Appendix S Hazard Assessment

Preliminary Hazard Analysis

AGL Newcastle Power Station, Tomago NSW

AGL Energy Limited (AGL) proposes to develop a dual fuel power station in Tomago, New South Wales. AGL is seeking approval for the Proposal from the NSW Minister for Planning and Environment under the NSW Environmental Planning and Assessment Act 1979.

Aurecon

Executive Summary

AGL Energy Limited (AGL) is an Australian company, established in 1837. AGL operates the country's largest electricity generation portfolio with assets in solar, wind, thermal, hydroelectric power, natural gas, gas storage and LNG resources.

AGL proposes to develop a dual fuel power station in Tomago, New South Wales (NSW) ('the Proposal'). AGL is seeking approval for the Proposal from the NSW Minister for Planning and Environment under the NSW Environmental Planning and Assessment Act 1979.

The Secretary's Environmental Assessment Requirements (SEARs) for Hazard and Risk include:

- A Preliminary Hazard Analysis (PHA), covering all aspects of the Proposal which may impose public risks, to be prepared consistent with Hazardous Industry Planning Advisory Paper No. 6 – Guidelines of Hazard Analysis [Reference (1)] and Multi-level Risk Assessment. The PHA must:
  - include a pipeline risk assessment to estimate the risks from the pipeline to the surrounding land uses, with reference to Australian Standards AS2885 Pipelines – Gas and Liquid Petroleum, Operation and Maintenance
  - Demonstrate that the risks from the Proposal comply with the criteria set out in Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning [Reference (2)]

The objective of this study is to develop a comprehensive understanding of the hazards and risks associated with the Proposal. The hazard analysis process encompasses qualitative and quantitative methods to assess the adequacy of controls. This report evaluates the design and operation of the Proposal to determine if it can be carried out with the hazards as low as reasonably practicable+ (ALARP) and ensure appropriate land use safety planning.

Findings

Schedule 3 of the Environmental Planning and Assessment Regulation provides a description of several categories of industry with a potential for significant environmental impact.

Electricity generating stations, including associated water storage, ash or waste management facilities, are considered offensive if they are supplying or are capable of supplying more than 30 megawatts of electrical power from other energy sources (including coal, gas, wind, bio-material or solar powered generators, hydroelectric stations on existing dams or co-generation).

Since the Proposal includes a new power station with a nominal capacity of about 250 MW from a gas energy source, it is considered a "potentially offensive industry" per Schedule 3 of the Environmental Planning and Assessment Regulation. Consequently, an analysis of the potential impacts to neighbouring facilities and land uses is required.

The following technical studies provide a detailed description of the quantity, nature and significance of all offences likely to be caused by the development that could produce air, noise, water or other emissions:

- Surface Water and Ground Water Assessment
- Air Quality Assessment
- Noise Assessment

Included in the technical studies are the safeguards required to ensure potential offensiveness can be controlled to a level which is not significant.

The Proposal was also found to be potentially hazardous. Risks were assessed against the criteria which have been developed by the Department as set out in *HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning* [Reference (2)] as detailed in Table 1and found to be satisfied.

Table 1: *Risk Criteria for Land Use Safety Planning*

Land Use	Criteria Satisfied
Hospitals, schools, child-care facilities, old age housing	Yes
Residential, hotels, motels, tourist resorts	Yes
Commercial developments including retail centers, offices and entertainment centres	Yes
Sporting complexes and active open space	Yes
Industrial	Yes

The societal risk criteria, is also met as the F_N Curve is within the ALARP and negligible range.

Conclusion

The PHA has been completed and demonstrates that the risks from the Proposal comply with the criteria set out in Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning [Reference (2)]. The risk criteria are easily met for the Proposal. The societal risk in particular is low due to the relatively low population density associated with the large essentially rural land surrounding the Proposal.

A complimentary pipeline risk assessment in line with Australian Standards AS2885 Pipelines – Gas and Liquid Petroleum, Operation and Maintenance has been conducted and is documented as part of the conceptual design and in a separate report.

Recommendations

A number of recommendations have been made throughout this report that would be incorporated into the design stage.

- During the detailed design phase of the Proposal the minimum safety requirements would be reviewed to confirm the frequency of explosion in the generator building/housing, if proposed.
- The detailed design of the generator building/housing and associated equipment would clearly outline the basis of safety used to ensure that the explosive situations do not arise.
- Reference would be made to European ATEX Directive 94/9/EC and the UK HSE Guidance Note PM84: 'Control of safety risks at gas turbines used for power generation' or other guidance / regulation of equivalent safety.
- Rotating machines would be designed such that the risk associated with failure leading to the uncontained projectiles is minimised.
- The safety assessment process should continue to identify controls that prevent or limit the effects of a major hazardous incidents on-site, such as fire and explosion that could result in significant off-site effects. The detailed design must also consider whether there are further controls that could be implemented to reduce risk to limit both on and off site effects.

The results of the risk assessment are based on the following key assumptions.

- The Proposal would comply with all applicable Australian Standards.
- There would be no liquified gas within the pipelines.
- Pipeline pressure, size and lengths would be as per those detailed in this report.
- The Power Station would be a dual fuel facility incorporating gas and diesel fuel.
- Recommendations from the AS2885 Pipelines – Gas and Liquid Petroleum, Operation and Maintenance study are incorporated into the design.

- The detailed design safety requirements for the generator housing will include as a minimum:
  - Highly reliable ventilation fan system and ventilation detection system.
  - Independent gas detection linked to automatic emergency shut down system.
  - Prevention of ignition sources within the generator building/housing.
  - Explosion panel (to minimise effect of confinement) and fire quenching (e.g. carbon dioxide).
  - Separation distances to nearby generators and pressure piping.

If these key assumptions change during detailed design development, then the outcomes of this PHA should be reassessed.

Contents

1 Introduction

1.1 Background

AGL Energy Limited (AGL) proposes to develop a dual fuel power station in Tomago, New South Wales (NSW) ('the Proposal'). AGL is seeking approval for the Proposal from the NSW Minister for Planning and Environment under the NSW Environmental Planning and Assessment Act 1979.

The NSW Department of Planning has developed an integrated assessment process for safety assurance of potentially offensive or hazardous development projects. This comprises a Preliminary Hazard Analysis (PHA) in accordance with:

- HIPAP No. 4 – Risk Criteria for Land Use Safety Planning [Reference (2)
- HIPAP No. 6 – Hazard Analysis [Reference (1)]
- Applying SEPP 33 – Hazardous and Offensive Development Application Guidelines [Reference (3)]
- Multi-Level Risk Assessment Guidelines [Reference (4)]

1.2 Proponent

AGL is an Australian company, established in 1837. AGL operates the country's largest electricity generation portfolio with assets in solar, wind, thermal, hydroelectric power, natural gas, gas storage and Liquified Natural Gas (LNG) resources.

1.3 Objective

The Secretary's Environmental Assessment Requirements (SEARs) for Hazard and Risk include:

- A PHA, covering all aspects of the Proposal which may impose public risks, to be prepared consistent with Hazardous Industry Planning Advisory Paper No. 6 – Guidelines of Hazard Analysis [Reference (1)] and Multi-level Risk Assessment. The PHA must:
  - include a pipeline risk assessment to estimate the risks from the pipeline to the surrounding land uses, with reference to Australian Standards AS2885 Pipelines – Gas and Liquid Petroleum, Operation and Maintenance;
  - Demonstrate that the risks from the Proposal comply with the criteria set out in Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning [Reference (2)].

The objective of this study is to develop a comprehensive understanding of the hazards and risks associated with the Proposal. The hazard analysis process encompasses qualitative and quantitative methods to assess the adequacy of controls. This report evaluates the design and operation of the Proposal to determine if it can be carried out with the hazards as low as reasonably practicable (ALARP) and ensure appropriate land use safety planning.

A complimentary pipeline risk assessment in line with Australian Standards AS2885 Pipelines – Gas and Liquid Petroleum, Operation and Maintenance has been conducted and is documented as part of the Environmental Impact Study in a separate report.

1.4 Scope of Assessment

The scope of the assessment includes:

- A new power station with a nominal capacity of about 250 MW comprising of either large reciprocating engine generators or aero-derivate gas turbine generators.

- Facilities ancillary to the power station include gas compression facilities, gas pipelines, fuel storage tanks and infrastructure including diesel storage and truck unloading facilities, water management facilities and office, administration / amenities areas, workshop / storage facilities.
- Connection of the power station to the existing Tomago to Hexham high pressure gas pipeline.
- Connection of the power station to the existing TransGrid operated Tomago switchyard with a new 132 kV transmission line.

The design of the facility at the time of this PHA is at concept stage. Assumptions have been made around the type and operation of equipment and pipelines. These assumptions need to be confirmed during detailed design to ensure no change in the risk profile of the facility. A detailed Quantitative Risk Assessment is also recommended during detailed design to ensure the appropriate location of any onsite occupied buildings.

2 PHA Methodology

This preliminary hazard analysis is based on the Proposal to determine if the handling, storing or processing of any substances may create an off-site risk or offence to people, property or the environment in the absence of locational, technical or operational controls.

2.1 Preliminary Risk Screening

Applying SEPP 33 Application Guidelines [Reference (3)] has been used to determine whether or not SEPP 33 applies to the Proposal. SEPP 33 applies if a proposal for an industrial development requires consent, and it is either a potentially hazardous industry or a potentially offensive industry.

The following information was used in the risk screening process:

- Identification and description of dangerous goods and hazardous chemicals handled or stored at the Proposal site.
- Maximum quantities of dangerous goods and otherwise hazardous chemicals involved in the Proposal.
- Dangerous Goods classifications for the dangerous goods handled or stored at the Proposal site.
- Distance from the boundary for each hazardous chemical.
- Average number of road movements (and the quantities) of dangerous goods and otherwise hazardous chemicals to and from the Proposal site.
- The Proposal Site layout plan.
- Locality plan showing immediate neighbours including residential properties and land use.

The dangerous goods which are likely to be stored, handled and produced at the Proposal site are outlined in Section 5.1, Table 12.

2.2 Assessment Approach

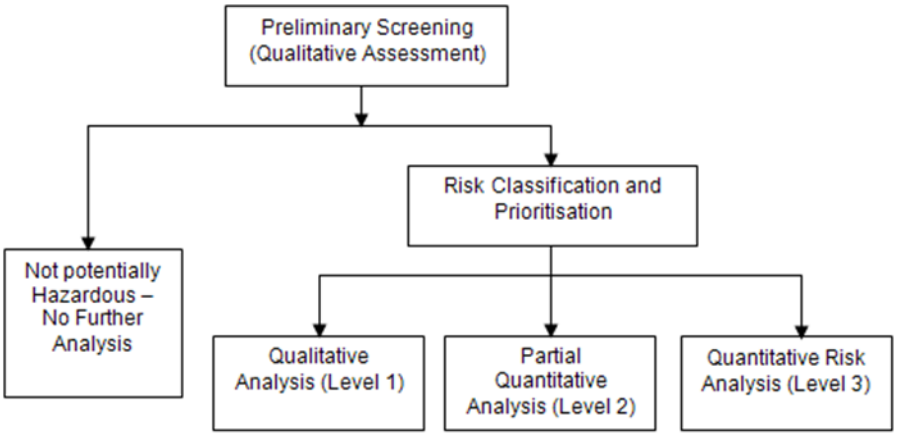
2.2.1 Potentially Hazardous Industry

The Department of Planning has developed the *Multi-Level Risk Assessment Guidelines*, which provide a graded or multi-level framework to ensure an appropriate level of analysis and assessment when determining if the Proposal is deemed as a potentially hazardous industry. The guidelines set out criteria for using the results of the screening, classification and prioritization steps to determine which of the three levels of analysis is appropriate. The levels are as follows [Reference (4)]:

- Level 1 – a qualitative approach based on comprehensive hazard identification to demonstrate that the activity does not pose a significant risk.

- Level 2 – a quantitative approach that supplements the qualitative analysis by sufficiently quantifying the key risk contributors to show that risk criteria will not be exceeded.
- Level 3 – full quantitative analysis.

Figure 1: Multi-Level Risk Assessment Approach



A qualitative assessment (Level 1) would be sufficient in the following circumstances. [Reference (4)]

- Where materials are relatively non-hazardous (for example, corrosive substances and some classes of flammables).
- Where there are no major worst-case consequences.
- Where the technical and management safeguards are self-evident and readily implemented.
- Where the surrounding land uses are relatively non-sensitive.

A quantitative assessment (Level 2) should address the elements as described in a Level 1 assessment as well as provide sufficient quantification of risk (consequence and likelihood) contributors to demonstrate the following:

- Consequences of events using appropriate modelling tools.
- An estimate of the likelihood for each event confirmed to have significant off-site effects.
- An indicative estimate of the off-site risk.
- Demonstration in principle that no individual event would have a fatality or injury frequency greater than that appropriate for the exposed land use.
- Demonstration in principle that no combination of events would cumulatively cause individual risk criteria to be exceeded.

A full quantitative risk assessment (Level 3) is required where a Level 2 assessment is unable to demonstrate that the significant offsite risk criteria can be met.

To conduct a Level 3 quantitative risk assessment, specialist software programs can be utilized. Aurecon makes uses of the DNV GL PHAST version 8.1 and SAFETI version 8.2 modelling tool.

2.2.2 Potentially Offensive Industry

Following the multi-level risk assessment approach, the Proposal must be assessed as potentially offensive in accordance with the requirements of the *Applying SEPP 33 Guideline* [Reference (3)]. The guideline provides a list of categories of industries with the potential for off-site offensive impacts. Off-site offensive impacts may include air emissions, water quality, noise or other environmental impacts.

The quantity, nature and significance of the offences likely to be caused by the development, as well as the need for any licences, are required for the assessment of an offensive industry. It should be demonstrated that there are adequate safeguards in place to ensure that emissions from a facility can be controlled to a level such that they are not considered significant.

2.3 Risk Criteria

2.3.1 Potentially Hazardous Industry

Risks need to be assessed against the criteria which have been developed by the Department as set out in *HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning* [Reference (2)].

In assessing the tolerability of risk from potentially hazardous development, both qualitative and quantitative aspects need to be considered.

2.3.1.1 Qualitative Risk Criteria

The following qualitative risk criteria are considered:

- All 'avoidable' risks should be avoided;
- Particular attention needs to be given to eliminating or reducing major hazards, irrespective of whether numerical criteria are met; and
- As far as possible, the consequences of significant events should be kept within the facility boundaries.

2.3.1.2 Quantitative Risk Criteria

The main quantitative criteria considered are risks to individuals and society.

2.3.1.2.1 Individual Risk

Individual risk considers the acceptability of a particular level of risk to an exposed individual. Individual risk is segmented into fatality, injury and property damage and accident propagation.

Fatality Risk

'Individual fatality risk' is the risk of death to a person at a particular point. It is assumed that the person will be at the point of interest 24 hours per day for the whole year. Regulators have concluded that if a risk from a potentially hazardous installation is below most risks being experienced by the community, then that risk may be tolerated. Table 1 outlines the risk assessment criteria that is suggested for the assessment of the safety of location of a proposed development of a potentially hazardous nature.

Table 2: Individual Fatality Risk Criteria

Land Use	Suggested Criteria (risk in a million per year)
Hospitals, schools, child-care facilities, old age housing	0.5
Residential, hotels, motels, tourist resorts	1
Commercial developments including retail centers, offices and entertainment centers	5
Sporting complexes and active open space	10
Industrial	50

Injury Risk

'Individual injury risk' captures the associated risk of injury as a result of the Proposal. The impact of injury must be considered for the following scenarios: heat radiation and explosion over-pressure. The suggested injury/damage risk criterion for these scenarios are included in Table 3.

Table 3: Injury Risk Criteria

Injury Risk Criteria	Maximum Tolerable Risk ($x10^{-6}$ per year)
Maximum Over-pressure	
7 kPa	50 (at residential & sensitive use areas)
Maximum Heat Radiation	
4.7 kW/m^2	50 (at residential & sensitive use areas)

2.3.1.2.2 Property Damage and Accident Propagation

In accordance with *HIPAP No 4 – Risk Criteria* [Reference (2)], the risk criteria for damage to property and of accident propagation is outlined in Table 4.

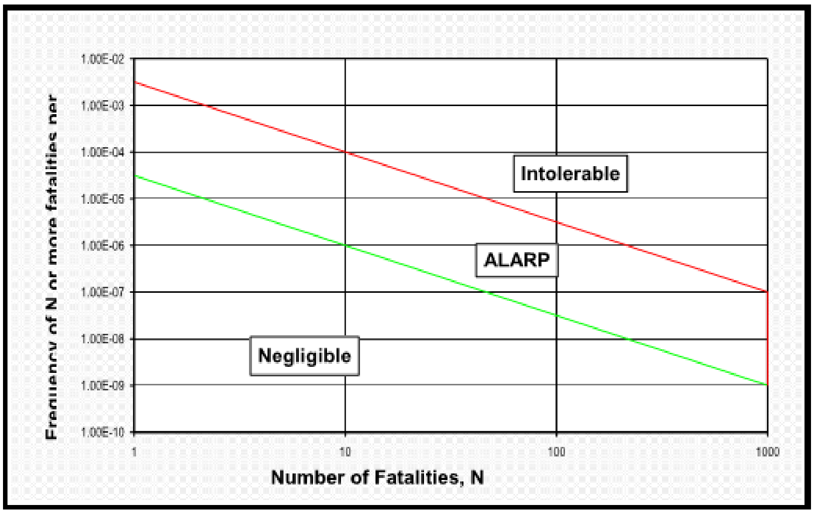
Table 4: Property Damage and Accident Propagation Criteria

Property Damage	Maximum Tolerable Risk ($x10^{-6}$ per year)
Maximum Over-pressure	
14 kPa	50 (at neighboring/land zoned potentially hazardous installations)
Maximum Heat Radiation	
23 kW/m^2	50 (at neighboring/land zoned potentially hazardous installations)

2.3.1.3 Societal Risk

Societal risk criteria are based on the ALARP (as low as reasonably practicable) principle. The NSW Department of Planning has provisionally adopted the indicative criteria in Figure 2 for addressing societal concerns arising when there is a risk of multiple fatalities occurring in one event.

Figure 2: Indicative Societal Risk Criteria [Reference (3)]



2.3.2 Potentially Offensive Industry

Applying SEPP 33 Guideline [Reference (3)] must be used to determine if the Proposal is potentially offensive. The key consideration in the assessment of a potentially offensive industry is that the consent authority is satisfied there are adequate safeguards. These safeguards must ensure that emissions from a facility can be controlled to a level at which they are not significant.

Applying SEPP 33 Guideline lists industry types with the potential for significant environmental impact.

3 Proposal Description

3.1 Proposal Site Location

The Proposal would be located at in Tomago, approximately five kilometres south west of Raymond Terrace and about two kilometres north east of Hexham..

The Newcastle Power Station (NPS) would be developed on Lot 3 DP1043561 and would cover about 15 hectares. Road access to the proposed power station site would be via new road access that would extend from Old Punt Road.

The proposed gas and electrical transmission corridors would be situated to the east of the NPS site in part Lots 4 DP 1043561, 1201, 1202 and 1203 DP1229590, and 202 DP1173564. The layout of the Proposal is shown in Figure 3.

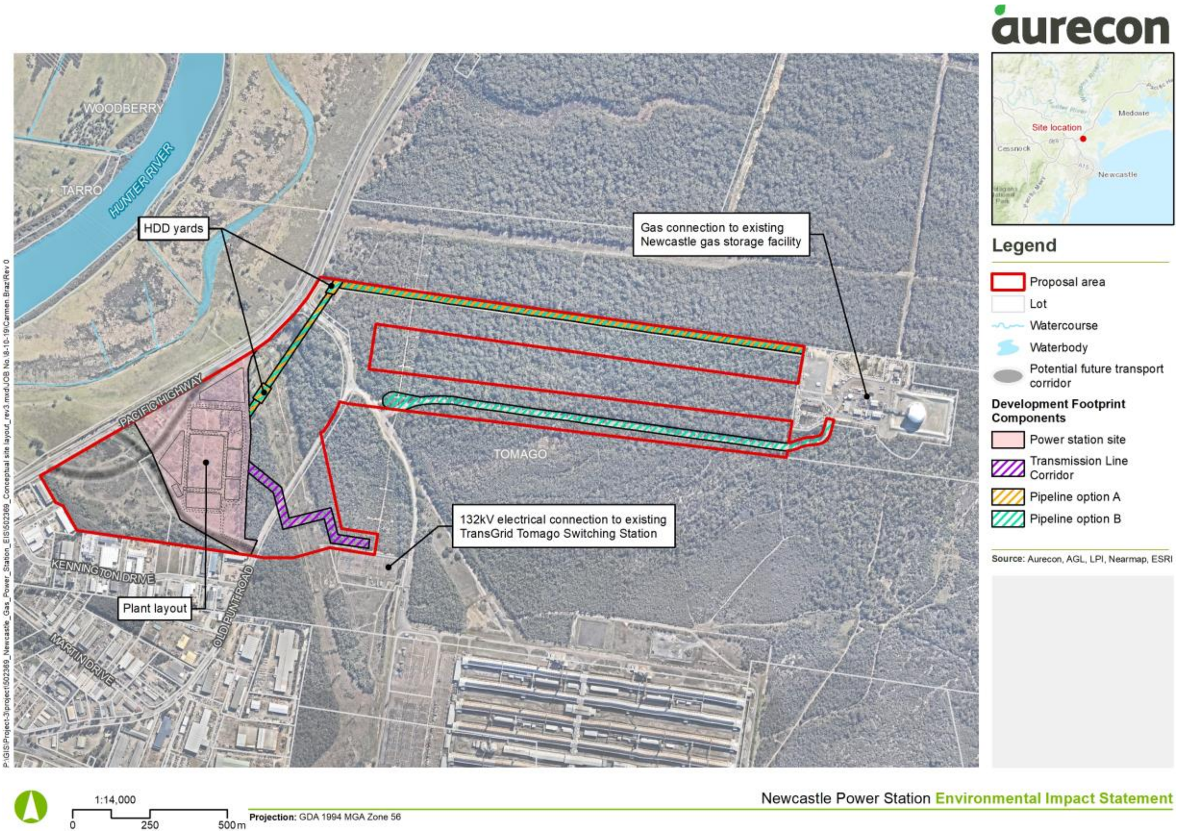


Figure 3: Site Layout Plan

3.1.1 Newcastle Gas Storage Facility

The Newcastle Gas Storage Facility (NGSF) is utilized to liquify and store natural gas supplied from the Jemena network. Gas is transferred from the NGSF through Hexham via the high pressure DN 400 Eastern Australian gas transmission pipeline.

3.1.2 Jemena Gas Network (JGN)

The Jemena Gas Network (JGN) is a series of pipelines that supply gas from eastern Australia gas transmission network to residential and industrial customers across NSW from Wollongong to Newcastle. The NGSF sources from and delivers gas to the JGN via an AGL owned DN 400 pipeline (PL42) that connects to the JGN at Hexham (Tomago to Hexham Pipeline)..

3.2 Surrounding land use

The NPS site is more than two kilometers from the closest residential zoned area. There is a house in the north-west corner of the site that is owned by AGL and which will be demolished unless repurposed during construction. Other major infrastructure in the near vicinity includes:

- The NGSF
- Tomago to Hexham Pipeline
- TransGrid Tomago switching station
- Tomago Aluminum Smelter
- Pacific Highway

3.3 Sensitive receptors

The surrounding land use is industrial. The closest residential zoned area is located more than two kilometers away from the Proposal Site. There are no sensitive receptors identified near the NPS site. The nearest sensitive receptors include a single residence owned by Tomago Aluminium Corporation on Tomago Road near its intersection with the Pacific Highway, and the Tomago Village Van Park, which are around 700 m and 900 m south west of the NPS, respectively. These properties are partially visually and acoustically screened from the Proposal by the industrial developments along Tomago Road.

3.4 Population data

The population present in the vicinity of the Proposal site is used to determine the societal risk.

The population density data for the rural area surrounding the Proposal site at Tomago was estimated using data from the Australian Bureau of Statistics [Reference (5)] website and the Tomago Wikipedia page [Reference (6)]. The estimated population density for rural land which makes up most of the Tomago region is given in Table 5.

Table 5: Tomago Rural Land Population Density

Data	Quantity	Source
Population at Tomago as of 2016 census	277 persons	Australian Bureau of Statistics [Reference (5)]
Area	7,100,000 m^2	Wikipedia [Reference (6)]
Rural Population Density	0.000039 persons/m^2	-

To estimate the population density for the industrial areas surrounding the Proposal site, the number of employees and area covered by the Tomago Aluminium Smelter was used. The smelter has a high proportion of the industrial workforce in the area. The estimated industrial population density is shown in Table 6. It is assumed that all industrial sites in the Tomago region has the same population density.

Table 6: Tomago Industrial Land Population Density

Data	Quantity	Source
Number of employees at Tomago Aluminium Smelter	1200 persons	Pacific Aluminium Website [Reference (7)]
Area	1,055,178 m^2	Google Earth Pro
Industrial Population Density	0.0011 persons/m^2	-

The presence of the population in the vicinity of the Proposal site is further examined using guidelines from Section 5.3 of the Purple Book – Guidelines for Quantitative Risk Assessment [Reference (8)]. This considers the change in population densities depending on time of day and location of the population (i.e. indoors or outdoors). It is assumed that the following fractions listed in Table 7 apply to the population in the surrounding industrial areas of the Proposal site.

Table 7. Fraction of the population present indoors ($f_{pop, in}$) and outdoors ($f_{pop, out}$) for daytime and night-time

	Daytime	Night-time

Industrial Population, indoors	0.93	0.99
Industrial Population, outdoors	0.07	0.01
Population Rural	1	1

Factoring in the above fractions to the estimation results in the population densities listed in Table 8. It is conservatively assumed that people are always outdoors in the rural areas during the day and night.

Table 8: Population Density for the Tomago Region

Population Density		Day	Night
Industrial (persons/m^2)	Indoors	1.06E-03	1.13E-03
	Outdoors	7.96E-05	1.14E-05
Rural (persons/m^2)	Outdoors	3.90E-06	3.90E-06

3.5 Meteorological and topographical considerations

The weather trends for the Newcastle region have been summarised in Table 9. The predominant predicted wind condition and humidity levels are taken from the closest Bureau of Meteorology weather station to the site, which is the University of Newcastle [Reference (9)]. This weather station is located 8.5 km to the south of the power station and has been operating since 1998.

Table 9. University of Newcastle BOM Weather Data

Bureau of Meteorology Data	Value
Ambient dry bulb maximum temperature	40 °C
Ambient dry bulb minimum temperature	0 °C
Mean Maximum Daily temperature (1998-2019)	24 ºC
Mean Minimum Daily temperature (1998-2019)	13.6 ºC
Mean 9am Temperature (1998-2010)	17.9 ºC
Mean 3pm Temperature (1998-2010)	22.1 ºC
Mean 9am relative humidity (1998-2010)	73%
Mean 3pm relative humidity (1998-2010)	56%
Mean 9am wind (1998-2010)	6.3 km/h (1.75m/s)
Mean 3pm wind speed (1998-2010)	12.9 km/h (3.6m/s)

The proposed Site is located 12 m above sea level in a predominantly flat farm and grass area.

Dispersion of gas clouds and impacts of thermal radiation is governed by the prevalent weather conditions including, wind speed and direction (essentially horizontal mixing) and stability of the atmosphere (essentially vertical mixing). The latter is essentially the extent to which wind turbulence, which is responsible for the dispersion, is suppressed or assisted. On cold windless nights, cold air is trapped close to the surface of the earth and any gas release would not be easily dispersed. On the contrary, on a hot summer’s day there is generally a lot of turbulence in the air due to heating of the earth’s surface and the air in contact with it. This aids dispersion of gases. These conditions had been labelled weather stability classes with the letters A to F. Using the wind and weather information presented in BOM, four broad dominant weather categories were selected, and summarised in Table 10.

Table 10. Weather Parameters

Category	1/D	3/B/C	1/A	5/D
Wind speed (m/s)	1	3	1	5
Pasquill stability	D – neutral	B/C – moderately unstable, moderate sun and moderate wind	A – very unstable, sunny and light winds	D – neutral, little sun and high wind
Atmospheric temperature (°C)	15	19	28	23
Relative humidity (%)	76	66	76	56
Solar radiation flux (kW/m²)	0	0.5	1	0.25

The average wind speeds for the area provided by BOM were presented as a wind rose, which was then analysed to provide the fraction of time the weather fell into each weather stability class. This data is shown in Table 11. Further details on the wind class stability classification see Appendix 1.

Table 11. Weather Stability Class Classification

Weather Categories	Night/9am	Day/3pm
Fraction of time weather is taken as falling into the 1/D category	37 %	13 %
Fraction of time weather is taken as falling into the 3/B-C category	49.5 %	-
Fraction of time weather is taken as falling into the 1/A category	-	48.5 %
Fraction of time weather is taken as falling into the 5/D category	13.5 %	38.5 %

There are many dispersion combinations included in the risk assessment, due to the different probabilities of weather stability's and wind speeds. The wind direction was considered in the eight major wind directions.

3.6 Operations and staff

The Proposal will operate 24 hours a day, 7 days a week with 600 hours of scheduled down-time for plant maintenance. Up to approximately 23 personnel on shifts (including a site manager, administrational support and maintenance) would be required during operation.

4 Process Description

AGL is proposing to establish a power station approximately two to three kilometres from AGL's existing NGSF. The AGL NGSF is utilized to liquify and store natural gas supplied from the Jemena network. The primary source of natural gas for the NPS would be via a take-off on the Tomago to Hexham Pipeline via a new connection east of the Proposal off Old Punt Road. The pipeline would be constructed of approximately 12" pipe, laid with approximately 900 to 1200 mm ground cover, and designed as per AS 2885.

To supplement this supply AGL would construct a new gas pipeline capable of storing natural gas in compressed gaseous form. Gas would be drawn from the JGN during periods of lower gas demand, compressed, and stored in the pipeline for use by the NPS during periods of higher power demand.

4.1 Power Station

It is proposed that the NPS will be a 250 MW (nominal) dual fuel (natural gas / diesel) fired peaking power plant. The NPS will consist of either large reciprocating gas engines or aero-derivative gas turbine technology to generate electricity. Selection will depend on a number of factors including statutory and licensing requirements, suitability to the market, and cost.

4.2 Gas Supply

4.2.1 Tomago to Hexham Pipeline

Natural gas will primarily be taken from the Tomago to Hexham Pipeline. This pipeline is bi-directional – the NGSF utilizes this line to import and export gas.

The Proposal take-off from the Tomago to Hexham Pipeline will run underground for approximately 430 m from the tie-in point to the NPS site. The tie-in pipeline will be likely be constructed from DN300, Schedule 60 API 5L Grade X56 ERW PSL2 line pipe. The tie-in pipeline has been assessed as having a design pressure of 6.895 MPag, a 1.5 mm corrosion allowance, and will be wrapped and cathodically protected. The pipeline will have 1500 mm minimum depth of cover.

The planned site-layout plan and tie-in connection propose that the line will rise above ground prior to arriving at the NPS.

4.2.2 Jemena Gas Network Pipeline

The Hexham gate station is connected to the JGN and gas can be drawn from the network when required. Gas supplied from the JGN will be odorised as per regulation. The JGN has an operating pressure of approximately 2.2 MPag. Since the JGN is an existing pipeline and is not considered further in this report.

4.2.3 Fuel Gas 'Storage Pipeline'

A fuel gas 'Storage Pipeline' has been included in the design of the NPS. Gas would be obtained from the JGN during periods of low gas demand, compressed and stored in the pipeline (at a nominal pressure of 15 MPag). The NPS will be able to use this gas supply during periods of high power demand.

The Storage Pipeline would likely be constructed from DN1050, 28.58 mm wall thickness API 5L Grade X80 ERW PSL2 line pipe or similar, depending on design requirements. The storage pipeline has been assessed ashaving a design pressure of 15.3 MPag, a 3 mm corrosion allowance, and would be wrapped and cathodically protected. Preliminary sizing calculations indicate that a total approximate length of 5 km is required to provide the sufficient storage capacity. To fit within the available land two parallel lines, each of approximately 2.5 km, would be constructed. The design requirement is for a working volume equivalent to approximately five hours of fuel supply at the design rate of 71,000 Sm^3/h.

The considered 'Storage Pipeline' design includes pigging facilities to comply with the inspection requirements of AS 2885.

The gas storage pipeline would have 900 mm general depth of cover and 1200 mm cover at road crossings, with a total construction corridor width of 25 meters as shown in Figure 4.

Figure 4: Storage Pipeline General Arrangement

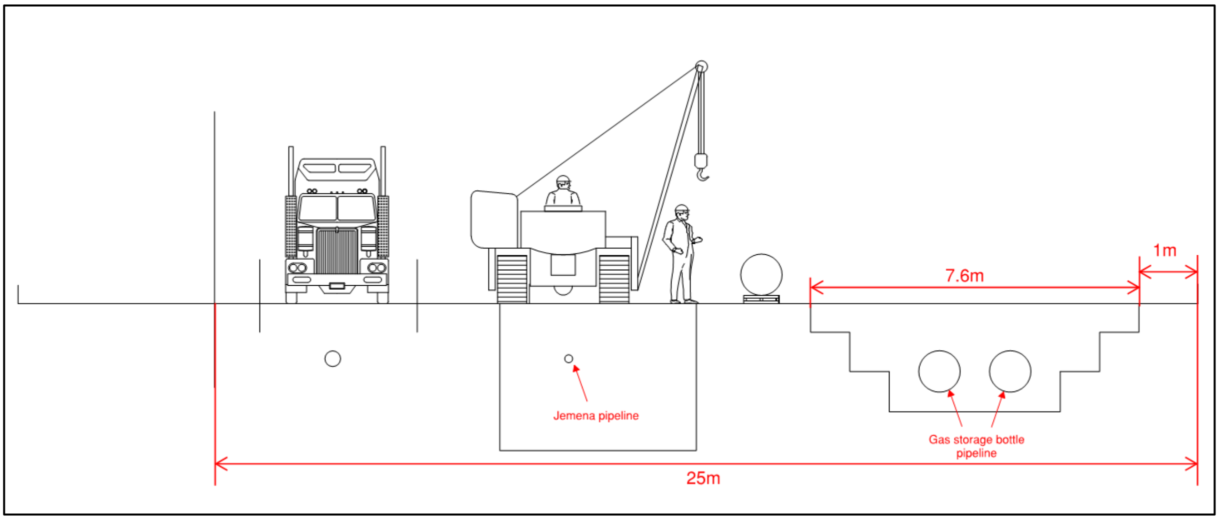


Figure 3 illustrates where the pipelines will be located within the existing corridors.

4.3 Fuel Gas Metering Skid

The fuel gas metering skid would use gas chromatography to determine the composition of the supplied gas and hydrocarbon dew point. Natural gas from the JGN and NGSF would be routed through the meter prior to compression and/or gas conditioning.

4.4 Fuel Gas Compression System

Fuel gas compression would occur downstream of the fuel gas metering skid. Reciprocating compressor units have been designed to increase the fuel gas pressure from the minimum pipeline supply pressure to the required supply pressure (5,500 kPag) and storage pipeline pressure (maximum 15,000 kPag).

The compression system is likely to consist of several identical compressor units to provide turndown capability and control at lower flow rates. Provision would be made at the facility for any future expansion.

4.5 Gas Conditioning Skid

The gas conditioning skid is used to reduce the gas pressure required for the NPS turbines or engines. A water bath heater would supply superheat prior to pressure let-down. Superheat is designed to overcome the Joule-Thomson (J-T) cooling effect caused by the pressure reduction.

4.6 Diesel Storage

Unconstrained operation with liquid fuel for base load operation (24 hours per day) requires approximately 1.5 ML diesel storage. Diesel will be stored in above ground bulk storage tanks.

5 Hazard Analysis and Risk Assessment

This hazard analysis and risk assessment is developed in accordance with *Hazardous Industry Planning Advisory Paper No 6 – Guidelines for Hazard Analysis* [Reference (1)].

This hazard analysis and risk assessment includes:

- A list of all materials being handled, stored or processed at the facility, with maximum and average quantities shown
- Hazard identification assessment to identify all hazardous chemicals and the type of associated hazard they may pose.

5.1 Hazardous Chemicals

The list of all significant chemicals being handled, stored or processed at the facility are included in Table 12. Maximum and average quantities to be handled, stored or processed are featured. These chemical substances are subject to SEPP 33.

LNG is natural gas that has been chilled and compressed into liquid form. LNG is excluded from the assessment due to the fact that it will have been converted back to gaseous form by the existing NGSF process prior to entering the existing Tomago to Hexham Pipeline. Accordingly, no LNG will be supplied to the NPS.

Additionally, minor quantities of hazardous chemicals are not considered. From a land use safety planning perspective, the storage of minor quantities of hazardous chemicals is not considered to be a significant contributor to the overall risk profile of the Proposal. For this reason, such hazardous chemicals are also not considered in Table 12.

Table 12: Hazardous Chemicals

Hazardous materials	Maximum quantity stored on site	Dangerous goods class including subsidiary class(es)	Packing Group	UN No.	Chemical Abstract Number (CAS No.)	Physical and Chemical Properties	Type of storage	On-site Location	Average number of road movements
Natural Gas	Pipelines: 42,600 Sm³/h (Fuel Gas ‘Storage Pipeline’) + 71,000 Sm³/h (Hexham to NGSF Tomago to Hexham Pipeline)	Class 2.1 Flammable Gas	N/A	N/A	8006-14-2	Clear, highly flammable gas which readily forms explosive mixtures in air Odorant in form of tertiary butyl mercaptan (TBM) 30% and tetrahydrothiophene (THT) 70% is added to allow leak detection	Fuel Gas ‘Storage Pipeline’	Fuel Gas ‘Storage Pipeline’, piping, skids and compression	N/A
Diesel Fuel	1500 kL (24 hours emergency storage)	Class C1 Combustible Liquid	N/A	N/A	68334-30-5	Liquid Mild Odour	Bulk Storage Tanks	Designated Diesel storage area located in the east of the site	100% transport by road 30 x 50m³ capacity heavy vehicles road tankers per emergency shutdown period transport product to Site

Natural gas is composed predominantly of methane gas. The gas in the JGN is required to meet AS 4564-2011 – Specification for general purpose natural gas. As the same gas is taken and stored in the NGSF, a gas sample from the NGSF is sufficient for preliminary design and PHA purposes. The difference in gas specification of gas originating from the Jemena network and the NGSF should not significantly impact equipment operation or the PHA. Table 13 below summarizes the Liquified Natural Gas (LNG), taken from the NGSF LNG tank.

Table 13: NGSF Natural Gas

Components	Name	Composition (mol%)
C_1	Methane	93.3
C_2	Ethane	6.239
C_3	Propane	0.349
iC_4	Iso Butane	0.011
nC_4	Normal Butane	0.005
iC_5	Iso Pentane	0.001
nC_5	Normal Pentane	0.001
C_6	Hexane	0
C_7	Heptane	0
C_8	Octane	0
C_9+	Nonane+	0
CO_2	Carbon Dioxide	0.006
N_2	Nitrogen	0.093
LHV @ Standard Conditions		49,640 kJ/kg
Mass Density		0.7226 kg/m^3
LHV		35.4 MJ/m^3
HC Dew Point @ 2,500 kPag		-71.76 °C

5.2 Hazardous Chemicals

The following information describes the types of hazardous chemicals to be stored, handled or processed at the site.

5.2.1 Natural Gas 100 Mole %

Natural Gas 100 Mole % is a Class 2.1 Flammable Gas. Natural Gas is an invisible, highly flammable gas which readily forms explosive mixtures in air. Natural gas must be stored in a location that is segregated from oxygen gas and oxidising agents.

Natural Gas will be transported to Site via the Hexham to NGSF Bi-directional Pipeline (at 71,000 Sm^3/h) and the Fuel Gas 'Storage Pipeline' (at 42,600 Sm^3/h). The considered 'Storage Pipeline' design includes pigging facilities to comply with the inspection requirements of AS 2885.

5.2.2 Diesel Fuel

Diesel Fuel is a C1 Combustible Liquid. Diesel is incompatible with oxidizing materials.

All diesel fuel will be transported to site by road tanker. Heavy vehicles of approximately 50 m^3 capacity will be used, equating to approximately thirty movements per day to deliver diesel fuel to the site.

The diesel storage facility would be designed in accordance with AS 1940:2017 [Reference (10)] especially in relation to bund sizing and appropriate separation distances. The total diesel storage volume would beequivalent to approximately 24 hours demand.

6 Hazardous Event Screening

6.1 Screening Assessment

State Environmental Planning Policy No. 33 – Hazardous and Offensive Development (SEPP 33) applies if a proposal for an industrial development requires consent, and it is a potentially hazardous industry and/or potentially offensive industry [Reference (3)].

Applying SEPP 33 – Hazardous and Offensive Development Application Guidelines [Reference (3)], Section 7 and Appendix 4 provides a risk screening method through tables and graphs to determine whether a proposed development is potentially hazardous. The preliminary screening assessment for the hazardous chemicals identified is summarized and detailed in Table 14.

The natural gas is transported to the site via the Tomago to Hexham Pipeline that is designed as a pipeline, rather than a storage vessel, and is therefore be assessed as such where possible.

6.1.1 Class 2.1 Flammable Liquid (Natural Gas 100 Mole %)

According to *Applying SEPP 33* [Reference (3)], Figure 5 is utilized for risk screening.

Figure 5 indicates that the minimum separation distance for 3 tonnes of natural gas is 70 m. The actual separation distance of the natural gas is <20 m. Therefore, the actual separation distance exceeds the threshold and it can be assumed that there is the potential for off-site risk. Risks associated with the storage of natural gas has been carried forward for further analysis.

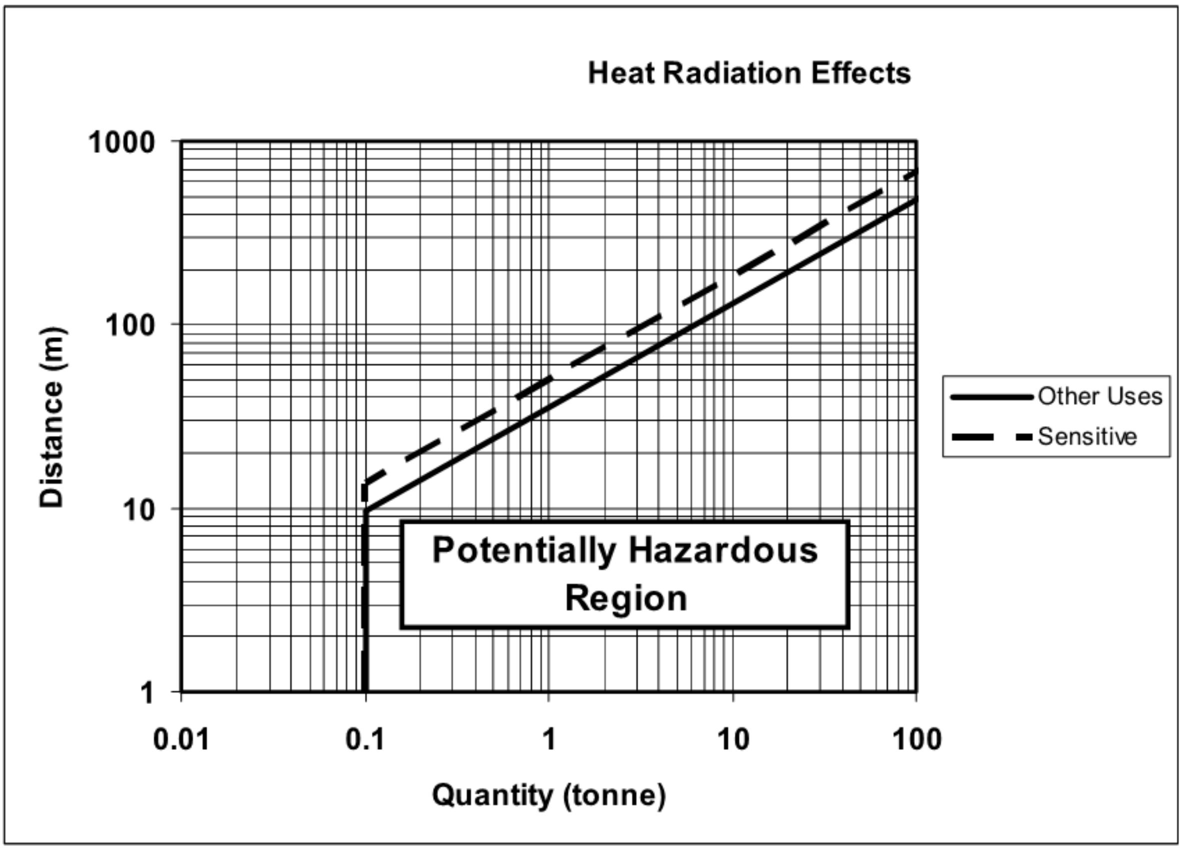
The natural gas transported to Site via the Tomago to Hexham Pipeline (at approximately 71,000 Sm^3/h) would also be assessed in this further analysis, even though it is not designed as a storage vessel.

Table 14: Preliminary Screening Assessment Natural Gas

Material	Type	Max Quantity on site	Distance to Site Boundary [m]	Distance to Sensitive Receptor	Screening Threshold or minimum separation distance (Other Land Uses)	Screening Threshold or minimum separation distance (Sensitive Receptors)	Notes
Natural Gas	Class 2.1 Flammable Gas	3 tonnes (Note 1)	< 20 m	2,000 m	70 m (Figure 6)	90 m (Figure 6)	Above threshold

Note 1: Assuming density equal to 0.7226 kg/m^3

Figure 5: Class 2.1 Flammable Gases Pressurised (Excluding LPG) [Reference (3)]



6.1.2 Class C1 Combustible Liquid (Diesel)

According to *Applying SEPP 33* [Reference (3)] if combustible liquids of class C1, such as diesel, are present on site and are stored in a separate bund or within a storage area where there are no flammable materials stored, they are not considered to be potentially hazardous. Flammable materials include Class 3PGI, II or III flammable liquids. Diesel would be stored in two liquid fuel storage tanks within a bunded area. No class 3PGI, II or II flammable liquids are held on-site so diesel is not considered to be potentially hazardous.

6.1.3 Transport Risk

Natural gas would be transported to the site via pipelines.

Liquid fuel, diesel and/ or bio-diesel would be stored on site to accommodate unconstrained operations, such as loss of gas fuel. The amount of fuel required should provide up to 24 hours of base load operations, which requires approximately 1.5 ML diesel storage.

Diesel would be transported to the Proposal site by road and is classified as a Class 9 Dangerous Good for road transport purposes.

The State Environmental Planning Policy No.33 (SEPP 33) provides Transportations Screening Thresholds for all dangerous goods transport classes [Reference (3)]. The threshold for Class 9 (Diesel) is >1000 cumulative annual or >60 peak weekly transport movements.

Currently, there are not any expected number of transport movements during normal operations, as the site is only going to require diesel for unconstrained operations.

SEPP 33 states that proposed development may be potentially hazardous if the number of generated traffic movements (for significant quantities of hazardous materials entering or leaving the site) is above the annual or weekly cumulative vehicle movements.

Therefore, the site is not found to be potentially hazardous with respect to transportation, due to the minimal quantity of transport movements required during normal operation.

If the requirement for diesel changes to regular deliveries, and the number of transport movements exceed criteria, a route evaluation study would be completed in accordance with the Department of Planning's HIPAP 11: Route Selection. [Reference (11)].

6.1.4 Potentially Offensive Industry

Schedule 3 of the Environmental Planning and Assessment Regulation provides a description of several categories of industry with a potential for significant environmental impact.

Electricity generating stations, including associated water storage, ash or waste management facilities, are considered offensive if they are supplying or are capable of supplying more than 30 megawatts of electrical power from other energy sources (including coal, gas, wind, bio-material or solar powered generators, hydroelectric stations on existing dams or co-generation).

Since the Proposal includes a new power station with a nominal capacity of about 250 MW from a gas energy source, it is considered a potentially offensive industry. Consequently, an analysis of the potential impacts to neighbouring facilities and land uses is required.

The following technical studies provide a detailed description of the quantity, nature and significance of all offences likely to be caused by the development that could produce air, noise, water or other emissions:

- Surface Water and Ground Water Assessment
- Air Quality Assessment
- Noise Assessment
- Environmental Management and Monitoring.

Included in the technical studies are the safeguards required to ensure potential offensiveness can be controlled to a level which is not significant.

7 Hazardous Identification

7.1 Major Hazardous Event Identification

Hazardous accident events where identified during a desktop analysis based on the Hazard and Operability and Pipeline Safety Studies. A Hazard Identification Summary Table can be found in Appendix 2 which lists the preventative and mitigation measures incorporated in the Proposal to prevent a hazardous event. The hazards identified to have potential offsite impacts i.e. major hazardous events are listed below:

1. Tomago to Hexham Tomago to Hexham Pipeline connection to gas compression inlet/ bypass (around 1750 to 4000 kPag)
2. Piping from gas compression units to gas generator, when sourced from the Tomago to Hexham PipelineTomago to Hexham Pipeline (5,500 kPag). Water bath bypassed
3. Piping from gas compression bypass to let down station, when sourced from the Tomago to Hexham PipelineTomago to Hexham Pipeline (2,500 kPag). Water bath bypassed
4. Piping from gas let down station to gas engines, when sourced from the Tomago to Hexham Pipeline Tomago to Hexham Pipeline(1,000 kPag)
5. Piping from gas compression units to storage pipeline (15,000 kPag)
6. Gas storage pipelines (15,000 kPag)
7. Gas storage pipeline to let down station, including water bath heater (15,000 kPag)
8. Piping from gas let down station to gas engines, when sourced from storage pipeline (1,000 kPag)
9. Piping from gas let down station to gas generators, when sourced from storage pipeline (5,500 kPag)
10. Gas leak within a compressor house.

A fire at the transformer is a potentially hazardous scenario with significant onsite risks. A Fire Safety Study in line with HIPAP Paper No 2 [Reference (12)] is being conducted for the site to evaluate appropriate fire safety design and controls.

8 Consequence Effects

8.1 Dangerous Dose Human Health

8.1.1 Heat Radiation Dangerous Dose to Human Health

The consequences of flammable hazardous events are fire, blast and shock wave damage. In general, every flammable release has the potential for heat radiation and explosive effects. The consequences of fires are damage to equipment and heat radiation burns. In terms of burns there are two aspects that are important, the intensity of the heat radiation and the duration of exposure.

The effects arising from exposure to thermal radiation is generally in relation to exposure of bare skin. Generally vulnerable land uses shall not be exposed to a heat radiation impacts that exceed 4.7 kW/m^2 and this is deemed to be dangerous dose. This level of radiation relates to a cause of pain in 15-20 seconds an injury after 30 seconds exposure (at least second degree burns will occur). The level of heat radiation to have a fatal effect is 12.6 kW/m^2, further details are shown in Table 15.

Table 15. Consequences of heat radiation

Heat radiation (kW/m^2)	Effect
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second-degree burns will occur) Dangerous Dose
12.6	Significant chance of fatality for extended exposure. High chance of injury Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure Fatal Dose
23	Likely fatality for extended exposure and chance of fatality for instantaneous exposure Spontaneous ignition of wood after long exposure Unprotected steel will reach thermal stress temperatures which can cause failure Pressure vessel needs to be relieved or failure would occur
35	Cellulosic material will pilot ignite within one minute's exposure Significant chance of fatality for people exposed instantaneously

8.1.2 Explosion Dangerous Dose to Human Health

Explosion effect models predict the impact of blast overpressure on people and structures. Explosions are hazardous to people due to blast overpressure, collapsing buildings and projectiles. Explosion effects are determined by correlating overpressure resulting from the explosion to its potential to cause damage. The level of explosion overpressure that is considered to be a dangerous dose is 7 kPa. Additional pressure and effect details are shown in Table 16.

Table 16. Effects of explosion overpressure [Reference (13)].

Explosion overpressure	Effect
3.5 kPa (0.5 psi)	% glass breakage No fatality and very low probability of injury
7 kPa (1 psi)	Damage to internal partitions and joinery but can be repaired Probability of injury is 10%. No fatality Dangerous dose
14 kPa (2 psi)	House uninhabitable and badly cracked

21 kPa (3 psi)	Reinforced structures distort Storage tanks fail 20% chance of fatality to a person in a building Fatal dose
35 kPa (5 psi)	House uninhabitable Wagons and plants items overturned Threshold of eardrum damage 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open
70 kPa (10 psi)	Threshold of lung damage 100% chance of fatality for a person in a building or in the open Complete demolition of houses

8.2 Dangerous Dose to Built Environment

8.2.1 Heat Radiation Dangerous Dose to Built Environment

Fire damage estimates are based upon correlations with recorded incident radiation flux and damage levels. Dangerous dose to the built environment means thermal radiation from fire exceeds 23 kW/m^2 This would cause spontaneous ignition of wood after long exposure, unprotected steel will reach thermal stress temperatures which can cause failure and pressure vessels need to be relieved or failure would occur.

8.2.2 Explosion Dangerous Dose to Built Environment

Dangerous dose to the built environment is considered to be an overpressure of 14 kPa. At this pressure a house is considered uninhabitable and badly cracked.

8.3 Modelling

Consequence modelling for the major hazardous events was performed using the Det Norske Veritas Global (DNV-GL) PHAST software package Version 8.1 to model the plume dispersion, and determine the specific heat radiation and over-pressure consequences related to each of the major hazardous event scenarios.

Table 17: Consequence scenarios - Summary

Scenario	PHAST set up Scenario	Release Scenario
Pipe leak/ rupture Tomago to Hexham Pipeline to gas compression inlet/ bypass	Pipeline 2,500 kPag operating pressure 15 – 30°C operating temperature Modelled @ MAOP = 6,895 kPag, T = 15°C Elevation = 1 m	25 mm and 50 mm orifice diameter Horizontal gas release (above ground)
Full-bore rupture Tomago to Hexham Pipeline to gas compression inlet/ bypass (full bore rupture)	Pipeline 2,500 kPag operating pressure 15 - 30°C operating temperature Modelled @ MAOP = 6,895 kPag, T = 15°C Elevation = 1 m	295.36 mm orifice diameter Horizontal gas release (above ground)

Scenario	PHAST set up Scenario	Release Scenario
Pipe leak/ rupture Piping from gas compression units to gas generator, when sourced from Tomago to Hexham Pipeline. Water bath bypassed	Pipeline 5,500 kPag operating pressure 30 - 60°C operating temperature Modelled @ MAOP = 6,895 kPag, T= 30°C Elevation = 1 m	25 mm and 50 mm orifice diameter Horizontal gas release (above ground)
Full-bore rupture Piping from gas compression units to gas generator, when sourced from Tomago to Hexham Pipeline. Water bath bypassed	5,500 kPag operating pressure 30 - 60°C operating temperature Modelled @ MAOP = 6,895 kPag, T= 30°C Elevation = 1 m	295.36 mm orifice diameter Horizontal gas release (above ground)
Pipe leak/ rupture Piping from gas compression units to storage pipeline	Pipeline 15,000 kPag operating pressure 30 – 60°C operating temperature Modelled @ MAOP = 15,300 kPag, T = 30°C Elevation = 1 m	25 mm and 50 mm orifice diameter Horizontal gas release (above ground)
Full-bore rupture Piping from gas compression units to storage pipeline (full bore rupture) (above ground)	Pipeline 15,000 kPag operating pressure 30 – 60°C operating temperature Modelled @ MAOP = 15,300 kPag, T = 30°C Elevation = 1 m	1009.84 mm orifice diameter Horizontal gas release (above ground)
Pipe leak/ rupture inside Compressor House	Gas filled compressor house	23 m x 16.5 m x 5m building filled with natural gas to UEL
Pipe leak/ rupture Gas Storage Pipeline due to excavator collision	Pipeline 15,000 kPag operating pressure 15 - 60°C operating temperature Modelled @ 15,300 kPag, T = 15°C 760,734 kg mass inventory Elevation = 0 m	30 mm and 50 mm orifice diameter Vertical gas release
Pipe leak/ rupture NPS Fuel Gas Supply Line due to excavator collision	Tie-in Pipeline 2,500 kPag operating pressure 15 - 30°C operating temperature Modelled @ MAOP = 6,895 kPag, T= 15°C 134,732 kg mass inventory Elevation = 0 m	30 mm and 110 mm orifice diameter Vertical gas release
Fuel gas release from the pig receiver and/or launcher on Gas Storage Pipeline	Relief Valve 15,000 kPag operating pressure 15 - 60°C operating temperature Modelled @ MAOP = 15,300 kPag, T = 15°C 193.7mm pipe diameter 3 m pipe length Elevation = 4 m	193.7 mm orifice diameter Vertical gas release
Full-bore rupture Gas Storage Pipeline	Pipeline 15,000 kPag operating pressure 15 - 60°C operating temperature Modelled @ MAOP = 15,300 kPag, T = 15°C 760,734 kg mass inventory Elevation = 0 m	1009.84 mm orifice diameter Vertical gas release

Scenario	PHAST set up Scenario	Release Scenario
Full-bore rupture NPS Fuel Gas Supply Line	Pipeline 2,500 kPag operating pressure 15 - 30°C operating temperature Modelled @ MAOP = 6,895 kPag, T = 15°C 134,732 kg mass inventory Elevation = 0 m	295.36 mm orifice diameter Vertical gas release

The PHAST software has a set of default parameters for variables such as discharge, dispersion, weather, building, surface, pool vaporisation, toxicity, flammability, explosion, fireball and BLEVE blast, jet fire and pool fire. Table 18summarises the parameters that have been modified for this analysis.

Table 18: Deviation from PHAST Default Parameters

Parameter Set	Parameter	Default	Value Used	Justification
Discharge	Capping of pipe flow rates	Use leak scenario cap, disallow flashing	No capping	Flow rate will be large, therefore should not be capped
Dispersion	Maximum height for dispersion	100 m	2,000 m	Maximum dispersion height is above 100 m
Weather	Wind speed reference height	1 m	10 m	-
Surface	Surface roughness length	User defined length	30 mm – open flat terrain; grass, few isolated objects	Most accurately represents site terrain
Flammable	Solar radiation	Exclude from calculations	Include in calculations	Solar radiation being included in the calculations produces a more accurate result
General	Height of interest	1 m	0 m	Majority of pipework is underground, and PHAST is limited to a minimum height of release and interest of 0 m
Release direction - underground piping	Direction	Horizontal	Vertical	As pipework is underground, a rupture will produce a vertical release

8.4 Results

8.4.1 Release rates

The worst case energy release rate in the event of a pipeline rupture due to collision, full bore rupture and venting at the pig launcher or receiver are summarised in Table 19,Table 20 and Table 21.

Table 19: Pipeline location specific breach worst-case energy release rate

Parameter	Unit	Value				Reference
		Storage Pipeline		NPS Fuel Gas Supply Line		
		30 mm	50 mm	30 mm	50 mm	
Discharge mass flow rate	kg/s	20.8	57.8	14.2	23.7	PHAST output

Discharge velocity	m/s	329.1	329.1	370.4	370.4	PHAST output
Energy release rate	GJ/s (LHV basis)	1.03	2.87	0.71	1.18	Calculated based on the heat of combustion

Table 20: Storage Pipeline venting at pig launcher/ receiver worst-case energy release rate

Parameter	Unit	Value	Reference
Discharge mass flow rate	kg/s	1021	PHAST output
Discharge velocity	m/s	341.8	PHAST output
Energy release rate	GJ/s (LHV basis)	50.76	Calculated based on the heat of combustion

Table 21: Pipeline full bore rupture worst-case energy release rate

Parameter	Unit	Value		Reference
		Storage Pipeline	NPS Fuel Gas tie-in	
Discharge mass flow rate	kg/s	38,022	1,300	PHAST output
Discharge velocity	m/s	406.4	370.3	PHAST output
Energy release rate	GJ/s (LHV basis)	1,890.45	64.64	Calculated based on the heat of combustion

8.4.2 Types of Consequences

A number of different events can occur after the release of flammable gas from high-pressure pipework, these include:

- Jet fire
- Flash fire
- Vapour cloud explosion (VCE).

The consequences are presented in a typical event tree (refer Table 22).

Table 22: Event tree for release of flammable gas from high-pressure methane (natural gas)

Initiating event	Direct ignition (P_1)	Delayed ignition (P_2)	Flame front acceleration (P_3)	Final scenario
Release of methane	Yes			Jet fire
	No	Yes	Yes (or strong)/ Cloud confined	Explosion
			No (or weak) / Cloud unconfined	Flash fire (+ Jet fire)
		No		No fire or explosion consequences

8.4.3 Worst-Case Heat Radiation Contours

The worst-case heat radiation radii for a pipeline location specific breach, pig launcher or receiver venting, and above ground pipeline full bore rupture are shown in Table 23, Table 24 and Table 25 respectively.

Table 23: Pipeline location specific breach worst-case heat radiation radii

Consequence	Radiation intensity (kW/m^2)	Heat radiation radius (m)	
		Storage Pipeline	NPS Fuel Gas tie-in
Jet fire	4.7	30 mm: 54 (vertical release) 50 mm: 87 (vertical release) 25 mm: 71 (horizontal release) (1/A) 50 mm: 134 (horizontal release) (1/A)	30 mm: 34 (vertical release) 110 mm: 99 (vertical release) 25 mm: 46 (horizontal release) (1/A) 50 mm: 88 (horizontal release) (1/A)
	12.6	30 mm: 28 (vertical release) 50 mm: 45 (vertical release) 25 mm: 56 (horizontal release) 50 mm: 99 (horizontal release)	30mm: 17 (vertical release) 110mm: 50 (vertical release) 25 mm: 38 (horizontal release) 50 mm: 68 (horizontal release)
	23.0	30 mm: 9 (vertical release) 50 mm: 18 (vertical release) 25 mm: 50 (horizontal release) 50 mm: 87 (horizontal release)	30mm: 4 (vertical release) 110mm: 20 (vertical release) 25 mm: 34 (horizontal release) 50 mm: 61 (horizontal release)

Note: Unless noted otherwise, the heat radiation contours are reported at 5/D weather category which for a vertical release gives the longest distances.

Table 24: Storage Pipeline venting at pig receiver worst-case heat radiation radii

Consequence	Radiation intensity (kW/m²)	Heat radiation radius (m)
Jet fire	4.7	320 *(3/B/C weather category)*
	12.6	163 *(5/D weather category)*
	23.0	78 *(5/D weather category)*

Table 25: Pipeline full bore rupture worst-case heat radiation radii - above ground piping in horizontal direction

Consequence	Radiation intensity (kW/m²)	Heat radiation radius (m)	
		Storage Pipeline	**NPS Fuel Gas tie-in**
Jet fire	4.7	1,997 *(3/B/C weather category)*	445 *(1/A worst case weather category)*
	12.6	1,458 *(5/D weather category)*	316 *(5/D worst case weather category)*
	23.0	1,231 *(5/D weather category)*	271 *(5/D worst case weather category)*

8.4.4 Explosion over-pressure

The explosion over-pressure distances resulting from an explosion within the compressor house are shown in Table 48.

Table 48: Compressor house explosion over pressure radii

Consequence	Over- Pressure (kPa)	Over-pressure radius (m)
		Compressor House
Explosion	7	84
	14	53

9 Frequency Analysis

9.1 Frequency of gas leaks and ignition probability

The failure frequency data listed in Table 26 is taken from the latest report by the European Gas Pipeline Incident Data Group (EGIG), Table 6 [Reference (14)]. The EGIG database is considered a reliable source of failure frequencies based on failure data collected by a group of 17 major gas transmission system operators in Europe for onshore natural gas pipelines with a design pressure of greater than 15,000 kPag [References (14) (15)]. The total system exposure as of 2016 is approximately 4.41 million km.year [Reference (14)].

Data from Table 6 of the EGIG report is selected as it is most representative of the scenarios being studied related to the Proposal i.e. secondary frequencies given for a time period of 10 years. In addition, in contrast to primary failure frequency data, secondary failure frequencies calculations consider the influence of design parameters such as pressure, diameter, depth of cover, etc.

The natural gas is transported to the site via the Tomago to Hexham Pipeline that is designed as a pipeline, rather than a storage vessel. If assessed as a pipeline [Reference (14)], the failure frequency is zero. To allow for a low but conservative failure [Reference (8)], a generic failure frequency was taken for that of a stationary pressure vessel of 5×10^{-7} per year based per kilometre.

The Ignition Probability data is taken from the same report by EGIG, Table 7 [Reference (14)]. Rupture data for 'all diameters' is associated to full-bore rupture scenarios relating to piping >1000 mm. This is as opposed to using an ignition probability of 42.3% as per the EGIG data for ruptures > 16 inches (406.4 mm) which is considered high considering the small sample size used to determine the ignition probabilities and the high uncertainty associated with ignition events, as discussed in more detail in Section 3.4.2 of the EGIG report.

9.2 Frequency of Explosion in Gas Generator Housing

The design of the gas generators is at concept design stage. AGL have indicated that the minimum safety requirements for the gas generator design related to the Proposal will be as per those proposed for similar Power Stations. The frequency of a gas generator housing explosion has been taken from the Dalton Power Station PHA [Reference (16)]. The explosion frequency was found to be 7.2×10^{-8} per year per housing.

This estimation took into account the below safety requirements as a minimum:

- Highly reliable ventilation fan system and ventilation detection system;
- Independent gas detection linked to automatic emergency shut down system;
- Prevention of ignition sources within the housing;
- Explosion panel (to minimise effect of confinement) and fire quenching (e.g. carbon dioxide);
- Separation distances to nearby generators and pressure piping;

The frequency was calculated using the following assumptions:

- Gas leak frequency = 1.4×10^{-3} t/y;
- Ventilation fan failure probability, allowing accumulation of gas = 0.1;
- Gas detection failure and failure of the emergency shut down = 0.05 per gas detector, assume two independent detectors. Also, taken into account is a 0.0025 probability of common mode failure for gas detectors (e.g. due to maintenance failure affecting detector system);
- Ignition probability of accumulated gas = 0.1;
- Explosion of ignition probability = 1.

For more detail on the above safety requirements and frequency calculations, refer to Section 8.2 of the AGL Dalton Power Station PHA report [Reference (16)].

Using the gas turbine models being considered for the Proposal as either:

- 4 x 65 MW turbines; or
- 8 x 30 MW turbines.

the total frequency of explosion inside the turbine housing is:

- With four turbines:

- F (explosion in turbine housing) = 4 x 7.2 x 10^{-8} = 2.88 x 10^{-7} per year

- With eight turbines:
  - F (explosion in turbine housing) = 8 x 7.2 x 10-8 = 5.76 x 10^{-7} per year

It is recommended that during the detailed design phase of the Proposal that the minimum safety requirements are reviewed to confirm the frequency of explosion in the housing. The detailed design of the housing and associated equipment should clearly outline the basis of safety used to ensure that the explosive situations do not arise. Reference should be made to European ATEX Directive 94/9/EC and the UK HSE Guidance Note PM84: ‘Control of safety risks at gas turbines used for power generation’ or other guidance / regulation of equivalent safety. It is also advised that the rotating machines are designed such that the risk associated with projectiles is minimised (gas pipelines protected or not in probable line of projectile, extra design criteria for casings, people protected etc).

Table 26: Failure Frequencies associated per Scenario

Scenario	PHAST set up Scenario	Release Scenario	Size of Leak	Nominal Diameter (mm)	Failure Frequency (per km.year)	Ignition Probability (% of releases with ignition)
Pipe leak/ rupture Tomago to Hexham Pipeline to gas compression inlet/ bypass	Pipeline 2,500 kPag operating pressure 15 – 30°C operating temperature Modelled @ MAOP = 6,895 kPag, T = 15°C Elevation = 1 m	25 mm and 50 mm orifice diameter Horizontal gas release (above ground)	Hole	295.36	4.00E-05	2.2
Full-bore rupture Tomago to Hexham Pipeline to gas compression inlet/ bypass (full bore rupture)	Pipeline 2,500 kPag operating pressure 15 - 30°C operating temperature Modelled @ MAOP = 6,895 kPag, T = 15°C Elevation = 1 m	295.36 mm orifice diameter Horizontal gas release (above ground)	Rupture	295.36	1.30E-05	10.0
Pipe leak/ rupture Piping from gas compression units to gas turbine, when sourced from Tomago to Hexham Pipeline. Water bath bypassed	Pipeline 5,500 kPag operating pressure 30 - 60°C operating temperature Modelled @ MAOP = 6,895 kPag, T= 30°C Elevation = 1 m	25 mm and 50 mm orifice diameter Horizontal gas release (above ground)	Hole	295.36	4.00E-05	2.2
Full-bore rupture Piping from gas compression units to gas turbine, when sourced from Tomago to Hexham Pipeline. Water bath bypassed	5,500 kPag operating pressure 30 - 60°C operating temperature Modelled @ MAOP = 6,895 kPag, T= 30°C Elevation = 1 m	295.36 mm orifice diameter Horizontal gas release (above ground)	Rupture	295.36	1.30E-05	10.0
Pipe leak/ rupture Piping from gas compression units to storage pipeline	Pipeline 15,000 kPag operating pressure 30 – 60°C operating temperature Modelled @ MAOP = 15,300 kPag, T = 30°C Elevation = 1 m	25 mm and 50 mm orifice diameter Horizontal gas release (above ground)	Hole	1009.84	5.00E-07	2.2
Full-bore rupture Piping from gas compression units to storage pipeline (full bore rupture) (above ground)	Pipeline 15,000 kPag operating pressure 30 – 60°C operating temperature Modelled @ MAOP = 15,300 kPag, T = 30°C Elevation = 1 m	1009.84 mm orifice diameter Horizontal gas release (above ground)	Rupture	1009.84	5.00E-07	14.4
Pipe leak/ rupture inside Compressor House	Gas filled compressor house	23 m x 16.5 m x 5m building filled with natural gas to UEL	N/A		5.76E-07	N/A

Pipe leak/ rupture Gas Storage Pipeline	Pipeline 15,000 kPag operating pressure 15 - 60°C operating temperature Modelled @ 15,300 kPag, T = 15°C 760,734 kg mass inventory Elevation = 0 m	30 mm and 50 mm orifice diameter Vertical gas release	Hole	1009.84	5.00E-07	2.2
Scenario	**PHAST set up Scenario**	**Release Scenario**	**Size of Leak**	**Nominal Diameter (mm)**	**Failure Frequency (per km.year)**	**Ignition Probability (% of releases with ignition)**
Pipe leak/ rupture NPS Fuel Gas Supply Line	Tie-in Pipeline 2,500 kPag operating pressure 15 - 30°C operating temperature Modelled @ MAOP = 6,895 kPag, T= 15°C 134,732 kg mass inventory Elevation = 0 m	30 mm and 110 mm orifice diameter Vertical gas release	Hole	295.36	4.00E-05	2.2
Fuel gas release from the pig receiver and/or launcher on Gas Storage Pipeline	Relief Valve 15,000 kPag operating pressure 15 - 60°C operating temperature Modelled @ MAOP = 15,300 kPag, T = 15°C 193.7mm pipe diameter 3 m pipe length Elevation = 4 m	193.7 mm orifice diameter Vertical gas release	Rupture	193.7	1.80E-05	14.4
Full-bore rupture Gas Storage Pipeline	Pipeline 15,000 kPag operating pressure 15 - 60°C operating temperature Modelled @ MAOP = 15,300 kPag, T = 15°C 760,734 kg mass inventory Elevation = 0 m	1009.84 mm orifice diameter Vertical gas release	Rupture	1009.84	5.00E-07	14.4
Full-bore rupture NPS Fuel Gas Supply Line	Pipeline 2,500 kPag operating pressure 15 - 30°C operating temperature Modelled @ MAOP = 6,895 kPag, T = 15°C 134,732 kg mass inventory Elevation = 0 m	295.36 mm orifice diameter Vertical gas release	Rupture	295.36	1.30E-05	14.4

10 Risk Analysis

10.1 Injury Risk

'Individual injury risk' captures the associated risk of injury as a result of the Proposal. The impact of injury must be considered for the following scenarios: heat radiation and explosion over-pressure at sensitive or residential area.

Table 27: Injury Risk Criteria

Injury Risk Criteria	Maximum Tolerable Risk ($x10^{-6}$ per year)	Criteria Satisfied
Maximum Over-pressure		
7 kPa	50 (at residential & sensitive use areas)	Yes
Maximum Heat Radiation		
4.7 kW/m^2	50 (at residential & sensitive use areas)	Yes

Sensitive and residential areas are located more than 2 kms from the site. The maximum over pressure and heat radiation injury levels did not reach these areas.

10.2 Property Damage and Accident Propagation

In accordance with *HIPAP No 4 – Risk Criteria* [Reference (2)], the risk criteria for damage to property and of accident propagation should be assessed at neighboring/land zoned potentially hazardous installations. The NGSF is considered to be a potentially hazardous installation within proximity of the Proposal.

Table 28: Property Damage and Accident Propagation Criteria

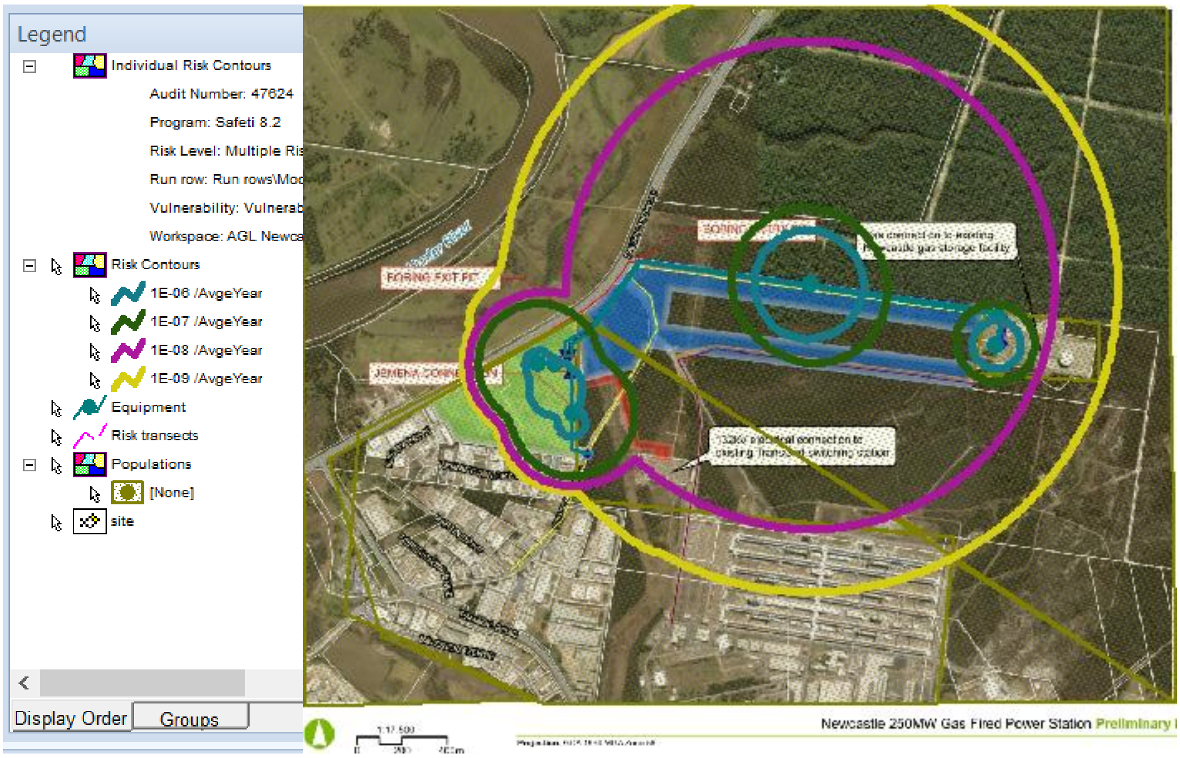
Property Damage	Maximum Tolerable Risk ($x10^{-6}$ per year)	Criteria Satisfied
Maximum Over-pressure		
14 kPa	50 (at neighboring/land zoned potentially hazardous installations)	Yes
Maximum Heat Radiation		
23 kW/m^2	50 (at neighboring/land zoned potentially hazardous installations)	Yes

The NGSF is located near to the proposed Gas Storage Pipeline so that the maximum over pressure and heat radiation property damage and accident propagation levels reach the facility. The failure frequency of the pipeline and associated infrastructure is low such that the risk criteria is satisfied.

10.3 Fatality Risk

'Individual fatality risk' is the risk of death to a person at a particular point. It is assumed that the person will be at the point of interest 24 hours per day for the whole year. Figure 6 is an indicative representation of the likely individual fatality risk.

Figure 6: Individual Fatality Risk Contours (based on a single leak location)



The SAFETI modeling results considered a leak scenario at a particular point along the gas pipelines and the storage pipeline. In reality the major hazardous event could occur anywhere along the pipelines. The Fatality Risk Criteria in relation to adjacent land uses is acceptable (approximately an order of magnitude lower) as demonstrated in Table 29.

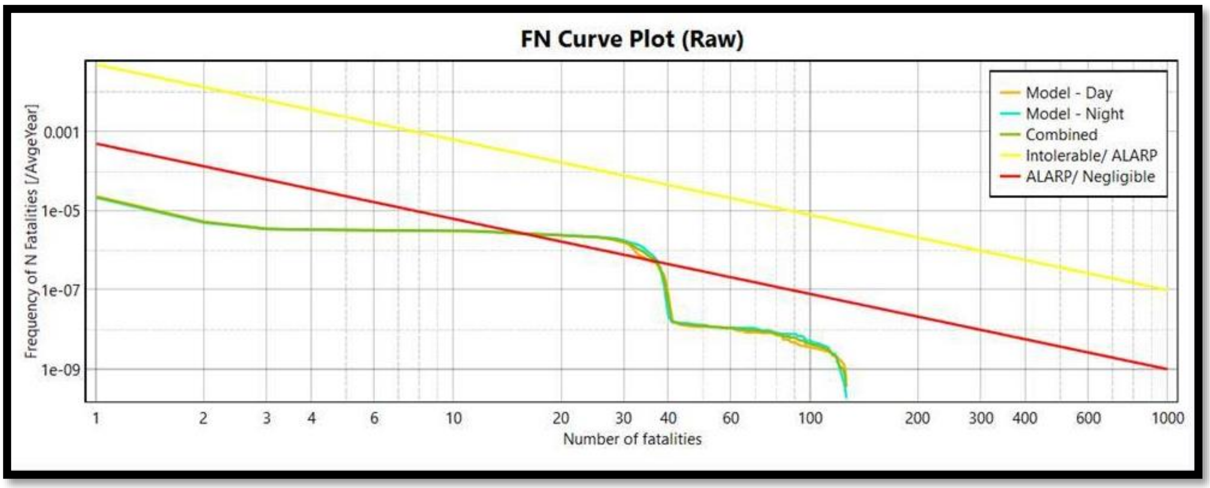
Table 29: Individual Fatality Risk Criteria

Land Use	Suggested Risk Criteria ($x10^{-6}$ per year or per million per year)	Criteria Satisfied
Hospitals, schools, child-care facilities, old age housing	0.5 (Blue risk contour in Figure 6)	Yes
Residential, hotels, motels, tourist resorts	1 (Green risk contour in Figure 6)	Yes
Commercial developments including retail centers, offices and entertainment centers	5	Yes
Sporting complexes and active open space	10	Yes
Industrial	50	Yes

10.4 Societal Risk

Societal risk criteria are based on the ALARP principle. The NSW Department of Planning has provisionally adopted the indicative criteria in Figure 2 for addressing societal concerns arising when there is a risk of multiple fatalities occurring in one event. The societal risk for the Proposal are plotted against these criteria in Figure 7.

Figure 7: Individual Fatality Risk Contours (based on a single leak location)



The societal risk criteria, is met as the F_N Curve is within the ALARP and negligible range. The likelihood of a multiple fatality event is tolerable.

The risk criteria are easily met for the Proposal. The societal risk in particular is low due to the relatively low population density associated with the large essentially rural land surrounding the Proposal.

The PHA has been completed and demonstrates that the risks from the Proposal comply with the criteria set out in Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning [Reference (2)].

A fundamental principle of a quantitative assessment is that hazardous chemical facilities are designed in accordance with Australian Standards including AS2885 Pipelines – Gas and Liquid Petroleum, Operation and Maintenance. The quantitative risk assessment has progressed based on the assumption that the Proposal will ensure compliance with Australian Standards.

Further to this, the safety assessment process for the Proposal would continue to identify controls that prevent or limit the effects of a major accident scenario. The detailed design would also consider whether there are further controls that could be implemented to reduce risk so far as is reasonably practicable.

11 References

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Appendices

Appendix 1
Weather Data – University of Newcastle

Table 30. Wind direction and frequency for Night/9am

Wind Directions	Percentage of time wind was in stability class 1/D.	Percentage of time wind was in stability class 3/B-C.	Percentage of time wind was in stability class 5/D.	Percentage of time wind blows from each of the 8 major directions
N	4.625	4.5	0.5	9.625
NE	4.625	8.5	1	14.125
E	4.625	0	0.5	5.125
SE	4.625	9.5	3.5	17.625
S	4.625	2	1	7.625
SW	4.625	6	1	11.625
W	4.625	2	1	7.625
NW	4.625	17	5	26.625
Total %	**37**	**49.5**	**13.5**	**100**

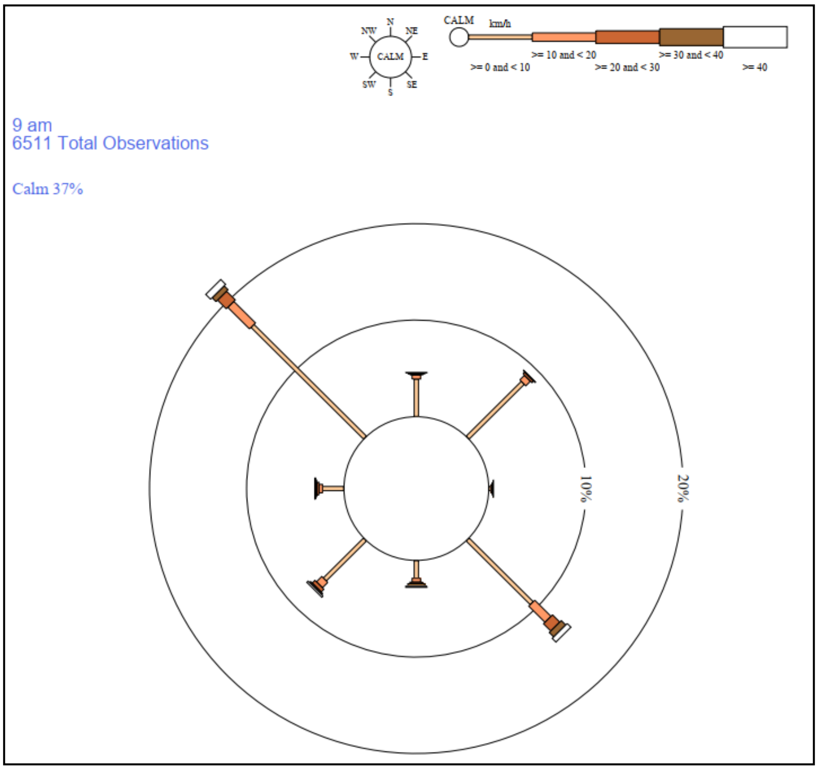

Figure 8. Wind Rose - Night/9am

Table 31. Wind direction and frequency for Day/3pm

Wind Directions	Percentage of time wind was in stability class 1/D	Percentage of time wind was in stability class 1/A.	Percentage of time wind was in stability class 5/D.	Percentage of time wind blows from each of the 8 major directions
N	1.625	1	0.5	3.125
NE	1.625	8	2.5	12.125
E	1.625	0.5	1.5	3.625
SE	1.625	25	16	42.625
S	1.625	1.5	3.5	6.625
SW	1.625	3	4	8.625
W	1.625	0.5	1.5	3.625
NW	1.625	9	9	19.625
Total %	**13**	**48.5**	**38.5**	**100**

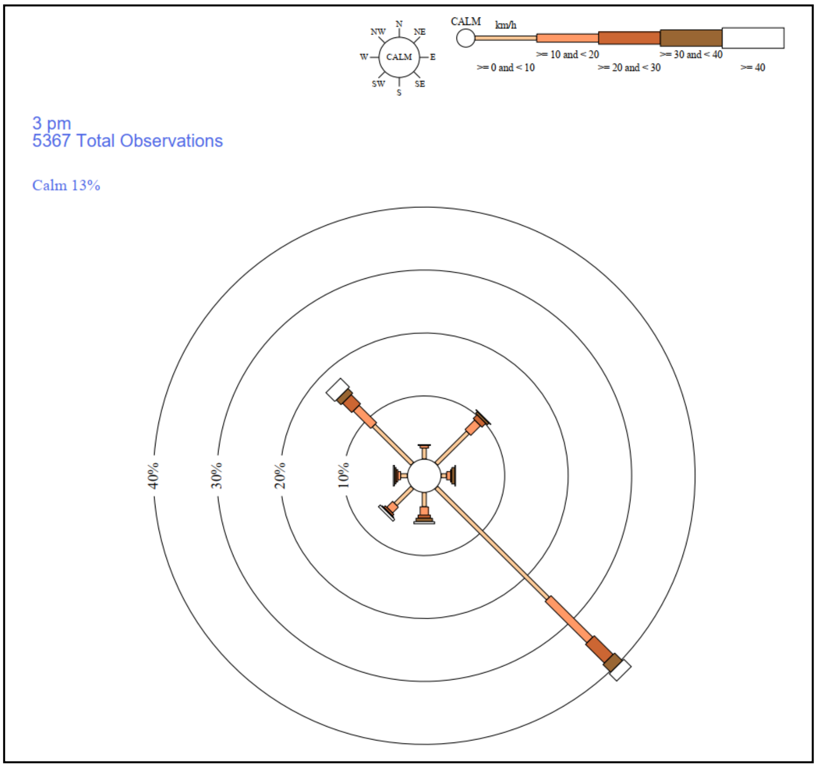

Figure 9. Wind Rose - Day/3pm

Appendix 2

Hazard Identification Table

#	Location/ Equipment	Hazard Cause	Consequence	Safeguards	Potential Offsite Impact
1	Tomago to Hexham Pipeline to gas compression inlet / bypass (2,500 kPag operating pressure)	- Excavation impact - Vehicle collision - Construction fault - Material fault - Thermal expansion - Ground movement - Corrosion	- Pipe rupture or leak potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion	- Underground pipe marker installed - Piping in restricted access areas - Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Majority of the piping is thermally insulated underground - Low risk area for earthquakes - Cathodic protection on underground piping and painted above ground piping - Dry gas used to minimise internal corrosion risk - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements)	Yes
2	Piping from gas compression units to gas turbine, when sourced from Tomago to Hexham Pipeline (5,500 kPag). Water bath bypassed	- Excavation impact - Vehicle collision - Construction fault - Material fault - Thermal expansion - Ground movement - Corrosion - Over-pressure due to gas compressor failure	- Pipe rupture or leak potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion	- Underground pipe marker installed - Piping in restricted access areas - Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Majority of the piping is thermally insulated underground - Low risk area for earthquakes - Cathodic protection on underground piping and painted above ground piping - Dry gas used to minimise internal corrosion risk - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements) - Pressure reducing valves and pressure relief valve at let down station - Slam shut Over-pressure valve at let down station - Redundant let down train	Yes

3	Piping from gas compression bypass to let down station, when sourced from Tomago to Hexham Pipeline (2,500 kPag). Water bath bypassed	- Vehicle collision - Construction fault - Material fault - Thermal expansion - Ground movement - Corrosion	- Pipe rupture or leak potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion	- Piping in restricted access areas - Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Low risk area for earthquakes - Painted above ground piping - Dry gas used to minimise internal corrosion risk - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements)	Yes
4	Piping from gas let down station to gas engines, when sourced from Tomago to Hexham Pipeline (1,000 kPag).	- Excavation impact - Vehicle collision - Construction fault - Material fault - Thermal expansion - Ground movement - Corrosion - Over-pressure due to failure of let down station	- Pipe rupture or leak potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion '- Pressure relief valve release potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion	- Underground pipe marker installed - Piping in restricted access areas - Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Majority of the piping is thermally insulated underground - Low risk area for earthquakes - Cathodic protection on underground piping and painted above ground piping - Dry gas used to minimise internal corrosion risk - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements) - Pressure relief valves - Multiple pressure reducing valves at let down station - Slam shut Over-pressure valve at let down station	Yes

5	Piping from gas compression units to storage pipeline (15,000 kPag)	- Vehicle collision - Construction fault - Material fault - Thermal expansion - Ground movement - Corrosion - Over-pressure due to gas compressor failure	- Pipe rupture or leak potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion	- Piping in restricted access areas - Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Low risk area for earthquakes - Painted above ground piping - Dry gas used to minimise internal corrosion risk - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements) - Manual pig launcher / receiver vent, vented to an elevated location. Venting methodology for usage.	Yes
6	Gas storage pipelines (15,000 kPag)	- Excavation impact - Vehicle collision - Construction fault - Material fault - Thermal expansion - Ground movement - Corrosion	- Pipe rupture or leak potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion	- Underground pipe marker installed - Piping in restricted access areas - Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Majority of the piping is thermally insulated underground - Low risk area for earthquakes - Cathodic protection on underground piping and painted above ground piping - Dry gas used to minimise internal corrosion risk - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements)	Yes
7	Gas storage pipeline to let down station, including water bath heater (15,000 kPag)	- Vehicle collision - Construction fault - Material fault - Thermal expansion - Ground movement - Corrosion - Water bath heater failure overheating the gas pipe lowering pressure rating	- Pipe rupture or leak potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion	- Piping in restricted access areas - Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Low risk area for earthquakes - Painted above ground piping - Dry gas used to minimise internal corrosion risk - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements) - Level, pressure and temperature alarms with system trips on heaters - Redundant heater - Manual pig launcher/ receiver vent, vented to an elevated location. Venting methodology for usage.	Yes

8	Piping from gas let down station to gas engines, when sourced from storage pipeline (1,000 kPag).	- Excavation impact - Vehicle collision - Construction fault - Material fault - Thermal expansion - Ground movement - Corrosion - Water bath heater failure resulting in low pressure gas being supercooled and embrittling the pipe lowering pressure rating - Over-pressure due to failure of let down station	- Pipe rupture or leak potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion '- Pressure relief valve release potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion	- Underground pipe marker installed - Piping in restricted access areas - Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Majority of the piping is thermally insulated underground - Low risk area for earthquakes - Cathodic protection on underground piping and painted above ground piping - Dry gas used to minimise internal corrosion risk - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements) - Pressure relief valves - Multiple pressure reducing valves at let down station - Slam shut Over-pressure valve at let down station - Low temperature trip downstream of let down station - Redundant let down train and heater	Yes

9	Piping from gas let down station to gas turbines, when sourced from storage pipeline (5,500 kPag).	- Excavation impact - Vehicle collision - Construction fault - Material fault - Thermal expansion - Ground movement - Corrosion - Water bath heater failure resulting in low pressure gas being supercooled and embrittling the pipe lowering pressure rating - Over-pressure due to failure of let down station	- Pipe rupture or leak potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion - Pressure relief valve release potential for - Immediate ignition leading to jet fire - Delayed ignition leading to flash fire or explosion	- Underground pipe marker installed - Piping in restricted access areas - Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Majority of the piping is thermally insulated underground - Low risk area for earthquakes - Cathodic protection on underground piping and painted above ground piping - Dry gas used to minimise internal corrosion risk - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements) - Pressure relief valves - Multiple pressure reducing valves at let down station - Slam shut Over-pressure valve at let down station - Low temperature trip downstream of let down station - Redundant let down train and heater	Yes
10	Engine house	- Construction fault - Material fault - Thermal expansion - Corrosion	- Pipe rupture or leak potential for building to fill will flammable atmosphere - Delayed ignition leading to flash fire or explosion	- Construction works in areas to have permitting and trained and competent operators - NDT testing and hydrotesting of installed pipe - Hold points on material certs for piping and equipment - Painted above ground piping - Flanges are minimised and majority of connections full penetration butt weld. (Pipe wall thickness to exceed design requirements)	Yes