships 1973 as modified by the Protocol of 1978.

MOF *abbr.* materials offloading facility.

N

NEPM *abbr.* National Environment Protection Measure.

NO *abbr.* nitrogen oxide.

NO_2 *abbr.* nitrogen dioxide.

NO_x *abbr.* oxides of nitrogen.

NPI *abbr.* National Pollutant Inventory.

NTU *abbr.* nephelometric turbidity units.

OP

pers. comm. *abbr*. personal communications.

PetroChina *abbr*. PetroChina International Investment Company Ltd.

$PM_{2.5}$ *abbr.* particulate matter of 2.5 micrometres or less.

PM_{10} *abbr.* particulate matter of 10 micrometres or less.

putrescible waste *n.* waste, such as food waste, that can be readily decomposed through biological activity.

PWAF *abbr.* permanent worker's accommodation facility.

Q

Qld *abbr.* Queensland.

R

recyclable waste *n.* waste that can be practicably recycled.

regulated waste *n.* regulated wastes as defined in the Queensland *Environmental Protection (Waste Management) Regulation 2000*.

right of way *n.* the area required to construct a pipeline, road or railway.

RO *abbr.* reverse osmosis.

ROPAX *abbr.* roll on-roll off passenger ship or ferry.

ROW *abbr.* right of way.

S

SEPP *abbr.* State Environment Protection Policy.

SO_2 *abbr*. sulphur dioxide.

study area *n.* an area defined by each of the relevant specialist studies and specific to the particular environmental aspect being considered.

T

TDS *abbr.* total dissolved solids.

TEG *abbr.* triethylene glycol.

TPI *abbr.* Transpacific Industries Group Pty Ltd.

trackable waste *n.* a regulated waste of a type mentioned in Schedule 1 of the *Environmental Protection (Waste Management) Regulation 2000* (Queensland).

TSS *abbr.* total suspended solids.

TWAF *abbr.* temporary worker's accommodation facility.

UVWZ

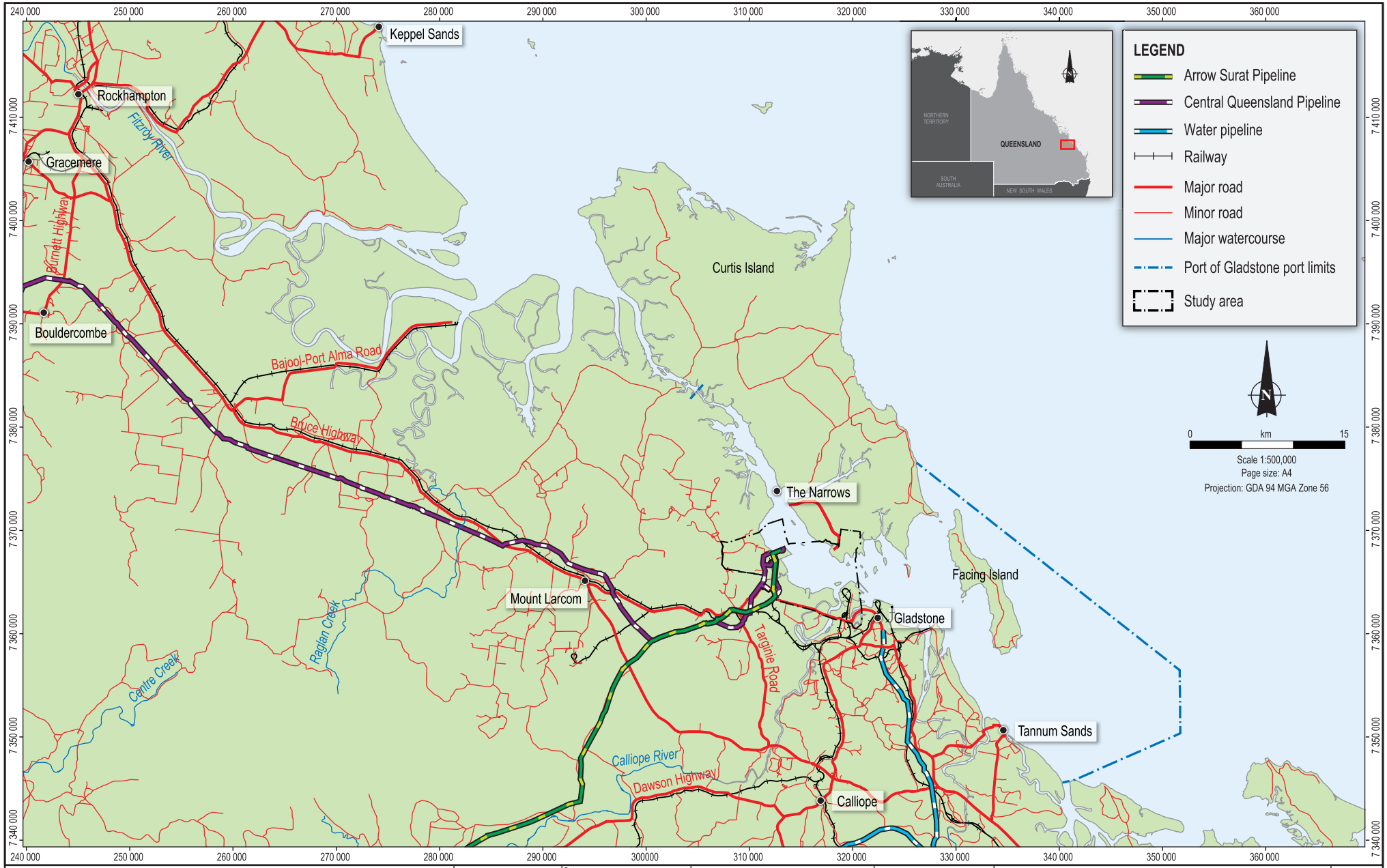
UV *abbr.* ultraviolet.

Veolia *abbr.* Veolia Environmental Services.

waste *n.* any gas, liquid, solid or energy that is surplus to, or unwanted from any industrial, commercial, domestic or other activity, whether or not of value.

Figures

Arrow LNG Plant
Waste Impact Assessment



Source:
Place names, roads, railways, watercourses and pipelines from GEODATA250k (Optimum scale 1:250,000)
Coastline from GBRMPA.
Port of Gladstone port limits digitised by Coffey Environments.

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Date: 19.07.2011
MXD: 7033CA_07_GIS036_v1_1
File Name: 7033_WST_F02.01_GIS_GL

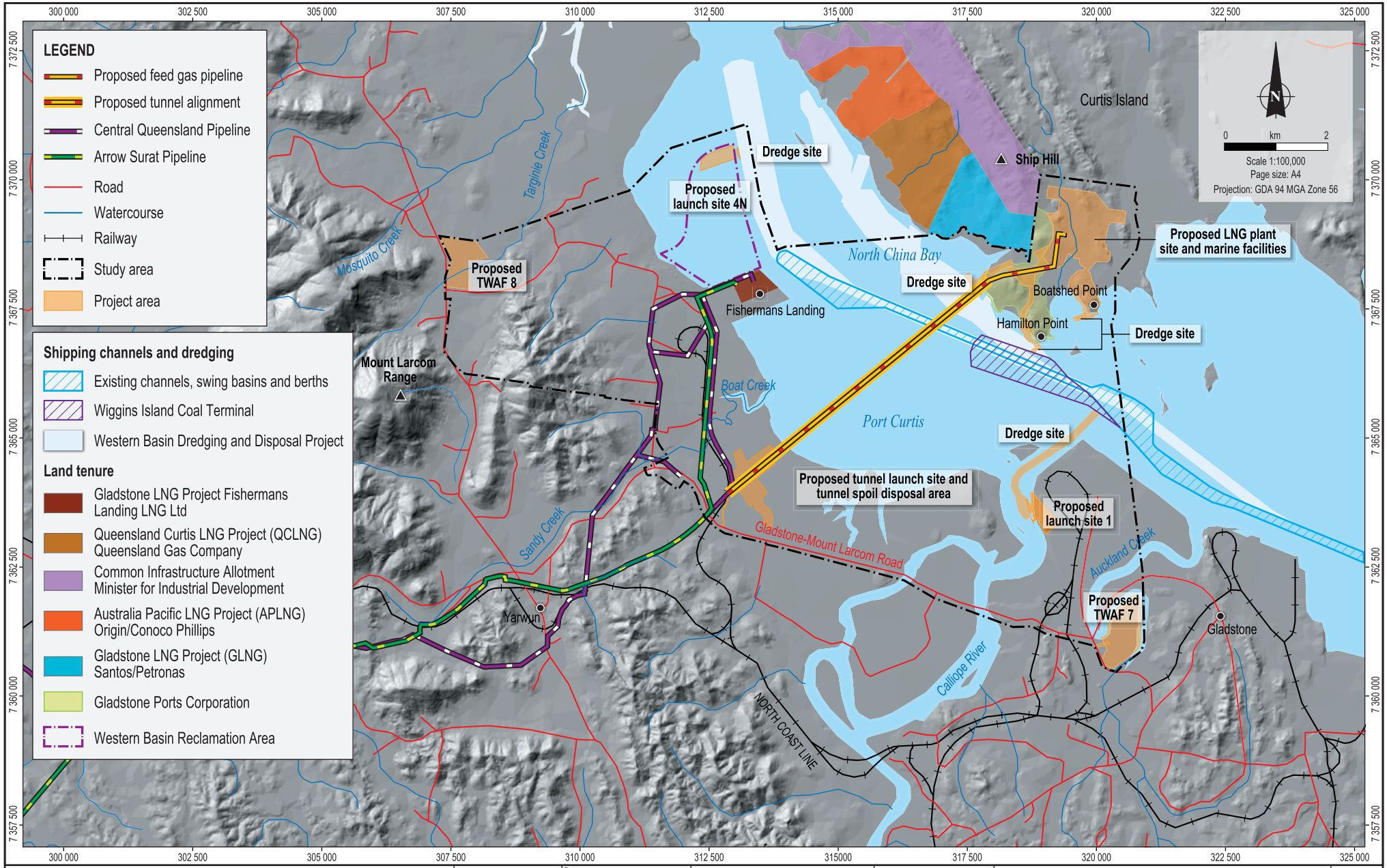
Arrow Energy

Arrow LNG Plant

arrow energy go further

Regional context

Figure No: 2.1



Source:
Place names, roads and watercourses from DME.
Study area, pipelines, proposed auxiliary facilities and marine infrastructure from Arrow Energy.
Proposed feed gas pipeline, proponents and DEM from Coffey Environments.
Western Basin Dredging Master Plan from Gladstone Ports Corporation.

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Date: 13.07.2011
MXD: 7033CA_07_GIS034_v1_1
File Name: 7033_WST_F02.02_GIS_GL

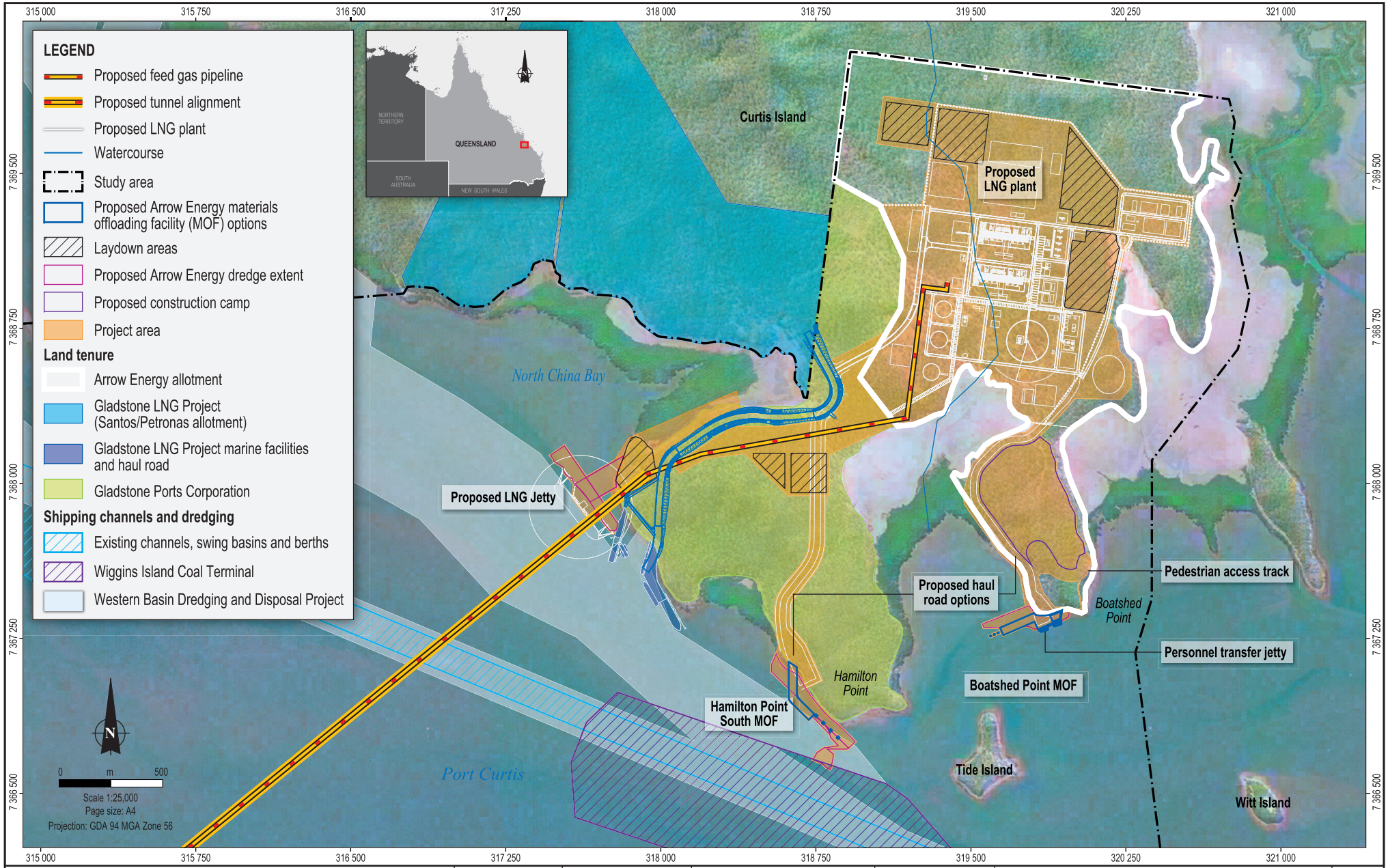
Arrow Energy

Arrow LNG Plant

arrow energy go further

Site locality

Figure No: 2.2



Source:
Place names, roads and watercourses from DME.
Study area, proposed auxiliary facilities and marine infrastructure from Arrow Energy.
Western Basin Dredging Master Plan and Disposal Project from Gladstone Ports Corporation.
Study area and proposed feed gas pipeline from Coffey Environments. Imagery from SPOT (2004-2007).

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Date: 13.07.2011
MXD: 7033CA_07_GIS035_v1_1
File Name: 7033BC_WST_F02.03_GIS_GL

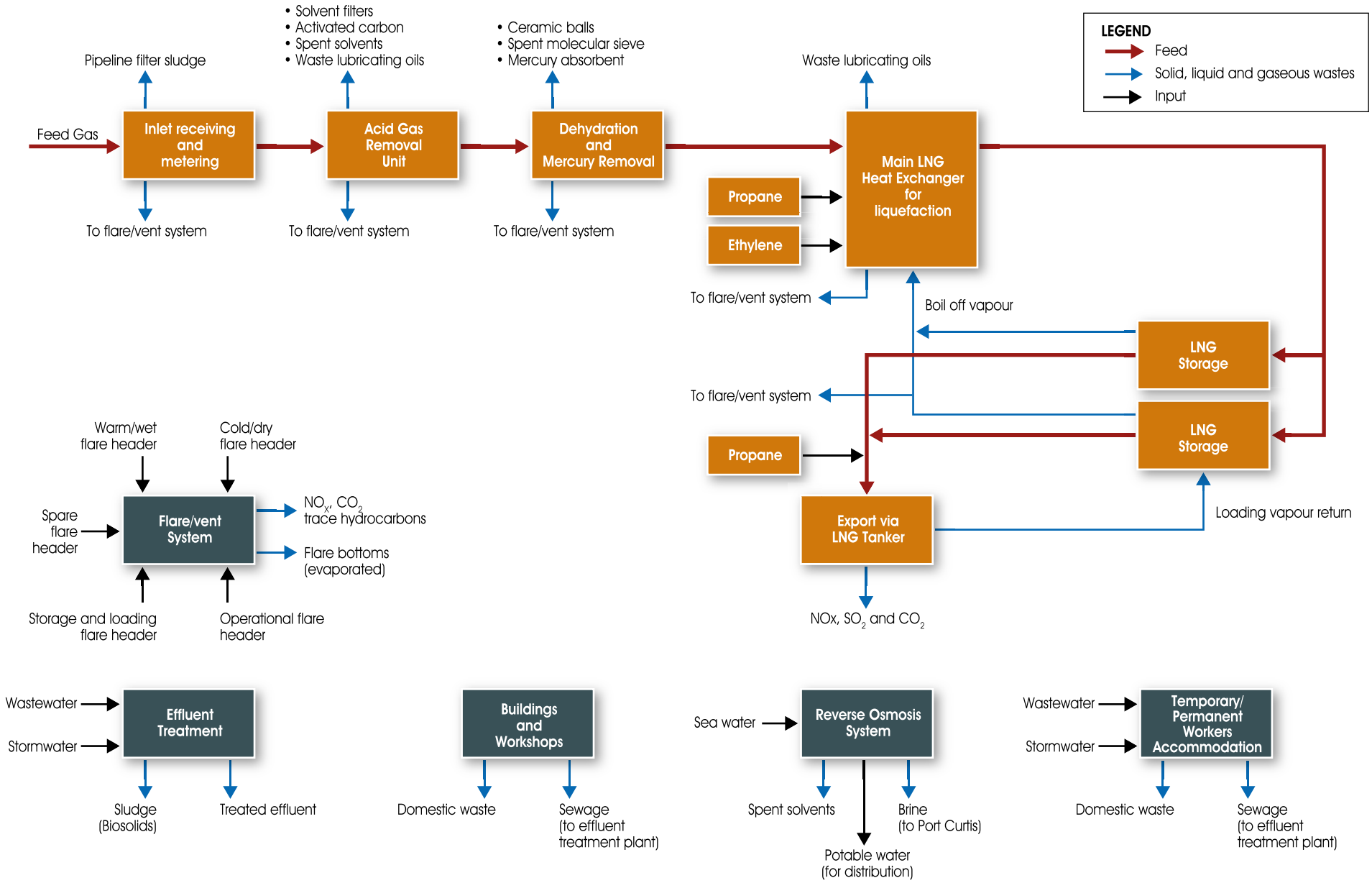
Arrow Energy

Arrow LNG Plant

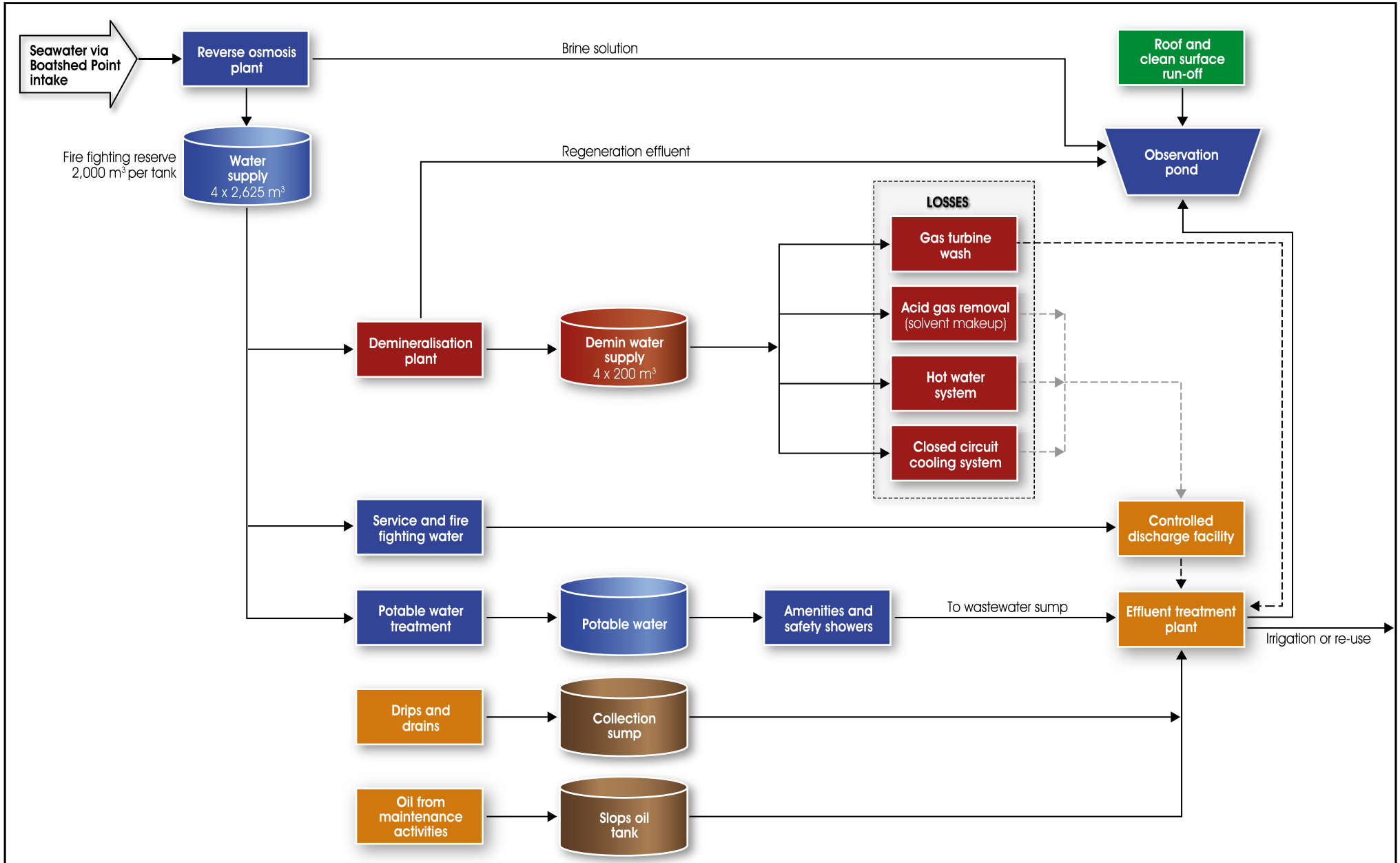
arrow energy go further

LNG plant and associated infrastructure

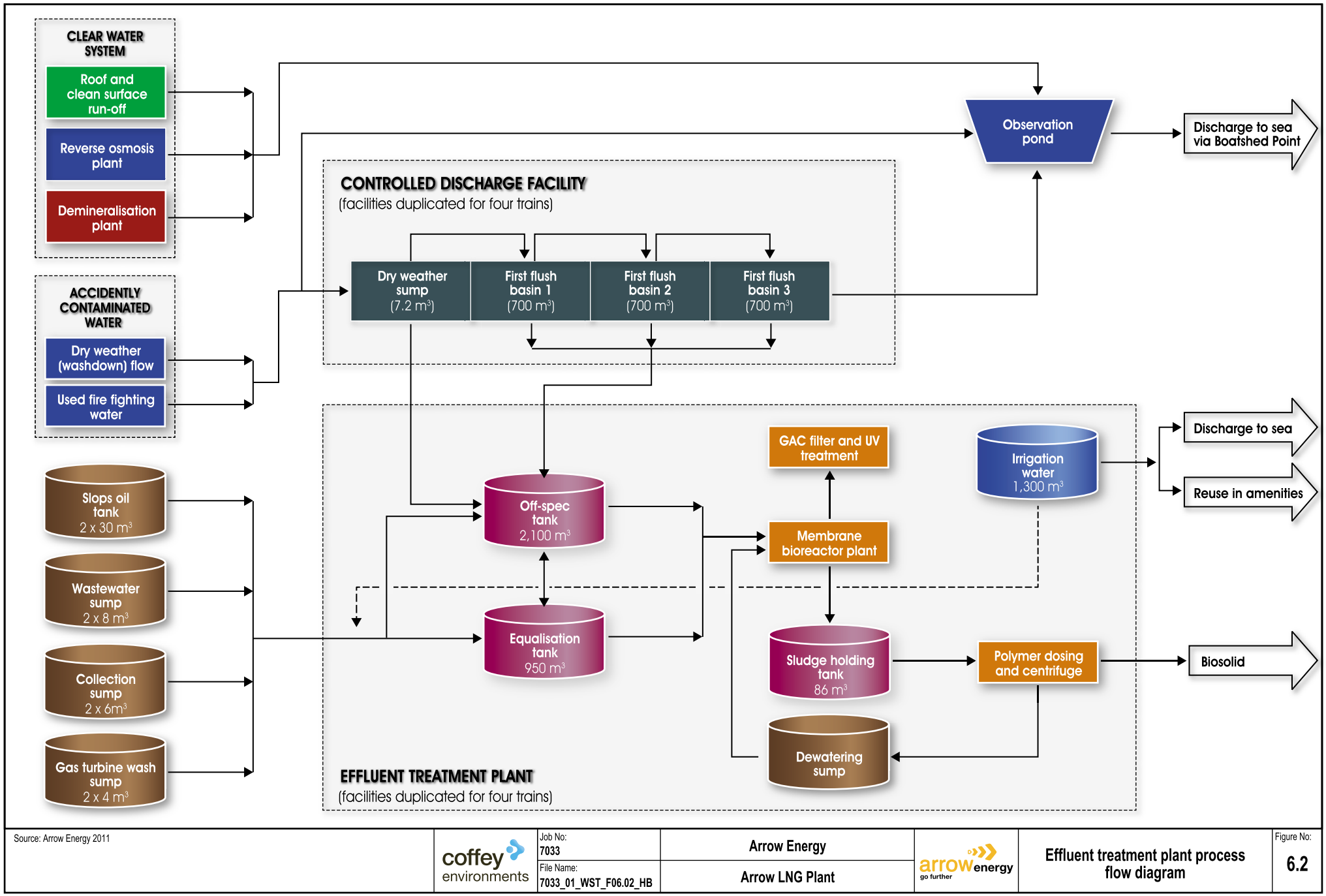
Figure No: 2.3



Authored by Coffey Environments	coffey environments	Job No: 7033	Arrow Energy	arrow energy go further	Arrow LNG Plant process flow diagram	Figure No: 2.4
		File Name: 7033_01_WST_F02.04_HB	Arrow LNG Plant			



Source: Arrow Energy 2011	coffey environments	Job No: 7033 File Name: 7033_01_WST_F06.01_HB	Arrow Energy Arrow LNG Plant	arrow energy go further	Effluent treatment plant and site drainage system	Figure No: 6.1



Source: Arrow Energy 2011

coffey environments

Job No: 7033

File Name: 7033_01_WST_F06.02_HB

Arrow Energy

Arrow LNG Plant

arrow energy go further

Effluent treatment plant process flow diagram

Figure No: 6.2

Attachment A

Terms of Reference Cross Reference Table

Attachment A: Terms of Reference Cross Reference Table

Terms of Reference		Coffey Environments Pty Ltd	
Section	**EIS requirement**	**Technical Study Name**	**Technical Specialist Report Section**
2.1.1 Description of the Project	• Disposal of wastes including hydrostatic test water.	Waste Impact Assessment	Section 8.7 Waste Disposal
2.3 Description of the Project	• Nature and volume of solid and liquid wastes, and their storage, handling and disposal.	Waste Impact Assessment	Section 2.3.1 Waste Generation - Construction Section 8 Avoidance, Mitigation and Management Measures
	• Disposal of plant-matter left after clearing vegetation.	Waste Impact Assessment	Section 6.1 (Table 6.1) Avoidance, Mitigation and Management Measures – General Principles
	• Disposal/reuse of surplus excavated material and if this material can be coordinated with concurrent construction activities in the vicinity.	Waste Impact Assessment	Section 6.1 (Table 6.1) Avoidance, Mitigation and Management Measures – General Principles
2.3.1.1 Description of the Project	This section should also describe the proposed management of cleared trees (following removing of millable timber) in relation to waste management (i.e. vegetation – chipped or ground to assist in rehabilitation or soil stabilisation).	Waste Impact Assessment	Section 6.1 (Table 6.1) Avoidance, Mitigation and Management Measures – General Principles
2.5.2 Description of the Project	Describe arrangements for the transport of plant, equipment, construction material, products, wastes and personnel during both the construction phase and operational phases of the project.	Waste Impact Assessment	Section 8.6 Waste Transportation
2.5.5 Description of the Project	Describe, in general terms, the sewerage infrastructure required to service each project component.	Waste Impact Assessment	Section 6.2 Sewage
	Volume estimates of existing and likely industrial and domestic effluent that will be produced should be outlined and the proposed method of disposal identified.	Waste Impact Assessment	Section 6.2 Sewage Section 6.5 Effluent Treatment Plant Wastewater
	This should include the expected physical and chemical characteristics of such effluent.	Waste Impact Assessment	Section 6.5 Effluent Treatment Plant Wastewater
2.6.1 Description of the Project	Details should be provided on how the pipeline and ancillary equipment, including buildings and structures, would be removed or made safe if left in-situ.	Waste Impact Assessment	Section 2.3.3 Decommissioning Waste

Attachment A (Cont'd). Terms of Reference Cross Reference Table

Terms of Reference		Coffey Environments Pty Ltd	
Section	**EIS requirement**	**Technical Study Name**	**Technical specialist report section**
3.2.5.2 Environmental Values and Management of Impacts	The EIS should describe the possible contamination of land resulting from project actions including spillage, waste, acid generation from exposed sulphuric material, spills at chemical and fuel storage areas, and storage/spillage of associated water or waste from treated water at the CSG fields.	Waste Impact Assessment	Section 7.1 Discharges to Land and Water
	The means of preventing land contamination (within the meaning of the EP Act) should be addressed and the strategies and methods proposed for preventing, recording, containing and remediating any contaminated land outlined.	Waste Impact Assessment	Section 8.2 Waste Avoidance
3.4.1.2 Environmental Values and Management of Impacts	Where on-site storage of water sourced from waste water treatment plants is proposed, the EIS should detail how this water would be managed to ensure environmental harm and human health risk is avoided. The EIS should also describe the design features of any such storages to effectively contain saline water and other harmful constituents.	Waste Impact Assessment	Section 8.4 Waste Storage
	The EIS should include a risk assessment for uncontrolled emissions to water due to system or catastrophic failure, implications of such emissions for human health and natural ecosystems, and strategies to prevent, minimise and contain impacts.	Waste Impact Assessment	Section 9 Residual Impacts Section 8.8.10 Wastes from Abnormal or Emergency Operating Conditions

Attachment A (Cont'd). Terms of Reference Cross Reference Table

Terms of reference		Coffey Environments Pty Ltd	
Section	**EIS requirement**	**Technical Study Name**	**Technical specialist report section**
3.4.1.2 (Cont'd) Environmental Values and Management of Impacts	The EIS should describe the proposed project component stormwater drainage systems and the proposed disposal arrangements, including any off-site services and downstream impacts.	Waste Impact Assessment	Section 8.8.1 Stormwater
3.8 Environmental Values and Management of Impacts	Provide technical details of waste generation, treatment, minimisation and management.	Waste Impact Assessment	Section 2.3 Waste Sources Section 6 Waste Quantities Section 8 Avoidance, Mitigation and Management Measures
3.8.1 Environmental Values and Management of Impacts	Sources of waste associated with the construction, operation and decommissioning of the project should be identified and described including:	Waste Impact Assessment	
	• The type and indicative amount of wastes produced, including an estimated inventory of solid and liquid (including wastewater, brine and sewage) wastes generated by each stage and component of the project.	Waste Impact Assessment	Section 6 Waste Quantities
	• Volumes and chemical analysis of wastewater generated by the treatment of associated water for beneficial use.	Waste Impact Assessment	Associated water not assessed.
	• Collection, handling, transport and fate of wastes including storage.	Waste Impact Assessment	Section 8 Avoidance, Mitigation and Management Measures
	• Market demand for recyclable waste (where appropriate).	Waste Impact Assessment	Section 5.2.2 Recycling Facilities
	• Opportunities for waste avoidance, reuse within the project, and minimisation techniques.	Waste Impact Assessment	Section 8.2 Waste Avoidance Section 8.3 Waste Recycling
	• Location, site suitability, dimensions, source and volume of any landfill, including method of construction.	Waste Impact Assessment	Section 8.7.1 Waste Disposal on Curtis Island

Attachment A (Cont'd). Terms of Reference Cross Reference Table

Terms of reference		Coffey Environments Pty Ltd	
Section	**EIS requirement**	**Technical Study Name**	**Technical specialist report section**
3.8.2 Environmental Values and Management of Impacts	Provide details of waste management methods, which demonstrate that waste minimisation and cleaner production techniques and designs have been implemented through the selection of processes, equipment and facilities to prevent or minimise environmental impacts. The proposals for waste avoidance, reuse, recycling, treatment and disposal should be described having regard for best practice waste management strategies and the Environmental Protection (Waste) Policy 2000. This section should assess the potential impacts generated by wastes during the construction, operational and decommissioning stages of the project. This information should include:	Waste Impact Assessment	
	• Descriptions of processes, equipment and facilities to be incorporated into the overall project specifically for the purpose of avoiding waste generation, separation of wastewater from solid waste, reusing or recycling wastes, or on-site treatment methods for wastes to lessen their effect on the natural environment.	Waste Impact Assessment	Section 8.2 Waste Avoidance Section 8.5 Waste Treatment Section 6.5 Effluent Treatment Plant Wastewater
	• Proposed means for management of wastes produced under circumstances other than as a result of normal project development, including wastes generated during modification (e.g. run-off, chemical cleaning before commissioning), unusual conditions when the facilities are operating (e.g. start-up, maintenance, shut-down) and domestic sewage and refuse.	Waste Impact Assessment	Section 8.8.10 Wastes from Abnormal or Emergency Operating Conditions
	• Council waste facilities within the project development areas and their ability to handle expected waste generation.	Waste Impact Assessment	Section 5.2 Socio-Economic Environment Section 11.2 Utilisation of Regional Infrastructure

Attachment A (Cont'd). Terms of Reference Cross Reference Table

Terms of reference		Coffey Environments Pty Ltd	
Section	**EIS requirement**	**Technical Study Name**	**Technical specialist report section**
3.8.2 (Cont'd) Environmental Values and Management of Impacts	• Methods to prevent seepage and contamination of groundwater from waste stockpiles.	Waste Impact Assessment	Section 8.4 Waste Storage and Handling Section 8.7.1 Waste Disposal On Curtis Island
	• Methods to avoid stormwater contamination by raw materials, wastes or products and present the means of containing, recycling, reusing, treating and disposing of stormwater, having regard for the requirements of the EPP (Water).	Waste Impact Assessment	Section 8.8.1 Stormwater
	• Risk assessment and monitoring procedures for individual sites in relation to the above points.	Waste Impact Assessment	Section 9 Residual Impacts Section 10 Monitoring
	Stormwater management should also address:	Waste Impact Assessment	
	• Nominated stormwater discharge points and discharge criteria.	Waste Impact Assessment	Not addressed as discharge points and criteria not known.
	• Design criteria, diversions, volume and capacity of any retention ponds, Process tanks or bunded areas, as well as those reasonable and practicable measures proposed to prevent the likely release of contaminated stormwater to any drain or waters.	Waste Impact Assessment	Section 8.4 Waste Storage and Handling
	• Potential impacts during extreme rainfall events.	Waste Impact Assessment	Section 8.8.10 Wastes from Abnormal or Emergency Operating Conditions
	• Information on the collection, treatment and disposal of contaminated stormwater runoff from plant and associated materials handling facilities.	Waste Impact Assessment	Section 6.5 Effluent Treatment Plant Wastewater Section 8.7.1 Waste Disposal on Curtis Island Section 8.8.10 Wastes from Abnormal or Emergency Operating Conditions

Attachment A (Cont'd). Terms of Reference Cross Reference Table

Terms of reference		Coffey Environments Pty Ltd	
Section	**EIS requirement**	**Technical Study Name**	**Technical specialist report section**
3.8.2 (Cont'd) Environmental Values and Management of Impacts	• Details of expected contaminants (e.g. chemical composition, particulates, metals, effluent temperature and pH) in controlled discharges of proposed wastewater and stormwater management systems.	Waste Impact Assessment	Section 6.4 Reverse Osmosis Brine Section 6.5 Effluent Treatment Plant Wastewater
	• Impacts of discharges on potential receiving waters, particularly effects on the downstream environment of stormwater releases (i.e. water-salt balance).	Waste Impact Assessment	To be addressed by Marine Water Quality Impact Assessment
	• An outline the expected disposal strategies, where solid or liquid wastes are to be disposed of off-site.	Waste Impact Assessment	Section 8.7.2 Waste Disposal Off-Site
	Details of discharge wastewater into Gladstone harbour should identify any potential contaminants likely to impact on approvals for disposal of material from maintenance dredging operations.	Waste Impact Assessment	To be addressed by Marine Water Quality Technical Experts
7 Cumulative Impacts	The purpose of this section is to provide a summary of the cumulative impacts from the project which should have regard to both geographic location and environmental values. Cumulative impacts should take into consideration the effects of other known, existing or proposed project(s) where details of such projects have been provided to the proponent by the DIP or which are otherwise published to the greatest extent possible. In particular, the likelihood of cumulative impacts arising from possible shared gas transmission pipeline easements and adjoining or nearby LNG plant proposals should be addressed, where adequate information is available. With respect to Gladstone in particular, the cumulative social and economic impacts arising from large project workforces associated with proposed industrial projects being constructed in overlapping timeframes should be addressed.	Waste Impact Assessment	Section 11 Cumulative Impact Assessment

Attachment A (Cont'd). Terms of Reference Cross Reference Table

Terms of reference		Coffey Environments Pty Ltd	
Section	**EIS requirement**	**Technical Study Name**	**Technical specialist report section**
7 (Cont'd) Cumulative Impacts	The methodology used to determine the cumulative impacts of the project should be discussed, including (to the extent possible) qualitative and quantitative criteria.	Waste Impact Assessment	Section 11 Cumulative Impact Assessment
10 Conclusions and Recommendations	The EIS should make conclusions and recommendations with respect to the project based on the studies presented, the EM Plan and conformity of the project with legislative and policy requirements.	Waste Impact Assessment	Conclusions
11 References	All references consulted should be presented in the EIS in a recognised format.	Waste Impact Assessment	References