Appendix T Fire Safety Study

Newcastle Power Station

Fire Safety Study

AGL Energy Limited

2019-09-06

Document control record

Document prepared by:

Aurecon Australasia Pty Ltd

ABN 54 005 139 873

Level 5, 116 Military Road
Neutral Bay NSW 2089

PO Box 538
Neutral Bay NSW 2089
Australia

T +61 2 9465 5599
F +61 2 9465 5598
E sydney@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Report title		Fire Safety Study				
Document code			**Project number**		503269	
File path		Https://aurecongroup.sharepoint.com/sites/503269/5 Deliver Design/Environmental/05. Technical studies/09. Fire Safety Study/NGPS - Fire Safety Study final.docx				
Client		AGL Energy Limited				
Client contact		Andrew Carman	**Client reference**		Newcastle Power Station	
Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Verifier** (if required)	**Approver**
A	2019-05-31	Draft – issued for comment	J Green	M Willard		
B	2019-09-06	Final	J Green	M Willard		M Hicks
Current revision		**B**				

Approval			
Author signature		Approver signature	
Name	Jim Green	Name	Martin Hicks
Title	Fire Safety and Risk Engineer	Title	Associate

Contents

Appendices

Appendix A

Drawings

Appendix B

Fire system calculations

Appendix C

Consequences of Heat Radiation Exposure

Appendix D

Consequences of Overpressure Exposure

Appendix E

Hazard Word Diagram

Appendix F

Statement of intent

Appendix G

Emergency Response Plans

Appendix H

Weather Stability Criteria

Figures

Tables

Executive summary

Aurecon has completed a preliminary Fire Safety Study for AGL Energy Limited (AGL) for a dual fuel power station to be built in Tomago, New South Wales. The study provides a summary of fire safety measures that are recommended to be considered as part of the design development of the power station. Such measures are expected to minimise the consequences of injuries and fatalities, damage to the power station assets and damage to the environment to acceptable levels.

The study is based on:

- A review of the hazards identified in the Preliminary Hazard Analysis and other concept design documents to determine the requirements for fire prevention, detection and protection
- An estimation of the type, capacity and operability of fire and explosion prevention, detection and protection measures (equipment and systems) recommended to be included in the design development.

The FSS emphasises that fire and explosion preventative measures at the power station will have the largest risk reduction impact. The effectiveness and reliability of these measures will have a direct effect on the level of fire and explosion risk.

It has been assumed that AGL would implement a maintenance and safety management system that would ultimately be a key factor in ensuring that the fire and explosion risk would be designed and maintained at acceptable levels.

This Fire Safety Study recommends that the fire prevention, detection and protection measures recommended be reviewed as the design develops and more detailed information comes to hand. The list of standards, codes of practice and regulations referenced by this Fire Safety Study would be used to provide the performance criteria for firefighting plant, equipment and systems in a design basis.

An effective fire safety training programme including emergency response and preparedness and tactical response planning for both design and escalation / non-design scenarios would be developed by AGL.

Consultation with Fire and Rescue New South Wales is recommended for all aspects of the fire detection and protection systems that would ultimately be included in the final design.

Summary of main conclusions, findings and recommendations

The following decisions can only be finalised once detailed design has been completed:

Fire prevention:

- Spacing of potential fire hazards and the provision of fire barriers as necessary
- Inherent safe design processes to minimise the potential loss of containment and resulting fire scenarios
- Hazard and risk analysis and control to ensure that the likelihood of a fire scenario is reduced
- The type and spacing of hydrocarbon detection systems within the gas processing areas and Gas Yard, which act to isolate flow and likelihood of a fire scenario
- The control and shut-down systems for the gas-fired combustion system.

Fire detection and protection:

- The size, capacity and arrangement for static firewater storage, nominally sized for 679 m^3 at this stage in the design development
- The type and duty points of firewater pumps, nominally one 100% diesel and a 100% electric pump for redundancy at this stage in the design development

- The size and routing of the hydrant ring main, including hydrant landing valves and isolation valves and a jockey pump for maintenance of ring main pressure – if required.
- The size, capacity and number of mobile monitors
- The type and size of sprinkler systems to be installed in the gas yard and power plant
- Delineation of the processing and power generating areas into fire compartments
- The use of fireproofing and firewalls
- Provision of portable fire extinguishers for minor first aid or initial response for small fire scenarios
- Smoke detection systems installed around the facility
- VESDA / FM200 suppression systems installed in cabinets and switch rooms
- Emergency response planning
- Maintenance and inspection including periodic performance testing regime.

Abbreviations

Abbreviation	Description
AGL Energy Limited	AGL
Australian Standard/New Zealand Standard	AS/NZS
Combustion Turbine	CT
Compressed Air Foam System	CAFS
Cross-Linked Polyethylene	XPLE
Dangerous Goods Classification	DGC
Drum Storage Area	DSA
Early Warning and Indication System	EWIS
Environmental Impact Statement	EIS
Fire and Rescue NSW	FRNSW
Fire Control Centre	FCC
Fire Indicator Panel	FIP
Fire Resistance Level	FRL
Fire Safety Study	FSS
Global Asset Protection Services	GAPS
Internal Combustion Engine	ICE
Intrinsically Safe	IS
Jemena Gas Network	JGN
Layer of Protection Analysis	LOPA
Liquified natural gas	LNG
Low Voltage	LV
Lower Flammability (Explosion) Limit	LEL
Medium Voltage	MV
Motor Control Centre	MCC
National Construction Code	NCC
New South Wales	NSW
Newcastle Gas Storage Facility	NGSF
Newcastle Power Station	NPS
Polyvinyl Chloride	PVC
Preliminary Hazard Analysis	PHA
Remote Terminal Unit	RTU
State Environmental Planning Policy	SEPP
Supervisory Control and Data Acquisition	SCADA
Ultraviolet / Infrared	UV/IR
Uninterruptible Power Supply	UPS
Upper Flammability (Explosion) Limit	UEL
Vapour Cloud Explosion	VCE

1 Scope of Report

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 Government Project Approval Process for such a major development requires that a Fire Safety Study (FSS) be carried out, based on the guidelines detailed in Hazardous Industry Planning Paper No. 2[1]. The FSS includes information and analysis prepared as part of the Preliminary Hazard Analysis (PHA), and the methodology and scope of the report is presented in Figure 1.

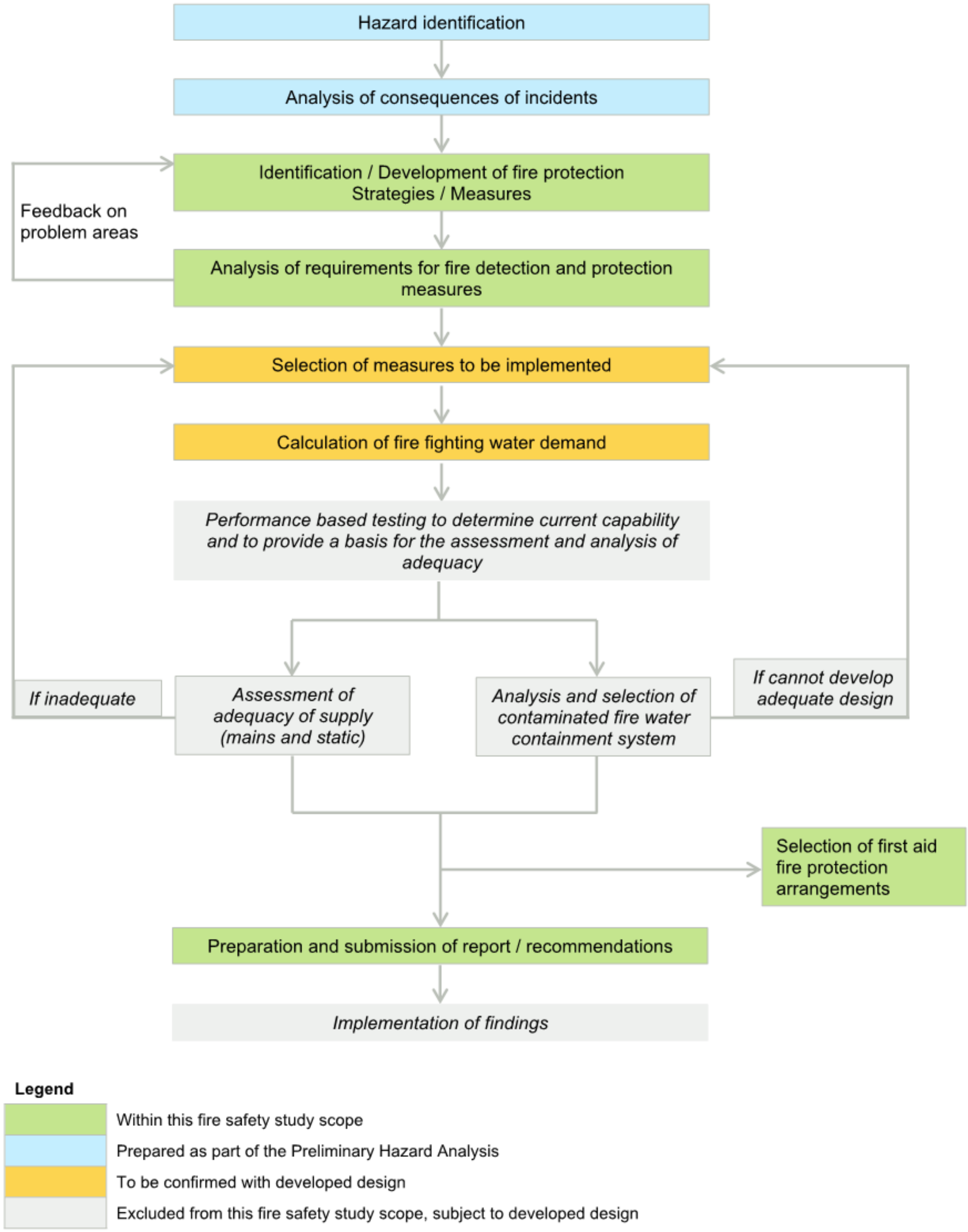

Figure 1 Fire Safety Study scope and methodology

[1] NSW Department of Planning & Environment, Hazardous Industry Planning Advisory Paper No 2 - *Fire Safety Study Guidelines* (2011)

The preliminary FSS recognises that there are two components to a fire system:

- The physical or hardware components such as hydrocarbon detectors, smoke detectors, alarms, fire suppression water and foam systems sprinklers, first aid fire mitigation systems, and
- Operational arrangements and software: maintenance, testing, training and emergency response and planning.

The preliminary FSS prepared is based on hazards identified in a Preliminary Hazard Analysis and a preliminary assessment of the consequence effects of potential fires and explosions associated with such hazards..

The preliminary FSS will identify firefighting systems, plant and equipment that will reduce the risk of a fire or/and explosion to acceptable levels at the new facility. Performance testing of fire prevention and protection plant and equipment is only required for a FSS of an existing facility, to determine whether existing systems are sufficiently effective and reliable.

An FSS generally requires evaluation of an existing fire safety management system, emergency response plans and pre-fire plans. As this is a new facility, it is expected that such a safety management system, emergency response plans and pre-fire plans will only be developed when the facility becomes operational.

The key outcome from this preliminary FSS is to define the minimum performance requirements envisaged for fire and explosion preventative and protective systems and equipment. These requirements will be based on relevant and applicable standards, codes of practice and regulations.

The level of detail prepared for this preliminary FSS is based on a preliminary conceptual design. Plant and equipment have not been sized and only basic layout sketches have been provided. it is recommended that this FSS be revised and amended once detail design has been completed and layouts have been decided.

Fire prevention methods in the overall system are emphasised.

This FSS is a preliminary document only, based on the concept design development of the Proposal. Once the design develops, the FSS would be revised and specific details included in the design development of the Proposal. This FSS would, therefore, be used for information only.

1.1 References

The following referenced documents have been used in the development of this preliminary FSS:

- Preliminary Hazard Analysis: AGL dual fuel Power Station Project, Tomago NSW
- Newcastle Power Station AS 2885 Pipeline SMS Report

1.2 Standards, Codes of Practice & Technical References

Standards, Codes of Practice and technical references used in the development of this preliminary FSS:

- NSW Department of Planning & Environment, Hazardous Industry Planning Advisory Paper No 2 - Fire Safety Study Guidelines (2011)
- AS 1940 The storage and handling of flammable and combustible liquids
- AS 2067 Substations and high voltage installations exceeding 1 kV a.c.
- AS 5577 Electricity network safety management systems and others
- SAA HB37.1 Handbook of Australian Fire Standards Part 1 Fire –General
- CIGRE 537 WG A2.33 Guide for Transformer Fire Safety Practices
- CIGRE A2_101 The Risk of transformer fires and strategies which can be applied to reduce the risk

- IEC 60076-1 Power transformers – Part 1 General
- IEC 60137 Bushings for alternating voltages above 1000 V
- NFPA 70 National Electrical Code Article 450
- NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
- IEEE 97 and 9 Guide of Substation fire protection
- IEEE 980 INT 1-3 Guide for Containment and Control of Oil Spills in Substations
- FM Global Property Loss Prevention Data sheet 5-4 Transformers
- National Construction Code

1.3 FRNSW documents

The following documents developed by Fire and Rescue NSW (FRNSW) have been used in the development of this preliminary FSS:

- FRNSW Fire Safety Guidelines - Emergency services information package and tactical fire plans
- FRNSW Fire Safety Guidelines - Emergency vehicle access
- FRNSW Technical information sheets - Fire brigade booster connection with inlet insert
- FRNSW Technical information sheets - Compatible Storz hose connections
- FRNSW Guide sheet 1: Features of AS 2419.1 Booster Assembly
- FRNSW Guide sheet 2: Location of AS 2419.1 Booster Assembly
- FRNSW Guide sheet 3: Pump performance of FRNSW appliances
- FRNSW Guide sheet 5: Hardstand areas for FRNSW appliances

2 Description of the Facility

This section presents a description of the facility associated with the Proposal. Further information is available within the Environmental Impact Statement (EIS), PHA and other referenced documents supporting the development of the Proposal.

2.1 Newcastle Power Station

The proposed Newcastle Power Station (NPS) site is located at 1940 Pacific Highway, Tomago, NSW (Lot 3 DP1043561). Ancillary infrastructure would be gas pipelines and transmission line. The proposed site is about five kilometres south west of Raymond Terrace and about two kilometres north east of Hexham. Hexham is a suburb of the city of Newcastle approximately 15 kilometres inland from the Newcastle Central Business District. The site is owned by AGL and is zoned as an industrial area. Road access would be via new road access that would extend from Old Punt Road.

The proposed site is shown in Figure 2. The figure gives a preliminary layout and sketched gas yard, diesel storage, buildings, switchyard, generators, pondage and construction lay down areas.

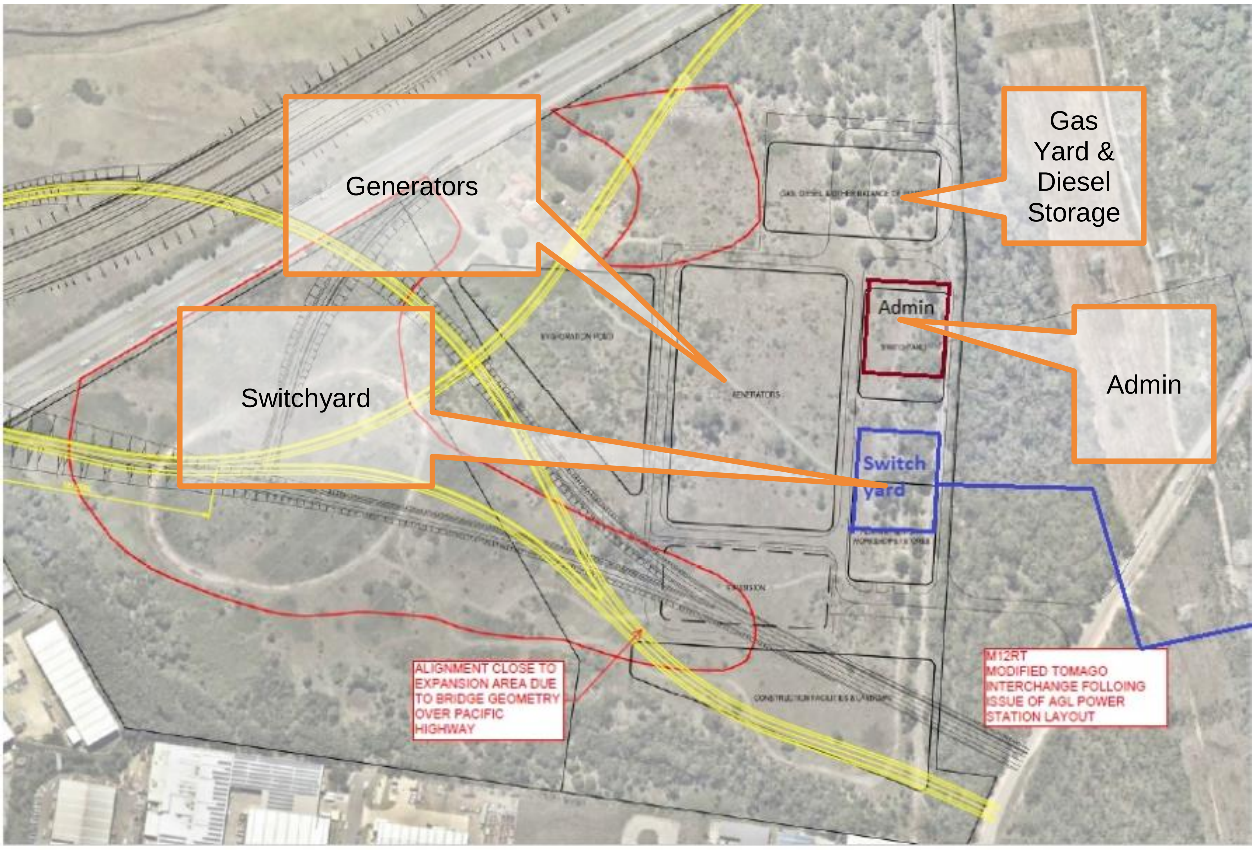

Figure 2 Proposed Site

2.2 Newcastle Gas Storage Facility

The Newcastle Gas Storage Facility (NGSF) is an existing facility that is utilised to liquify and store natural gas supplied from the Jemena network. Gas is withdrawn from and injected into the Jemena network at Hexham via a connecting high pressure DN 400 gas pipeline.

2.3 Tie-in Pipeline

The primary source of natural gas would be via a connection to the Hexham to NGSF DN 400 pipeline. This connection pipeline would run underground for approximately 430m from the tie-in point to the NPS site. The pipeline would rise above ground prior to arriving at the NPS.

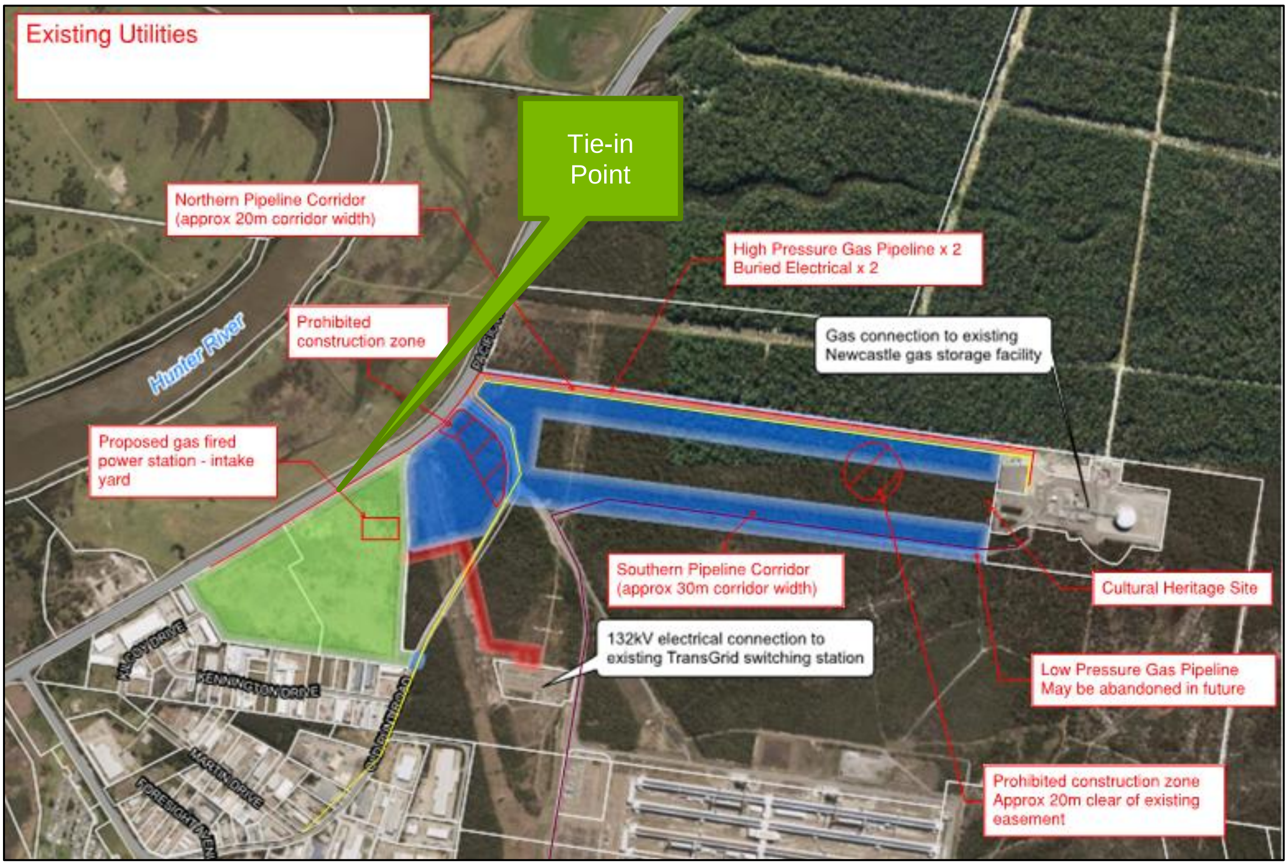

Figure 3 Gas Pipelines & Tie-in Point

A fuel gas ‘storage pipeline’ has been included in the design of the NPS as a gas supply option. 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 MPa(g).

2.4 Surrounding land use

The proposed facility is located at a distance of more than two kilometres from the closest residential zoned area. A house exists in the north-west corner of the site. It is proposed to demolish this during construction, unless the house can be utilised for other purposes. Most of the surrounding land is zoned as industrial land.

Major infrastructure in the surrounding area comprises:

- The Newcastle Gas Storage Facility
- Tomago to Hexham Pipeline
- TransGrid Tomago switching station
- Tomago Aluminium Smelter
- Pacific Highway

2.5 Sensitive receptors

There are no sensitive receptors identified near the NPS site.

2.6 Meteorological and topographical considerations

The weather trends for the Newcastle region have been summarised in Table 1. The predominant predicted wind condition and humidity levels are taken from the closest Bureau of Meteorology (BOM) weather station to the site, which is the University of Newcastle. This weather station is located 8.5 km to the south of the facility and has been operating since 1998.

Table 1 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°C
Mean Minimum Daily temperature (1998-2019)	13.6°C
Mean 9am Temperature (1998-2010)	17.9°C
Mean 3pm Temperature (1998-2010)	22.1°C
Mean 9am relative humidity (1998-2010)	73%
Mean 3pm relative humidity (1998-2010)	56%
Mean 9am wind (1998-2010)	6.3 km/hr (1.75 m/s)
Mean 3pm wind speed (1998-2010)	12.9 km/hr (3.6 m/s)

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

2.7 Operations and staff

The NPS would supply electricity to the grid at short notice during periods of high electricity demand, and/or low supply

3 Process description

3.1 Power Station

3.1.1 Reciprocating Gas Engines - proposal

The following is proposed for the option of using reciprocating engines.

- The engines will be installed in a large engine hall based on modular configuration along with the auxiliary systems and equipment.
- The following equipment will be installed with each of the reciprocating engine generators sets:
  - Dual fuel fired reciprocating engine genset complete with generator on base frame
  - Intake air and exhaust gas module
  - Lubrication oil system
  - Engine auxiliary module
  - Engine cooling system
  - Exhaust gas stack
  - Emission control system
  - Fuel gas regulating system
  - Liquid fuel (diesel) supply system (local connection to units)
  - Starting system
- The reciprocating engine plants will be pre-assembled and pre-engineered modules - connected on site.
- The engines would be housed within an engine hall and include the intake air and exhaust gas module, starting system, and engine auxiliary module. The engine hall would include a ventilation system, maintenance laydown areas and means of access and egress to the equipment.
- The engine hall would be fitted with an overhead travelling crane for maintenance on the engines and associated equipment.
- Exhaust gas from the exhaust gas module would be ducted outside of the engine hall and through the exhaust gas stack to atmosphere.
- Engine cooling radiators would be included to cool the jacket water circulating through the engine block which in turn cools the lubricating oil, and charge air.
- Separate to the engine modules - the required balance of plant to be included, would be the fuel supply, compressed air supply system, lube oil tanks, forwarding pump units and water utilities.

3.1.1.1 Fuel - Natural Gas

The reciprocating engines would be fired with natural gas – the gas reticulation system feeding the engines will include the following equipment:

- Distribution manifold from supply terminal point and associated pipework and valving to each of the individual reciprocating engine's gas regulating skid
- Final filtering and pressure control (as required)
- Fuel gas flow meter on each unit line (for performance testing and on-line performance monitoring)
- Instrumentation and control integration with the plant control system

- The fuel gas system downstream of the terminal point is proposed to be designed to provide gas at a pressure and temperature as required by the genset's individual fuel system (typically <1MPa)
- Underground pipework is proposed to supply gas from the fuel gas conditioning system and also to each of the generating sets inside the engine hall.

3.1.1.2 Fuel - Diesel

The liquid fuel (diesel) system would nominally include the following equipment:

- Tanker unloading bays (two), suitable for B double tankers, with provisions for spill management and unloading pump facilities
- Liquid fuel storage tanks (2 x 50%) providing a nominal capacity of 1.5 ML
- Secondary containment for the liquid fuel storage tanks
- Forwarding pumps (2 x 100%)
- Filtering
- Metering
- Heating (as required)
- Supply and distribution pipework to units (including tank return), valving, and instrumentation.

3.1.1.3 Cooling systems

Each reciprocating engine generating would be provided with an auxiliary cooling system that would reject heat from the engine jacket water, cylinder heads, turbochargers; and cool the engine lubricating oil and charge air. The same cooling system would provide cooling of the direct engine auxiliaries including the generator cooler.

The cooling systems to be provided would typically consist of a cooling radiator, low temperature expansion tank, and associated pipework, pumps, valves and instrumentation.

3.1.1.4 Lubricating oil storage tanks

Lubricating oil would be circulated around each engine through each engine's auxiliary unit. The auxiliary unit forms part of the engines auxiliaries which would complete cooling and filtration of the lubrication oil.

Lubricating oil would be delivered to site via tanker and stored on site in dedicated lube oil storage tank(s).

Waste oil is would be pumped out to a waste oil tank and disposed offsite.

3.1.2 Gas Turbines - proposal

Gas turbine engines burn fuel in a combustion chamber and utilise the high velocity, pressurised combustion gases to drive the turbine and generate power. A secondary turbine is typically mounted on the same shaft as the generating turbine. This secondary turbine, the air turbine (compressor) draws in air, compresses it and feeds it into the combustion chamber, thereby increasing the intensity of combustion.

As the gas turbine speeds up, it causes the compressor to speed up forcing more air through the combustion chamber which in turn increases the rate of combustion, increasing the flowrate of high pressure hot gas into the turbine, increasing the turbine speed. Controls on the fuel supply line limit the amount of fuel fed to the turbine, thus controlling the speed.

Each gas turbine would include, but not be limited to, the following equipment:

- Air intake system including silencing and filtration
- Offline compressor cleaning system
- Dual fuel combustion system and associated local supply connections

- Acoustic enclosure
- Inlet air cooling for power augmentation (including wet compression) for power augmentation (based on manufacturer offered arrangement)
- Dry Low NO_x or Wet Low NO_x combustion system based on manufacturer offering for dual fuel unit
- Fire and gas detection and protection system
- Lubricating and control oil systems
- Exhaust stack and silencer
- Starting system
- Auxiliary systems

3.2 Gas supply

3.2.1 Hexham to NGSF Pipeline

The natural gas would be primarily sourced from the NGSF to Hexham DN 400 pipeline. The take-off line from the Hexham to NGSF pipeline would be routed underground for approximately 430 m from the tie-in point to the NPS site. The NPS tie-in connection line would be located above ground prior to entering the NPS. Gas from the pipeline would be odourised.

Refer to Appendix A for the proposed flow diagram and Figure 4, which depicts the proposed site layout plan and tie in connection.

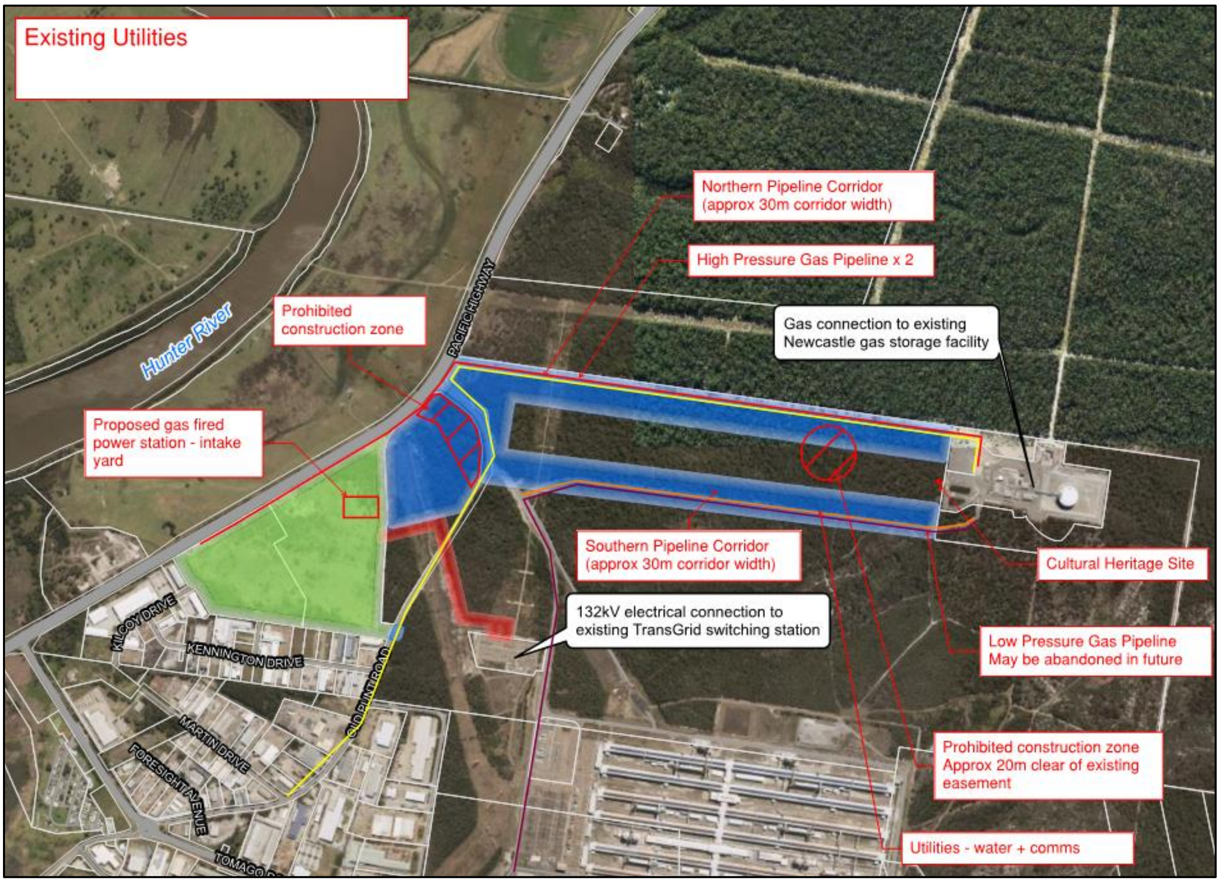

Figure 4 Storage Pipelines in Northern Corridor

3.2.2 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 is expected to be odourised.

3.2.3 Fuel Gas 'Storage Pipeline'

A fuel gas storage pipeline' has been included in the design of the facility as a gas supply option. Gas would be obtained from the JGN during periods of low gas demand, compressed and stored in the pipeline This gas would be supplied during periods of high power demand.

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

This option considers two independent pipelines (twin pipelines) from NGSF to the new Newcastle Power Station with a combined length of approximately 4.6 km. The pipelines would be located within the existing easement in the northern corridor. Boring pits have been nominated at the north west corner of the corridor and the option of either tunnelling or HDD (horizontal directional drilling) of the pipelines to cross this portion of the route have been considered.

The gas storage pipeline is intended to be buried at a depth of approximately 0.75 m, with a total construction corridor width of 25 m to the Northern corridor easement as shown in Figure 4.

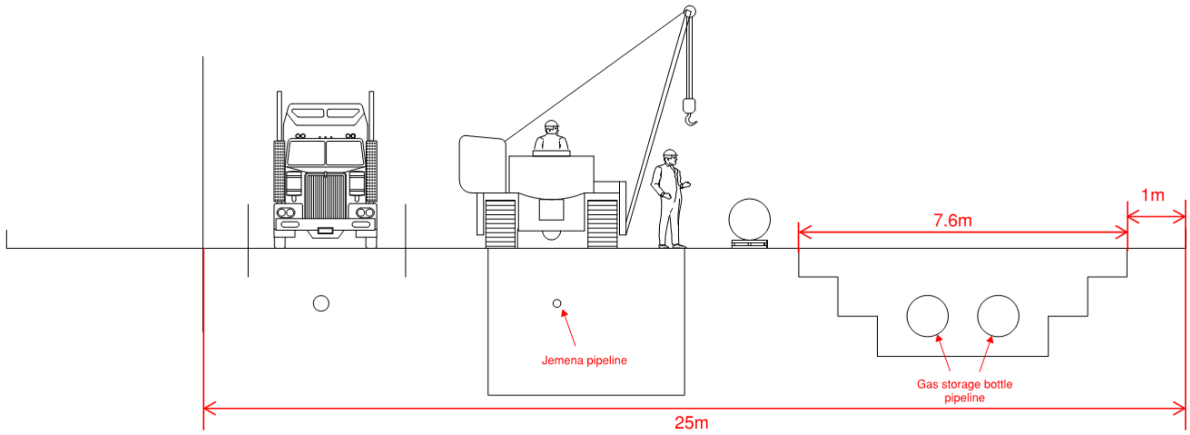

Figure 5 Storage Pipeline Northern Corridor Easement

3.2.4 NGSF Liquified Natural Gas

Using the liquified natural gas (LNG) stored at the NGSF has also been considered as a source of gas supply. The LNG may be withdrawn and transferred using the proposed 'Storage Pipeline' or transferred directly via the Hexham to NGSF bi-directional pipeline. .

3.2.5 Fuel Gas metering skid

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

3.2.6 Fuel Gas compression system

Fuel gas compression if required would occur downstream of the fuel gas metering skid. Reciprocating compressor units wouldbe designed to increase the fuel gas pressure from the minimum pipeline supply pressure to the required turbine supply pressure (5 to 6 MPa and storage pipeline pressure (approximately 15 MPa).

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

3.2.7 Diesel Storage

Thirty (30) B double tanker deliveries are expected to be required for every 24 hours of continuous operation of the power station on diesel, to refill 1.5 ML of diesel storage capacity. (Note: B double tanker volume is around 50 m^3). Two 750 m^3 diesel storage tanks are proposed to be constructed. The location of the storage tanks is yet to be determined however they are expected to be installed in the additional space outside the gas yard.

3.2.8 Gas Conditioning Skid

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

3.2.9 Gas Yard layout

The Gas Yard would require a nominal 70 m x 40 m footprint. Figure 6 presents a concept model of a layout option that could be considered for the gas conditioning system.

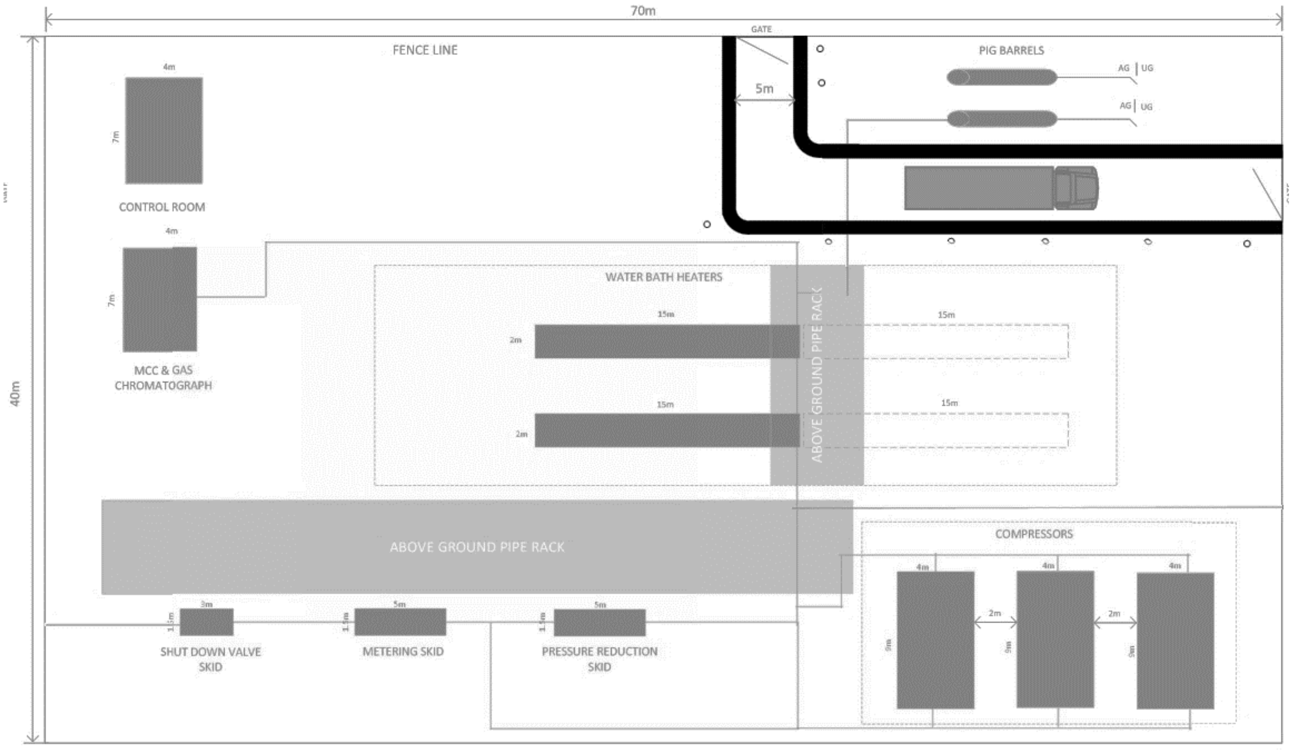

Figure 6 Gas Yard Layout

3.3 Electrical plant and systems

The following electrical generating plant and systems are proposed.

3.3.1 Generators

Gas turbine generators proposed wouldbe 2-pole 3,000 rpm machines with a cylindrical rotor. It is expected that the terminal voltages for the generators will be in the range of 10.5 kV to 18 kV.

3.3.2 Air Coolers

Generators wouldbe air-cooled.

3.3.3 Generator circuit breaker and connection equipment

A generator circuit breaker for each generator is proposed to be specified.

3.3.4 Generator transformer

Transformers are proposed to be located outdoors and designed to ensure temperature rise limits are not exceeded under continuously rated power.

Transformers are proposed to have “oil natural air forced”, “oil directed air forced” or “oil forced air forced” cooling. Transformers are proposed to be capable of continuous operation at the rated power with one cooling element out of service. Transformers are proposed to be designed to ensure they can operate at their continuous rated power under the maximum and minimum defined site ambient temperature. Transformers are proposed to be located within a bund.

3.3.5 Unit auxiliary transformers

Unit auxiliary transformers are proposed to be provided to step down the generator terminal voltage to the power station medium voltage (MV) and low voltage (LV) distribution voltages.

Auxiliary transformers are proposed to be located outdoors, close to the generator transformer and designed to ensure temperature rise limits are not exceeded under continuously rated power. The auxiliary transformer is proposed to be separated from the generator transformer by a blast wall, within a bunded area.

These transformers are proposed to have oil natural/air natural cooling and designed to ensure that they are able to operate at the continuous rated power under the maximum and minimum defined site ambient temperature.

3.3.6 Generator and MV switchgear

Generator voltage switchgear and MV switchgear are proposed to be housed indoor and be fully withdrawable modular vacuum or SF6 type units. The switchgear housing is proposed to be pressurised and dust-free.

The minimum fault level rating of the Generator and MV switchgear will need to be selected based on current and forecast fault levels. It is proposed to be arc proof certified, and the equipment selected is proposed to be fully type-tested at an approved testing station in accordance with relevant standards.

3.3.7 LV switchboards

LV Switchboards are proposed to contain:

- Over-current and other protective devices
- Buses
- Instruments.

The switchboards are proposed to distribute power to transformers, panel boards, control equipment, and to individual system loads.

LV switchboards and motor control centres (MCC) installed are proposed to conform to relevant standards. Arc fault containment is proposed to be considered as a safety measure.

3.3.8 Emergency diesel generator

For the generators, loss of the network connection coinciding with a unit trip would mean the loss of normal auxiliary power supply. In this case an emergency diesel generator provided must start to enable the safe shutdown of the unit. This is proposed to also enable an immediate restart of the NPS when the auxiliary supply from the network is restored. Two emergency 500 kVA diesel generators are proposed to be provided for the power station, each capable of providing the needs of the entire station.

3.3.9 Uninterruptable power supply system

A single uninterruptible power supplies (UPS) system is proposed to supply AC loads such as control system hardware and emergency equipment loads. Several small UPS systems may be provided rather than a single large UPS, subject to design development.

3.3.10 Battery and charger system

DC systems are proposed to provide auxiliary power to protection systems, MV auxiliary boards and other critical equipment. Two identical and separated battery X and Y sub-systems are proposed to be installed.

Batteries may also be required to supply emergency drives such as the turbine emergency lube oil pumps.

For safety reasons, batteries and battery chargers are proposed to be located in a separate battery room.

3.3.11 Electric motors

AC motors of the squirrel cage induction type are proposed to be installed for auxiliary drives.

3.3.12 Protection systems

All electrical plant and equipment is proposed to be provided with suitable electrical protection systems, in accordance with the National Electricity Rules (where applicable), relevant international standards, applicable legislation and safe engineering practice. Primary protection is proposed to be backed up by a secondary protection scheme.

3.3.13 Cabling

Cross-linked Polyethylene (XLPE) insulated cables is proposed to be provided for MV power cables, and either XLPE or polyvinyl chloride (PVC) for LV power cables.

Copper or aluminium conductors is proposed to be provided for all cabling.

3.3.14 Electrical Safety Design

Electrical fire and explosion safety issues to be addressed in the design is expected to include the following:

- Earthing including soil resistivity
- Lightning protection
- Arc flash
- Hazardous areas.

3.3.14.1 System methods of earthing

The following neutral earthing methods are proposed:

- Generator neutral - high impedance via a neutral earthing transformer with its secondary loaded by a neutral earthing resistor is preferred. This system is proposed to be designed to limit earth fault currents for a single phase to earth fault in the range of 5 A to 15 A
- Generator transformer; solidly earthed on transformer neutral high voltage side
- MV auxiliaries; low resistance. Value to be determined following fault level studies
- LV auxiliaries; solidly earthed
- DC System; ungrounded with a ground fault detection system, and both positive and negative polarities protected by circuit-breakers suitably sized for the DC loads.

3.3.14.2 Earthing and lightning protection

An earthing system consisting of a buried copper earth grid is proposed to be installed around the NPS foundations and bonded to the steel columns of any buildings.

A low overall earth grid resistance for the site is proposed to be specified. This is expected to limit the potential for dangerous voltages to appear within the NPS, should a significant earth fault occur.

A separate lightning protection study is expected to be required, to effectively protect equipment from lightning strikes. Lightning poles are typically required around outdoor electrical equipment, and on tall structures if not constructed of metal. The actual number and location wouldbe determined as the design develops. The station earth grid is expected to be used to dissipate the effects of lightning strikes.

3.3.14.3 Hazardous areas

A general hazardous area study is expected to be conducted once major plant items have been selected, to determine whether intrinsically safe (IS) barrier and isolator enclosures are required.

4 Hazards Identified

This section presents a qualitative assessment of hazardous materials to be stored, handled or processed at the site based on the conceptual level of design development.

The hazards and potential consequences for various areas are given in the Hazard Word Diagram.

4.1 Potentially hazardous materials

The list of all significant chemicals being handled, stored or processed at the facility are listed in Table 5. These chemical substances are subject to State Environmental Planning Policy No. 33 – Hazardous and Offensive Development (SEPP 33).

Table 2 Hazardous Chemicals

Hazardous Materials	Maximum Quantities / Flow Rates Stored / Processed on Site	Dangerous Goods Class	Chemical Abstract Number	Physical and Chemical Properties	Type of Storage	On-Site Location
Natural Gas	42,600 Std m^3 / hr (Fuel Gas 'Storage Pipeline') + 71,000 Std m^3 / hr (Hexham to NGSF Bidirectional Pipeline)	Class 2.1 Flammable Liquid	8006-14-2	Clear, highly flammable gas which readily forms explosive mixtures in air Odorant in form of tertiary butylmercaptan 30% and tetrahydrothiophene 70% is added to allow detection	Fuel Gas 'Storage Pipeline'	Fuel Gas 'Storage Pipeline'
Diesel Fuel	1,500 m^3	Class C1 Combustible Liquid	68334-30-5	Liquid Density: 830 kg/m3 Boiling and freezing points: Not well defined because they are mixtures. In general, these fuels remain liquid to 30 ºC. Vapour pressure varies between 1 kPa and 10 kPa at 38 ºC. Flash-point > 61.5 C.	Bulk Storage Tanks	Designated Diesel storage area located in the east of the Site

Table 3 NGSF Natural Gas

Components	Name	Composition (mol%)
C1	Methane	93.3
C2	Ethane	6.239
C3	Propane	0.349
iC4	Iso Butane	0.011
nC4	Normal Butane	0.005
iC5	Iso Pentane	0.001
nC5	Normal Pentane	0.001
CO2	Carbon Dioxide	0.006
N2	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

4.1.1 Natural Gas

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

Natural gas is proposed to be transported to Site via the Hexham to NGSF Bi-directional Pipeline (at 71,000 Std m^3/hr) and/or the Fuel Gas 'Storage Pipeline' (at 42,600 Std m^3/hr).

4.1.2 Diesel Fuel

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

Diesel fuel (1.5 ML/day) is expected to be transported by road to the facility. Heavy vehicles of approximately 50 m^3 capacity are expected to be used, equating to approximately thirty movements per day to deliver diesel fuel to site.

4.2 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.

Applying SEPP 33 – Hazardous and Offensive Development Application Guidelines (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 7.

The natural gas transported to site via the Hexham to NGSF Bi-directional Pipeline (at 71,000 Std m^3/hr) is proposed to be by pipeline, rather than a storage vessel, and was assessed as such.

Table 4 Preliminary Screening Assessment

Material	Type	Maximum Quantity at the Facility	Distance to Site Boundary (m)	Distance to Sensitive Receptor (m)	Screening Threshold or minimum separation distance (Other – including Industrial Land Uses) (m)	Screening Threshold or minimum separation distance (Sensitive Receptors) (m)	Notes
Natural Gas	Class 2.1 Flammable Liquid	3.116 tonnes (Note 1)	16.4	2,000	70 (Figure 7)	90 (Figure 7)	Above threshold

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

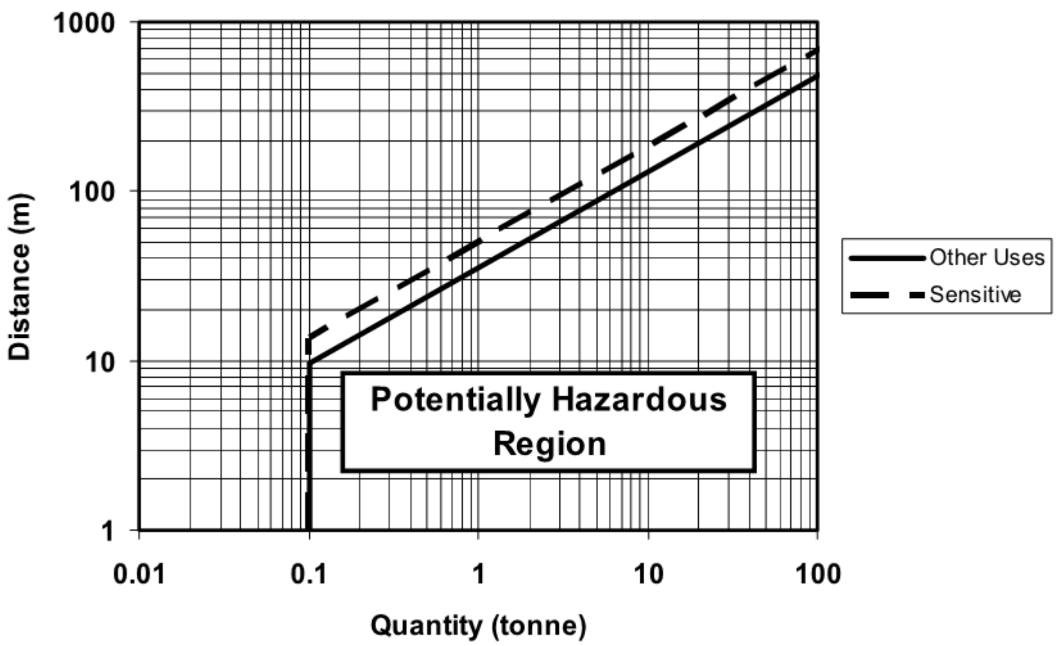

Figure 7 Class 2.1 Flammable Gases Pressurised (Excluding LPG) (NSW Department of Planning, 2011)

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

According to *Applying SEPP 33* (NSW Department of Planning, 2011, Table 1), Figure 7 was utilised for risk screening purposes. Figure 7 indicates that the minimum separation distance for 3.116 tonnes of natural gas is 70 m. The actual separation distance of the natural gas to the site boundary is currently designed to be 16.4 m.

The actual separation distance exceeds the threshold and it was assumed that there is the potential for offsite risk.

4.2.2 Class C1 Combustible Liquid (Diesel)

According to *Applying SEPP 33* (NSW Department of Planning, 2011), if combustible liquids of class C1 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. Diesel is proposed to be stored in liquid fuel storage tanks within a bunded area at the facility. Hence Diesel was not considered to be potentially hazardous.

No class 3PGI, 3PGII or 3PGIII flammable liquids are proposed to be processed or handled at the Facility.

4.3 Transport fire hazards

Natural gas is proposed to be transported to the site via pipeline/s. Diesel is proposed to be transported to site by road. As Diesel was not considered to be potentially hazardous, no transport risk assessment is required.

4.3.1 Natural Gas

The following potential transport risk hazards associated with natural gas have been identified:

- Loss of containment from station pipework and equipment due to corrosion, mechanical damage during construction activities (tiger teeth damage), flange, gasket and fitting leaks, etc
- External events including earthquake, flooding, lightning, bushfire, etc
- Releases due to venting operations
- Loss of containment during pigging operations
- Failure of temperature and pressure control
- Dispersion of natural gas from the stack during venting operations with the potential for ignition.

The following issues specific to the storage pipeline operation were identified:

- Fatigue resulting from the pressure cycling
- The provision for blowdown and venting in the storage pipeline design
- Low temperatures during storage pipeline pressure reduction and blowdown operations
- Inadequate support of the pipeline resulting in increased pipeline stress and reduced pipeline life.

4.4 Storage pipeline fire hazards

4.4.1 Pressure cycling

The operation of the storage pipeline results in a pressure cycling as the gas is compressed over a period of up to 24 hours per day to a pressure of approximately 14.5 MPa and then reduced to a pressure of about 4.5 MPa as the gas is drawn off the storage via the pressure reduction station over a period of 3 hours.

The design life of the storage pipeline facility is approximately 30 years. The expected number of cycling operations is 200 per year totalling 6,000 pressure cycles over the design life. A fatigue assessment is expected to be completed as part of the design development to ensure that the design of the storage pipeline is expected to meet the cycling demand as per the requirements of AS 2885.

Fatigue may result in fracture failureof the pipeline. The potential for fatigue induced fracture failure is expected to be detected from the records of the operating history and maintenance inspections during the lifetime of the storage pipeline. If problems were detected, mitigation measures such as pressure restriction or reducing the design life of the pipeline are expected to be implemented.

Another potential effect, which could result from pressure cycling, is stress corrosion cracking. As the storage pipeline is located aboveground, the potential for corrosion is reduced. The potential for stress corrosion cracking will be addressed in the design and effective preventative measures identified at that stage.

4.4.2 Blowdown and venting Provision

Details of the requirements for venting and blowdown operations have not been provided for the conceptual design.

4.4.3 Low temperature

While the gas is being drawn off to the power station, the pressure is reduced and is expected to reduce in temperature due to the gas expanding through an orifice, reduced diameter piping or restriction in piping (the Joule-Thompson effect – the temperature of a gas undergoing such an expansion, can be reduced substantially). A pressure drop study has been completed as part of the design development which indicates that the temperature of gas drawn off from the storage pipeline may reduce to 0°C or lower. The temperature specification for the discharge pipework from the storage pipeline is proposed to be capable of operating safely at this temperature, subject to further design development.

In addition, during blowdown operations, the discharge temperature would drop as the pressure is reduced. The temperature specification of the discharge pipework, valves and the vent stack is expected to allow for the resulting temperature drop.

The same effect would occur during venting of the storage pipelines prior to access for maintenance and inspection. However, venting of individual storage pipelines for maintenance can be undertaken in a planned manner over a longer period when storage pressure is at a selected low pressure, thus limiting the temperature reduction.

4.4.4 Releases from storage pipeline facility

The main hazard with potential for offsite impact are releases of natural gas from the storage pipeline equipment. Gas releases could result in:

- Jet fires
- Flash fires
- Vapour cloud explosion

A gas release would result in a jet fire if ignited immediately. Heat radiation from the jet fire may impact people, plant and other aspects of the biophysical environment within the vicinity of the release.

If ignition was delayed, a vapour cloud could form, however as natural gas is buoyant, the potential for a significant cloud build-up is low. If the vapour cloud reached an ignition source a flash fire or a vapour cloud explosion could result.

In the event of a flash fire, the vapour cloud burns rapidly without a blast wave and would then continue to burn as a jet flame from the release point. In the event of a flash fire, there is a high (100%) chance of a fatality within the vapour cloud; however, due to the short duration of the flame, there is a low chance of significant impact outside the vapour cloud radius. However, after the flash fire, the jet fire continues to burn until the inventory is depleted, or the leak is isolated.

A vapour cloud explosion could occur if there is a potential for build-up of natural gas in congested areas, which restricts the flame front and results in an explosive overpressure which will impact people in the area. As there are no major structures near the pipeline, there is a very low likelihood of congestion and resulting vapour cloud explosion.

There is a potential for gas build-up in the compressor enclosure to result in an explosion in the event of ignition of the gas. The compressor enclosure is proposed to be provided with gas detection (alarm on 20% LFL and shutdown on 40% LFL), fire detectors (UV/IR) to detect lube oil fires and ventilation. The compressor unit is proposed to be designed to minimise the number of potential leak sources in the enclosure (e.g. by placing flanged equipment outside the enclosure).

Dispersion of natural gas from the vent stack reaching an ignition source could result in fire incidents; however, ignition sources in this area are negligible, if any.

4.5 Transformer fire hazards

CIGRÉ A2.33 *Guide to Transformer Fire Safety Practices* is the main reference guideline and considered to be the Power Industry recognised document for best practice.

As per CIGRÉ A2.33, when a transformer failure results in a fire, the transformer is often damaged to a degree where repair is not economical. The aim is, therefore, not to save the transformer if a transformer fire occurs but rather:

- To prevent and minimise consequential damage to the substation installation and other plant items located near the transformer on fire
- To avoid the loss of supply from the substation and if not possible then to minimise the time of loss of supply
- To minimize, and if, possible avoid pollution and contamination to the surrounding environment. Especially the environment outside the substation boundary. The potential pollution includes both the airborne pollution in form of smoke, soot and noxious fumes and runoff causing ground water contamination by oil or other chemicals including foams and other fire suppressant chemicals which may be used in firefighting.

In addition to the CIGRÉ A2.33 recommendations, safety of personnel and the public must also be considered when reviewing the consequences of a transformer fire and explosion.

4.5.1 Overpressure scenarios

4.5.1.1 Transformer tank failure

Internal arcing causes high temperatures and very rapid decomposition into gases. As per CIGRÉ A2.33, Section 2.2.1 and Section 2.2.2, the process of an internal arc leading to a tank rupture is described. The transformer tank is not typically rated to withstand the pressure from the gases and in this event is likely to rupture, however not necessarily catastrophically. In the event of a rupture a mixture of hot oil and gases are expected to be released. The Energy Networks Association, *Guideline for the Fire Protection of Electricity Substations*, confirms the failure mechanisms for high energy arcs under oil[2].

Multiple consequences may result from the event of overpressure of a transformer tank. A potential event tree is presented in Figure 8.

[2] ENA, 2015, *Guideline for the Fire Protection of Electricity Substations*

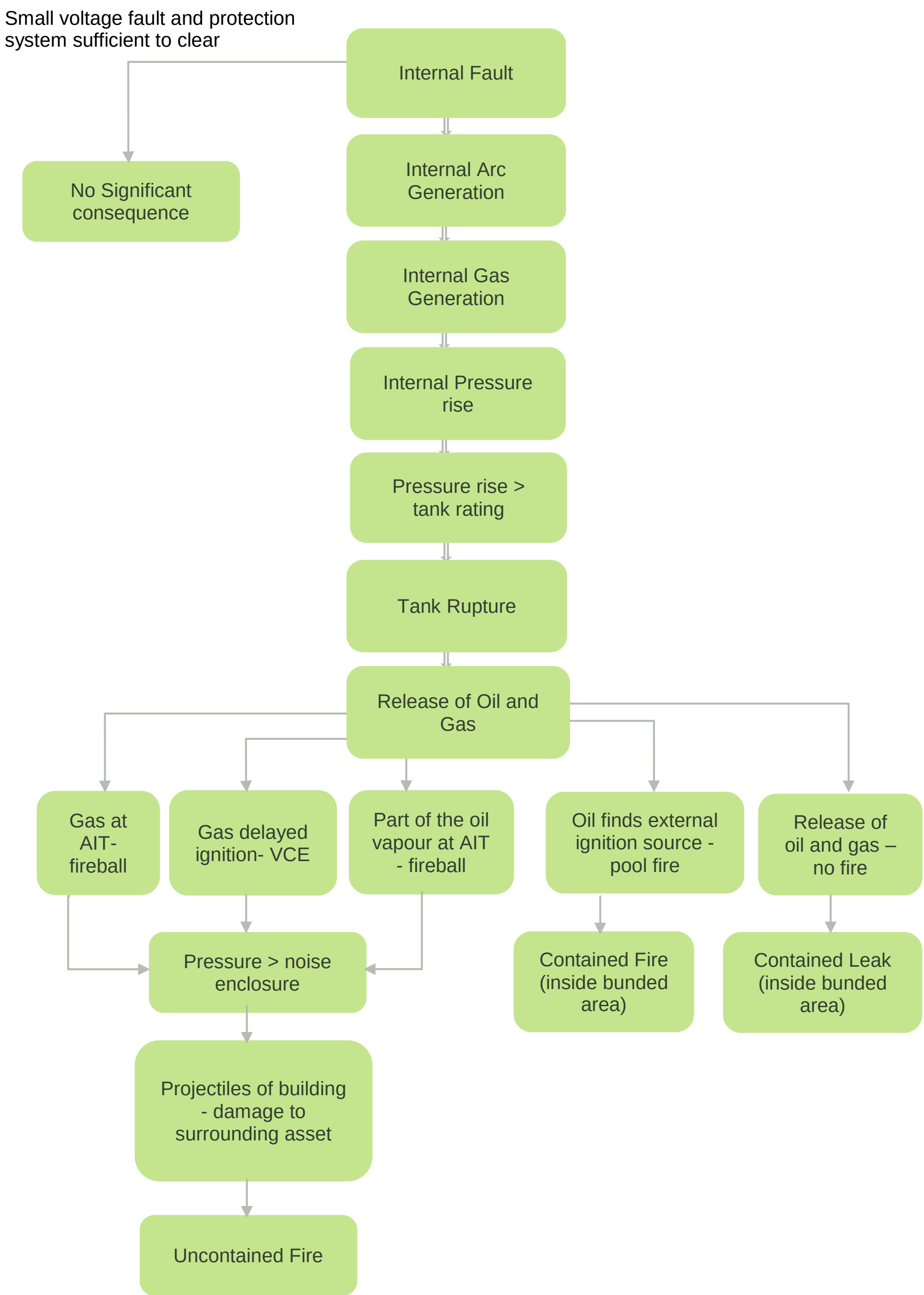

Figure 8 Typical transformer overpressure event tree

As demonstrated in Figure 8, there are multiple consequences that could cause a fireball or vapour cloud explosion and associated pressure wave.

1.1.1 Heat radiation scenarios

4.5.1.2 Bushings failure

A bushing failure can lead to a fire on top of the transformer. Oil is expelled after a bushing failure and if there is a rupture and electric arc at the oil end of the bushing housing, oil from the transformer will feed a fire and the fire will spread to the transformer tank. A fire inside the transformer tank would be very difficult to put out and would create toxic smoke.

The specific nature of the bushings failure and fire scenario is dependent on the bushing selection and installation and should be reviewed as part of the design development.

4.5.1.3 Bund pool fire

A failure of oil containing equipment (e.g. conservator, oil cooler etc.) can lead to a bund pool fire. The equipment could fail for a number of reasons, pumps and air coolers could have a mechanical failure from general wear and tear. An external flash over and subsequent sustained fault, if the excessive over-current is not rapidly interrupted and sufficient heating occurs, could cause overflowing and possibly boiling of the oil, which could cause spilling from the conservator, pressure relief valves or damage to gaskets.

A release of oil would still require an ignition source for a fire scenario. Ignition sources could include pump failure and circuit protection failure and external ignition sources such as sparks from equipment.

5 Consequences of Incidents

Preliminary consequence effects modelling was conducted to identify the size and extent of a worst-case pipeline rupture of:

- The storage bottle supplying fuel gas to the NPS
- The NPS fuel gas supply pipeline
- A gas release from the pigging barrels at either end of the storage bottle.

The hazard analysis conducted indicates that smaller jet fires, diesel pool fires and 3-dimensional combustible liquid fires can occur. The consequence effects of these were not modelled. These should be modelled when plant and equipment layouts have been finalised and the FSS finalised.

The design of the plant is still in the conceptual design stage. Power and process plant and equipment sizing; plant layout and plant spacing have not been detailed. This information is critically important for the specification of firefighting plant, equipment and systems, and the sizing and operating capacity of firefighting equipment.

The type and size of potential fires and explosions have been identified. Modelling the effects and severity of such events is at a preliminary stage. Without detailed design layouts of plant and equipment, the following could only be estimated:

- The impact of radiant heat and the level of exposure of plant, equipment and structures
- The impact of explosion overpressure and the level of exposure of plant, equipment and structures
- The operating ranges of fire protection equipment, such as hydrants and monitors
- The surface area and volumes of surfaces and enclosures that could be exposed to radiant heat or overpressure.

Full details of the consequence modelling performed is included in the PHA.

6 Fire Prevention Strategies/Measures

Key fire prevention strategies/measures as recommended by Standards, Codes of Practice and Regulations are listed in Table 5.

Table 5 Fire prevention strategies/measures

Fire prevention strategies/measures	Recommended performance requirements
Safe design, including inherently safer design Inherently safe design applies the hierarchy of risk control measures at the design stage. Requires use of hazard identification tools e.g. HAZOP. The first principle is to avoid the hazard wherever possible by designing it out. The second principle is to reduce the severity of the hazard by intensification, substitution or attenuation. Without careful engineering, the probability of protection failure increases as one moves from inherent, to add-on passive, to add-on active, to procedural.	Safe design is proposed to be achieved as follows: • Safe Design process as per relevant Regulations • HAZOP • cHAZOP • Pipeline SMS • Hazardous Area classification • PHA and associated identification of layers of protection • Others as required (eg LOPA)
Separation distances Adequate separation should be provided between the following: • Adjacent Combustion Turbine (CT) and Internal Combustion Engine (ICE) units • Adjacent structures or exposures • Adjacent properties (e.g., tank farms or natural gas facilities that could present a severe exposure) Consideration should be given to equipment layout that is adjacent to CTs and ICEs and in line with planes of turbine and compressor disks that have a higher potential for damage from flying debris. Loss experience indicates that fires or explosions in congested areas at potentially hazardous facilities can result in extensive losses. Wherever explosion or fire hazards exist, proper plant layout and adequate spacing between hazards are essential to loss prevention and control. Layout relates to the relative position of equipment or units within a given site. Spacing pertains to minimum distances between units or equipment. Guidelines are intended to limit explosion overpressure and fire exposure damage and possible escalation.	Separation is expected to be implemented on the finalisation of the layout and design development. Specifically: • Segregation, bunding and spacing of the Diesel storage tanks is proposed to comply with AS 1940 • In the gas yard, gas conditioning area, and storage gas pipeline, pipeline, process plant and piping is proposed to be designed to comply with separation requirements between the Control Room, Gas Chromatograph Station, Water Bath Heaters, Shut Down Valve Skid, Metering Skid, Pressure Reduction Skid, Compressors, Pig Barrels and storage pipelines or separated by firewalls or barriers for protection against impinging Jet Fires • Flanges and leak points are proposed to be minimised within the piping and instrumentation system and process plant • Flanges are proposed to be orientated to prevent Jet Fires from impinging against plant and equipment in the Gas Yard • Natural gas shut-off valves should comply with AS 3814. Double “block and bleed” valves are proposed to be considered
Pipework and piping design The storage and associated piping systems for gases in the gaseous or liquefied states should comply with NFPA 54, NFPA 55, NFPA 56, NFPA 58, and ASME B31.1/B31.3/B31.8 as applicable.	The piping system would be designed to an acceptable Standard as agreed with the AGL. Robust piping design is intended to ensure that the material being carried stays in the pipework so as not to escape to the environment where it may ignite and result in a fire scenario. Pipework is proposed to be cathodically protected, where required. Pipework is proposed to be constructed using fracture tough steel and be inherently flexible to account for freedom of movement, including considering cycling of the pipework as per the design intent. The use of dry gas will also be a critical factor in reducing corrosion causing pipework failure.

Fire prevention strategies/measures	Recommended performance requirements
Gas shutoff valve The facility fuel gas shutoff valve should be located in a remote area and accessible under emergency conditions. The valve should be provided with both manual and automatic closing capabilities locally, and remote closing capability from the control room. The valve should be arranged to fail closed on the loss of power or pneumatic control.	The facility fuel gas shutoff valve is expected to be located in a remote area and accessible under emergency conditions. The valve is expected to be provided with both manual and automatic closing capabilities locally, and remote closing capability from the control room. The valve should be arranged to fail closed on the loss of power or pneumatic control. The intention is to minimise the amount of lost produce from the pipework and minimise the likelihood of a fire event.
Ignition prevention International standards (various) requirements for minimisation of typical sources of ignition and incorporation of design features that minimise the risk of ignition have been adopted. Requirements are: • Lightning: Appropriate protection against lightning to be ensured by adherence to API RP 545 / AS 1768 as applicable • Static electricity: Appropriate design procedures need to be in place to ensure that this hazard is eliminated • Electric equipment sparking: Ignition sources, resulting from sparking etc; of electrical or electronic components are eliminated or minimised, refer AS/NZS 60079.10.1.	The following measures are proposed to be implemented: • Hot equipment: Exposure minimised by good plant layout and spacing • Maintenance activities: The potential for ignition due to welding, building, use of cranes, vehicles and other hot work is proposed to be strictly controlled by Control of Work processes. Appropriate spacing is proposed to be provided between plant and equipment in the Gas Yard to protect against ignition potential in adjacent areas during the performance of maintenance work • Vehicle traffic: Control of traffic movement, access and egress ensures that ignition from the Diesel vehicles is minimised • Lightning: Appropriate protection against lightning on the tanks should be considered during the design development and if necessary, provided • All electrical plant and equipment is proposed to be designed and certified to the hazardous zone that they are installed within.
Security Security minimises the potential for external events that could result in fire scenarios.	It is proposed that the facility be provided with a security fence and remotely operated gates for access.
Hydrocarbon detection In the event of a loss of containment of hydrocarbon material, detection and process control to minimise the loss and potential for ignition is critical to preventing a fire.	It is proposed that hydrocarbon detection be provided in areas of the facility where congestion and hydrocarbon loss may occur. More specifically, it is proposed that the compressor enclosure be provided with gas detection (alarm on 20% LFL and shutdown on 40% LFL) and fire detectors (UV/IR) to detect lube oil fires and ventilation. The compressor unit is proposed to be designed to minimise the number of potential leak sources in the enclosure (e.g. by placing flanged equipment outside the enclosure).
Control of work Control of work procedures, a component of the SMS, governs safe work practices.	A permit to work system including additional risk mitigation for hot work, as applicable, is proposed to be included in the facility SMS.
Overpressure protection Overpressure of the storage pipeline may result in equipment damage.	It is proposed that an appropriate standard such as API RP 521 "*Guide for Pressure-Relieving and Depressuring Systems*" be used for the detailed design of the blowdown and venting system for the pipeline. It is also proposed that a blowdown philosophy, including the blowdown times, flow rates and inventory, be prepared for the storage pipeline.

Fire prevention strategies/measures	Recommended performance requirements
Fire area subdivision The electric generating plant and the high voltage switchyard should be subdivided into separate fire areas for the purpose of limiting the spread of fire, protecting personnel, and limiting the resultant consequential damage to the plant. Fire areas should be separated from each other by fire barriers, spatial separation, or other approved means. Determination of fire area boundaries should be based on consideration of the following: • Types, quantity, density, and locations of combustible material • Location and configuration of plant equipment • Consequence of losing plant equipment • Location of fire detection and suppression systems Fire area boundaries should be provided to separate the following: • Cable spreading room(s), and cable tunnel(s) and high voltage lead shafts from adjacent areas • Control room, computer room, or combined control/ computer room from adjacent areas • Rooms with major concentrations of electrical equipment, such as a switchgear room or relay room, from adjacent areas • Battery rooms from associated battery chargers, equipment, and adjacent areas • Maintenance shop(s) from adjacent areas • Fire pumps from adjacent areas • Emergency generators from each other and from adjacent areas • Storage areas for flammable and combustible liquid tanks and containers from adjacent areas • Office buildings from adjacent areas • Telecommunication rooms, supervisory control and data acquisition (SCADA) rooms, and remote terminal unit (RTU) rooms from adjacent areas • Adjacent turbine generators beneath the underside of the operating floor • Switchgear area from adjacent areas Fire barriers separating fire areas should be a minimum of 2 hour fire resistance rating.	Fire area subdivision is expected to be implemented on the finalisation of the layout and design development. The intention is to minimise the potential for escalation of a fire event so far as is reasonably practicable so as to limit any fire event to a single scenario.

7 Fire detection and protection measures

The fire/explosion prevention and mitigation measures required by relevant Standards and Codes of Practice, are given in the following sections.

7.1 Applicable Standards

Applicable Standards and Codes of Practice referenced and used in the identification of fire/explosion detection and protective measures are:

- AS 2067 “Substations and high voltage installations exceeding 1 kV a.c.”
- NFPA 850 "Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations"
- AS 1940 “The storage and handling of flammable and combustible liquids”
- AS 2419.1 “Fire Hydrant Installations – System Design and Commissioning”
- AS 2118.1 “Automatic Fire Sprinkler Systems, Part 1: General Systems”
- AS 1670.1 “Fire detection, warning, control and intercom systems – System design, installation”

7.2 Fire detection

7.2.1 Fire detection systems

Fire detection is proposed to be generally manual through the fire alarm and indication systems. However, the following equipment is proposed to be provided with specific fire detection systems:

- A smoke detection system is proposed to be installed throughout rooms containing electrical equipment, including walk-in-type consoles, above suspended ceilings where combustibles are installed, and below raised floors. Where the only combustibles above the false ceiling are cables in conduit and the space is not used as a return air plenum, smoke detectors are permitted to be omitted from this area
- Switchgear rooms and relay rooms are proposed to be provided with smoke detection systems
- VESDA (aspirating smoke detection system) would be considered for fire detection with Argonite gaseous suppression systems in cabinets and FM200 gaseous suppression in the switch rooms
- Gas turbine or reciprocating engine fire detection system (manufacturer specified) is proposed to be provided
- Flame detection via UV/IR in areas of the NPS where a confined hydrocarbon fire may occur (eg compressor building).

7.2.2 Fire control centre

Designation of a fire control centre (FCC) is recommended. The FCC is an area within a building from where major emergency situations can be controlled and monitored and where supporting equipment is provided to assist in that function.

7.2.3 Alarms, communications and FRNSW Activities

A Fire Indicator Panel (FIP) is proposed to be installed designed in accordance with AS 1670 and AS 1603.5 and the following:

- Any automatic system would be capable of being manually activated at clearly identified positions

- The warning signal of the alarm system would be sufficiently distinguishable from other signals to permit ready recognition, and would be clearly audible throughout the whole facility. Note that a visual alarm system would be considered in areas of excessive noise
- The power supply for any alarm system would be independent of the main electricity isolating switch for the area
- Manual alarm call points would be located at convenient and safe locations near work stations.

7.2.4 Early warning and indication system

A comprehensive early warning and indication system (EWIS) for raising alarms and to mobilise emergency teams would be installed.

Emergency responders would be able to communicate by:

- Landline telephone
- Mobile phones
- Intrinsically safe 2-way radios.

An emergency command centre could be set up in the FCC. The location and activities within such a centre would be determined when the power plant is commissioned, but the type of equipment to be installed would be determined during the detail design phase.

7.3 Fire protection for fire scenarios

7.3.1 Protection against jet fires

Exposure protection involves spraying water directly onto an equipment item or structure to prevent failure due to heat or to prevent ignition of combustible components.

The required application rate depends upon the rate of heat transfer, the maximum allowable temperature, and the efficiency of heat absorption by the water. In general, suggested application rates are between 4.1 LPM/m^2 and 10.2 LPM/m^2.

These suggested rates are experience-based plus a safety factor of 2.0 LPM/m^2. The higher application rate of 10.2 LPM/m^2 is recommended for protecting steel surfaces that are stressed such as pressure vessels and load-bearing structural members such as vessel legs, pipe rack supports and vessel skirts. This application rate is good for moderately severe heat inputs, including direct, non-pressured, flame contact.

However, it is not sufficient for protection from flame impingement from a pressurised jet fire. The force of a jet fire can separate water from the surface it is intended to protect, making the water spray ineffective, or provide more heat input than the water density can absorb. Supplemental water application from hose streams or monitors directly to the point of flame impingement (at ca 1,900 LPM) is required to cool the area and prevent localised failure.

7.3.2 Protection against a Diesel pool fire

Application of aspirated foam can be used to supress combustible liquid pool fires, guidance is taken from NFPA 11 for foam systems, noting that combustible liquids are not included in that standard as the flash point is greater than 60°C. Fire suppression is included in this FSS considering emergency response planning activities and defining performance requirements

7.3.3 Protection of process equipment in enclosures or buildings

Gas processing equipment situated within congested buildings or partially open structures typically presents the highest potential for major fires. In addition, equipment within the process buildings and structures is typically the least accessible for protection with hose streams and monitors and thus represent appropriate applications for fixed water spray systems. In congested areas it is often impractical to cover each equipment item or structural member as described in the preceding sections.

In the event of a fire within enclosures or buildings, an automatic sprinkler system could be installed.

7.3.4 Protection against fire escalation events

Cooling is typically provided for the escalation in the event that heat radiation exposure on critical equipment and assets exceeds 8 kW/m^2 "*at some stage*" whereas in the event of heat radiation exposure exceeding 32 kW/m^2 fixed systems and automation is recommended.

Cooling of process plant and equipment is typically provided by means of monitors rather than fixed deluge systems due to blockage potential and maintenance concerns. Fixed deluge is typically provided where plant and equipment cannot be readily reached.

7.3.5 Summary of fire protection measures

Fire protection, detection and mitigation measures required by standards, codes of practice and regulations; together with performance requirements and criteria are presented in Table 6.

Table 6 Protection and Detection Measures

Fire protection strategies/measures	Recommended performance requirements
Extent and capacity of the firefighting capability Extent and capacity of the firefighting capability are based on the assumption that only one fire will occur at a time. The capacity of the foam system is determined by tankage and bunding requirements. Firewater capacity is a function of both foam and cooling water requirements. The largest single fire scenario determines the design of the major firefighting facilities. The sizing of the firefighting system components are not set by the same single fire contingency. Different firefighting methods are required for various storage tanks.	The probability of two independent fire scenarios occurring at the same time is not considered a design basis therefore, the maximum firewater demand will be for a single worst case design fire scenario. It is recognised in the design that a fire or explosion can escalate, involving other sections of the power station. Such escalation scenarios are considered non-design scenarios and managed through emergency response processes using fixed and mobile equipment. Calculations should be carried out to establish the required volume of firewater required, based on consideration of the application rates and run times required to fulfil the likely fire response strategies for the various scenarios, will be revised once the firewater requirements for transformers, generators have been finalised.

Fire protection strategies/measures	Recommended performance requirements
Fire water storage Scenario evaluation should be used to calculate total water quantity, but a minimum of two hours' supply should be considered as a baseline given the potential use of water or foam in a design event fire. However, in practice, this figure may vary depending on incident strategy, system run times, etc., as well as the likely duration of any fire and exposure to radiant heat and flame impingement. A realistic estimate of the amount of water required to control the facility's design event should be determined. HIPAP No 2 recommends that on-site water storage should be calculated to meet worst case demand. The minimum requirement is generally 90 minutes supply. NFPA 850 requires 2 hours storage capacity and full replenishment in 8 hours. AS 2118.1 requires a minimum water supply of 60 minutes plus 20%. AS 1940 requires a minimum water supply of the aggregate volume providing 90 minutes for cooling, foam water as per the design (NFPA 11) and hydrants for 240 minutes. EI MCSP P19 recommends a water volume for 2 hours	Fire water storage capacity will comply withmeet NFPA 850 requirements. The volume should be provided with connections to facilitate top up from water mains or other supplementary water sources. Water make up from mains should be automatic.
Radiant heat exposure protection Manual firefighting equipment not to be located within the 3 kW/m^2 heat flux contour regions or too close to the equipment being protected (within 15 metres) and would be difficult and / or dangerous to approach in a fire situation.	The consequence effects of jet fires and Diesel pool fires would need to be definitively specified – based on plant layout and separation distances to be determined in detail design of the NPS. Any firefighting tactics and strategies would require that people operating mobile monitors, hydrant hoses or activating fire pumps, will be located outside the 3 kW/m^2 heat flux contour regions determined in a consequence effects analysis.
Hydrant main A hydrant main should be provided that protects the fire hazards and hazardous operations identified. Hydrant landing valves should be installed on the hydrant main and hydrant spacing should not exceed 60 m along the hydrant main pipework. Monitors, where fixed should branch off the hydrant main.	The NPS would include a hydrant main designed in accordance with AS 2419.1 and the finalised FSS in consultation with FRNSW.
Functionality and isolation of the hydrant main in the event of impairment Each ring or pressure zone shall be able to be isolated in 25% increments, whilst maintaining not less than 50% of the hydrants required to protect each fire compartment.	The hydrant main would be designed to form a ring main and be provided with isolation valves to provide functionality in the event of impairment of a section of the pipework.
Fire water pumps A single pump system may be installed, provided that a risk assessment can demonstrate that an equivalent level of reliability is achieved. Normal practice is to provide n+1 pumping capacity where n is the minimum number of pumps to provide the design flowrate at pressure. 6.2.5.1 Where multiple fire pumps are required by the Fire Protection Design Basis Document, the pumps should not be subject to a common failure, electrical or mechanical, and should be of sufficient capacity to meet the fire flow require- ments determined by 6.2.1 with the largest pump out of ser-	A firewater pumping capacity would be based on the maximum water demand and specified to AS 2941. The necessity for installing multiple pumps will be determined during detailed design and the preparation of the design basis document for the fire protection system. It may be necessary to install 2 x 100% pumps – a diesel and electric pump for pump redundancy – this is normal practice.
Portable fire extinguishers Portable fire extinguishers should be provided in strategic locations and classified for the types of fires expected (electrical / dry powder / foam etc). Sizes are nominally 9 kg for small initial fires to prevent further escalation.	Portable fire extinguishers first aid measures would be provided according to requirements of the standards. These would enable operating personnel to extinguish small fires.

Fire protection strategies/measures	Recommended performance requirements
Monitor coverage Fixed spray deluge or sprinkler systems are typically installed in areas not readily accessible by monitors. Monitors are flexible, and a single monitor can protect the same area as a very extensive fixed pipe system if the area is unobstructed, or if the monitor can be positioned so as to negate obstructions. Elevated monitors can be used to negate obstructions. Combination straight stream or fog nozzles can be used for application of large volumes of cooling water onto process and storage tanks and plant equipment. For purposes of arrangement and spacing of monitors the following guidelines apply: • Maximum horizontal range of 35 m • Height of the straight stream at 75° elevation of 45 m	Mobile monitors are proposed to be used for protection against impinging jet fires and for extinguishing diesel bund fires, nominally designed for 1,900 LPM at 7 bar inlet pressure.
Fire brigade booster assemblies Fire brigade suction and booster assemblies should be installed in accordance with AS 2419.1 and FRNSW requirements.	A fire brigade booster assembly is proposed to be provided in consultation with FRNSW and designed in accordance with AS 2419.1
Outdoor Oil-Insulated Transformers Outdoor oil-insulated transformers should be separated from adjacent structures and from each other by fire-walls, spatial separation, or other approved means for the purpose of limiting the damage and potential spread of fire from a transformer failure.	Transformers would be separated as required by NFPA 850, AS 2067 and FM Global Property Loss Prevention Data Sheet 5-4.
Containment and Drainage Provisions should be made in all fire areas of the plant for removal of liquids directly to safe areas or for containment in the fire area without flooding of equipment and without endangering other areas. Drainage and prevention of equipment flooding should be accomplished by one or more of the following: • Floor drains • Floor trenches • Open doorways or other wall openings • Curbs for containing or directing drainage • Equipment pedestals • Pits, sumps, and sump pumps	Consideration of drainage and storage / treatment of material and fire water contaminated water would be included in the design development.
Turbine-Generator Area All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray, or oil accumulation should be protected by an automatic sprinkler or foam-water sprinkler system. This coverage normally includes all areas beneath the operating floor in the turbine building. The sprinkler system beneath the turbine-generator should take into consideration obstructions from structural members and piping and should be designed to a density of 12.2 LPM/m^2 over a minimum application of 464 m^2, as required by NFPA 850 Lubricating oil lines above the turbine operating floor should be protected with an automatic sprinkler system covering those areas subject to oil accumulation including the area within the turbine lagging (skirt). The automatic sprinkler system should be designed to a density of 12.2 LPM/m^2. If the lubricating oil equipment is in a separate room enclosure, protection can be provided by a total flooding gaseous extinguishing system.	An automatic sprinkler protection system would be provided for the Turbine-Generator area in accordance with NFPA 850 and AS 2118.1.

Fire protection strategies/measures	Recommended performance requirements
Turbine-Generator Bearings Turbine-generator bearings should be protected with an automatic closed-head sprinkler system utilizing directional nozzles. Automatic actuation is more reliable than manual action. Fire protection systems for turbine-generator bearings should be designed for a density of 10.2 LPM/m^2) over the protected area of all bearings.	An automatic sprinkler protection system would be provided for the Turbine-Generator bearings in accordance with NFPA 850 and AS 2118.1.
Control, Computer, and Communication Rooms A smoke detection system should be installed throughout these rooms, including walk-in-type consoles, above suspended ceilings where combustibles are installed, and below raised floors. Where the only combustibles above the false ceiling are cables in conduit and the space is not used as a return air plenum, smoke detectors are permitted to be omitted from this area. Automatic sprinkler protection or automatic water mist fire protection systems for computer or telecommunications rooms should be considered. A pre-action system can be used. In addition, total flooding gaseous fire extinguishing systems should be considered for areas above and below raised floors that contain cables or for areas or enclosures containing equipment that is of high value or is critical to power generation. Individual equipment and cabinet protection could be considered in lieu of total flooding systems.	Smoke detection is proposed to be installed throughout these rooms, including walk-in-type consoles, above suspended ceilings where combustibles are installed, and below raised floors. Where the only combustibles above the false ceiling are cables in conduit and the space is not used as a return air plenum, smoke detectors are permitted to be omitted from this area. Any automatic sprinkler protection / water mist / total flooding system should be provided in accordance with NFPA 850 (and AS 2118.1, where applicable).
Switchgear and Relay Rooms Switchgear rooms and relay rooms should be provided with smoke detection systems.	A smoke detection system wouldbe installed throughout these rooms.
Battery Rooms Battery rooms should be provided with ventilation to limit the concentration of hydrogen to 1 per- cent by volume. For further information refer to ANSI/IEEE.	The battery room would be provided with ventilation to limit the concentration of hydrogen to 1% by volume. For further information refer to ANSI/IEEE.
Transformers Oil-filled main, power station service, and start-up transformers not meeting the minimum separation distances as specified in Standards and Codes of Practice should be protected with automatic water spray or foam-water spray systems.	The transformers would be protected with an automatic water-spray system, subject to risk assessment and criticality of the transformers in the event of failure and / or fire. Such scenarios include where adequate spacing of outdoor transformers cannot be achieved and fire barriers not provided. Separation would be based on AS 2067, NFPA 850 and FM Global Property Loss Prevention Data Sheet 5-4.
Hydraulic equipment, reservoirs, coolers, and associated oil-filled equipment Should be provided with automatic sprinkler, water spray protection, or compressed air foam systems. Protection should be over oil-containing equipment and for 6.1 m beyond in all directions. A density of 10.2 LPM/m^2 should be provided. Compressed air foam systems, where required should be designed and installed in accordance with NFPA 11.	Hydraulic equipment, reservoirs, coolers, and associated oil-filled equipment would to be provided with automatic sprinkler, water spray protection, or a compressed air foam system.

Fire protection strategies/measures	Recommended performance requirements
Emergency response planning Fire Emergency Plan. A written fire emergency plan should be developed, and, as a minimum, this plan should include the following: • Response to fire alarms and fire systems supervisory alarms • Notification of personnel identified in the plan • Evacuation of employees not directly involved in fire- fighting activities from the fire area • Coordination with security forces or other designated personnel to admit public fire department and control traffic and personnel • Fire preplanning that defines fire extinguishment activities • Periodic drills to verify viability of the plan • Control room operator(s) and auxiliary operator(s) activities during fire emergencies Pre Incident Plans. A written pre incident plan(s) should be developed in consultation with FRNSW for fire scenarios expected at the NPS. Tactical Response Plans. Written tactical response plans should be developed in consultation with FRNSW for fire scenarios expected at the NPS, including escalation scenarios to assist with emergency response planning.	A full range of emergency response planning documents would be developed in consultation with FRNSW.

7.4 Firefighting equipment

7.4.1 FRNSW hardstand and suction/booster connections

A hardstand suitable for FRNSW vehicles and their approaches is proposed to be provided. The hardstand area is proposed to be provided with suction and booster connections as required by FRNSW and AS 2419.1.

7.4.2 Hydrant ring main

A hydrant ring main is proposed to be provided. The layout of the hydrant ring main would be confirmed when the plant layout and separation distances have been specified in the development of the design.

The hydrant ring main would be fed from onsite firewater pumps providing supply to the existing sprinklers, hydrants, monitors and hose reel as required. In the event of such a system being damaged by an explosion, the damaged section should be provided with the capability of being isolated to allow the use of a mobile monitor/s or hydrants in another section of the ring main.

The hydrant ring main is proposed to be provided with hydrants approximately every 60 m along the pipework and positioned such that they are accessible.

The design of the hydrant ring main is proposed to be in accordance with AS 2419.1.

7.4.3 Sprinkler Systems

Automatic water sprinkler, spray, water mist and CAFS systems are proposed to be installed for protection of various items of plant equipment within the power plant, in accordance with AS 2067 and NFPA 850.

Protected Area	Spray/Deluge/Sprinkler	Performance Required
Hydraulic equipment, reservoirs, coolers, and associated oil-filled equipment	Hydraulic equipment, reservoirs, coolers, and associated oil-filled equipment to be provided with automatic sprinkler, water spray protection, or compressed air foam systems	NFPA 850

Internal Combustion Engine Generators (ICE)	Either water spray systems, where permitted by the turbine configuration or total flooding gaseous / mist systems	NFPA 850
Combustion Turbine (CT)	Either water spray systems, where permitted by the turbine configuration or total flooding gaseous / mist systems	NFPA 850
Plastic ducts	Automatic sprinkler protection should be provided in plastic ducts over 300 mm in diameter.	NFPA 850
Cable spreading rooms and cable tunnels	Automatic sprinkler, water spray, water mist, or automatic gaseous extinguishing systems	NFPA 850
Transformers and Bunds Transformers not spaced or segregated from adjacent equipment or plant, or where the risk of fire and catastrophic damage is not acceptable	Automatic water spray or foam-water spray systems	NFPA 850 AS 2067 FM Global Property Loss Prevention Data Sheet 5-4
Control, Computer, and Communication Rooms	To be considered during design development and considering the requirements of the NCC	NFPA 850 NCC AS 2118.1

7.4.4 Hose Reels and Fittings

Hose reels are proposed to be provided as a first aid measure providing an initial response in the early stages of small fires.

Hose reels are proposed to be located throughout the site to provide coverage for equipment where a release of flammable or combustible material is possible. Hose reels should be fitted combination straight stream / fog nozzles in all operating areas as a means of quickly applying water in the incipient stage of a fire.

Hose reels and fittings are to comply with AS/NZS 1221 and be installed in accordance with the requirements of AS/NZS 2441.

Hose reel coverage drawings are proposed to be developed once the layout of the NPS and separation distances have been finalised.

7.4.5 Fire extinguishers

Portable fire extinguishers first aid measures are proposed to be provided according to requirements of AS/NZS 1841.1 and AS/NZS 1850. These are expected to enable operating personnel to extinguish small fires.

The location and coverage of portable fire extinguishers is proposed to be developed once the layout of the NPS and separation distances have been finalised.

7.4.6 Electrical switch rooms and transformers

VESDA (aspirating smoke detection system) would be considered for fire detection with Argonite gaseous suppression systems in cabinets and FM200 gaseous suppression to the room.

The switch rooms would be fire separated from surrounding areas by walls constructed of concrete block.

7.4.7 Protection against escalation events

Protection against escalation events may be achieved by mobile monitors, which would be provided to assist with combatting and managing fire scenarios that are not provided with fixed infrastructure. This is expected to assist with the emergency response planning and capability offered to FRNSW. Mobile monitors would be designed and specified to be operated from hydrants.

7.5 Maintenance, inspection and testing

A site specific maintenance, inspection and testing plan would be developed that will be based on manufacturer recommendations and AS 1851.

8 Conclusions, findings and recommendations

8.1 Fire / escalation prevention

8.1.1 Separation distances & safe spacing

The results from jet fire consequence effects modelling and analysis should be used to plan plant layout and plant spacing – this will in turn establish the sizing and operating capacity of firefighting equipment**.**

Some preliminary analysis indicates that a a worst-case jet fire impact could be a significant event, with potentially severe consequences – depending on the spacing between the point of release, the gas processing and diesel storage area, the generator area, the switchyard and the administration buildings.

For a large release jet fire from the NPS fuel gas tie-in, or storage pipeline, plant and equipment could be exposed to radiant heat levels in excess of 12.6 kW/m^2. In the design, inherent safety design principles may be used, to prevent jet fire exposure. If exposure cannot be eliminated, due to spacing constraints, then the actual area of impact would be determined and minimised by judicious location of plant and equipment. Any exposure will cause a rapid rise in temperature and a weakening of any load bearing structures, plant and equipment or the shell of containing vessels or tanks containing combustible material. Directly exposed piping, plant and equipment could be damaged or may collapse. People exposed to this level of radiation will suffer third degree burns, with a high probability death.

For a large release jet fire from the NPS fuel gas tie-in people should not be exposed to radiant heat levels in excess of 4.7 kW/m^2. Such an exposure will cause severe injury (second degree burns) to exposed firefighters or people within range.

8.2 Fire and explosion escalation prevention measures

The following fire escalation measures to be implanted are discussed in detail in Table 5.

8.2.1 Inherent safety in design

The following inherent fire safety design principles will be adopted in the design:

- Segregation, effective bunding and spacing of the Diesel storage tanks. Separation distances will comply with AS 1940.
- Process and power generation plant. Separation distances of plant and equipment will comply with NFPA 850.
- Flanges and leak points will be minimised in all areas where flammable gas is transferred or stored.
- Flanges will be orientated to prevent Jet Fires from impinging against plant and equipment.
- Natural gas shut-off valves will comply with AS 3814. Double "block and bleed" valves will be considered, based on the requirements of the standard.
- Materials of construction for atmospheric storage of Diesel will be appropriate for the operating environment and the facility will have an inspection and maintenance regime for ensuring continued integrity of the systems.

8.2.2 Remote isolation

Remote or manual isolation in the Gas Yard and Diesel storage area will be installed as required in AS 3814 or any other standard or code of practice – whichever is the more stringent

8.2.3 Vents, emergency venting

Each tank shall be fitted with a vent or vents.

8.2.4 Hydrocarbon, fire and smoke detectors

Hydrocarbon detectors will be installed in areas where natural gas leaks may occur.

Hydrocarbon detectors will be placed in optimal locations. These locations will be in areas where the natural gas concentration has a higher probability of being in the flammable range – to be determined by dispersion modelling.

Smoke and fire detection and alarming to be installed in compliance with the NCC for any buildings on site.

8.2.5 Ignition prevention measures

Measures will be implemented for:

- Hot equipment: Exposure to hot equipment minimised by good plant layout and spacing.
- Maintenance activities.
- Vehicle traffic: Control of traffic, access and egress -ignition from vehicles is minimised.
- Lightning: Appropriate protection against lightning on the tanks is provided.
- Static electricity build-up in Diesel.

All electrical plant and equipment will comply with the requirements of the hazardous area classification in AS 2430. Equipment installed will comply with the classification.

8.2.6 Minimise risk of fire and explosion

Areas where procedures and protective design features will be implemented to reduce the potential for the occurrence of flammable mixtures – within the flammable range are:

- Diesel liquid pumping.
- Natural gas system.
- Hydrocarbon detectors to be implemented at strategic locations.

For explosive and flammable mixtures that may occur during start – up and shutdown or upsets, procedures will be implemented that prevent this from occurring.

The plant's fuel gas shutoff valve will be located in a remote area and accessible under emergency conditions.

Fire area subdivision will be implemented on the finalisation of the layout. Adequate separation will, where possible, be provided, in accordance with a 'Fire Protection Design Basis Document' (to be developed during detail design) between the following:

- Adjacent CT and ICE units
- Adjacent structures or exposures
- Adjacent properties (e.g., tank farms or natural gas facilities that could present a severe exposure)
- Consideration will be given to equipment layout that is adjacent to CTs and ICEs and in line with planes of turbine and compressor disks that have a higher potential for damage from flying debris.

8.2.7 Atmospheric tank hazards

- Appropriate tanks will be installed for Diesel service;
- Diesel is an electrostatic accumulator – appropriate filling procedures will be adopted;
- Diesel has a very low vapour pressure – vapour generation should not occur;
- Level controls and high temperature controls and alarms will be provided in the Diesel tanks;
- Procedures will be implemented for reducing spill potential;
- Adequate vent capacity will be provided – in accordance with API Standard 2000, AS 1940; and
- Overpressure protection will be provided for the Diesel tanks.

8.2.8 High-flash cone roof tanks

The design basis of the firefighting facilities for the tanks will be limited to providing firewater cooling to adjacent tanks to prevent the spread of any fire that may develop.

Firewater and foam systems for the tank on fire are not required for tanks containing high-flash point materials, due to the low probability of ignition.

A mobile monitor will be used for cooling or extinguishing a Diesel pool fire.

8.2.9 AS 1940 requirements

AS 1940 requires that where only combustible liquids are stored, the installation shall be provided with at least the following:

- A hydrant system comprising at least one hydrant riser per tank, which is capable of reaching all parts of all compounds. A mobile monitor will be provided to be fed from a hydrant riser at each tank.
- Accessories and foam concentrate will be provided – in the event that large amounts of Diesel vapour are generated – an unlikely event.
- One powder-type extinguisher will be provided per tank, with a minimum of three powder-type extinguishers for the storage area.

8.2.10 Fireproofing

Fireproofing of supports and structures exposed to a jet fire, will be considered during design; in conjunction with any firewalls or barriers that may be considered. This will be considered once the layout has been decided.

Plant and equipment processing natural gas for power generation will be considered as ‘high fire potential’ material.

Diesel aerosol vapour being released at high pressure will be considered to be “high fire potential”.

Fireproofing recommendations will be based on a “needs” analysis – as required in API 2118.

8.2.11 Layout and design

Spacing and layout should be in accordance with the GAPS guidelines– unless there are prohibitive physical constraints preventing this. In this case, fireproofing, the construction of firewalls or barriers should be considered as an alternative.

Access and egress will be provided for in the layout of all areas and interconnecting roads; this will be implemented in the Emergency Response Plan in conjunction with the NSW Fire Brigade.

8.2.12 Bund capacity

Bund size will be sufficient for spill containment and firefighting purposes in the Diesel storage area. Diesel piping and storage tanks will be bunded.

Sufficient bund capacity will be provided in accordance with AS 1940.

8.2.13 Dangerous Goods Regulations

All operations, process and storage of hazardous goods, will comply with the requirements of the appropriate Dangerous Goods Regulation.

8.2.14 Security

The site will be provided with a security fence and remotely operated gates for access.

8.2.15 Fire and explosion detection, protection and mitigation measures

The following fire and explosion detection, protection and mitigation measures to be implanted are discussed in detail in Table 6.

8.2.16 Firefighting flexibility and size of firewater system to be provided

The capacity of the fire protection and mitigation system and firemain system to effectively fight a fire is based on the maximum firewater requirements – either for a Diesel pool fire or a jet fire. The probability of two independent fire scenarios occurring at the same time is extremely low (double jeopardy situation) – therefore, the maximum firewater demand will be for a single worst case credible fire scenario. It will be recognised in the design that a fire or explosion can escalate, involving other sections of the power station.

The typical strategy for extinguishing a large ground fire is to apply a foam blanket. Foam for fighting such a fire will not be provided for in the design.

Water spray, by means of mobile monitors will be used. These monitors will be fed from hydrant stand pipes. Mobile monitors will provide the means for effective firefighting for both Diesel storage and the gas processing and power generating facilities:

- With Diesel, having flash points well above 38°C or, more specifically, above the temperature of the water used, extinguishment can be achieved with the water spray from monitors.
- Proper application of water cools the hot product surface below its flash point while steam evolved from vaporization of the firewater helps to exclude air. When vaporization of the product stops, the fire is extinguished.
- Mobile monitors can be deployed for mitigating the impact of impinging jet fires.

8.2.17 Fire area subdivision

The power plant site will be subdivided into fire areas, such areas defined in NFPA 850. Fire area subdivision will be implemented on the finalisation of the layout.

Transformers will be separated as required by NFPA 850.

8.2.18 Firefighting strategies and tactics

Firefighting strategies and methods for fighting cone roof Diesel tank fires, Diesel pool or bund fire, Natural gas jet fires will be detailed in fire plans after consultation with the NSW Fire Brigade. It is expected that such plans may be more definitive once detailed design of the NPS is finalized.

8.2.19 Ringmain

The firewater system will form a ringmain – the layout of the ringmain will be decided when the plant layout and separation distances have been specified.

The firewater system will probably consist of the following:

A 150 mm ringmain fed from the on-site firewater pumps providing supply to the existing sprinklers, hydrants, monitors and hose reels;

In the event of such a system being damaged by an explosion, the damaged section will have the capability of being isolated with suitable isolation valves, to allow use of a mobile monitor/s or hydrants in another section of the ringmain.

8.2.20 Functionality and isolation of the grid during impairment.

The ringmain shall be provided for the gas processing plant, power generation plant and switchyard and the Diesel storage facility. Each ring or pressure zone shall be able to be isolated in 25% increments, whilst maintaining not less than 50% of the hydrants required to protect each fire compartment.

This will be implemented in the design of the ring main.

8.2.21 Radiant heat exposure protection.

The consequence effects of jet fires and Diesel pool fires would need to be definitively specified – based on plant layout and separation distances to be determined in detail design of the NPS.

Any firefighting tactics and strategies would require that people operating mobile monitors, hydrant hoses or activating fire pumps, will be located outside the 4.7 kW/m^2 heat flux contour regions determined in a consequence effects analysis.

8.2.22 Firewater pump and static firewater storage facilities

A firewater pump system, together with a static firewater tank will be provided, if the town main has insufficient supply (volumetric flow rate and inlet pressure in the external firewater supply).

If the town main has a sufficient flow capacity (flow rate), but insufficient pressure, a booster fire pump will be considered.

A firewater pump selected shall comply with the design and maintenance requirements in the standards and codes of practice indicated in Table 6.

Calculations carried out to establish the required volume of firewater required, based on consideration of the application rates and run times required to fulfil the likely fire response strategies for the various scenarios, will be revised once the firewater requirements for transformers, generators and gas yard have been finalised.

Sufficient firewater will be provided for fire monitor, sprinkler system and hydrant operations. A sufficiently sized static firewater tank will be installed for this purpose.

The sprinkler systems recommended to be installed will require a minimum water supply from the static firewater tank of 60 minutes plus 20%. A 2-hour period will be adopted as NFPA 850 requires a 2 hour duration.

Consequence modelling will be used to determine the safe location area of pumps, monitors and hydrants – outside 3.0 kW/m^2 contour.

8.2.23 Firewater requirements

The duration of supply for a maximum fire scenario demand is for a period of 2 hours.

The maximum volume of firewater required – for a period of 2 hours, is for a turbo – generator fire, with extinguishment or cooling by installed sprinklers. The volume of water required is a preliminary estimate of 679 m^3.

A wastage factor will be used in the calculation of cooling water application by monitors and hydrants.

8.2.24 Hydrocarbon gas detectors

Hydrocarbon detectors will be installed in the Gas Yard and at optimum locations near the reciprocating engine or combustion turbine enclosures. The locations will be determined by means of dispersion modelling and once the layouts have been specified.

8.2.25 Mobile monitors & hydrants

Mobile monitors will be used to cool plant and equipment exposed to impinging jet fires, to cool a diesel tank exposed to a diesel pool fire and to extinguish a diesel pool fire.

Mobile monitors have great flexibility and can be moved into position for maximum effectiveness. The mobile monitors will be operated from hydrants.

It may be necessary to deploy two mobile monitors in the event of a bund fire. Monitors will be located so that monitor streams are available from opposite directions, so that at least one monitor will be available for various wind directions.

Mobile monitors can be rapidly deployed to provide firewater where required in the event of a vehicle fire in any of the roads within the plant.

A full surface diesel tank fire will be extinguished by directing firewater via a mobile monitor onto the exposed liquid surface.

Monitor operational specifications could be based on information provided in NFPA 850 and NFPA 15.

A monitor and hydrant coverage plan will be developed once the plant layout has been determined and ringmain designed.

Hydrant protection for the Administration Building will be determined once the floor area has been decided.

Hydrants will be sufficiently located to provide firewater where required in the event of a vehicle fire in any of the roads within the plant.

8.2.26 Hydrants and hose reels

Hydrants and hose reels will be provided, spaced and located in accordance with the requirements of the specified standards and codes of practice in Table 6.

8.2.27 Maintenance of fire protection equipment

Pump sets, mobile monitors, hydrants, isolation valves, hose reels, fire extinguishers will be maintained by the operator AGL using the following standard - AS 1851-2005: Maintenance of fire protection systems and equipment.

8.2.28 Fire brigade booster assemblies

Fire brigade booster assemblies installed will be in accordance with AS 2419 and NSWFB requirements.

The booster assemblies will be protected from radiant heat exposure. All locations will have minimum and maximum input pressures shown on signage boards.

8.2.29 Drainage & flooding

Drainage and prevention of equipment flooding will be accomplished by one or more of the following:

- Floor drains
- Floor trenches
- Open doorways or other wall openings
- Curbs for containing or directing drainage
- Equipment pedestals
- Pits, sumps, and sump pumps

8.2.30 Sprinkler Systems

Automatic water sprinkler, spray, water mist and CAFS systems will be installed for protection of various items of plant equipment within the power plant, in accordance with NFPA 850.

Details are given in Section 7.4.3.

8.2.31 Turbine generator protection

A sprinkler system will be installed beneath the turbine- generator – if there are obstructions from structural members. This will be addressed in detail design. If such a system is installed, the sprinkler discharge density to be provided will be 12.2 LPM/m^2 over a minimum application of 464 m^2.

Turbine-generator bearings will be protected with an automatic closed-head sprinkler system utilizing directional nozzles. Automatic actuation will be implemented.

Fire protection systems for turbine-generator bearings will be designed for a density of 10.2 LPM/m^2 over the protected area of all bearings.

A listed fire resistant (i.e., less hazardous or less flammable) lubricating oil will be used

8.2.32 Smoke detectors

A smoke detection system will be installed throughout rooms containing electrical equipment, including walk-in-type consoles, above suspended ceilings where combustibles are installed, and below raised floors. Where the only combustibles above the false ceiling are cables in conduit and the space is not used as a return air plenum, smoke detectors are permitted to be omitted from this area.

Switchgear rooms and relay rooms will be provided with smoke detection systems.

8.2.33 Computer or telecommunication rooms

Automatic sprinkler protection or automatic water mist fire protection systems for computer or telecommunications rooms will be considered in a ‘Fire Protection Design Basis Document’ (Document to be developed during detail design).

8.2.34 Battery room protection

Provide battery room with ventilation to limit the concentration of hydrogen to 1 per- cent by volume. For further information refer to ANSI/IEEE

8.2.35 Transformers

The transformers will be protected with an automatic water-spray system.

The separation distances in the FM data sheets should be determined in detail design.

Transformer sprinkler design and separation distances given in Table 6, Page 32 and 7.4.6, Page 37.

8.2.36 Electrical switch rooms

VESDA (aspirating smoke detection system) will be considered for fire detection with Argonite gaseous suppression systems in cabinets and FM200 gaseous suppression in the switch rooms.

The switch rooms could be fire separated from surrounding areas by walls constructed of concrete block.

Low voltage switch rooms

Fire protection measures to be provided for low voltage (LV) switch rooms will be:

Switch rooms to have a minimum of two (2) hour fire resistance level (FRL) unless separated from main buildings and equipment by more than 10 m.

Portable fire extinguishers to be installed within the switch room.

Sub-floor cable areas to be sprinkler protected.

High Voltage (HV) Switch Rooms

Fire protection measures to be provided for high voltage (HV) switch rooms will be the same as low voltage rooms with additional requirements for oil type transformers from FM data sheet 5-4. The following will be provided:

Indoor transformer; 1-hour FRL rating, with sprinkler system installed with 15 LPM/m^2 density.

Indoor transformer: 3-hour FRL rating, including all Low Voltage Switch Room fire protection requirements the same as for low voltage switch rooms.

Outdoor transformers have an increased separation distance, according to FM requirements, with 2 m fire separation between units and a firewall with a 2-hour rating.

Outdoor transformers, with no or inadequate spatial or physical separation, will be provided with a water spray (deluge) system with 10 LPM/m^2 density.

Dry type transformers could be used where possible as these have lower fire and explosion risks.

8.2.37 Cables, grouped cabling, ducts

Fire- retardant cable insulation will be used.

Grouped electrical will be routed away from exposure hazards or protected as required by the ‘Fire Protection Design Basis Document’ (Document to be developed during detail design).

Cable trays will not be routed near sources of diesel. Where such routing is unavoidable, cable trays will be designed and arranged to prevent the spread of fire.

Automatic sprinkler systems should be designed for a density of 12.2 LPM/m^2 over 232 m^2 or the most remote linear 30 m of cable tunnels up to 232 m^2.

Sprinklers will be installed if plastic ducts are installed.

8.2.38 Indoor Diesel receiving areas

Any indoor diesel receiving areas will be provided with automatic sprinkler protection throughout.

Design details are given in Table 6.

8.2.39 Access/availability of hard stand areas for Fire Brigade devices

Adequate hardstand areas for firefighting appliances will be provided in the specification of the plant layout. This would need to comply with the FRNSW requirements.

8.2.40 Hose reels and fittings

Hose reels will be provided as a first aid measure providing an initial response in the early stages of small fires.

Hose reels will be located throughout the site to provide coverage for equipment where a release of flammable or combustible material is possible.

Hose reel coverage drawings will be developed once the layout of the NPS and separation distances have been finalized.

Details are given in Section 7.4.4.

8.2.41 Fire extinguishers

Portable fire extinguishers first aid measures will be provided according to requirements of standards, codes of practice and regulation and in particular AS/NZS 1841.1 and AS/NZS 1850. These will enable operating personnel to extinguish small fires.

Details are given in Section 7.4.5.

8.2.42 Fire control centre (FCC)

Designation of a fire control centre (FCC) is recommended – a special area within a building from where major emergency situations can be controlled and monitored and where supporting equipment is provided to assist in that function.

8.2.43 Alarms, communications & FRNSW Activities

A Fire Indicator Panel (FIP) will be installed.

The following are suggestions to be investigated in a revised FSS when the site layout and firefighting systems have been definitively specified.

A site emergency to be activated by any one of the following means:

Manual operation of the site EWIS system in the Fire Control Centre; and

Break glass alarm (BGA) panels.

Automatic Alarms to be installed that will occur with:

Activation of any monitor, hydrant, hose reel, sprinkler on site;

Hydrocarbon, heat and smoke detectors installed in any location on site

8.2.44 Early warning and indication system (EWIS)

A comprehensive early warning and indication system (EWIS) for raising alarms and to mobilise emergency teams will be installed.

Emergency responders will be able to communicate by:

- Landline telephone;
- Mobile phones; and
- Intrinsically safe 2-way radios.

An emergency command centre could be set up in the fire control centre (FCC). The location and activities within such a centre will be determined when the power plant is commissioned, but the type of equipment to be installed should be determined during the detail design phase.

8.2.45 Prefire plans and emergency procedures

A Fire Emergency Plan will be developed by AGL, after detail design, to include the following:

- Response to fire alarms and fire systems supervisory alarms
- Notification of personnel identified in the plan
- Evacuation of employees not directly involved in fire- fighting activities from the fire area
- Coordination with security forces and emergency services
- Fire preplanning that defines fire extinguishment activities
- Periodic drills to verify viability of the plan
- Control room operator(s) and auxiliary operator(s) activities during fire emergencies

Pre-fire plans and emergency procedures for various “worst case” explosions and fire scenarios will be developed by the operator AGL. Further information for the development of such plans is given in Section 7.4.7.

8.2.46 Flash fires and explosions

Releases of natural gas, diesel and transformer oil aerosols, if ignited, can lead to flash fires and explosions.

If ignition was delayed in the event of a gas, a vapour cloud could form. As natural gas is buoyant, the potential for a significant cloud build-up is low. If the vapour cloud reached an ignition source a flash fire or a vapour cloud explosion could result.

In the event of a flash fire, the vapour cloud burns rapidly without a blast wave and will then continue to burn as a jet flame from the release point. In the event of a flash fire, there is a high (100%) chance of a fatality within the vapour cloud, but due to the short duration of the flame, there is a low chance of significant impact outside the vapour cloud radius. However, after the flash fire, the jet fire continues to burn until the inventory is depleted, or the leak is isolated.

A vapour cloud explosion could occur if there is a potential for build-up of natural gas in congested areas, which restricts the flame front and results in an explosive overpressure which will impact people in the area. As there are no major structures near the pipeline, there is a very low likelihood of congestion and resulting vapour cloud explosion.

There is a potential for gas build-up in the compressor enclosure to result in an explosion in the event of ignition of the gas. The compressor enclosure will be provided with gas detection (alarm on 20% LFL and shutdown on 40% LFL), fire detectors (UV/IR) to detect lube oil fires and ventilation. The compressor unit should be designed to minimise the number of potential leak sources in the enclosure (e.g. by placing flanged equipment outside the enclosure).

Dispersion of natural gas from the vent stack reaching an ignition source could resulting in fire incidents.

Appendices

Appendix A
Drawings

Process Flow Diagrams

Preliminary process flow diagrams developed not included as some of the process is in development.

Power Generation System Drawings

Preliminary power generation system drawings developed are not included as some of the process is still in development.

Fire Service Layout Diagram

To be developed in consultation with FRNSW after the design and layout are completed.

Appendix B
Fire system calculations

Basic calculations

Fire Scenario	Firewater Flowrate (LPM)	Density LPM/m2	Coverage Area (m2)	Duration (min)	Firewater Volume (kL)	Cooling/Foam Application
Pool fire extinguishment	1,900			20	38	Mobile monitor
Cooling of tanks during a bund fire	1,900			120	228	Mobile monitor
Cooling of equipment impinged by jet fire	1,900			20	38	Mobile monitor
Cable Spreading Room and Cable Tunnels	2,830.4	12.2	232	120	340	Sprinklers
Turbine Generator Area	5,660.8	12.2	464	120	679	Sprinklers
Hydraulic equipment, reservoirs, coolers, and associated oil-filled equipment	1,468.8	10.2	144	120	176	Sprinklers
Indoor diesel receiving areas	2,845.8	10.2	279	120	341	Sprinklers
Oil filled transformer fire	1,468.8	10.2	144	120	176	Sprinklers

Firewater demands/maximum demand

The maximum cooling water rate required 5,660.80 LPM required in the turbo generator area and is based on a fixed deluge sprinkler system. The associated fire water storage requirement is calculated at 679 kL for a 2-hour application duration. The size of the firewater tank would be determined once the following information is available:

- The area of coverage required by the sprinkler system.
- The supply of firewater to the site for tank filling.
- Pressures, Flow Rates and Supply Duration

Appendix C
Consequences of Heat Radiation Exposure

Consequences of Heat Radiation

The table below is reproduced from the New South Wales Hazardous Industry Planning Advisory Paper No 2: *Fire Safety Study Guidelines*, Appendix 8, Guidance from FRNSW and other fire and emergency juristictions within Australia and AS 1940.

Radiation Intensity (kW/m^2)	Effect
1.0 - 1.2	Considered ‘routine’ tenability condition with 25 minute exposure limitation without protection Received from the sun at noon in summer
2.1	Minimum to cause pain in one minute
3.0	Considered ‘hazardous’ tenability condition with 10 minute exposure limitation without protection Maximum exposure for locating fire water / foam capable monitors assuming a maximum exposure of 10 minutes
4.5 - 4.7	Considered ‘extreme’ tenability condition with 1 minute exposure limitation without protection Will cause pain in 15 – 20 seconds and injury after 30 seconds exposure (likely second degree burn injury)
12.6	Significant chance of fatality for long exposure. High chance of injury Causes the temperature of wood to rise to a temperature where it will be ignited with 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
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 causing failure Pressure vessels will need to be relieved or failure will occur
35	Cellulose material will pilot ignite with one minute exposure Significant chance of fatality if people are exposed instantaneously

Heat Radiation Effect on Human Skin

The table below is reproduced from API 521 Section 5.7.2.3.1 “Effect on Human Skin” and gives the exposure time necessary to reach the pain threshold as a function of radiation intensity. It is important to note that the data was derived from tests given to people who were radiated on the forearm (i.e. bare skin exposure) at room temperature.

Radiation Intensity (kW/m^2)	Time to Pain Threshold (seconds)
1.74	60
2.33	40
2.90	30
4.73	16
6.94	9
9.46	6
11.67	4
19.87	2

Recommended Design Thermal Radiation for Personnel

The table below is reproduced from API 521 Section 5.7.2.3.1 “Effect on Human Skin” and presents the recommended design radiation levels for personnel at grade or on adjacent platforms. The extent and use of personal protective equipment can be considered as a practical way of extending the times of exposure beyond those listed Note that Appropriate clothing consists of hard hat, long-sleeved shirts with cuffs buttoned, work gloves, long-legged pants, and work shoes. Appropriate clothing minimises direct skin exposure to thermal radiation.

Radiation Intensity (kW/m^2)	Conditions
9.46	Maximum radiant heat intensity at any location where urgent emergency action by personnel is required. When personnel enter or work in an area with the potential for radiant heat intensity greater than 6.31 kW/m^2, radiation shielding and/or special protective apparel (e.g. a fire approach suit) should be considered. Safety Precaution—It is important to recognise that personnel with appropriate clothing cannot tolerate thermal radiation at 9.46 kW/m^2 for more than a few seconds.
6.31	Maximum radiant heat intensity in areas where emergency actions lasting up to 30 s can be required by personnel without shielding but with appropriate clothing.
4.73	Maximum radiant heat intensity in areas where emergency actions lasting 2 min to 3 min can be required by personnel without shielding but with appropriate clothing.
1.58	Maximum radiant heat intensity at any location where personnel with appropriate clothing can be continuously exposed.

Appendix D
Consequences of Overpressure Exposure

The table below provides impairment criteria for exposure to explosion overpressure. Data has been extracted from a number of sources including Loss Prevention in the Process Industries; Lees (1996), *Diagnostic features of explosion damage*; Clancey V J, 1972, *Guidelines for Chemical Process Quantitative Risk Analysis*; CCPS 2nd Edition, and NSW DPE HIPAP No. 2 *Fire Safety Study Guidelines*.

Peak side-on overpressure (kPa)	Potential damage
0.14	Annoying noise (137 dB) if of low frequency (1-15 Hz)
1.03	Typical pressure for glass failure
2.07	“Safe distance” (high probability no serious damage beyond this value) Missile limit; some damage to house ceiling, 10% window glass broken
2.76	Limited minor structural damage
3.5 - 7	Large and small windows usually shattered (90% glass damage) Occasional damage to window frames Partial demolition of houses, made uninhabitable
7 - 14	Steel frame of clad building slightly distorted Partial collapse of walls and roofs of houses Damage to internal partitions and joinery but can be repaired Probability of injury is 10%. No fatality
14 - 21	Unreinforced concrete or cinder block walls shattered (Lower limit of serious structural damage) 50% destruction of brickwork of houses
21 - 28	Reinforced structures distort Storage tanks fail 20% chance of fatality to a person in a building Heavy machines (3,000 lb) in industrial building suffer little damage Steel frame building distorted and pulled away from foundations Frameless, self-framing steel panel building demolished
30 - 48	Wooden utilities poles (telegraph etc.) snapped. Damage to buildings - nearly complete destruction of houses
48 - 55	Loaded train wagons overturned Brick panels, 8 – 12 in thick, not reinforced, fail by shearing or flexure

Appendix E
Hazard Word Diagram

Refer to the Preliminary Hazard Analysis

Appendix F
Statement of intent

AGL to provide a statement of intent once the design has been finalised

Appendix G
Emergency Response Plans

AGL to provide Emergency Response Plan documents once the design is finalised

Appendix H
Weather Stability Criteria

Refer to the Preliminary Hazard Analysis

Document prepared by

Aurecon Australasia Pty Ltd
ABN 54 005 139 873
Level 5, 116 Military Road
Neutral Bay NSW 2089
PO Box 538
Neutral Bay NSW 2089
Australia

T +61 2 9465 5599
F +61 2 9465 5598
E sydney@aurecongroup.com
W aurecongroup.com

aurecon

Bringing ideas to life