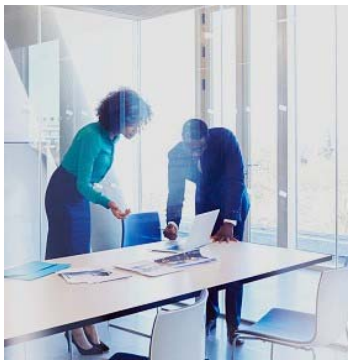
GHD Advisory



Assumption Register for Leewood CPF and Medium Pressure Trunkline Quantitative Risk Assessment

Narrabri Gas Project

08 August 2019

GHD

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1. Introduction

1.1 Background

The NSW Department of Planning, Industry and Environment (DPIE) has requested a Quantitative Risk Assessment (QRA) for the Leewood Central Gas Processing Facility (CPF) and incoming medium pressure (MP) Trunkline from the Bibblewindi Compressor Station.

The purpose of the QRA is to analyse the risk contours for Leewood CPF and MP Trunkline, and to check for compliance with Hazardous Industry Planning Advisory Paper No. 4 (HIPAP 4) risk criteria for offsite risk to the public (DoP 2011).

The QRA will inform the Hazard and Risk Assessment prepared for the Narrabri Gas Project (NGP) Environmental Impact Statement (EIS) (GHD 2016a).

1.2 Purpose of this document

The purpose of this document is to clearly document the assumptions underlying the QRA such that the work can be easily reviewed and understood.

1.3 Scope and limitations

The scope of the assumption register is to document the assumptions relating to data input, methodology, modelling philosophy and modelling limitations that will be required for analysing hydrocarbon loss of containment (LOC) events. Process related LOC events will be analysed to determine the offsite risk to the surrounding community.

The risk contours to be prepared in this QRA scope are for:

- Leewood CPF; and
- MP Trunkline from Bibblewindi to Leewood.

The NGP is at an early stage of concept design, and technical and engineering documentation of a nature suitable for a full QRA is not yet available. This QRA is therefore a preliminary study of the risk contours around the Leewood CPF and MP Trunkline.

1.4 Terminology

In this document, the following terms are defined.

Term	Definition
As Low As Reasonably Practicable (ALARP)	A level of risk that is below the intolerable level and either the cost of further risk reduction is disproportionate to the benefit gained or where the solution is technically impractical to implement.
Consequence	The severity associated with an event in this instance the heat radiation from jet fire, flash fire and fireball events or explosion overpressure, i.e. the potential effects of a hazardous scenario.

Term	Definition
Consequence Event	The end event associated with a failure and release, considering all detection, isolation and ignition factors, e.g. jet fire, flash fire etc.
Event Frequency	The frequency assigned to a specific consequence event
Fireball	The instantaneous flashing of the material due to the catastrophic failure of the container vessel creates an expanding cloud of material. A fireball is created if this cloud is ignited, often from the flame source that caused the initial vessel failure. As buoyancy forces of the hot gases begin to dominate, the burning cloud rises and becomes more spherical in shape.
Flash Fire	The delayed ignition of a vapour cloud. A flash fire occurs when a vapour cloud burns but no significant overpressure is created at the flame front. Unlike a vapour cloud explosion, the negligible overpressure created does not accelerate the flame front and thus energy released from the combustion does not take the form of an explosive blast. It is assumed there is a 100% likelihood of fatality within the ignited vapour cloud.
Frequency	The number of occurrences of an event expressed per unit time. It is usually expressed as the likelihood of an event occurring per annum.
Hazard	A physical situation with the potential for human injury, damage to property, damage to the environment or some combination of these.
Hazardous Scenario	The accidental release of a hazardous material from equipment or piping, from identified isolatable section of equipment.
Individual Risk	The frequency at which an individual may be expected to sustain a given level of harm from the realisation of specified hazards.
Individual Risk of Fatality	Individual risk, with “harm” measured in terms of fatality. It is calculated at a particular point for a stationary, unprotected person for 24 hours per day, 365 days per year. Commonly expressed in chances of fatality per year.
Jet Fire	A jet fire occurs when a flammable liquid or gas, under some degree of pressure, is ignited after release, resulting in the formation of a long stable flame. A jet fire risk is present whenever there are pressurised flammable gases or liquids. Turbulence evoked by pressurised fluid escape entrains ambient oxygen and can create a mixture that lays within the materials flammability limits.
Probability	The expression for the likelihood of an occurrence of an event or an event sequence or the likelihood of the success or failure of an event on test or demand. By definition, probability must be expressed as a number between 0 and 1.
Quantitative Risk Assessment	A risk assessment undertaken by combining quantitative evaluations of event frequency and consequence.
Risk	The combination of frequency and consequences, the chance of an event happening that can cause specific consequences.
Vapour Cloud Explosion	Vapour cloud explosions result from the combustion of flammable vapour clouds within a congested or confined area

Term	Definition
	creating an overpressure in the process. Under certain conditions the flame front may be accelerated by the overpressure created to a high velocity producing considerable blast effects.

1.5 Glossary

In this document, the following abbreviations are used.

Abbreviation	Meaning
ALARP	As Low As Reasonably Practicable
BBL	Bibblewindi (Compressor Station)
BIV	Boundary Isolation Valve
BLEVE	Boiling Liquid Expanding Vapour Explosion
CPF	(Leewood) Central Gas Processing Facility
CSG	Coal Seam Gas
dia	Diameter
DN	Diameter Nominal
DNV GL	Det Norske Veritas Germanischer Lloyd
DoP	Department of Planning
DPIE	Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
FBR	Full Bore Rupture
HIPAP	Hazardous Industry Planning Advisory Paper
HP	High Pressure
IP	Intermediate Pressure
kPag	Kilo Pascal Gauge
LOC	Loss of Containment
mm	Millimetre
m/s	Metres per second
MP	Medium Pressure
NGP	Narrabri Gas Project
Phast	Process Hazard Analysis Software Tool
QRA	Quantitative Risk Assessment
SAFETI (Phast Risk)	Software for the Assessment of Flammable, Explosive and Toxic Impact
TEG	Tri Ethylene Glycol
Tj/d	Terra joules per day
UK HSE	United Kingdom Health and Safety Executive
VCE	Vapour Cloud Explosion

2. Software and Input Parameters

Release, dispersion and subsequent fire and explosion effect calculations are performed using Det Norske Veritas Germanischer Lloyds (DNV GL) Software for the Assessment of Flammable, Explosive and Toxic Impact (SAFETI or Phast Risk) Version 6.7. This version has been used for consistency with the previous consequence analysis studies undertaken for the EIS Hazards and Risks Assessment (GHD 2016a).

Each hazardous release scenario calculation in SAFETI starts with discharge modelling. Based on release duration and release phase (methane gas in this case), SAFETI performs the dispersion and consequence calculations for all alternate consequence outcomes in terms of hazard range and event duration (where applicable) for each selected weather class / wind speed combination.

Hydrocarbon flammable consequence events modelled by SAFETI include:

- Jet fire;
- Flash fire;
- Fireball;
- Pool fire;
- Boiling Liquid Expanding Vapour Explosions (BLEVE); and
- Vapour Cloud Explosions (VCE).

SAFETI determines the consequence events based on all of the hazardous release scenarios and associated process conditions.

2.1 Consequence modelling assumptions from the NGP, Hazard and Risk Assessment

The consequence analysis has already been undertaken for the NGP, Hazard and Risk Assessment (GHD 2016a). This QRA will be based on the same consequence modelling. Therefore, the assumptions made in GHD (2016), are applicable here. These assumptions are listed below in Table 1.

Table 1 Assumptions adopted from NGP Hazard and Risk Assessment (GHD 2016a)

Assumption	Adopted from
1. The only hazardous material modelled is Coal Seam Gas (CSG)	---
2. Gas composition, 100% Methane. Although the EIS notes that the gas contains up to 9% other components, assuming 100% Methane gives the most conservative results	Section 2.3.6 of GHD 2016a
3. Effects of heat radiation	HIPAP 4 (DoP 2011)
4. Effects of explosion overpressure	HIPAP 4 (DoP 2011)
5. Risk criteria for individual and societal risk	HIPAP 4 (DoP 2011)

Assumption	Adopted from
6. Carbon steel pipe with software default roughness	Section 2.5.4 of GHD 2016a
7. The congestion area for modelling a VCE scenario in Leewood CPF is assumed to be 37%	Section 2.5.5 of GHD 2016a
8. Three representative weather scenarios of A1, D3.5 and F1	Table 2-12 of GHD 2016a
9. Wind rose for Narrabri	Figure 4-10 of GHD 2016b
10. Risk contours are modelled for 1.5 m height above ground level	Section 2.5.7 of GHD 2016a
11. Bibblewindi to Leewood MP gas pipeline modelling scenarios: • The length of the MP Trunkline from Bibblewindi to Leewood CPF is 16 km; • Hole sizes: 10 mm, 50 mm, 100 mm, full bore rupture every 500 m for 16,000 m; • Pressure of 2,000 kPag; • Gas flowrate: 177,000 kg / hr (for full bore rupture) equivalent to 200 Tj/d; and • Pipeline diameter from Bibblewindi to Leewood is 864 mm	Table 2-8 of GHD 2016a
12. LOC frequency of 0.0025 per 100 km per year for buried steel pipes	Section 4.3.2 of GHD 2016a
13. Release scenario outcomes including jet fires, flash fires, fireballs and explosions are all modelled in the software	Table 2-10 of GHD 2016a
14. Meteorological conditions	Table 2-11 of GHD 2016
15. Gas release event trees	Figure 4-1 of GHD 2016

The Leewood CPF consequence modelling scenarios listed in Table 2-9 of GHD 2016a have been used to provide the pressure, temperature and hole sizes. The models and segments used in the QRA are described in Section 2.2 below.

2.2 Risk modelling assumptions

The following SAFETI (Phast Risk) parameter sets are used as an input to calculate the risk contours in the QRA.

2.2.1 Segment modelling

Segments modelled are shown in Table 2 below.

Table 2 Segments modelled for Leewood CPF

Segment (Note 1)	Pressure (kPag)	Size / length (note 1)
Plant inlet to MP compressors	2,000	Refer Table 5
4 x vertical MP first stage inlet scrubbers	2,000	1,000 mm dia x 2,000 mm length
4 x vertical MP second stage inlet scrubbers	4,000	1,000 mm dia x 2,000 mm length
4 x MP compressors (two stage) (Note 2)	Stage 1; 4,000 Stage 2: 6,500	Each 50 Tj/d Refer Table 5
4 x MP lube oil filters	6,500	1000 mm dia x 3,000 mm length
MP compressors discharge header	6,500	Refer Table 5
4 x Amine membrane units	6,500	1000 mm dia x 8,000 mm length
4 x vertical HP first stage inlet scrubbers	6,500	1,000 mm dia x 2,000 mm length
4 x vertical HP second stage inlet scrubbers	10,000	1,000 mm dia x 2,000 mm length
4 x HP compressors (two stage) (Note 2)	Stage 1; 10,000 Stage 2: 15,000	Each 50 Tj/d Refer Table 5
4 x vertical HP lube oil filters	15,000	1000 mm dia x 3,000 mm length
4 x TEG dehydration units	15,000	1000 mm dia x 8,000 mm length

Segment (Note 1)	Pressure (kPag)	Size / length (note 1)
2 x vertical glycol filters	15,000	700 mm dia x 3,000 mm length
Plant discharge header	15,000	Refer Table 5
Fuel gas to MP compressors and HP compressors	1,000	Refer Table 5
Fuel gas header to 10 (active) x gas turbine engines (note two are in built redundancy in Figure 1)	1,000	Refer Table 5
Pig receiver (Notes 3 and 4)	2,000	16 m

Notes:

1. Vessel volumes estimated from a QRA performed by GHD for a similar facility (refer Section 2.2.7).
2. Two stages have been assumed for compressors.
3. The MP trunkline pig receiver length is estimated from scaling of the Leewood CPF schematic (Figure 1).
4. The metering station in the Leewood CPF is included in the parts count (Table 5).

The segments are shown in the Leewood CPF Schematic in Figure 1 below.

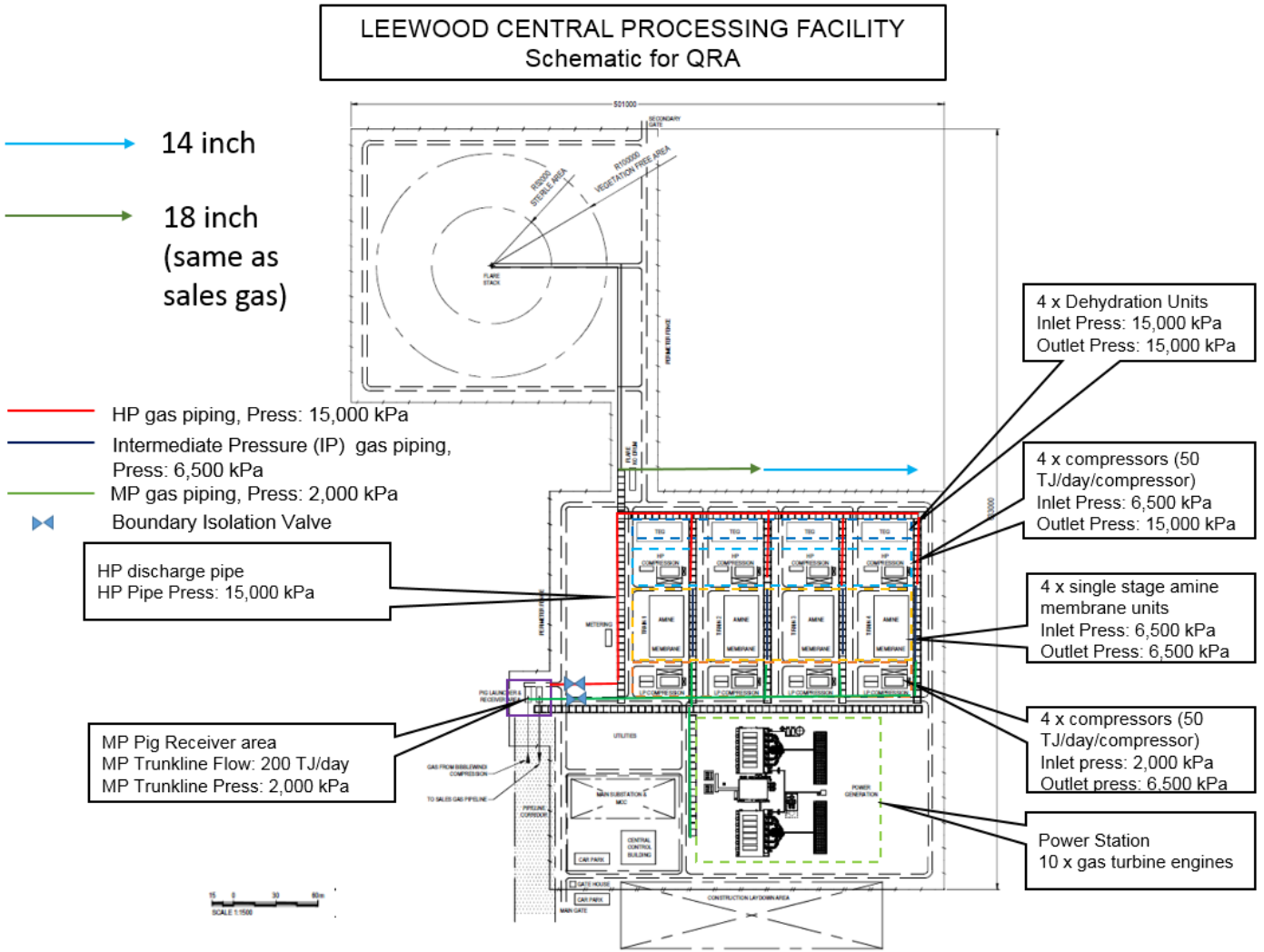

Figure 1 Leewood CPF Schematic for QRA

2.2.2 Leak detection, isolation and depressurising

It is assumed that gas is detected by instrumentation including gas detectors and isolation occurs within 60 seconds of the release initiating. Therefore, the inventory available for release is based on 60 seconds flow from the release point (hole size and process conditions dependent) and the volume of gas within the section between the two isolation points. The assumption of 60 seconds flow of gas is based on industry experience in selecting a conservative value, and may be further examined during final design.

2.2.3 Location of isolation valves for automatic isolation

It is assumed that automatic isolation valves exist on Leewood CPF inlet piping and discharge piping. Isolation of the gas in the Leewood CPF will occur within 60 seconds. This assumption is also based on industry experience.

2.2.4 Leewood CPF release height and orientation

Releases from plant equipment are modelled in the directions outlined in Table 3 at a height of 1 m from ground.

Table 3 Release orientation and distribution

Release direction	Plant / above ground pipelines
Vertical upwards	17%
Horizontal (free jet)	33%
Horizontal (impinging)	33%
Downward impinging on the ground	17%

One sixth of releases are modelled as vertical, and one sixth as downward impinging with the remainder modelled as horizontal releases. The split between horizontal (one third), and horizontal impinged releases (one third) for the plant is to account for the possibility of impingement on other plant and equipment.

Impingement is modelled at 25% of original jet velocity (this is the default in SAFETI).

2.2.5 Release rates

In the event of loss of containment, the rate of release is dependent on a number of factors including the hole size, gas pressure and release location.

The release rates are assumed to be time varying over 20 seconds. This assumption is based on industry experience.

2.2.6 Release frequencies

Release frequencies per annum for above ground piping and equipment are from UK HSE data from 2004 to 2016 (United Kingdom Health and Safety Executive 2017) was used. The base leak frequency data is provided in Table 4.

Table 4 Base leak frequency data used for QRA modelling

Equipment Type	Leak Size Category (Leak Frequencies)						
	≤5 mm	5-10 mm	10-25 mm	25-50 mm	50-75 mm	75-100 mm	>100 mm
COMPRESSORS / CENTRIFUGAL	7.92E-03	1.09E-03	8.20E-04	0.00E+00	0.00E+00	0.00E+00	2.73E-04
COMPRESSORS / RECIPROCATING	2.71E-02	4.34E-03	1.08E-03	1.08E-03	1.08E-03	0.00E+00	0.00E+00

Equipment Type	Leak Size Category (Leak Frequencies)						
DEGASSERS	0.00E+00	0.00E+00	7.84E-04	0.00E+00	0.00E+00	0.00E+00	7.84E-04
DIVERTERS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
DRAIN OPENING	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
DRAIN PLUG	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EXPANDERS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FILTERS	2.62E-03	1.01E-04	2.02E-04	0.00E+00	1.01E-04	1.01E-04	1.01E-04
FIN FAN COOLERS	4.24E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FLANGES / 3" < D < = 11"	2.34E-05	2.20E-06	8.82E-07	0.00E+00	0.00E+00	4.41E-07	8.82E-07
FLANGES / D < = 3"	1.24E-05	1.41E-06	2.34E-07	7.03E-07	0.00E+00	0.00E+00	0.00E+00
FLANGES / D > 11"	2.79E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.53E-06
HEAT EXCHANGERS / HC IN SHELL	2.95E-03	0.00E+00	0.00E+00	2.69E-04	0.00E+00	0.00E+00	0.00E+00
HEAT EXCHANGERS / HC IN TUBE	1.06E-03	0.00E+00	1.52E-04	0.00E+00	0.00E+00	0.00E+00	1.52E-04
HEAT EXCHANGERS / PLATE	3.95E-03	5.64E-04	5.64E-04	2.82E-04	0.00E+00	0.00E+00	0.00E+00
INSTRUMENTS	3.00E-04	5.44E-05	2.78E-05	1.21E-06	1.21E-06	0.00E+00	2.42E-06
PIG LAUNCHERS / 12" < D < = 16"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIG LAUNCHERS / 8" < D < = 12"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIG LAUNCHERS / D < = 8"	7.45E-02	0.00E+00	4.65E-03	0.00E+00	0.00E+00	0.00E+00	4.65E-03
PIG LAUNCHERS / D > 16"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIG RECEIVERS / 12" < D < = 16"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIG RECEIVERS / 8" < D < = 12"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIG RECEIVERS / D < = 8"	1.44E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-03
PIG RECEIVERS / D > 16"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPELINES / FLEXIBLE / D> 16"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPELINES / FLEXIBLE / 12" < D < = 16"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPELINES / FLEXIBLE / 4" < D < = 8"	3.75E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.75E-06
PIPELINES / FLEXIBLE / 8" < D < = 12"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPELINES / FLEXIBLE / D < = 4"	8.75E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPELINES / STEEL / 12" < D < = 16"	0.00E+00	0.00E+00	2.13E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPELINES / STEEL / 4" < D < = 8"	3.52E-06	0.00E+00	5.86E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPELINES / STEEL / 8" < D < = 12"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPELINES / STEEL / D < = 4"	9.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPELINES / STEEL / D > 16"	8.14E-07	0.00E+00	2.44E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPING / FLEXIBLE / 3" < D < = 11"	5.23E-05	6.97E-05	3.48E-05	0.00E+00	0.00E+00	0.00E+00	1.74E-05
PIPING / FLEXIBLE / D < = 3"	2.27E-03	4.69E-04	8.59E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PIPING / FLEXIBLE / D > 11"	1.01E-04	0.00E+00	0.00E+00	5.05E-05	0.00E+00	0.00E+00	0.00E+00
PIPING / STEEL / 3"(DN 75) < D < = 11"(DN 280)	2.67E-05	5.15E-06	2.25E-06	6.44E-07	0.00E+00	0.00E+00	3.54E-06
PIPING / STEEL / D < = 3" (DN 75)	1.09E-04	9.31E-06	1.10E-05	2.19E-06	1.10E-06	5.48E-07	1.10E-06

Equipment Type	Leak Size Category (Leak Frequencies)						
PIPING / STEEL / D > 11" (DN 280)	2.55E-05	6.12E-06	6.12E-06	0.00E+00	0.00E+00	0.00E+00	3.06E-06
PRESSURE VESSEL / HORIZONTAL / ADSORBER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PRESSURE VESSEL / HORIZONTAL / K.O. DRUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.14E-03
PRESSURE VESSEL / HORIZONTAL / OTHER ()	2.43E-03	1.62E-03	8.10E-04	0.00E+00	0.00E+00	0.00E+00	1.62E-03
PRESSURE VESSEL / HORIZONTAL / REBOILER	0.00E+00	3.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PRESSURE VESSEL / HORIZONTAL / SCRUBBER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PRESSURE VESSEL / HORIZONTAL / SEPARATOR	1.64E-04	0.00E+00	6.57E-04	1.64E-04	1.64E-04	0.00E+00	1.64E-04
PRESSURE VESSEL / HORIZONTAL / STABILISER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PRESSURE VESSEL / VERTICAL / ADSORBER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PRESSURE VESSEL / VERTICAL / K.O. DRUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PRESSURE VESSEL / VERTICAL / OTHER ()	2.64E-03	6.59E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.59E-04
PRESSURE VESSEL / VERTICAL / REBOILER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PRESSURE VESSEL / VERTICAL / SCRUBBER	4.75E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-04
PRESSURE VESSEL / VERTICAL / SEPARATOR	2.44E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PRESSURE VESSEL / VERTICAL / STABILISER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PUMPS / CENTRIFUGAL / DOUBLE SEAL	3.84E-03	1.54E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PUMPS / CENTRIFUGAL / SINGLE SEAL	5.50E-03	1.96E-03	5.89E-04	0.00E+00	0.00E+00	0.00E+00	1.96E-04
PUMPS / RECIPROCATING / DOUBLE SEAL	5.41E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-04
PUMPS / RECIPROCATING / SINGLE SEAL	2.82E-03	9.41E-04	1.88E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
STORAGE TANKS	1.00E-03	1.00E-03	2.91E-04	7.27E-05	2.18E-04	7.27E-05	1.60E-05
TURBINES / DUAL FUEL	5.51E-02	6.72E-03	2.69E-03	0.00E+00	0.00E+00	0.00E+00	2.69E-03
TURBINES / GAS	1.84E-02	2.16E-03	2.16E-03	0.00E+00	0.00E+00	0.00E+00	1.08E-03
VALVE ACTUATED / BLOCK / 3" < D < = 11"	3.13E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / BLOCK / D < = 3"	2.33E-04	5.81E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / BLOCK / D > 11"	2.79E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / BLOWDOWN / 3" < D < = 11"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-04	0.00E+00	0.00E+00
VALVE ACTUATED / BLOWDOWN / D < = 3"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / BLOWDOWN / D > 11"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / CHOKE / D > 11"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / CHOKE / 3" < D < = 11"	3.42E-04	5.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / CHOKE / D < = 3"	2.42E-04	8.08E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / CONTROL / 3" < D < = 11"	6.45E-04	0.00E+00	0.00E+00	2.81E-05	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / CONTROL / D < = 3"	1.26E-03	5.73E-05	0.00E+00	0.00E+00	0.00E+00	2.86E-05	0.00E+00
VALVE ACTUATED / CONTROL / D > 11"	1.85E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / ESDV / 3" < D < = 11"	1.86E-04	2.07E-05	2.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Equipment Type	Leak Size Category (Leak Frequencies)						
VALVE ACTUATED / ESDV / D < = 3"	1.91E-04	8.17E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / ESDV / D > 11"	6.92E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / P/L ESDV / 12" < D < = 16"	8.47E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / P/L ESDV / 4" < D < = 8"	1.64E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / P/L ESDV / 8" < D < = 12"	2.12E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / P/L ESDV / D < = 4"	1.79E-03	2.99E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / P/L ESDV / D > 16"	1.41E-03	4.70E-04	0.00E+00	0.00E+00	0.00E+00	4.70E-04	0.00E+00
VALVE ACTUATED / RELIEF / 3" < D < = 11"	2.64E-04	8.79E-05	8.79E-05	0.00E+00	4.40E-05	4.40E-05	4.40E-05
VALVE ACTUATED / RELIEF / D < = 3"	4.81E-04	4.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE ACTUATED / RELIEF / D > 11"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE MANUAL / BLEED	3.07E-05	5.12E-06	5.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE MANUAL / BLOCK / 3" < D < = 11"	6.89E-05	3.13E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.13E-06
VALVE MANUAL / BLOCK / D < = 3"	4.32E-05	7.04E-06	7.04E-06	2.01E-06	1.01E-06	0.00E+00	0.00E+00
VALVE MANUAL / BLOCK / D > 11"	2.84E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE MANUAL / CHECK / 3" < D < = 11"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE MANUAL / CHECK / D < = 3"	8.23E-05	1.65E-05	0.00E+00	0.00E+00	1.65E-05	0.00E+00	0.00E+00
VALVE MANUAL / CHECK / D > 11"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE MANUAL / CHOKE / 3" < D < = 11"	3.82E-04	1.27E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE MANUAL / CHOKE / D < = 3"	4.29E-04	0.00E+00	1.07E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
VALVE MANUAL / CHOKE / D > 11"	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

2.2.7 Parts count

As noted above, the NGP is at an early stage of concept design, and technical and engineering documentation of a nature suitable for a full QRA is not yet available. Therefore, GHD has based the parts count on its experience in undertaking QRA for the design of a similar facility, and modified the equipment and pipe sizes to the Leewood CPF process conditions shown in Figure 1.

The parts count below in Table 5 excludes the main vessels and equipment, which have been listed above in Table 2.

Table 5 Parts count assumptions

Segment	Inlet header	Each LP or HP compressor	LP or HP Compressors discharge header	Each glycol coalescer	Each TEG contactor or amine membrane	Plant discharge header and metering skid	Fuel gas header
Filters	---	---	---	---	---	---	18
Fin Fan Coolers	---	2	---	---	1	---	---
Flanges 75<DN<= 280	111	26	65	19	24	15	229
Flanges DN<=75	70	25	21	11	8	7	181
Instruments	25	10	6	4	5	4	51
Piping / flexible / DN<= 75	---	---	---	---	---	---	18
Piping / steel / DN > 280 (note 3)	380 m	9 m	LP comp. dis. header = 336 m HP comp. dis. header = 176 m	---	---	456 m	---
Piping / steel / 75< DN <= 280 (note 3)	---	---	---	4 m	6 m	---	760 m
Piping / steel / DN<= 75	16 m	8 m	10 m	3 m	3 m	2 m	50 m
Valve actuated / block / 75<DN<= 280	---	---	---	---	---	---	6

Segment	Inlet header	Each LP or HP compressor	LP or HP Compressors discharge header	Each glycol coalescer	Each TEG contactor or amine membrane	Plant discharge header and metering skid	Fuel gas header
Valve actuated / blowdown / 75<DN<= 280	---	1	---	---	---	1	---
Valve actuated / control / 75<DN<= 280	2	---	---	---	1	1	---
Valve actuated / control / DN<= 75	4	1	---	---	---	1	27
Valve actuated /ESDV / 75<DN<= 280	11	---	4	---	---	1	24
Valve actuated /ESDV / DN<= 75	12	---	---	---	---	---	15
Valve actuated /relief / DN<= 75	2	2	---	1	1	1	13
Valve manual / bleed	35	1	6	7	6	2	29
Valve manual /block / 75<DN<= 280	29	---	17	6	5	3	20
Valve manual /block / DN<= 75	12	---	11	4	3	4	29
Valve manual /check / 75<DN<= 280	---	---	---	1	---	1	---
Valve manual /check / DN<= 75	---	1	---	---	---	---	1

Notes:

1. All the Nominal Diameters (DN) are in mm
2. The parts count for the inlet piping starts at the boundary isolation valve (BIV) at the MP trunkline pig receiver in Leewood CPF schematic (Figure 1) and ends at the HP discharge piping BIV.
3. The main piping header lengths are estimated from scaling of the Leewood CPF schematic (Figure 1)

2.2.8 Ignition Sources and probabilities

Ignition sources are assumed to be as follows:

1. Each LP compressor (4 total)
2. Each HP compressor (4 total)
3. Each gas turbine in power station (10 total)
4. Each generator in power station (10 total)
5. One reboiler in each TEG package (4 total).

The probability of ignition is assumed to be 0.5 for each ignition source and operating probability of each equipment is 1.

Unless stated above, all other parameters have used the default setting in Phast Risk 6.7.

3. References

1. GHD (2016a). Narrabri Gas Project – Environmental Impact Statement – Appendix S, Hazard and Risk Assessment.
2. NGP EIS (2016b) Narrabri Gas Project – Environmental Impact Statement Appendix L – Air quality impact assessment
3. NSW Department of Planning (DoP) (2011). *Risk Criteria for Land Use Safety Planning, Hazardous Industry Planning Advisory Paper (HIPAP) No 4.* January 2011.
4. United Kingdom Health and Safety Executive (2017). Hydrocarbon releases system http://www.hse.gov.uk/offshore/statistics.htmX

Level 9 145 Ann Street Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001 Australia

61 7 3316 3000
advisory@ghd.com

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