APPENDIX 26

ARROW LNG PLANT

Bushfire Hazard and Risk Assessment

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BUSHFIRE HAZARD AND RISK ASSESSMENT

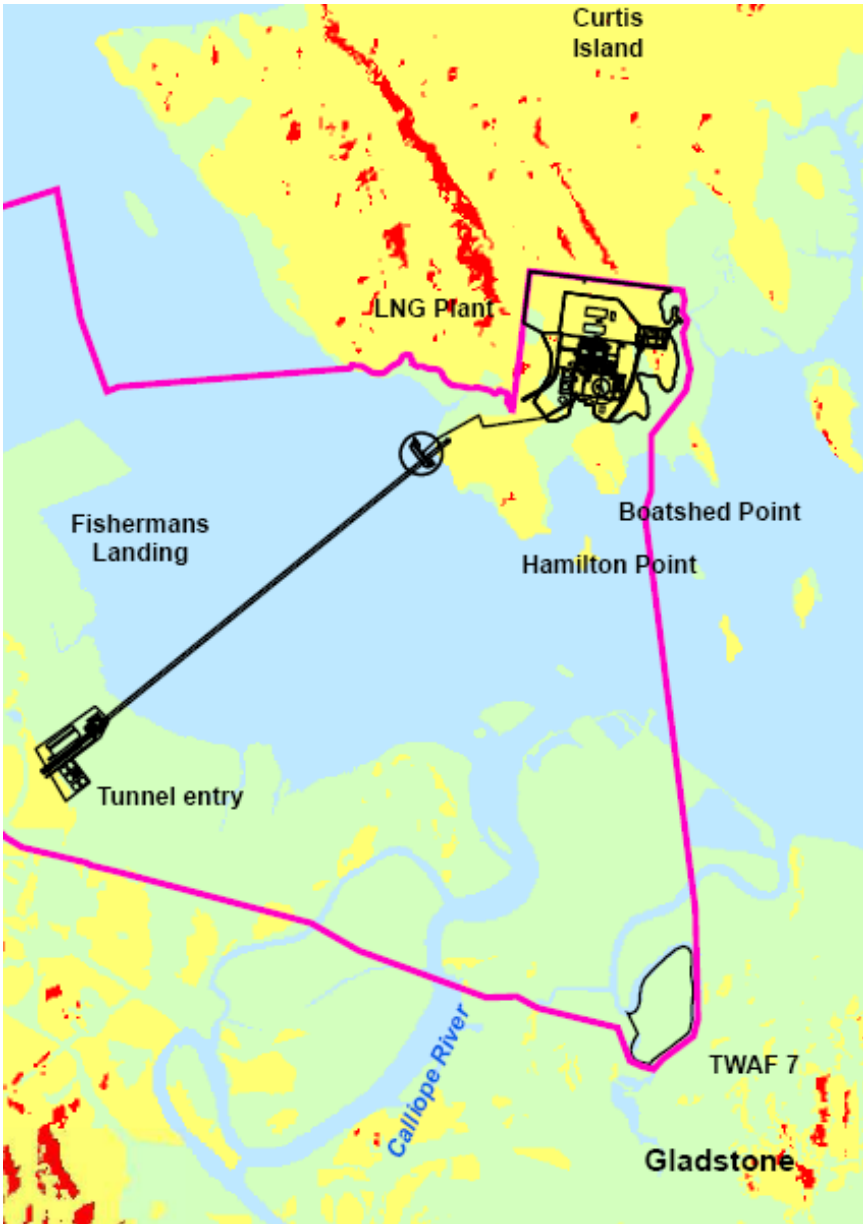
Arrow LNG Plant

Gladstone & Curtis Island, Queensland

Prepared for

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

September 2011



Bushfire Hazard & Risk Assessment

ARROW LNG PLANT, GLADSTONE QUEENSLAND

PREPARED FOR	**Arrow CSG (Australia) Pty Ltd and Coffey Environments Pty Ltd**
PROJECT NO	**10GOSBUS-0088**
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Contents

Executive Summary

This **Bushfire Hazard & Risk Assessment** was prepared for the proposed Arrow liquefied natural gas (LNG) Plant at Curtis Island and Gladstone. The **study area** includes all areas assessed for the direct and indirect impacts of the project such as the LNG plant on Curtis Island, construction camps on Curtis Island and in the Gladstone area, and associated infrastructure such as jetties and the feed gas pipeline corridor.

The Queensland Government within the **terms of reference** requested an assessment of bushfire risk for construction, operational and decommissioning phases of the project based on risk management principles. To provide this, the **objectives** of the bushfire assessment were set as:

- Prevent loss of and harm to human life;
- Minimise damage to built assets;
- Minimise disturbance to construction and plant operation; and
- Minimise impact of fire on the environment.

The **approach** to assessing bushfire risk and recommending mitigation measures in this assessment is based on the risk management process defined by *AS/NZS ISO 31000:2009 'Risk management – Principles and guidelines* (Standards Australia, 2009) and is two-fold:

a. Satisfy the legislative requirements of bushfire assessment of development within Queensland, namely the *State Planning Policy 1/03 Guideline - Mitigating the Adverse Impacts of Flood, Bushfire and Landslide (SPP 1/03)*. This process examines the protection of a development from the impact of an approaching bushfire.

b. Assess the risk of a fire being ignited at a project site and spreading and impacting assets surrounding the site using a risk assessment methodology developed for use in developing bushfire risk management plans in New South Wales (NSW) by the NSW Rural Fire Service (NSW Rural Fire Service, 2008). The methodology follows the procedures and considerations of AS/NZS ISO 31000:2009 and provides a risk classification scheme through qualitative scales to assess the likelihood and consequence of fire impact.

To achieve the above, the **method** for the Bushfire Hazard and Risk Assessment is summarised as follows;

a. Identify the asset base requiring protection associated with the study area;

b. Identify the bushfire risk factors such as bushfire history and known bushfire behaviour in the study area and within the surrounding lands;

c. Map the bushfire hazard at a site specific scale following SPP 1/03 method;

d. Determine assessment requirements under SPP 1/03 based on results of hazard mapping;

e. Assess (likelihood and consequence) and evaluate bushfire risk to and from the development proposal following AS/NZS ISO 31000:2009 risk assessment process. Link SPP 1/03 findings with this process; and

f. Produce mitigation and management treatments to address the risk.

The **assets requiring protection** from bushfires include life, property and the environment. This includes people (workforce, visitors and neighbours), buildings and infrastructure, the LNG product and the terrestrial biota.

The primary residential areas are not proximate (e.g., within kilometres) to the LNG Plant and are separated by Port Curtis in most instances. Some project infrastructure is located in adjacent bushland areas and therefore has a higher bushfire threat although the development types and use are not as vulnerable to the impacts of bushfire as compared to a residential area.

An analysis of the **bushfire setting** comprised research on bushfire history, weather and potential ignition causes. Gladstone experiences small summer fires associated with the rural interface areas however no spatial bushfire history information covering the study area is available. The bushfire period usually begins in September and continues until February. The peak occurs around October and November when grass curing is most advanced. Typically, it is the westerly and northwesterly winds that flow across the continent that provides the problematic weather associated with most fires. The Joint Local Disaster Mitigation Plan (Gladstone City and Calliope Shire Councils, 2005) identified a potential source of bushfire ignitions to be associated with industrial expansion in the Gladstone area.

Bushfire hazard has been evaluated through analysis of a combination of fuel (vegetation), slope and aspect following the SPP 1/03 methodology. Bushfire hazard was ranked according to severity as high, medium, or low. These severity classes provide a relative assessment of bushfire behaviour across the study area. The bushfire hazard severity map in Figure 7 (Attachment 1) provides a bushfire natural hazard management area to be used to determine the compatibility of development in that area under SPP 1/03.

On dry land where bushfires could occur, 69% of the study area is mapped as low hazard while the remaining is mapped as medium hazard (30%) and high hazard (1%). The low hazard areas are a result of gentle slopes and less hazardous vegetation types. The medium hazard areas (influenced by the presence of sclerophyll forests and woodlands) are concentrated on the mainland in the west of the study area near the proposed temporary workers accommodation facility (TWAF8) and on Curtis Island at and adjacent the site of the LNG plant. The presence of high hazard areas is very low and patchy, forming areas of approximately 1 hectare or less where wooded areas are situated on steeper slopes and ridgelines. The hazard severity map indicates areas where bushfire protection and mitigation strategies may be required. Combining fire hazard severity with asset location and known bushfire characteristics allows analysis of the bushfire risk.

Bushfire risk levels for impact scenarios were assessed by combining the likelihood and consequence to provide a risk level. The risk was influenced by the change in hazard, and the type and location of

asset base within the study area. The analysis also included an assessment of the **baseline projects** and the **cumulative impact** of planned future projects in the study area.

Assuming fire escapes the development, there is a low to medium risk (baseline assessment) and low to high risk (cumulative impact assessment) of fire impacting on the surrounding life, property and environment.

Risk treatments were chosen to reduce the likelihood and/or harmful consequences to assets through the process of selecting and implementing risk treatment options that modify the bushfire risk characteristics. The risk treatments include those required by SPP 1/03. The treatments are summarised in the table below.

An assessment of the **residual risk** after the proposed risk treatments are implemented demonstrated a risk reduction to an acceptable level, hence achieving the objectives of the study. An acceptable risk level was determined to be no greater than a 'medium' risk rating.

Risk Treatment Strategies	Risk Treatment Options
Avoid the risk	Prohibit ignition creation activities
Reduce the likelihood	Education
	Training
	Detection and monitoring
Reduce the consequence	Firebreak establishment for facility and buildings
	Firebreak establishment for construction activities in the field
	Adequate access for response and evacuation
	Afford assembly and administrative buildings protection
Accept and manage the risk	Suppression and response for operations
	Suppression and response for construction activities in the field
Transfer the risk	Adequate insurances
Retain the risk	Evacuation plan and residual risk

Abbreviations

4WD	Four wheel drive
AS/NZS	Australian Standard / New Zealand Standard
LNG	liquefied natural gas
COAG	Council of Australian Governments
EIS	environmental impact statement
EMP	Environmental Management Precinct
EPC	engineering, procurement and construction
GIS	geographical information systems
ISO	International Organisation for Standardisation
MOF	materials offloading facility
Mtpa	Million tons per annum
NSW	New South Wales
PPE	personal protective equipment
QFRS	Queensland Fire and Rescue Service
SPP	State Planning Policy
TWAF	temporary workers accommodation facility

Glossary of Terms

Asset Protection Zone	A management zone used in bushfire risk management planning that prescribes intensive fuel removal immediately adjacent to the asset to prevent flame contact and excessive radiant heat from reaching the asset.
Biota	All animal and plant life collectively.
Blow-up day	Increase in fireline intensity or rate of spread making conditions uncontrollable. Often accompanied by extreme convection and having characteristics of a fire storm.
Bushfire	A general term used to describe a fire in vegetation.
Bushfire hazard	A combination of environmental factors (usually slope, fuel and aspect) that creates a situation or condition with the potential for loss or harm to the community or environment. Bushfire hazard is given a relative ranking of high, medium and low.
Bushfire risk	The chance of a bushfire igniting, spreading and causing damage to assets of value to the community.
Fire Exclusion Zone	A management zone used in bushfire risk management planning that excludes fire from an area due to fire sensitive biota or where the fire interval has been exceeded.
Fire frequency	How many times a fire has occurred at a particular place over time.
Fire intensity	A measure of the heat of the fire front in kilowatts per m^2.
Fire interval	The time (years) between fires experienced by a species or ecological community that if exceeded (i.e. fires are more frequent or too infrequent) can impact on that species or the biodiversity of a community.
Fire pattern	The pattern of fire spread horizontally along the ground and vertically within the fuel column (from groundcovers to canopy).
Fire regime	The fire history characterising a particular ecosystem or area and includes the parameters of fire pattern, fuel consumption, fire intensity, fire severity, fire frequency and fire season.

Fire season	The time of the year the fire occurred or a term prescribed to describe the time of year when fires are more likely to occur, spread and cause sufficient damage to warrant organised fire management.
Fire severity	The severity of a fire usually measured by the amount of fuel consumed including the scorch height into the canopy.
Forest fire	A fire burning mainly in forest or woodland.
Fuel consumption	The consumption of available vegetative matter (dead or living) by a bushfire. A measure of fire severity.
Fuel load	The vegetative matter available to be consumed by fire contributing to rate of spread and intensity. Measured as a dry weight per unit area and expressed as tonnes per hectare.
Grass curing	The progressive sequence and drying out of grass after flowering or in response to dry periods such as drought. A cured grass offers more available fuel to fire.
Grass fire	A fire in which the predominant fuel is grass or grass like.
Land Management Zone	A management zone used in bushfire risk management planning that prescribes land management strategies for objectives other than fire control. These strategies are not mutually exclusive to fire protection planning for an area (e.g., prescribing prescribed burning for the maintenance of biodiversity).
Regional Ecosystem	A vegetation community in a bioregion that is consistently associated with a particular combination of geology, landform and soil as outlined in the Queensland Vegetation Management Act, 1999).
Residual risk	The risk remaining after the implementation of risk treatments.
Strategic Fire Advantage Zone	A management zone used in bushfire risk management planning that prescribes less intense methods of fuel reduction across the landscape with the objective of reducing fore rates of spread or intensity towards an asset or otherwise providing strategic advantaged for fire control purposes such as access and backburning.
Total Fire Ban	A ban of all fire and ignition creating activities declared per day by state government.
Worst-case fire scenario	The worst fire in regards to intensity and behaviour planned under a planning instrument.

1 Introduction and Context

1.1 BACKGROUND

This Bushfire Hazard & Risk Assessment (the assessment) was prepared for the Arrow LNG Plant (the project) on behalf of Arrow CSG (Australia) Pty Ltd and Coffey Environments Pty Ltd. Arrow CSG (Australia) Pty Ltd (Arrow Energy) proposes to develop a liquefied natural gas (LNG) facility on Curtis Island, on the central Queensland coast, opposite Gladstone. The assessment evaluates the vulnerability of the study area to bushfire and analyses the consequence of such an event on life, property and the environment within the study area.

1.2 LOCATION

Figure 1 shows the study area with respect to Gladstone and Curtis Island. Figures associated with this report are located in Attachment 1. The study area mapped is the area assessed for the direct and indirect impacts of the project. Within the study area, the area of disturbance includes the feed gas pipeline corridor, construction camps and the LNG plant on Curtis Island and associated infrastructure such as jetties.

1.3 PROJECT DESCRIPTION

1.3.1 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 subsidiaries of Royal Dutch Shell plc and PetroChina Company Limited.

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

1.3.2.1 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 undertaken 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 laydown 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).

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, precooled, 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 precooler 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 -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.

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 workers 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 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 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 1,100 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.

1.3.2.2 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 m^3 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.

1.3.2.3 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:

- 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.

1.4 OBJECTIVES OF BUSHFIRE HAZARD & RISK ASSESSMENT

The terms of reference for the Shell Australia LNG Project EIS (now Arrow LNG Plant) (Queensland Government, 2010) issued by the Coordinator-General for the State of Queensland in January 2010, states that the EIS should deal with external risk presented by bushfire determined on the basis of Australia/New Zealand Standard on Risk Management AS/NZS 4360:2004. Risk should be assessed for construction, operational and decommissioning phases of the project which would include an analysis of the consequences of bushfire impact on safety and the environment in the study area.

Bushfire management objectives for projects of this type are to:

- Prevent loss of and harm to human life;

- Minimise damage to built assets;

- Minimise disturbance to construction and plant operation; and

- Minimise impact of fire on the environment.

To achieve these objectives for this assessment, the following tasks were required:

- Identify the presence and extent of the existing bushfire hazard in the study area including known bushfire behaviour;
- With reference to applicable guidelines, standards and policy assess the bushfire risk posed by bushfire hazards during construction, operation and decommissioning phases of the project;
- Preparation of a management and mitigation plan to address bushfire risk to create an acceptable outcome within regulatory limits and guidelines, inclusive of any safety buffers and levels of construction for the development project; and
- Assessment and quantification of residual and cumulative bushfire risk.

1.5 LEGISLATION AND POLICY REQUIREMENTS

This section outlines the legislation and policy requirements for bushfire assessment, and management of bushfire risk on land in Queensland.

The primary legislation related to bushfire in Queensland is the Queensland *Fire & Rescue Services Act 1990.* An objective of the Fire & Rescue Services Act is the management of bushfire risk related to proposed development. The Act outlines provisions for the control and prevention of bushfires and the overriding responsibility of land managers to take measures to reduce fire risk to people, property and the environment.

There is no federal or local legislation that that places controls on development in regards to bushfire protection. The analysis of bushfire risk can and should be undertaken following the approach as set out in the National Inquiry on Bushfire Mitigation and Management (COAG, 2004), based on AS/NZS ISO 31000:2009 'Risk management – Principles and guidelines' (Standards Australia, 2009).

Queensland's *State Planning Policy 1/03 'Mitigating the Adverse Impacts of Flood, Bushfire and Landslide' (SPP 1/03)* (Department of Emergency Services and Department of Local Government and Planning, 2003) outlines the state's interest in ensuring that natural hazards, such as bushfire, are appropriately considered by development proposals. The policy expires on 31 August 2013 and at the time of report preparation it was under review by the Queensland Department of Community Safety. The policy remains applicable to the assessment of the project.

SPP 1/03 defines risk and hazard in the following manner; these definitions apply within this report.

Risk: is a concept used to describe the likelihood of harmful consequences arising from the interaction of hazards, community and the environment.

Natural hazard: a naturally occurring situation or condition with the potential for loss or harm to the community or environment. The natural hazards addressed in SPP 1/03 are flood, bushfire and landslide.

The policy requires the assessment of identified development within a bushfire hazard analysis framework. The compatibility of the development is assessed against the bushfire hazard rating and the mitigation measures applied. Where the local council authority has not prepared a bushfire hazard analysis of the locality, a site bushfire hazard analysis is required to be undertaken as part of the assessment. Gladstone Regional Council has available an analysis for the local government area,

although it is not at a scale suitable for the study area, and does not provide sufficient detail. As such a hazard analysis is prepared for the study area.

Developments that require consideration under SPP 1/03 include those that:

- Increase the number of people living or working within an area effected by bushfire;
- Involve the manufacture or storage of hazardous materials in bulk; and
- Involve institutional uses where evacuating people may be particularly difficult.

The project involves these criteria and therefore is required to be assessed under SPP 1/03. The methodology required for this assessment is detailed in Section 1.6. SPP 1/03 introduces the concept of 'natural hazard management areas', which includes bushfire, as the principal mechanism for triggering the development outcomes and development assessment components of the policy.

Medium and high hazard areas on the bushfire risk analysis maps produced by the Queensland Fire and Rescue Service constitute a natural hazard management area. Slope, aspect and vegetation are analysed spatially according to a formula within SPP 1/03 to prepare the bushfire hazard analysis maps and hence a natural hazard management area.

Within natural hazard management areas, development is required to be compatible with the nature of the hazard (some exceptions exist e.g., overriding need for the development in the public interest). Compatibility is determined against specific outcomes and planning scheme codes. Specific outcomes include a suite of bushfire protection measures such as access and road standards, building setbacks from bushland and fire breaks and the provision of water supply to name a few.

A Bushfire Risk Assessment and Management Plan exists for Gladstone City and Calliope Shire Councils (ENSR, 2008) which have since amalgamated with Miriam Vale Shire to form Gladstone Regional Council. For the local government areas this plan fulfils assessment and treatment of bushfire risk at a strategic and landscape scale under state legislation. The project should be consistent with the approach to risk assessment and treatment of the local government areas as outlined by ENSR (2008).

The Australian Standard *AS 3959:2009 Construction of Buildings in Bushfire Prone Areas* (Standards Australia, 2009) provides construction standards for buildings in a bushfire hazard area to protect against the effects of ember attack, radiant heat and flame contact. AS 3959:2009 is the approach deemed to satisfy *Building Code of Australia* compliance for building on bushfire prone land.

The Vegetation Management Act 1999 (Section 22A) requires a permit for vegetation clearing for the establishment of firebreaks and for projects declared to be a significant project under the State Development and Public Works Act 1971 (Section 26).

1.6 ASSESSMENT APPROACH AND METHODOLOGY

1.6.1 Assessment Approach

The approach to bushfire risk analysis and applying risk mitigation and management measures in this assessment is based on the risk management process defined by AS/NZS ISO 31000:2009 'Risk management – Principles and guidelines' (Standards Australia, 2009). The approach also complies with the requirements of SPP 1/03.

The National Inquiry on Bushfire Mitigation and Management (COAG, 2004) recommends an assessment process for:

- Analysis and evaluation of bushfire risk; and
- Acceptable risk treatments that will avoid the risk, reduce the likelihood, reduce the consequences, accept the risk, transfer the risk and retain the risk.

A flowchart illustrating the process of emergency risk management is included as Figure 2 in Attachment 1.

1.6.2 Method

Details on the method used are provided within each section of this document. To summarise, the method for the Bushfire Hazard and Risk Assessment is as follows;

a. Identify the asset base requiring protection (Section 1.7);

b. Identify the bushfire risk factors such as bushfire history and known bushfire behaviour in the study area and within the surrounding lands (Section 1.8);

c. Determine whether the development area has been mapped as a natural hazard management area under SPP 1/03 (Section 1.9);

d. Map the bushfire hazard at a site specific scale following the SPP 1/03 guidelines and compare with natural hazard management area mapping (Section 1.9);

e. Determine assessment requirements under SPP 1/03 based on results of hazard mapping (Section 2.1);

f. Assess (likelihood and consequence) and evaluate bushfire risk to and from the development proposal following AS/NZS ISO 31000:2009 risk management process. Link SPP 1/03 findings with this process (Section 2.2); and

g. Produce risk mitigation and management treatments and satisfy SPP 1/03 requirements (Section 3).

1.7 ASSET DESCRIPTION

The assets requiring protection from bushfires include life, property and the environment. These assets are recognised within the study area. Thus the assets requiring protection include workforce, visitors and neighbours, buildings and infrastructure, the LNG product and the terrestrial ecology.

The primary residential areas are not proximate (e.g., within kilometres) to the LNG Plant and are separated by Port Curtis in most instances. The small village of South End on Curtis Island to the east is over 10 kilometres away from the LNG site by distance of fire spread around the estuarine areas. This reduces the bushfire risk to these assets as the further an asset is located from the potential source of a fire (e.g., the LNG Plant on Curtis Island) the greater the likelihood of the fire being controlled prior to reaching the asset. The project infrastructure such as the LNG Plant and TWAF 8 are located adjacent to bushland areas and therefore have a higher bushfire threat although the development types and use are not as vulnerable to the impacts of bushfire as compared to a residential area.

Environmental assets include the Curtis Island Environmental Management Precinct located adjacent and northeast of the LNG Plant on Curtis Island and the general array of flora and fauna and ecological communities located within the local region. The Environmental Management Precinct was assigned in 2008 within the Gladstone State Development Area to protect areas of ecological significance.

Due to the lack of spatial information pertaining to the historical coverage of bushfire, fire consultants are unable to determine the current fire regime status for these bushland areas and their species (ENSR, 2008) and hence the vulnerability of these ecosystems to frequent fire regimes.

1.8 BUSHFIRE SETTING

1.8.1 Bushfire History

Every summer there are small fires around Gladstone associated with the rural interface areas of Gladstone's urban areas (ENSR, 2008). Queensland Fire & Rescue Service holds ignition point data dating back to 1993; however no spatial bushfire history information covering the study area or surrounding area is available. Spatial mapping of bushfire history provides a foundation to analyse likely ignition patterns, bushfire behaviour and spread. Given this lack of information, from a development assessment perspective, it is assumed that a fire could be ignited and develop into a worst-case scenario fire within areas mapped as medium and high bushfire hazard (as defined under SPP 1/03). This assumption is based upon climatic and vegetation data and nationally accepted fire behaviour formulae (e.g., McArthur, 1967).

1.8.2 Bushfire Weather

An analysis of fire weather experienced in the study area and the surrounding region provides insight into bushfire behaviour potential. The Gladstone area experiences a sub-tropical and sub-humid climate with considerable variation in temperature. Winters can be cool (mean 13º - 22º) and are typically the drier months (June, July and August). The drier winters and subsequent higher temperatures in spring typically bring the onset of the bushfire period which runs through to the beginning of the wet season in the summer months which are hot (mean 22º - 31º).

Weather factors that influence the length, severity of the fire season and the direction of fire spread include temperature, relative humidity, wind direction, and rainfall (seasonal dryness). These factors collectively increase the risk of fire during the bushfire period, which usually begins September and

continues until February each year. The peak occurs around October and November when grass curing is most advanced due to low humidity and high temperature.

Typically, it is the westerly and northwesterly winds that flow across the continent that provides the problematic weather associated with most fires. The winds from this sector can be hot and dry providing an environment that can assist in higher fire intensity and potentially uncontrollable bushfire behaviour. The passage of cold fronts may also produce problematic fire behaviour through wind changes to the west southwest, turning an eastern flank into a fire front. Wind changes, such as these, may result in a substantial increase in the fire area (the size of the fire) and increase danger to personnel and fire-fighters.

A fire weather danger rating and total fire ban restrictions can be checked daily by contacting the Queensland Rural Fire Service. The rating is a relative measure of the weather expected for the day and its influence on fire behaviour should ignition and fire spread occur. The ratings are listed as Catastrophic, Extreme, Severe, Very High, High and Low-Medium. A total fire ban will always occur on days of a catastrophic rating.

1.8.3 Potential Ignition Causes

The Joint Local Disaster Mitigation Plan (Gladstone City and Calliope Shire Councils, 2005) identifies the potential sources of bushfire ignitions to primarily be a result of the industrial expansion in the Gladstone area relating to construction and activities such as rail and transport and the handling of hazardous materials. These issues require consideration for the Arrow LNG Plant.

1.9 BUSHFIRE HAZARD

Bushfire hazard has been evaluated through analysis of a combination of fuel (vegetation), slope and aspect. The bushfire hazard has been completed by following the SPP 1/03 methodology for determining a bushfire natural hazard management area.

The bushfire hazard is assessed based on vegetation coverage and slope prior to any vegetation clearing or levelling of the sites as a result of the development or baseline projects, including Queensland Curtis LNG Project (QCLNG Project) and Gladstone LNG Project (GLNG Project) on Curtis Island. The assessment of hazard is relevant only for those areas surrounding a site in order to assess bushfire behaviour approaching a site. It is accepted that a development site will be cleared and levelled for construction, and this does not affect the bushfire hazard analysis.

The impact of vegetation clearing associated with the baseline projects on the overall risk assessment was considered however (see Section 2 for risk assessment).

1.9.1 Fuels (Vegetation)

The nature of bushfire fuels is determined from an assessment of vegetation floristics and structure. In this case Queensland Regional Ecosystem (DERM 2010) information was used with some ground-truthing by ecologists (Ecosure Pty Ltd pers comm, 2010) during a site visit in the summer of 2010. The vegetation communities are categorised and provided a score between 0 (least hazardous e.g., intact rainforest) and 10 (most hazardous e.g., tall open forest with mixed understorey). The fuel scores provide a relative weighting based on the influence of expected fuel loads and structure on fire intensity. It is based upon a relative measure of structure (e.g., forest, woodland or grassland) and floristics (e.g., rainforests, mangroves or saline wetlands).

Table 1 demonstrates how a fuel score is applied to vegetation as set out in SPP 1/03 methodology. The distribution of vegetation communities and their fuel scores is shown in Figures 3 and 4 respectively (Attachment 1).

Only fuel scores of 0, 2, 6, and 8 were found within and surrounding the study area. For those areas having a fuel score greater than 0, the most abundant score was 6 indicating a dominance of grassy eucalypt forest in the region. These areas also surround the LNG Plant and TWAF 8. Grassy forests are not as hazardous as those with a shrubby understorey due to a lack of fine fuels and a ladder up into the canopy. The higher fuel score of 8 (eucalypt forest with understorey) was found along the range running north-south to the west of TWAF 8 and on Curtis Island further to the north of the LNG Plant.

Table 1: Fuel hazard score applied to various vegetation groupings as per SPP 1/03

Vegetation communities	Hazard Score
Wet sclerophyll forest, tall eucalypts (>30m), with grass and mixed shrub understorey	10
Paperbark heath and swamps, eucalypt forest with dry-shrub ladder fuels	8
Grassy eucalypt and acacia forest, exotic pine plantations, cypress pine forest, wallum heath	6
Native grasslands (ungrazed), open woodlands, canefields	5
Intact acacia forests, with light grass to leaf litter, disturbed rainforest	4
Orchards, farmlands, kikuyu pastures	2
Grazed grasslands, slashed grass	2
Desert lands (spares fuels), mowed grass	1
Intact rainforest, mangrove forest, intact riverine rainforest	0

Source: *State Planning Policy 1/03 Guideline – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* (Department of Emergency Services and Department of Local Government and Planning 2003).

1.9.2 Slope

Steeper slopes significantly increase the rate of spread of fires, and with each 10º increase or decrease in slope a corresponding doubling or halving, respectively, in the rate of spread can be expected (McArthur, 1967). Thus, the relationship of the steepness of slope, and whether a fire moves upslope or downslope, is vital to understanding bushfire behaviour potential. Slope and wind are often the major factors determining the direction of fire spread.

The gradient of the local topography was derived from a contour data set of 10 m created by the Queensland Department of Environment and Resource Management (DERM) converted into a digital terrain model. Each digital terrain model square (25 m cell) for the study area was divided into one of five slope classes; Plain 0-5%, Undulating >5-10%, Rolling Hills >10-20%, Steep Hills >20-30%, and Gorges and Mountains >30%. Each category was provided a hazard score (relative weighting) based on the influence of gradient on rates of fire spread. Table 2 demonstrates the allocation of the slope class weightings. A map illustrating the distribution and occurrence of these slope classes is shown in Figure 5 (Attachment 1).

Most of the study area is flat land, estuaries or ocean. Mountainous areas associated with the range lie to the west of the study area near TWAF 8. Some steep areas are also found on Curtis Island to the north of the LNG Plant. A fire in these steeper areas is harder to control due to increased fire behaviour on steeper slopes and the wind effects created by the gullies and ridgelines. Access to control the fire is also usually limited in steeper terrain.

Table 2: Slope score applied to various slope classes as per SPP 1/03

Slope	Score
Gorges and Mountains >30%	5
Steep Hills >20-30%	4
Rolling Hills >10-20%	3
Undulating >5-10%	2
Plain 0-5%	1

Source: *State Planning Policy 1/03 Guideline – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* (Department of Emergency Services and Department of Local Government and Planning 2003).

1.9.3 Aspect

Aspect generally refers to the horizontal direction to which a hill slope faces. For example, a slope on the western edge of the Great Dividing Range is described as having a westerly aspect. Aspect affects bushfire hazard through the effects of sunlight and wind exposure on the topography and especially in the drying, heating and availability of fuels. Across the study area, the aspect of each digital terrain model grid cell was allocated into one of five categories providing a relative aspect score to be later used in determining the overall bushfire hazard score (see Section 1.9.4). The aspect of 'north to northwest' carries the highest hazard score, with the 'east to south' having the lowest hazard score. All land under 5% slope is excluded from the aspect scope as it is assumed the slope is not great enough to produce an aspect effect.

Table 3 demonstrates the allocation of the weightings for aspect. A map highlighting the distribution and occurrence of the relative aspect weightings across the development area is shown in Figure 6 (Attachment 1).

Table 3: Aspect score applied as per SPP 1/03

Aspect	Score
North to northwest	3.5
Northwest to west	3
West to south	2
North to east	1
East to south and all land under 5%	0

Source: *State Planning Policy 1/03 Guideline – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* (Department of Emergency Services and Department of Local Government and Planning 2003).

As the mountain range to the west of the study area and the ridgelines on Curtis Island align northwest to southeast, the aspect of these hilly areas is west to south (score of 2) and north to east (score of 1). These scores are at the lower end to mid range of the spectrum presented in Table 3 above. As the rest of the study area is flat, these areas have a zero influence on aspect.

1.9.4 Bushfire Hazard Score

The mapping of areas into 'high', 'medium' and 'low' bushfire hazard does not indicate how often an area will receive potentially damaging fires, nor the actual intensity of a fire. It does however provide a useful comparative ranking, indicating sites of higher and lower potential fire behaviour compared to others within a designated area.

A bushfire hazard is determined by simply adding the scores for vegetation, slope and aspect (Sections 1.9.1 to 1.9.3). This was performed in GIS. Bushfire hazard considers the probability of fire occurring within the hazard and spreading to threaten assets. Bushfire hazard has been ranked according to severity as high, medium, or low. These severity classes provide a relative assessment of bushfire behaviour across the development area and are used in the assessment pathway of development under SPP 1/03. Table 4 provides the matrix division for the final bushfire hazard score. The bushfire hazard map is shown in Figure 7 (Attachment 1).

Table 4: Hazard score matrix as per SPP 1/03

Total score by adding Vegetation, Slope & Aspect	Severity of Bushfire Hazard
13 or greater	High
6 to 12.5	Medium
1 to 5.5	Low

Source: *State Planning Policy 1/03 Guideline – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* (Department of Emergency Services and Department of Local Government and Planning 2003).

On land where bushfires could occur, 69% of the study area is mapped as low hazard while the remaining is mapped as medium hazard (30%) and high hazard (1%). The low hazard areas are a result of gentle slopes and less hazardous vegetation types, such as the cleared non-remnant areas and those vegetation types associated with the estuarine environment. The medium hazard areas are concentrated on the mainland to the west near TWAF8 and on Curtis Island in the east of the study area at and adjacent to the LNG plant. This is a result of the presence of dry sclerophyll forests and woodlands. The presence of high hazard areas within the study area is very low and patchy, forming areas of approximately 1 hectare or less within the medium hazard areas where forest and wooded areas are situated on steeper slopes and ridgelines. These small areas of high hazard are in the area of Targinie State Forest to the east and southeast of TWAF 8 and at the LNG Plant location.

In accordance with the SPP 1/03 assessment methodology, there are no elements within the bushfire hazard severity map that suggest precluding development (of a type associated with the project) within any part of the study area. However, the hazard severity map does indicate medium and high hazard areas where bushfire protection and mitigation strategies are required. Considering fire hazard severity against the proposed infrastructure allows analysis of the bushfire risk. Areas within the project footprint where bushfire risk could influence the development of strategies are listed below:

- TWAF8 is to be located within the vicinity of a medium hazard area, with patchy areas of high hazard; and
- The proposed LNG plant will be surrounded by medium hazard areas generally to the north and east, with isolated small areas of high hazard within the plant site (four patches around 1 hectare each that will be cleared) and along ridgelines running northwest from the LNG plant site. The baseline projects QCLNG and GLNG will be situated to the west removing any hazard in this direction.

The remainder of the development will be within or adjacent to areas of low hazard.

2 Bushfire Risk Assessment and Evaluation

2.1 SPP 1/03 ASSESSMENT

The information in this section is required to satisfy the legislative requirements of bushfire risk assessment within Queensland. It focuses on the protection of the development and its use from bushfire impact.

The bushfire hazard severity map in Figure 7 provides a bushfire natural hazard management area to be used to determine the compatibility of development in that area under SPP 1/03. A similar region-wide map has been produced by Queensland Fire and Rescue Service; however it does not offer site specific detail applicable to the LNG Plant study area.

Under SPP 1/03 the development is required to maintain the safety of people and property by either avoiding areas of high or medium bushfire hazard, or mitigating the risk through specific mitigation measures listed within SPP 1/03 ,such as firebreaks, access provisions and water supply through the preparation of a Bushfire Management Plan. An evaluation of these measures is contained within Section 3.3.

2.2 AS/NZS ISO 31000:2009 RISK ASSESSMENT

2.2.1 Bushfire Risk Assessment

The following sections assess the risk of a fire being ignited at a project site and spreading and impacting assets surrounding the site. The definition of bushfire risk is the chance of a bushfire igniting, spreading and causing damage to assets of value to the community.

The method was developed for use in developing bushfire risk management plans in New South Wales (NSW) by the NSW Rural Fire Service (NSW Rural Fire Service, 2008). The method follows the procedures and considerations of AS/NZS ISO 31000:2009 'Risk management – Principles and guidelines' (Standards Australia, 2009); it provides a risk classification scheme through qualitative scales to assess the likelihood and consequence of fire impact.

The likelihood of bushfire risk for all assets is defined as the chance of a bushfire igniting and spreading. There are four possible likelihood ratings: unlikely, possible, likely and almost certain. It is often challenging to determine the likelihood rating for assets. This is mainly due to a lack of fire history records. Fire history data, if available or local knowledge and an understanding of the landscape may be used to determine the likelihood of a bushfire occurring. Where data is not available, subjective estimates may be used which reflect the degree of belief that a bushfire will occur. Likelihood should be considered in the context of long term planning, not just the likelihood of a bushfire occurring in the next few years. Table 5 outlines the process for determining likelihood.

Table 5: Likelihood ratings for assessing bushfire risk (NSW Rural Fire Service, 2008)

	Fires are expected to spread and reach assets	**Fires are not expected to spread and reach assets**
Fires occur frequently	Almost certain	Possible
Fires occur infrequently	Likely	Unlikely

Source: *Bush Fire Risk Management Planning Guidelines for Bush Fire Management Committees* (NSW Rural Fire Service 2008).

Consequence is the outcome or impact of a bushfire event. The assessment process for consequence is subjective and includes consideration of threat, vulnerability and other issues such as level of impact and recovery costs. There are four possible consequence ratings: minor, moderate, major and catastrophic. A description of each is provided in Table 6.

Table 6: Consequence ratings for assessing bushfire risk (NSW Rural Fire Service, 2008)

Consequence rating	**Description**
Minor	• No fatalities. • Some minor injuries with first aid treatment possibly required. • No persons are displaced. • Little or no personal support (physical, mental, emotional) required. • Inconsequential or no damage to an asset. • Little or no disruption to community. • Little or no financial loss.
Moderate	• Medical treatment required but no fatalities. Some hospitalisation. • Localised displacement of persons who return within 24 hours. • Personal support satisfied through local arrangements. • Localised damage to assets that is rectified by routine arrangements. • Community functioning as normal with some inconvenience. • Local economy impacted with additional financial support required to recover. • Small impact on environment / cultural asset with no long term effects.

Consequence rating	Description
Major	• Possible fatalities. • Extensive injuries, significant hospitalisation. • Large number of persons displaced (more than 24 hours duration). • Significant resources required for personal support. • Significant damage to assets that requires external resources. • Community only partially functioning, some services unavailable. • Local or regional economy impacted for a significant period of time with significant financial assistance required. • Significant damage to the environment/cultural asset which requires major rehabilitation or recovery works. • Localised extinction of native species.
Catastrophic	• Significant fatalities. • Large number of severe injuries. • Extended and large number requiring hospitalisation. • General and widespread displacement of persons for extended duration. • Extensive resources required for personal support. • Extensive damage to assets. • Community unable to function without significant support. • Regional or state economy impacted for an extended period of time and financial assistance required. • Permanent damage to the environment. • Extinction of a native species in nature.

Source: *Bush Fire Risk Management Planning Guidelines for Bush Fire Management Committees* (NSW Rural Fire Service 2008).

The risk level is assessed by combining the likelihood and consequence to provide either a low, medium, high, very high or extreme level of risk using the matrix in Table 7. Table 8 presents the level of risk for varying bushfire impact scenarios. These scenarios consider the future pattern of vegetation as a result of the baseline projects.

Table 7: Matrix to determine level of bushfire risk (NSW Rural Fire Service, 2008)

Consequence / **Likelihood**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	High	Very High	Extreme	Extreme
Likely	Medium	High	Very High	Extreme
Possible	Low	Medium	High	Very High
Unlikely	Low	Low	Medium	High

Source: *Bush Fire Risk Management Planning Guidelines for Bush Fire Management Committees* (NSW Rural Fire Service 2008).

Table 8: Assessment of level of bushfire risk for the project

Impact No.	Impact	Level of risk
1	Loss of life and damage to property on the mainland *Likelihood = Unlikely* *Consequence = Moderate*	Low • The low availability of fuel across the mainland (low hazard areas) combined with cleared and developed land and many roads does not lend itself to severe, widespread fires. A widespread grassfire may occur in extremely windy and dry conditions such as a 'blow-up' day. This fire could be fast moving but of lower severity than a forest fire. • Residential assets in proximity to the project are generally not vulnerable to bushfire due to their location in low hazard areas. • Bushland areas near TWAF8 (medium hazard areas) have the potential to carry a widespread fire of higher severity however the effects of fire will be mitigated as part of the recommendations of this report.
2	Loss of life and damage to property on Curtis Island *Likelihood = Unlikely* *Consequence = Major*	Medium • Bushland areas near the LNG plant (predominantly medium hazard areas) have the potential to carry a widespread fire of higher severity. • There is a very low density of vulnerable assets such as dwellings or communities proximate to the LNG Plant. • The small and isolated township of South End on the very southeastern tip of Curtis Island, approximately 10 km east of the proposed LNG plant would only be within a potential bushfire pathway if fire escaped from the LNG plant and travelled north and then east around extensive estuarine environments that dissect the worst-case scenario spread of bushfire from west to east. • The residential community at South End on Curtis Island would have the capacity to cope with a fire due to a degree of natural separation (estuarine environment) from bushland areas of Curtis Island.

Impact No.	Impact	Level of risk
3	Damage to other port and industrial facilities on the mainland *Likelihood = Unlikely* *Consequence = Minor*	Low • Port facilities and industrial assets on the mainland are surrounded by cleared and managed lands. • Port facilities and industrial assets are not considered vulnerable due to their location within low hazard areas, the nature of their construction and use, and mitigation and management measures (including redundancies for fire fighting in place).
4	Damage to other port and industrial facilities proposed on Curtis Island *Likelihood = Likely* *Consequence = Minor*	Medium • Other LNG facilities proposed on Curtis Island will be surrounded by bushland and will be close to the LNG Plant. If ignition occurs, fire spread towards other facilities is likely. • The facilities are not considered vulnerable due to the nature of their construction and use, and mitigation and management measures (including redundancies for fire fighting in place).
5	Damage to ecological values on the mainland *Likelihood = Likely* *Consequence = Minor*	Medium • Environmental assets such as vegetation or wildlife communities of concern could be vulnerable dependant on various fire regime thresholds, which are currently unknown. Risk is typically more dependent on the fire regime than a single fire event.
6	Damage to ecological values on Curtis Island *Likelihood = Likely* *Consequence = Minor*	Medium • Environmental assets, such as the Environmental Management Precinct, may be at risk, depending upon the species/communities and their current fire regime status (a fire regime is the frequency, intensity, season and pattern of fire) which is currently unknown.

2.2.2 Bushfire Risk Evaluation

The primary issues amongst the analysis of risk (Table 8) were influenced by the change in hazard, and the type and location of asset base from the mainland to Curtis Island as discussed below.

The mainland is mapped as predominantly low hazard and supports cleared and developed lands in inland areas and many port and industrial facilities on the coast. Dwellings on properties are scattered throughout. There are limited assets in those areas mapped as medium hazard (near TWAF8). Curtis Island, however, is predominantly medium hazard with areas of high hazard, and supports little residential development apart from the small township of South End at the southeastern tip of the Island. Curtis Island also features the GCLNG and GLNG baseline projects adjacent to the west. These other base line projects will remove some of the bushfire hazard to the west, yet they act as an asset that could be impacted by fire escaping from the site.

Assuming a fire escapes the development, there is a low to medium risk of fire (adversely) impacting on the surrounding life, property and environment on Curtis Island or the mainland.

The highest risk rating scored (Table 8) was medium in three situations, these are;

- The possible damage to property and chance of fatalities or major injuries to life on Curtis Island;
- Damage to other port and industrial facilities proposed on Curtis Island; and
- The possible chance of damage to ecological values on Curtis Island or the mainland.

It is the above bushfire risks to surrounding assets that are to be treated in the management and mitigation plan in the following Section 3.

2.2.3 Risk Acceptability

Risk acceptability is typically defined and assessed by the agency responsible for managing the land or the relevant fire authority. In this case, the risk acceptability is defined by the author based on bushfire risk management guidelines (NSW Rural Fire Service, 2008) and experience in preparing bushfire risk assessments.

Areas of low to medium risk are likely to be managed by routine procedures general to the development overall and may not require a specific allocation of a risk treatment. Generally speaking, serious consideration should be given to risks rated as high and above (includes very high and extreme risk ratings). Therefore risk ratings of low to medium are considered an acceptable level of risk, with a high risk rating being the point where risks may be considered as unacceptable.

Acceptable risks should be monitored or reviewed over time as conditions alter over time and they may need to be amended.

3 Bushfire Risk Treatments

3.1 INTRODUCTION

As detailed in Section 1.4, the bushfire management objectives for this project are to:

- Prevent loss of and harm to human life;
- Minimise damage to built assets;
- Minimise disturbance to construction and plant operation; and
- Minimise impact of fire on the environment.

This section describes the bushfire risk mitigation options designed to reduce the risks identified. This risk reduction is required to meet the above objectives and is to be considered as part of development approval and operation of the LNG plant.

The purpose of treating risks is to reduce the likelihood and/or harmful consequences to assets through the process of selecting and implementing mitigation and management that modify the bushfire risk characteristics. Section 4 – Residual Risk contains an assessment of the risk reduction as a result of the risk treatments recommended in this section.

The stakeholders of the plan include, but are not necessarily limited to, designers and planners, site and construction management and supervisors, construction crews, and fire fighters.

3.2 COMBINING SPP 1/03 ASSESSMENT WITH AS/NZS ISO 31000:2009

The bushfire risk assessment undertaken against SPP 1/03 (Section 2.1) is a statutory responsibility required under SPP 1/03 for the adequate protection of new development in a bushfire natural hazard management area. The mitigation measures required by SPP 1/03 to be considered conditions of development approval are included in the Bushfire Management Plan below and are identified by the following notation ***SPP 1/03*** .

The format of the recommended mitigation treatment options that formulate the Bushfire Management Plan follow the groupings set-out within AS/NZS ISO 31000:2009. Mitigation measures are provided for both the protection of the development proposal and protection of surrounding assets.

3.3 BUSHFIRE RISK TREATMENT OPTIONS

Bushfire risk treatment options should aim to reduce both the likelihood and consequence of bushfires, and allow provisions for addressing the risk that remains i.e., the residual risk. There are six broad groups of risk treatment options for bushfire protection for all types of assets as summarised in Table 9. Implementation of these strategies specific to the LNG plant provides an effective way of minimising the risks identified within this assessment.

Table 10 describes those risk treatments recommended to be carried out at the development site for the construction, operation and maintenance of the LNG plant.

Table 9: Recognised bushfire risk treatment option groups

Risk treatment option	Definition	Example treatment
Avoid the risk	By deciding not to proceed with the activity likely to generate the bushfire risk or relocate the activity to areas of no hazard.	• Ceasing or removing activities from threat.
Reduce the likelihood	Programs to reduce the number of deliberate and accidental man-made ignitions in the risk area.	• Deterrence; • Community education; • Access restrictions; • Regulation.
Reduce the consequence	Programs to reduce the level of fuel available to burn in a bushfire.	• Asset Protection Zones; • Strategic Fire Advantage Zones; • Land Management Zones; • Fire Exclusion Zones.
Accept and manage the risk	After risks have been reduced, some residual risks may still exist, which may need to be managed with fire response strategies.	• Detection and warning; • Response planning; • Suppression activities.
Transfer the risk	Involves another party sharing some part of the risk by providing capabilities or resources.	• Insurance arrangements.
Retain the risk	After risk has been changed or shared, there may be residual risk without any specific immediate action being required.	• Recovery planning. • Evacuation planning.

Table 10: Recommended Risk Treatments to Treat Risks to/from Project Identified in Risk Assessment

Risk treatment options and strategies			
Avoid the risk			
Specifically addressing Impacts 2, 4, 5 & 6 Table 8	***Prohibit ignition creation activities***	*What/who*	Site manager to prohibit welding, off road driving and other construction and maintenance activities that can cause fire, produce sparks and/or embers during days of total fire ban within 'field' areas that are outside of construction or facility compounds i.e., areas exposed to bushfire fuels.
		Where	'Field' areas outside of established construction or facility compounds.
		How	Monitor fire weather forecast. Ignition creating activities outdoors in the field such as welding should not occur on days of total fire ban. On days of extreme fire weather ignition creating activities can occur only with the presence of a fire appliance (for example - 4WD striker with slip-on water unit equipped with pump and hoses). Any work on these days will require notification of the local fire control centre and a permit to work from the construction manager/supervisor. Ignition creating activities may occur on days of severe fire danger and lower without these restrictions, and in combination with the measures listed under the remaining risk treatment options below.
		When	Daily during construction phases of the development.
Reduce the likelihood			
Generally addressing all Impacts Table 8	***Education***	*What/who*	Construction crew and maintenance staff should be educated on the topic of bushfire risk management and the risks that could be present at the site. This should also be included in any construction and operational environmental management plans and all personnel induction activities.
		Where	Facilities building or company office.
		How	Incorporate bushfire management procedures into staff and visitor inductions upon arrival at site.

Risk treatment options and strategies			
		When	Upon arrival at site. Applicable for construction and operation.
Generally addressing all Impacts Table 8	***Training***	*What/who*	Training construction crew and maintenance staff on basic first response fire fighting techniques including notification of fires and reporting. The training of selected personnel to include the use of specific equipment contained in the on site Fire Station including 4WD striker unit, extinguishers, knap-sacks (back mounted or hand-held suppression units) and hoes. All trained personnel are to be provided personal protective equipment suitable for the fire activities such as overalls, helmet, goggles and gloves. Notification and reporting of fires to follow a procedure of notifying site manager and fire authorities (000/112) immediately and provide a description of the fire location, size, proximity to assets and current access arrangements.
		Where	Construction camps or TWAF.
		How	Appropriate training session.
		When	Prior to construction activities in the field and on an on-going basis at regular intervals, such as annually prior to the bushfire season.
Generally addressing all Impacts Table 8	***Detection and monitoring***	*What/who*	Site security to include detection and monitoring of areas for ignition and arson.
		Where	Routine patrol around sites.
		How	During routine patrol.
		When	During routine patrol.

Risk treatment options and strategies			
Reduce the consequence			
Specifically addressing Impacts 2, 4, 5 & 6 Table 8	***Firebreak establishment for facility and buildings * SPP 1/03***	*What/who*	Establish a firebreak around all buildings and facility structures for a distance of at least 30 m. This firebreak width is compliant with SPP 1/03 (Appendix 5, Table B, Solution 1.2.b). This firebreak width will prevent an upper limit of 15 kW/m^2 radiant heat flux on the metal outer surface of an LNG tank in accordance with the European LNG Code EN 1473. The radiant heat flux model report is contained in Attachment 2. Apply the guideline for fuel management specifications within a firebreak as presented in Section 3.4.
		Where	All buildings and facilities.
		How	Zone can be created using mechanical slasher or hand held tools such as a trimmer. This is dependent on environmental controls. Canopy trees can be removed with a chainsaw if thinning is required.
		When	During all phases of the development.
Specifically addressing Impacts 2, 4, 5 & 6 Table 8	***Firebreak establishment for construction activities in the field *SPP 1/03***	*What/who*	Establish a fuel reduced zone around temporary construction sites where construction activities may result in ignition generation for a distance of at least 30 m (from perimeter fencing).
		Where	Around construction activities in or adjacent to medium and high hazard areas that may result in ignition generation. This includes the LNG Plant and all works on Curtis Island, the mainland tunnel launch shaft and TWAF 8 on the mainland.
		How	Zone can be created using mechanical slasher or hand held tools such as a trimmer. This is dependent on environmental controls. Canopy trees can be removed with a chainsaw if thinning is required.

Risk treatment options and strategies			
		When	During the construction phases of the development.
Specifically addressing Impacts 2, 4, 5 & 6 Table 8	***Adequate access for response and evacuation * SPP 1/03***	*What/who*	Access roads to construction sites, buildings and facilities are at a minimum 6 m wide (carriageway) with grades and turning radii allowing the movement of fire tankers. Passing bays may be required in wooded land. All fire breaks required for buildings, facilities and construction activities mentioned require a perimeter road or trail between the asset and the hazard to the same standards above.
		Where	All access roads.
		How	Appropriate planning controls and road maintenance activities such as grading surface and maintaining drainage.
		When	During all phases of the development.
Generally addressing all Impacts Table 8	***Afford assembly and administrative buildings protection from bushfire * SPP 1/03***	*What/who*	Ensure buildings used as assembly and refuge for workers are constructed to withstand bushfire impacts.
		Where	All buildings used as assembly and refuge for workers including administrative buildings. Facility and operational buildings/structures are excluded.
		How	Application of AS 3959:2009 'Construction of Buildings in Bushfire Prone Areas'.
		When	Consideration during detailed design. Application during construction.
Accept the risk			
Specifically addressing Impacts 2, 4, 5 & 6 Table 8	***Suppression and response for operations * SPP 1/03***	*What/who*	Provide water supply (static or reticulated) in conjunction with supply used for building and structural fires. Immediately notify fire authorities of any fire.
		Where	Primary buildings and facilities.
		How	The LNG Plant operation and maintenance includes: - Fire water pump supply. The design considers provision of 3 x 60% main firewater pumps, where one pump is

Risk treatment options and strategies			
			electrical motor driven and two pumps are diesel engine driven. - Fire water storage capacity. Designed for two hours of maximum fire water requirements with 100% back up. The combined fire and service water storage equals 2 x 2625 m^3 of which 2 x 1500 m^3 is reserved for fire water. Provision will be made to pump sea water as back up by pumps or through the tugs at the jetty. The pumps and the ring main system will be designed to provide a minimum pressure of 10 bar at the most remote location on the site. -Leak prevention. The facility includes a dedicated fire and gas detection system (FGS). - Shipping protection. Membrane LNG tanker berthing/unberthing escort tugs with full fire fighting capability (four which includes two stand-by). The facilities accommodation will include fire fighting and alarm services. Fire authorities to be notified immediately for assistance with fire suppression (000 or 112).
		When	Water supplies to be provided during construction and suppression of fire is to occur upon notification of fire.
Specifically addressing Impacts 2, 4, 5 & 6 Table 8	***Suppression and response for construction activities in the field **** ***SPP 1/03***	*What/who*	Provide and maintain fire fighting equipment capable of controlling and suppressing small initial outbreaks of fire. This includes a striker vehicle (4WD) with slip-on fire unit, hand tools, knap-sack, and PPE. Notify fire authorities when fire occurs that cannot be controlled by first response techniques described above.
		Where	Construction sites including but not limited to the LNG plant, launch site, tunnel launch site and TWAF.
		How	Initial response and suppression by construction crew followed by notification of fire authorities (000 or 112).
		When	During construction.

Risk treatment options and strategies			
Transfer the risk			
Generally addressing all Impacts Table 8	***Adequate insurances***	*What/who*	Ensure insurance policy relevancy based on the understanding of bushfire risk presented in this assessment.
		Where	Arrow LNG Plant administration.
		How	Review insurance policy.
		When	Prior to construction and could be reviewed again at completion of construction prior to operation phase.
Retain the risk			
Generally addressing all Impacts Table 8	***Evacuation plan and residual risk***	*What/who*	Understand the concept of residual risk described in Section 4.2 below. Prepare and execute a 'Bushfire Emergency and Evacuation Plan'.
		Where	At each of the construction site locations, including LNG plant, launch site, tunnel launch site and TWAF. At each of the operational site locations including, LNG plant and launch site.
		How	Bushfire Emergency and Evacuation Plan to be prepared to satisfy the requirements of Australian Standards AS 3745:2010 – *Planning for emergencies in facilities* (Standards Australia, 2010). The NSW Rural Fire Service document 'A Guide to Developing a Bushfire Evacuation Plan' (RFS, 2004) is a helpful document. The plan is to include, but not be limited to, roles and responsibilities of emergency control staff, evacuation guidelines including onsite refuge and offsite evacuation, recovery operations, and staff education and induction.
		When	During all phases of the development.

3.4 FIREBREAK FUEL MANAGEMENT SPECIFICATIONS

As a guide, fuel (vegetation) management within the minimum 30 m firebreak prescribed by SPP 1/03 for the project is to be as follows:

- The presence of a few mature, canopy trees in the firebreak is acceptable provided that they are well spread out and do not form a continuous canopy, however no tree or tree canopy is to occur within 10 m of a structure/asset;
- Understorey shrubs and saplings are not permitted; and
- Minimal ground fuel is to be maintained so that there is less than 4 tonnes per hectare of fine fuel. Fine fuel means any dead or living vegetation of less than 6 mm in diameter e.g., twigs less than a pencil in thickness. Four tonnes per hectare is equivalent to an approximately 1 cm thick layer of leaf litter. To achieve staying under this level of fuel, regular mowing/slashing or raking (depending on the ground surface and covering) will be required.

3.5 RESIDUAL RISK

Residual risk is defined as the bushfire risk that remains after the implementation of bushfire risk treatments. It acknowledges that despite the treatments that are able to be put in place, some bushfire risk will remain and bushfires may continue to threaten assets, at least to some extent. The concept of residual risk is inherent in most, if not all, risk plans. For example, there is no guarantee of 100% life and property protection when applying SPP 1/03 to new development. The level of residual risk also depends how the mitigation measures have been applied and assumes their effective implementation.

Table 11 discusses the change in the baseline risk assessment level due to the effect of the recommended risk treatments in Table 10.

Table 11: Change in baseline risk level as a result of risk treatment proposed

Impact	Risk level		Evaluation
	Before risk treatment	After risk treatment	
Loss of life and damage to property on the mainland	*Likelihood = Unlikely* *Consequence= Moderate* Low	*Likelihood = Unlikely* *Consequence = Minor* Low	The risk level pre-treatment was already Low and therefore remained the same after treatment. The asset base in context with the available hazard on the mainland does not produce a significant bushfire risk on the mainland.

Impact	Risk level		Evaluation
	Before risk treatment	After risk treatment	
Loss of life and damage to property on Curtis Island	*Likelihood = Unlikely* *Consequence = Major* Medium	*Likelihood = Unlikely* *Consequence= Moderate* Low	The risk level reduces one level from Medium to Low due to a reduction in consequence based on increased fire fighting capabilities involved with the development including baseline projects.
Damage to other port and industrial facilities on the mainland	*Likelihood = Unlikely* *Consequence = Minor* Low	*Likelihood = Unlikely* *Consequence = Minor* Low	The risk level pre-treatment was already Low and therefore remained the same after treatment. The asset base in context with the available hazard on the mainland does not produce a significant bushfire risk on the mainland.
Damage to other port and industrial facilities proposed on Curtis Island	*Likelihood = Likely* *Consequence = Minor* Medium	*Likelihood = Unlikely* *Consequence = Minor* Low	The risk level reduces one level from Medium to Low due to a reduction in likelihood based on controls to prevent fire spread from the project to other projects on Curtis Island.
Damage to ecological values on the mainland	*Likelihood = Likely* *Consequence = Minor* Medium	*Likelihood = Unlikely* *Consequence = Minor* Low	The risk level reduces one level from Medium to Low due to a reduction in likelihood based on controls to prevent fire spread from the project to impact on bushland.

Impact	Risk level		Evaluation
	Before risk treatment	After risk treatment	
Damage to ecological values on Curtis Island	*Likelihood = Likely* *Consequence = Minor* Medium	*Likelihood = Unlikely* *Consequence = Minor* Low	The risk level reduces one level from Medium to Low due to a reduction in likelihood based on controls to prevent fire spread from the project to impact on bushland.

3.6 CUMULATIVE IMPACT ASSESSMENT

The assessment of cumulative impact, from a bushfire risk assessment perspective, has considered projects located in the Gladstone region that has one or more of the following:

- Existing (baseline) developments constructed and operating in the Gladstone region, and those projects that have taken a financial investment decision as of 17 February 2011;
- The *State Development and Public Works Organisation Act 1971* (Qld) and has been declared by the Coordinator General as a 'project of state significance' for which the status of the EIS is either complete or, as a minimum, has an Initial Advice Statement published on the Department of Infrastructure and Planning (DIP) website;
- The *Environmental Protection Act 1994* (Qld) and has completed an EIS or has an Initial Advice Statement (or similar) listed on the Department of Environment and Resource Management (DERM) website; or
- The project is envisaged in statutory planning documentation.

Table 12 on the following page lists the projects considered in the cumulative impacts assessment.

Table 12: Other Projects Included in the Cumulative Impact Assessment

Name of project	Proponent(s)
Baseline – construction, operation or financial investment decision	
Queensland Curtis LNG Project	QGC Pty Limited (BG Group business)
GLNG Project	Santos Limited (and partners Petronas, Total and KOGAS)
Yarwun Alumina Refinery Expansion Project	Rio Tinto
Proposed – EIS or Advice Statement underway or project is envisaged in statutory planning documentation	
Australia Pacific LNG Project	Australia Pacific LNG (ConocoPhillips and Origin Energy)
Western Basin Strategic Dredging and Disposal Project	Gladstone Ports Corporation Limited
Fishermans Landing Northern Expansion Project	Gladstone Ports Corporation Limited
Arrow Surat Pipeline Project (formerly Surat Gladstone Pipeline Project)	Surat Gladstone Pipeline Pty Ltd
Central Queensland Pipeline Project	Enertrade (AGL Energy and Arrow CSG (Australia) Pty Ltd)
Wiggins Island Coal Terminal Project	Central Queensland Ports Authority and Queensland Rail
Gladstone Nickel Project	Gladstone Pacific Nickel Limited
Gladstone Steel Plant Project	Boulder Steel Limited
Moura Link-Aldoga Rail Project	Queensland Rail Ltd
Gladstone-Fitzroy Pipeline Project	Gladstone Area Water Board
Hummock Hill Island Community Project	Eaton Place Pty Limited
Boyne Island Aluminium Smelter Extension of Reduction Lines Project	Rio Tinto Aluminium
Gladstone LNG Project	Gladstone LNG Pty Ltd

Cumulative bushfire risk impacts have been assessed through the analysis of the potential change in the risk of a bushfire igniting and spreading to reach and impact on an asset due to the cumulative effect of many projects within an area. A risk analysis following the process identified in Section 2.2.1 was used to determine the change in bushfire risk when considering all projects (Table 12). The predominant outcome of the cumulative effect is an increased risk of ignition due to the additional construction and operation activities within bushfire natural hazard management areas. However, increased development in an area is also coupled with factors that can reduce risk such as a change in the coverage of bushland and fire fighting resources affecting the ability for fire to escape and spread to impact on an asset.

Table 13 below discusses the potential change in the bushfire environment due to the cumulative effect of many projects in the area. This discussion provides the basis of the risk assessment that follows.

Table 13: Cumulative impact on bushfire environment

Change in bushfire environment	Cumulative impact	Comment
Risk of bushfire ignition	• An increase in the number of people and their access to bushland areas potentially increases the risks of accidental or deliberate human caused ignition of a bushfire. This may increase the risk of bushfire impact on life, property and the environment. • An increase in the number of people in an area also increases the level of community surveillance which may decrease the occurrence of deliberately lit fires (arson). • The more development and access within a bushland area increases the chance of human-induced accidental ignitions.	The cumulative impact is mitigated by contemporary bushfire protection design for all new development. Also an increase in people improves bushfire detection and response times and therefore suppression effectiveness.
Changes to fuel availability and distribution	• The more development that takes place in an area, the less fuel coverage that remains. That is, a development or activity removes the available bushfire fuel (vegetation). The benefit of this reducing the occurrence of fires in an area needs to be coupled with the increased risk of ignitions (see above row). • Clustering developments is advantageous in removing large areas of fuel and reducing the bushland interface where ignitions can occur. This is the case for the projects on Curtis Island.	The cumulative impact in this case results in a reduction of bushfire risk by the continual removal of bushfire fuels.

Change in bushfire environment	Cumulative impact	Comment
Bushfire suppression capability and level of protection for development	• Fire suppression effectiveness and resourcing needs to keep pace with an enlarging bushland / development interface. The larger the interface the larger the fire fighting resource required.	It is unknown what increase in suppression resources are planned, but these typically grow with a population and development e.g., more brigades and fire fighters.
More assets requiring protection	• The cumulative effect of more developments in a bushland setting is that there are more assets to protect and defend.	The planned increase in fire detection and suppression resources (see row above) should counteract this.
Impacts of bushfire protection measures on natural environment	• An increase in the extent of development on bushfire prone land potentially increases the impacts on the environment through the provision of asset protection zones and fire fighter access roads.	This report does not assess the environmental impacts of the bushfire risk mitigation treatments. The treatments should be viewed as part of the development as a whole. If the impact of the treatments is deemed significant then the development needs to be re-designed.

Currently, and as assessed for the Arrow LNG Plant on its own, the likelihood rating was restricted to likely and unlikely only as fires were assessed as occurring infrequently in the area historically and as a result of the project (see Table 5 for the application of the likelihood rating). If the cumulative impact of many projects in the area leads to an increased chance of ignition, a test of a change in the likelihood scenario of fires occurring frequently has been applied, therefore resulting in almost certain or possible likelihood ratings. The consequence of fire impact remains the same (as in Table 8). The change in risk level influenced by the baseline projects and the cumulative impact of other proposed projects on fire ignition in the area is displayed in Tables 11 and 12 respectively.

Tables 14 and 15 show that if fires become more frequent due to accidental ignitions associated with increased activities in the area, the risk to some impact scenarios increases to high (loss of life and damage to property on Curtis Island and damage to ecological values). The assumption with this risk assessment is that fires become frequent, and is a good test to see the worst case risk ratings of such a scenario. Table 13 discusses the mitigating factors that are associated with increased activity (such as the clearance of bushland) and there is a matched increase in fire fighting resources, the ability to respond and improved access in areas otherwise not previously available.

The results of the analysis of the risk posed by the baseline projects are identical to the results of the analysis of the cumulative impact of the proposed projects (which include the baseline projects). This is due to both groups of projects consisting of development on Curtis Island and the mainland proximate to bushland (medium and high hazard areas). The amount of development, specific location or area

affected by each group within or adjacent medium and high hazard areas did not differ enough to significantly alter the risk levels. For example, the projects in addition to the baseline projects on Curtis Island is not significant in regards to number, size and location.

Considering the baseline and proposed projects collectively, the location and area of the projects and their effect on reducing the coverage of vegetation in these areas do not significantly reduce the bushfire risk to surrounding assets. On Curtis Island, the projects are clustered to the west of the LNG Plant and do not provide any strategic fire advantage for development in the area. The primary concern on Curtis Island is ignition occurring under a severe fire weather day and fire spreading west to east towards residential settlements at South End. On the mainland, the projects are scattered throughout and do not offer landscape wide fire protection for surrounding assets. There may be site specific examples of where vegetation clearance may reduce the risk to a neighbouring asset.

The most significant influencing factor on the risk assessment is the potential for an increase in ignitions. This is also identified in the Gladstone City Council and Calliope Shire Council Bushfire Risk Assessment and Management Plan (ENSR, 2008). An increase in the risk of ignition outweighs the change in risk offered by a reduction in the coverage of vegetation. As stated in Table 13 the projects come with an increase in surveillance, fire detection and suppression.

Table 14: Bushfire risk due to cumulative impact of baseline projects assuming more frequent fires due to increased ignition and no controls

Impact	Level of risk
Loss of life and damage to property on the mainland *Likelihood = Possible* *Consequence = Moderate*	Medium
Loss of life and damage to property on Curtis Island *Likelihood = Possible* *Consequence = Major*	High
Damage to port and industrial facilities on the mainland *Likelihood = Possible* *Consequence = Minor*	Low
Damage to port and industrial facilities on Curtis Island *Likelihood = Possible* *Consequence = Minor*	Low
Damage to ecological values on the mainland	Low

Impact	Level of risk
Likelihood = Possible *Consequence = Minor*	
Damage to ecological values on Curtis Island *Likelihood = Almost certain* *Consequence = Minor*	High

Table 15: Bushfire risk due to cumulative impact of proposed projects assuming more frequent fires due to increased ignition and no controls

Impact	Level of risk
Loss of life and damage to property on the mainland *Likelihood = Possible* *Consequence = Moderate*	Medium
Loss of life and damage to property on Curtis Island *Likelihood = Possible* *Consequence = Major*	High
Damage to port and industrial facilities on the mainland *Likelihood = Possible* *Consequence = Minor*	Low
Damage to port and industrial facilities on Curtis Island *Likelihood = Possible* *Consequence = Minor*	Low
Damage to ecological values on the mainland and Curtis Island *Likelihood = Almost certain* *Consequence = Minor*	High

4 Monitoring and Review

All strategies and plans must define mechanisms to allow for recommended actions to occur, to show that potential impacts are being managed and to monitor completion of prescribed actions. It is also necessary to determine the effectiveness of the plan and efficiency actions.

Monitoring should occur at both the management level and at the field level. Monitoring and evaluation against the aims and objectives is an effective way to monitor the implementation of risk treatments. Recording of details pertaining to achievement of risk treatments, fire occurrence (including ignition source and point, spread and behaviour) and damage sustained to assets is important for continual review and update of objectives and strategies.

An evaluation, review and update of this assessment should occur annually (at the end of each bushfire danger period) through the process of updating fire history and other resource data, and adjusting works programs if required. Matters that require a more significant variation should be discussed amongst the stakeholders prior to implementation. The objectives of a review are to:

- Consider whether the aims and objectives have been achieved;
- Reassess the strategies in light of current research and management practice;
- Reassess the strategies in light of recorded fire events within or nearby the site; and
- Reassess the strategies taking into account legislative changes, financial constraints, social philosophies, improvements in bushfire protection and suppression, and changes in vegetation.

5 Conclusion

This report assesses the bushfire hazard and risk to and from the Arrow LNG Plant and associated infrastructure. The proposal includes a gas pipeline from Gladstone to Curtis Island, an LNG plant, construction camp, mainland TWAF, mainland island launch sites and marine infrastructure on Curtis Island (jetty, MOF, quarantine facility). The objective of the assessment was to identify bushfire protection and mitigation measures required for the project to:

- Prevent loss of and harm to human life;
- Minimise damage to built assets;
- Minimise disturbance to construction and plant operation; and
- Minimise impact of fire on the environment.

The bushfire hazard and risk assessment is divided into two parts. Firstly, the assessment of the compatibility of the proposal with the surrounding bushfire hazard under the Queensland *State Planning Policy 1/03 'Mitigating the Adverse Impacts of Flood, Bushfire and Landslide'* (SPP 1/03) in relation to the protection of the development against the impacts of bushfire. Secondly, a risk assessment of the impacts to the surrounding land uses and assets following a risk assessment matrix based on a methodology developed specifically for assessing bushfire risk by the NSW Rural Fire Service which follows the principles of AS/NZS ISO 31000:2009 'Risk management – Principles and guidelines'.

To fulfil the first part, a bushfire hazard map was produced for the study area and surrounding land following the SPP 1/03 method. The hazard level was determined by a relative scoring matrix considering the effects of vegetation type, slope and aspect on bushfire behaviour. Much of the study area has been mapped as having predominantly no hazard or low hazard due to the presence of the estuarine environment, cleared areas and less hazardous vegetation types on gentle slopes surrounding the coastline. The LNG plant and TWAF8 will be within and adjacent to medium hazard areas with scattered small patches of high hazard that extend into the western (mainland) and eastern (Curtis Island) parts of the study area.

There are no elements within the bushfire hazard severity map that suggest precluding the development within any part of the study area. However, the medium and high hazard severity ratings indicate that bushfire protection and mitigation strategies are required.

The risk assessment in the second part consisted of a baseline assessment and an assessment of cumulative impacts of planned future projects. The risk assessment resulted in a risk rating for subsets of life, property and environment. These ranged from high to low. Risk treatments to address the risk and achieve the assessment objectives are presented in Section 3.3 (Table 14). Table 14 details the bushfire risk treatments either required by SPP 1/03 or recommended as a result of the baseline or cumulative impact risk assessments in order to address the risks identified. The treatments fall within the broad strategies of 'avoid the risk', 'reduce the likelihood', 'reduce the consequence', 'accept the

risk', 'transfer the risk' and 'retain the risk'. Treatments include firebreaks, operational and suppression preparedness, adequate access and training.

An assessment of the residual risk remaining after the proposed risk treatments are implemented has demonstrated that a medium to low level of risk will remain. This level of risk is deemed acceptable and therefore satisfies the study objectives.

6 References

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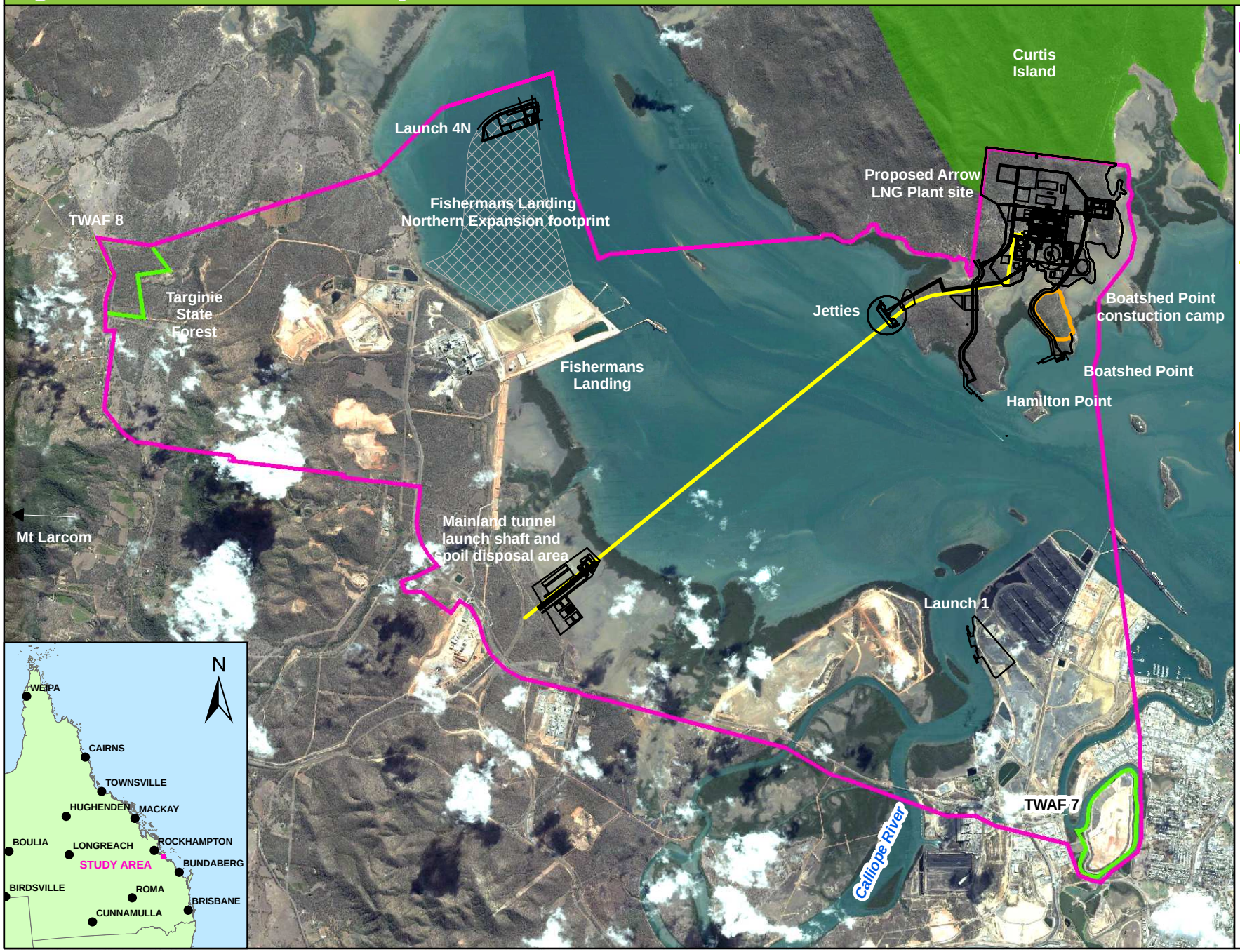
Attachment 1 – Figures 1 to 7

Figure 1: Arrow LNG Plant study area



Study area

Proposed temporary workers accomodation facility (TWAF) options

Proposed tunnel alignment

Environmental Management Precinct

Boatshed Point construction camp

Base air photo:
Google Earth

Data supplied by Coffey Environments Australia Pty Ltd:
Study area
Proposed infrastucture

0 0.5 1 2
Kilometres
(Scale relevant to any size print)

Datum/Projection:
GDA 1994 MGA Zone 56

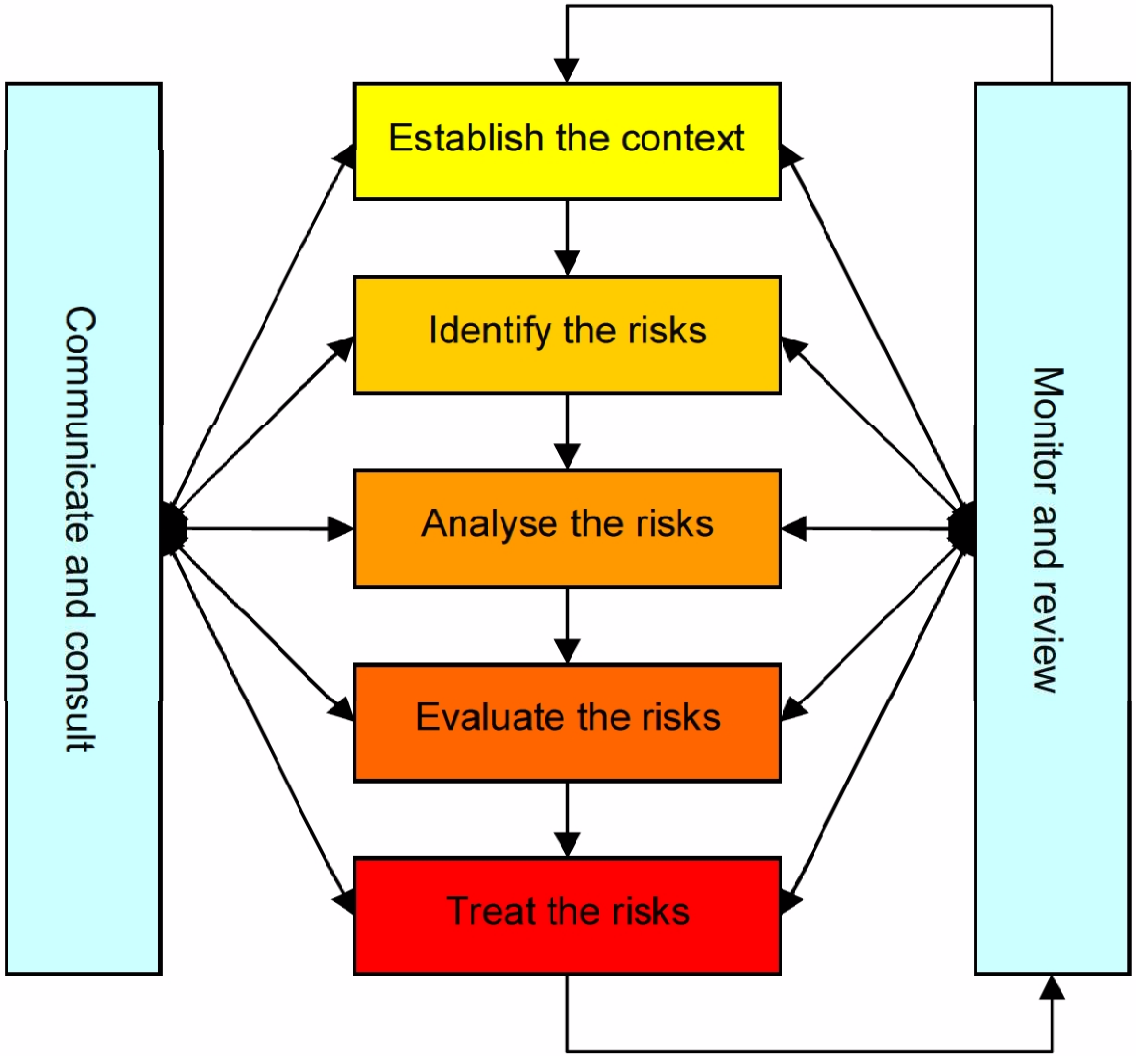
N

eco logical AUSTRALIA
www.ecoaus.com.au

Datum/Projection: GDA 1994 MGA zone 56 Client: Coffey Environments Australia Pty Ltd Project Number: 10GOSBUS-0088

Prepared by: SE Approved by: DP Status: Draft Date: 26/05/11

Figure 2: Emergency risk management planning (AS/NZS ISO 31000:2009 and COAG (2004))



Datum/Projection: GDA 1994 MGA zone 56 Client: Coffey Environments Australia Pty Ltd Project Number: 10GOSBUS-0088

Prepared by: SE Approved by: DP Status: Draft Date: 24/02/11

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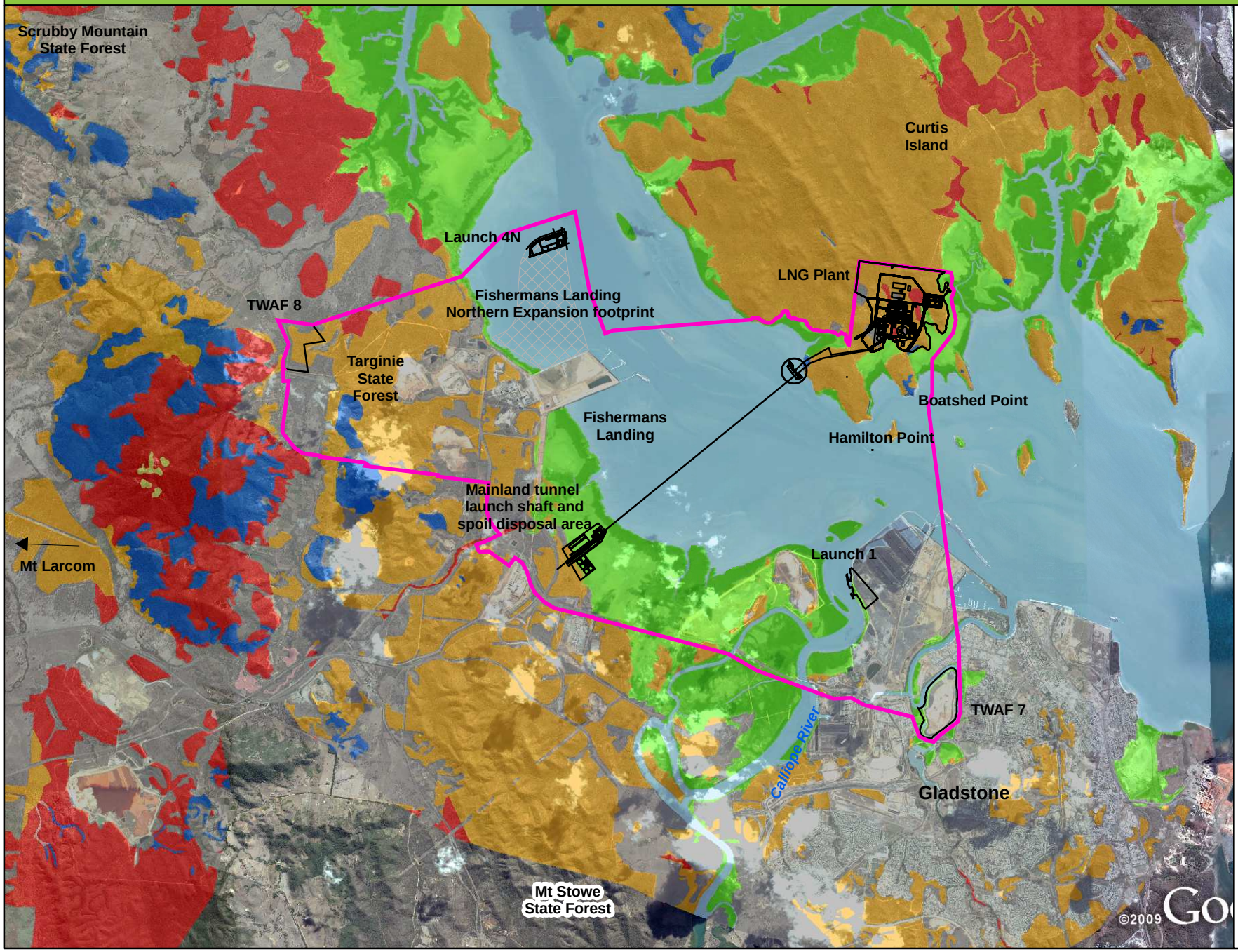
Figure 3: Vegetation communities



Study area
Dry sclerophyll forest
Grassy woodland
Forested wetland
Tall heath
Saline wetlands
Rainforest
Non remnant vegetation
Water/Estuary/ Ocean

Base air photo:
Google Earth

Data supplied by Coffey Environments Australia Pty Ltd:
Study area
Proposed infrastucture

Vegetation based on:
DERM's Regional Ecosystems

0 0.5 1 2
Kilometres
(Scale relevant to any size print)

Datum/Projection:
GDA 1994 MGA Zone 56

N

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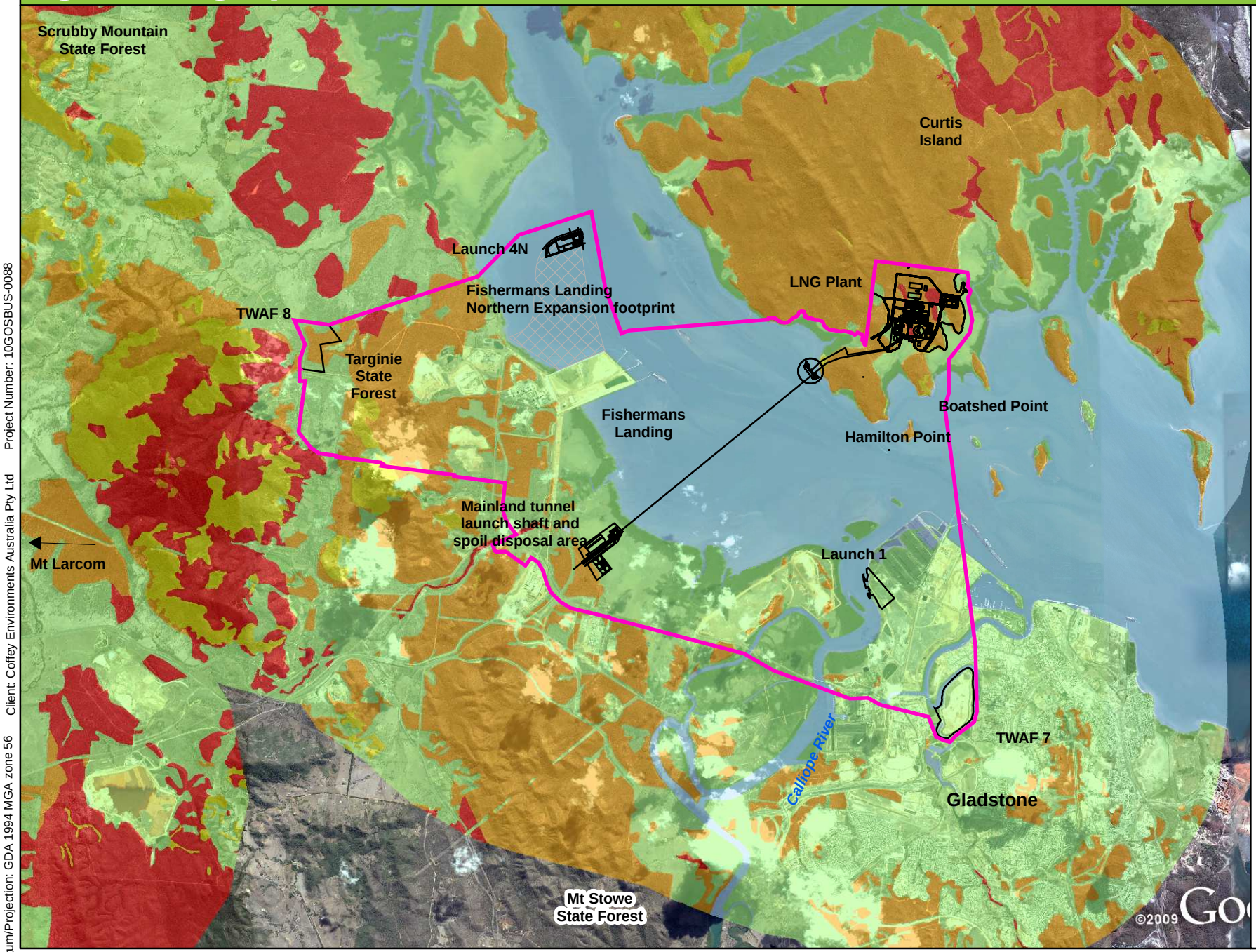
Prepared by: SE Approved by: DP Status: Draft Date: 26/05/11

Figure 4: Fuel groups



Study area

Relative hazard score *

8

6

2

0

Water/Estuary/ Ocean

*** Hazard scores range from the lowest "0" (virtully fireproof) to a maximum "10". There are no areas with a rating of 10 in this location.**

Base air photo:
Google Earth

Data supplied by Coffey Environments Australia Pty Ltd:
Study area
Proposed infrastucture

Fuel groups based on:
DERM's Regional Ecosystems

0 0.5 1 2
Kilometres
(Scale relevant to any size print)

Datum/Projection:
GDA 1994 MGA Zone 56

N

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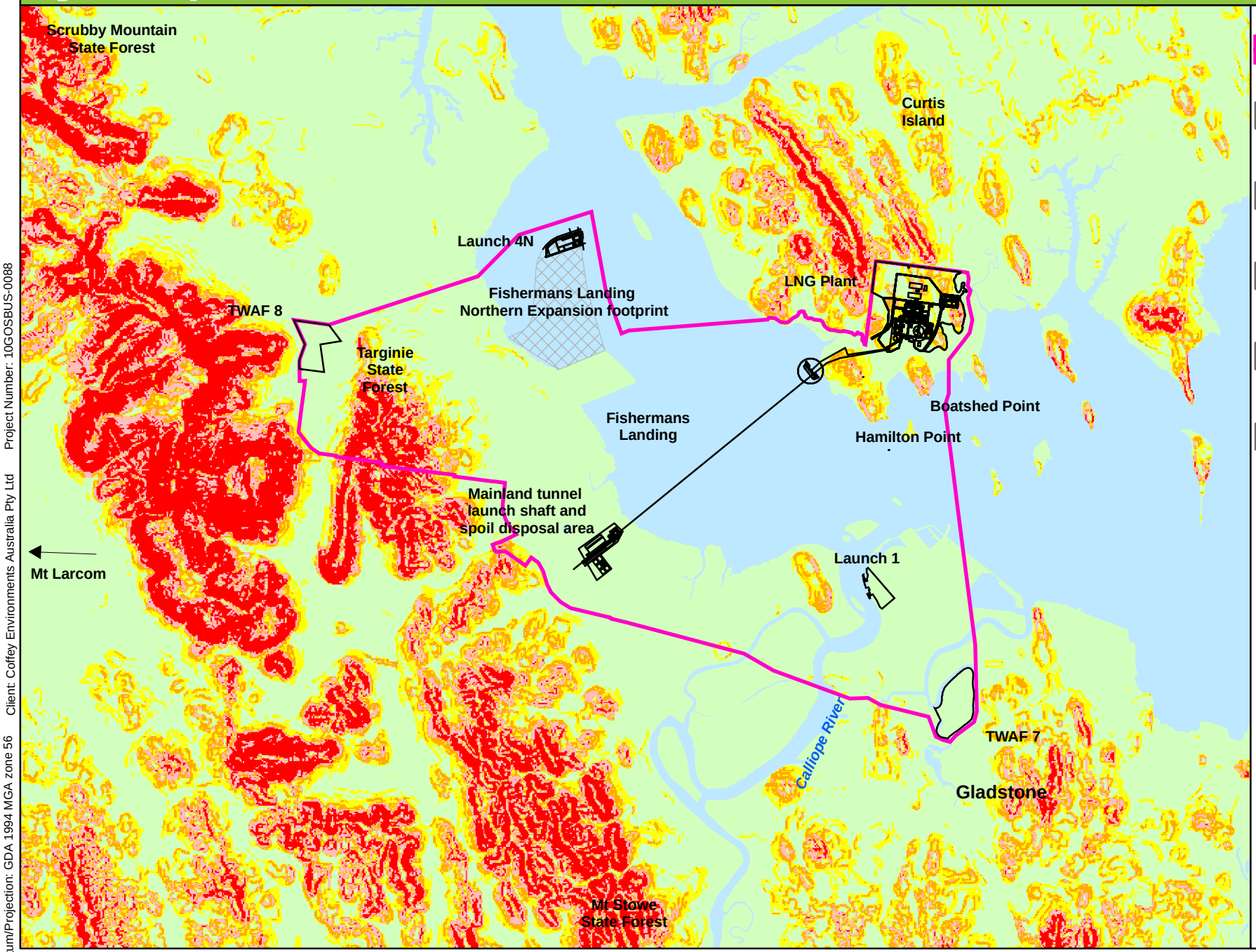
Prepared by: SE Approved by: DP Status: Draft Date: 26/05/11

Figure 5: Slope



Study area

0% - 5% (Plain) hazard score 1

>5% - 10% (Undulating) hazard score 2

>10% - 20% (Rolling Hills) hazard score 3

>20% - 30% (Steep Hills) hazard score 4

>30% (Gorges and mountains) hazard score 5

Water/Estuary/ Ocean

Data supplied by Coffey Environments Australia Pty Ltd:
Study area
Proposed infrastucture

Slope based on:
DERM's 10m contours

0 0.5 1 2
Kilometres

(Scale relevant to any size print)

Datum/Projection:
GDA 1994 MGA Zone 56

N

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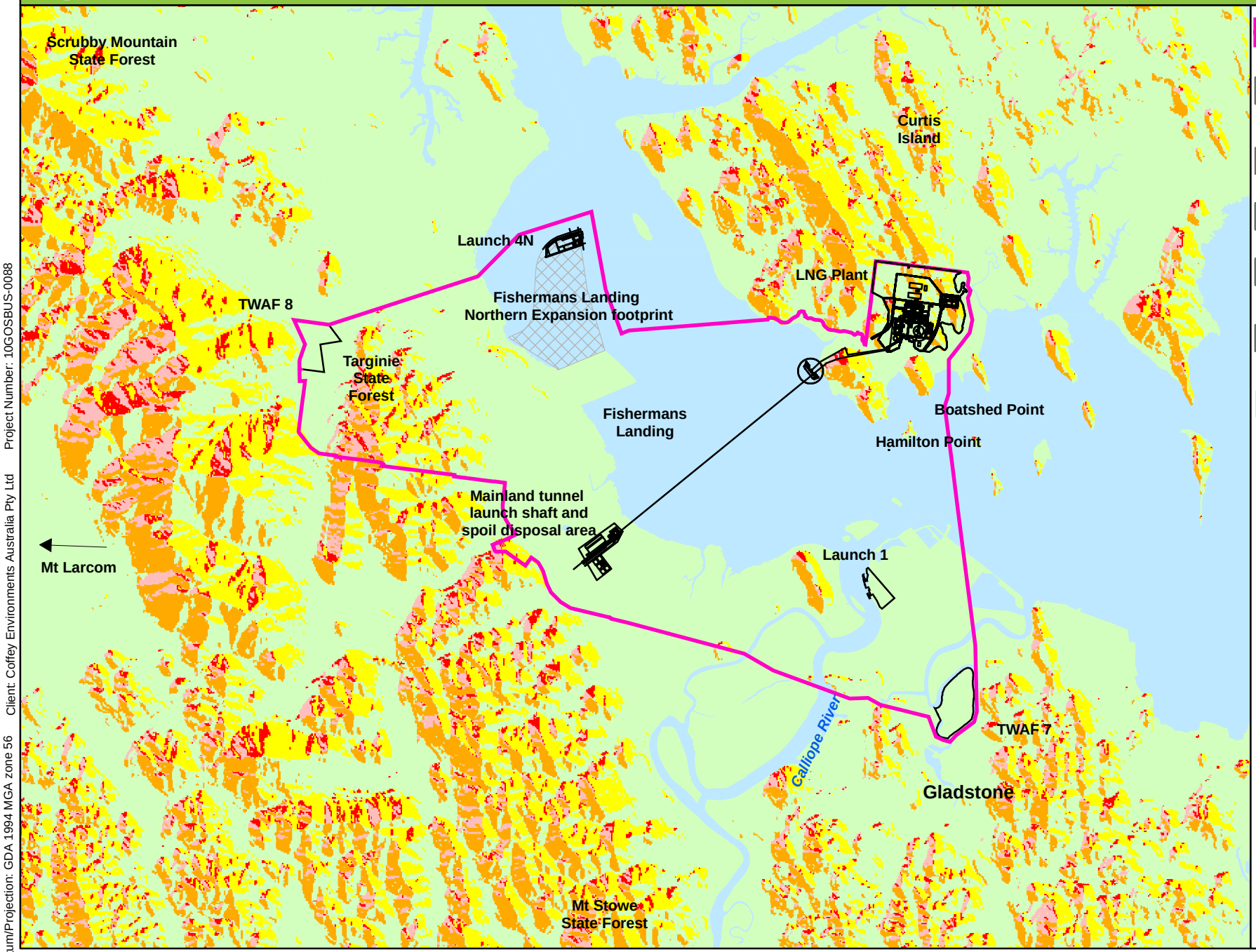
Figure 6: Aspect



Study area

E - S & slopes <5% hazard score 0

N - E hazard score 1

S - W hazard score 2

W - NW hazard score 3

NW - N hazard score 3.5

Water/Estuary/ Ocean

Data supplied by Coffey Environments Australia Pty Ltd:
Study area
Proposed infrastucture

Aspect based on:
DERM's 10m contours

0 0.5 1 2
Kilometres
(Scale relevant to any size print)

Datum/Projection:
GDA 1994 MGA Zone 56

N

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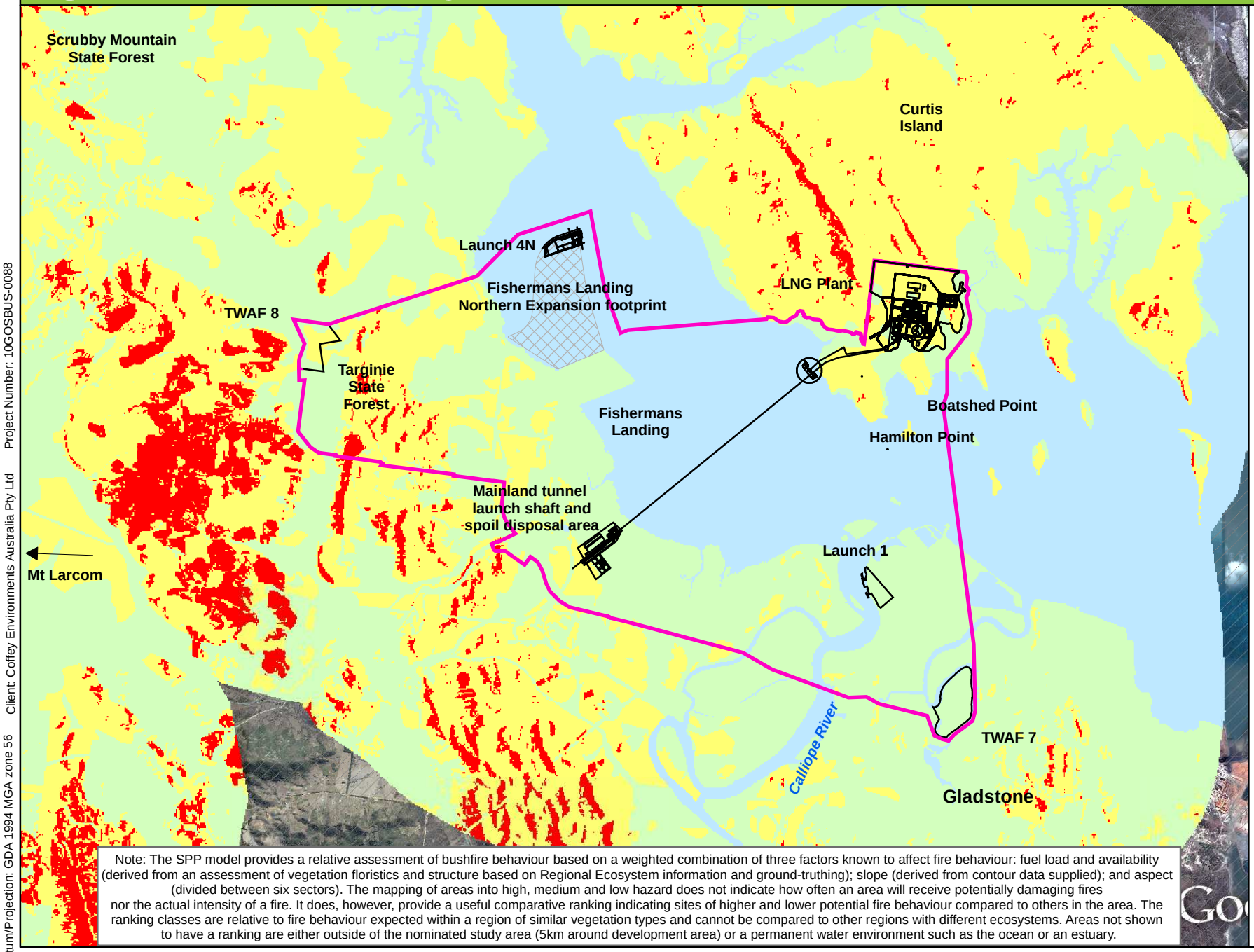
Prepared by: SE

Figure 7: Bushfire hazard severity



Study area
High
Medium
Low
Water/Estuary/ Ocean

Base air photo:
Google Earth

Data supplied by Coffey Environments Australia Pty Ltd:
Study area
Proposed infrastucture

Hazard severity calculated using:
DERM's 10m contours and Regional Ecosystems

0 0.5 1 2
Kilometres
(Scale relevant to any size print)

Datum/Projection:
GDA 1994 MGA Zone 56

N

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Note: The SPP model provides a relative assessment of bushfire behaviour based on a weighted combination of three factors known to affect fire behaviour: fuel load and availability (derived from an assessment of vegetation floristics and structure based on Regional Ecosystem information and ground-truthing); slope (derived from contour data supplied); and aspect (divided between six sectors). The mapping of areas into high, medium and low hazard does not indicate how often an area will receive potentially damaging fires nor the actual intensity of a fire. It does, however, provide a useful comparative ranking indicating sites of higher and lower potential fire behaviour compared to others in the area. The ranking classes are relative to fire behaviour expected within a region of similar vegetation types and cannot be compared to other regions with different ecosystems. Areas not shown to have a ranking are either outside of the nominated study area (5km around development area) or a permanent water environment such as the ocean or an estuary.

Datum/Projection: GDA 1994 MGA zone 56 Client: Coffey Environments Australia Pty Ltd Project Number: 10GOSBUS-0088

Prepared by: SE Approved by: DP Status: Draft Date: 26/05/11

Attachment 2 – Firebreak Radiant Heat Flux Model Report

NBC Bushfire Attack Assessment Report V2.0

AS3959 (2009) Appendix B - Detaied Method 2

Print Date: 30/06/2011 **Assessment Date:** 30/06/2011

Site Street Address: Arrow Gladstone LNG Project, Gladstone

Assessor: David Peterson; Bushfire+Environmental Services

Local Government Area: Ballina **Alpine Area:** No

Equations Used

Transmissivity: Fuss and Hammins, 2002
Flame Length: RFS PBP, 2001
Rate of Fire Spread: Noble et al., 1980
Radiant Heat: Drysdale, 1985; Sullivan et al., 2003; Tan et al., 2005
Peak Elevation of Receiver: Tan et al., 2005
Peak Flame Angle: Tan et al., 2005

Run Description: 15 kW LNG tank threshold

Vegetation Information

Vegetation Type:	Woodland	Vegetation Group:	Forest and Woodland
Vegetation Slope:	0 Degrees	Vegetation Slope Type:	Level
Surface Fuel Load(t/ha):	15	Overall Fuel Load(t/ha):	25

Site Information

Site Slope	0 Degrees	Site Slope Type:	Level
Elevation of Receiver(m)	Default	APZ/Separation(m):	30

Fire Inputs

Veg./Flame Width(m):	100	Flame Temp(K)	1090

Calculation Parameters

Flame Emissivity:	95	Relative Humidity(%):	25
Heat of Combustion(kJ/kg	18600	Ambient Temp(K):	308
Moisture Factor:	5	FDI:	80

Program Outputs

Category of Attack:	LOW	Peak Elevation of Receiver(m):	6
Level of Construction:	BAL 12.5	Fire Intensity(kW/m):	18600
Radiant Heat(kW/m2):	11.93	Flame Angle (degrees):	76
Flame Length(m):	12.36	Maximum View Factor:	0.194
Rate Of Spread (km/h):	1.44	Inner Protection Area(m):	30
Transmissivity:	0.808	Outer Protection Area(m):	0

Attachment 3 – Terms of Reference Cross Reference Table

Terms of Reference		Eco Logical Australia	
Section	**EIS requirement**	**Technical Study Name**	**Technical Specialist Report Section**
3.2.3.2	The potential for the construction and operation of the project to change existing land uses of the project sites and adjacent areas should be detailed. Consideration should be given to impacts arising from property disruption and severance, construction and maintenance. The potential environmental harm to adjacent areas currently used for agriculture, urban development, recreation, tourism or other business, and the constraints on land uses should be described. Incompatible land uses (existing and proposed) should be identified and measures to avoid unacceptable impacts defined. In particular, the discussion should: • Describe fragmentation of sites, increase of fire risk and impacts on residential and industrial uses.	Bushfire Hazard and Risk Assessment	Section 2 Bushfire Risk Assessment and Evaluation
6.1	The EIS should deal with on-site risks. External risks to the project should also be considered. External risks from natural hazards could be determined on the basis of Australia/New Zealand Standard on Risk Management AS/NZS 4360:2004. The study should assess risks during the construction, operational and decommissioning phases of the project. These risks should be assessed in quantitative terms where possible. Possible hazards, accidents, and abnormal events that may arise for the project, both during	Bushfire Hazard and Risk Assessment	Section 2 Bushfire Risk Assessment and Evaluation

Terms of Reference		Eco Logical Australia	
Section	**EIS requirement**	**Technical Study Name**	**Technical Specialist Report Section**
	construction and in operation should be described, including: • Vulnerability of the project area to bushfire, flooding, cyclones, seismic events and other natural disasters. Analysis of the consequences of each of these events on safety and environmental damage in the project area should be conducted, including direct harm to the environment as a result of project hazards. The analysis should examine the likelihood of these consequences being experienced, both individually and collectively.		
6.1.2	The LNG plant is considered to be a major hazard facility in terms of the Dangerous Goods Safety Management Act 2001. The study should assess risks associated with the LNG plant and the shipment of LNG, during the construction, operational and decommissioning stages. These risks should be assessed in quantitative terms where possible, and should involve a preliminary hazard identification exercise to identify the nature and scale of hazards which might occur. This exercise should consider the following matters: • Natural events such as cyclones, earthquakes, bushfires and local flooding.	Bushfire Hazard and Risk Assessment	Section 1.9 Bushfire Hazard
6.2	Preliminary information should be presented on the design and operation of proposed safety/contingency systems to address significant emergency issues delineated in the risk assessment, together with at least the following areas of emergency: • Terrorist attack. • Marine collision minimisation.	Bushfire Hazard and Risk Assessment	Section 3 Bushfire Management Plan

Terms of Reference		Eco Logical Australia	
Section	**EIS requirement**	**Technical Study Name**	**Technical Specialist Report Section**
	• Fire prevention/protection. • Leak detection/ minimisation. • Release of contaminants. • Emergency shutdown systems and procedures. An outline of the proposed emergency management procedures should be provided for the range of situations identified in the above risk assessment where there are measurable risks. This should include an overview of the objectives and management principles to be adopted for the preparation of a detailed emergency plan (including emergency response and recovery/cleanup procedures) in consultation with the relevant emergency services. Planning should include reference to State Planning Policy 1/03, Mitigating the Adverse Impacts of Flood, Bushfire and Landslide. In particular, the following should be presented: • Outline of contingency plans to account for natural disasters such as storms, flooding and fires during the construction, operation and maintenance phases.		
7	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	Bushfire Hazard and Risk Assessment	Section 3.6 Cumulative Impacts

Terms of Reference		Eco Logical Australia	
Section	**EIS requirement**	**Technical Study Name**	**Technical Specialist Report Section**
	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. The requirements of any relevant state planning policies, environmental protection policies, national environmental protection measures, statutory policies, water resource planning and any other relevant plans should also be addressed. The methodology used to determine the cumulative impacts of the project should be discussed, including (to the extent possible) qualitative and quantitative criteria.		

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