Hunter Power Project

Hazard and Risk Assessment

Rev 0

19 April 2021

Snowy Hydro Limited

Hunter Power Project

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Contents

List of figures

List of tables

Executive summary

Background

Snowy Hydro Limited (Snowy Hydro) ('the Proponent') proposes to develop a gas fired power station near Kurri Kurri, NSW ('the Proposal'). Snowy Hydro is seeking approval from the NSW Minister for Planning and Public Spaces under the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) for the Proposal.

The Proposal involves the construction and operation of an open cycle gas turbine power station and electrical switchyard, together with other associated infrastructure. The power station would have a capacity of up to approximately 750 Megawatts (MW) generated by two heavy duty gas turbines. Although primarily a natural gas fuelled power station, diesel operations are also expected as a backup, as required, if there were a constraint or unavailability in the natural gas system and there was a need to supply electricity to the National Electricity Market (NEM).

Assessment summary

The NSW Planning Secretary's Environmental Assessment Requirements (SEARs) for the environmental impact statement (EIS) requires that the level of risk assessment of likely impacts should be commensurate with the significance or degree or extent of impact within the context of the proposed location and surrounding environment and having regard to applicable NSW Government policies and guidelines. Specifically, the SEARs require a Hazard and Risk Assessment including:

- A Preliminary Hazard Analysis (PHA) consistent with Hazardous Industry Planning Advisory Paper No. 6 – Guidelines of Hazard Analysis (NSW, 2011) and Multi-level Risk Assessment (NSW, 2011) and demonstrating compliance with the criteria of Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011)
- An assessment of bushfire risk in accordance with Planning for Bush Fire Protection 2019 (NSW RFS, 2019)
- A plume rise impact assessment prepared in accordance with CASA's guidelines for conducting plume rise assessments, and an assessment of the potential impact to aviation in the vicinity of the Proposal.

Bushfire risk and aviation/ plume rise impact assessments have been delivered as separate studies in the EIS. This Hazard and Risk Assessment supports the EIS by providing analysis of industrial hazards potentially associated with the Proposal and in turn assessing the risk of harm to the community based on established planning criteria.

Key findings

HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011) provides risk criteria to evaluate the physical magnitude of a given risk and community concerns over risks that are imposed rather than voluntarily accepted. Risk criterion consider:

- Individual risk, which considers the acceptability of a particular level of risk to an exposed individual
- Societal risk, which takes into account society's aversion to accidents which can result in multiple fatalities.

The Proposal Site forms part of the now decommissioned Hydro Aluminium Kurri Kurri Pty Ltd, aluminium smelter site which ceased operation in late 2012 and was permanently closed in 2014. There is currently a proposal to rezone and subdivide portions of the Kurri Kurri aluminium smelter land as part of a future Industrial Estate. The Proposal Site is surrounded by undeveloped bushland to the north and west and proposed heavy and general industry land use immediately to the south and east. The nearest rural residential landuse is located some 1.15 km southeast of the Proposal Site in the suburb of Loxford. The residential areas of Kurri Kurri, Sawyers Gully and Cliftleigh are located some 2.5 km from the Proposal Site.

The more hazardous power station equipment supplying and handling natural gas is proposed to be positioned towards the western boundary of the Proposal Site, further away from any proposed future industrial development. The Proposal Site includes a buffer zone south of the main power station area which creates further space from proposed future industrial development.

In accordance with the SEARs assessment method, the Proposal is assessed to be a potential hazardous industry based on the volume of dangerous goods / hazardous chemicals proposed to be stored within the Proposal Site. Based on the Proposal's preliminary design, the greatest individual inventory of gas contained within a single confined item of plant is a mass of approximately 650 kg of ADGC Class 2.1 flammable gas. The Proposal Site's inventory of natural gas as "stored in process", totals approximately 1,300 kg inclusive of the third party's gas receiving station (GRS). When in operation the Proposal is well below the threshold for transportation risks associated with replenishing the diesel tanks or if combining all transport for Class C1 (combustible fluid, diesel) and Class 9 (miscellaneous chemicals). There is no credible operating scenario foreseen that this threshold would be exceeded.

Additional semi-quantitative consequence analysis of the Class 2.1 flammable gas hazards using the ALOHA modelling software indicated that the low-pressure gas turbine (GT) gas supply pipework (i.e. the power station gas infrastructure) is unlikely to generate an ignited gas release event having thermal radiation or blast overpressure consequences much beyond the power station site perimeter except for a small area along the western boundary adjoining rural bushland.

Supplementary risk analysis of the high-pressure (third-party designed, owned and operated) GRS indicated that there is risk of an ignited gas release event with thermal radiation and blast overpressure consequences extending to neighbouring industrial land-use allotments, but not to any residential or sensitive land-use zones.

Consequence frequency assessment demonstrated that while there is potential risk, the likelihood of the such events are within the range of safe land-use criteria.

No unusual risks have been identified that cannot be mitigated through the application of good industry practice, safety in design processes and operating practices. The Proponent has a long history of power generation and has developed and operates similar gas fired power stations across different Australian jurisdictions. Snowy Hydro have demonstrated systems to manage risks to satisfy enterprise and industry standards and to comply with statutory requirements.

1. Introduction

1.1 Background

Snowy Hydro (the Proponent) is seeking approval for the development and operation of a new gas fired power station (the Proposal) to be located at the now decommissioned Kurri Kurri aluminium smelter, owned by Hydro Aluminium Kurri Kurri Pty Ltd (Hydro Aluminium), in Loxford, north of Kurri Kurri in NSW. This report represents the Hazard and Risk Assessment component and addresses the Secretary's Environmental Assessment Requirements (SEARs) relating to the future operation of the Proposal.

The Proposal involves the construction and operation of an open cycle gas turbine power station and electrical switchyard, together with other associated supporting infrastructure. The power station would have a capacity of up to approximately 750 megawatts (MW) which would be generated via two heavy duty gas turbines. Although primarily a gas fired power station, the facility would also be capable of operating on diesel (as a back-up) as required, if there were a constraint or unavailability in the natural gas network and there was a need to supply electricity to the National Electricity Market (NEM).

The Proposal would operate as a "peak load" generation facility supplying electricity at short notice when there is a requirement in the NEM. The major supporting infrastructure that is part of the Proposal would be a 132 kV electrical switchyard located in the northern part of the Proposal Site. The Proposal would connect into existing 132 kV electricity transmission infrastructure located adjacent to the Proposal Site. A new gas lateral pipeline and gas receiving station (GRS) would also be required and this would be developed by a third party and be subject of a separate environmental assessment and planning approval.

Other ancillary elements of the Proposal include:

- Storage tanks and other water management infrastructure for potable water and demineralised water
- Fire water storage tanks and firefighting equipment such as hydrants and pumps
- Maintenance laydown areas
- Stormwater basin
- Diesel fuel storage tanks and truck unloading facilities
- Site access roads and car parking
- Office/administration, amenities, workshop/storage areas.

Construction activities are anticipated to commence early 2022 and the Proposal is intended to be operational by the end of 2023, with some operation potentially commencing by August 2023.

1.2 Secretary's Environmental Assessment Requirements (SEARs)

An Environmental Impact Statement (EIS) for the Proposal has been prepared under Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This Hazard and Risk Assessment has been prepared to support the EIS. The purpose of this report is to address the relevant sections of the Secretary's Environmental Assessment Requirements (SEARs) issued on 5 February 2021 (SSI 12590060). The report preparation has also taken cognisance of any applicable agency comments. Table 1.1 outlines the SEARs relevant to this assessment.

Table 1.1: SEARs relevant to this assessment.

Secretary's requirement
Hazard and Risks – including a Preliminary Hazard Analysis (PHA), covering all aspects of the project which may impose public risks, to be prepared consistent with *Hazardous Industry Planning Advisory Paper No. 6 – Guidelines of Hazard Analysis* (DPE, 2011) and *Multi-level Risk Assessment*. The PHA must demonstrate that the risks from the project comply with the criteria set out in *Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning* (DPE, 2011)

1.3 Hazard and risk assessment

The Hazard and Risk Assessment informs the environmental impact statement (EIS) by providing analysis of industrial hazards potentially associated with the Proposal and in turn assessing the risk of harm to the community based on established planning criteria as set out in the SEARs. This include:

- A Preliminary Hazard Analysis (PHA) consistent with Hazardous Industry Planning Advisory Paper No. 6 – Guidelines of Hazard Analysis (NSW, 2011) and Multi-level Risk Assessment (NSW, 2011) and demonstrating compliance with the criteria of Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011)
- An assessment of bushfire risk in accordance with Planning for Bush Fire Protection 2019 (NSW RFS, 2019)
- A plume rise impact assessment prepared in accordance with CASA's guidelines for conducting plume rise assessments, and an assessment of the potential impact to aviation in the vicinity of the Proposal.

Bushfire risk and aviation/ plume rise impact assessments have been completed as separate studies as part of the EIS.

The Hazard and Risk Assessment spans five processes:

1) The basis of design, information collection, data interpretation and hazard identification
2) Risk screening to direct the focus of the assessment towards those activities with a significant potential to impact the surrounding community
3) Detailed risk assessment of activities identified as potentially significant in the risk screening
4) Assessment of the Proponent's safety and risk management methods (safety management systems and emergency response)
5) Reporting of findings and conclusions regarding safe land use.

1.4 Scope of study

This Hazard and Risk Assessment is specific to the Proposal. The scope of the assessment includes:

a) The Open Cycle Gas Turbine (OCGT) power station with two generator units with a nominal output of up to approximately 750 MW
b) An on-site natural GRS and delivery lines to the OCGTs. Note that while the GRS is not part of the Proposal being assessed for approval, it is included in the PHA due to its proximity to the power station and potential contribution to hazard and risk
c) On-site bulk fuel storage tanks (diesel), bunding, tanker unloading, pumps and delivery lines to the OCGTs
d) Demineralised water and potable water facilities, storage, process chemicals and delivery systems
e) Ancillary infrastructure and buildings
f) Step-up transformers and 132 kV switchyard and associated infrastructure.

The scope of the assessment is limited to the current design of the Proposal, which is currently at a preliminary design stage. The scope of this Hazard and Risk Assessment does not include external propriety asset risks including:

- Third party proponent: a new gas lateral pipeline and gas delivery pipeline assets
- Network service provider: existing 132 kV transmission line assets
- Hydro Aluminium and the Industrial Estate Developer: demolition and contamination remediation of aluminium smelter site and proposed industrial estate development.

Bushfire risks and exhaust gas plume rise/ aviation risk assessments are presented as separate studies supporting the EIS.

1.5 Risk context

The Proponent has a long history of power generation and has developed and operates similar gas fired power stations in NSW and Victoria, diesel fired power stations in South Australia, and also the Snowy Mountains Hydro Electric Scheme in NSW. Within the Proponent's business, risks are managed to satisfy enterprise and industry standards and to comply with statutory requirements.

AS ISO 31000:2018 Risk Management – Guidelines provide a standardised approach to risk management and the framework for the Kurri Kurri OCGT power station EIS Hazard and Risk Assessment. Figure 1.1 summarises the risk assessment process.

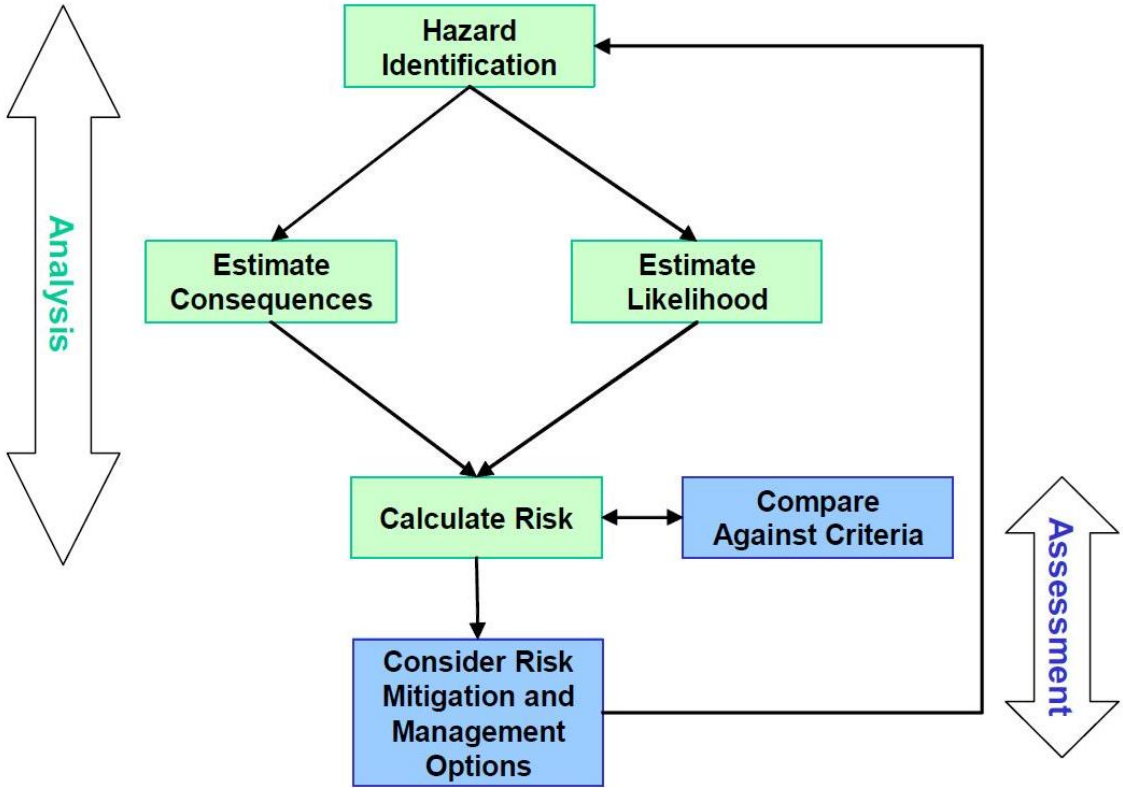


Figure 1.1: Standard Approach to Risk Assessment

NSW State Environmental Planning Policy No.33 (SEPP 33) Hazardous and Offensive Development instructs the identification of hazards and management of risks associated with hazardous or offensive industries to inform consent authorities assessing the proposed development. The former NSW Department of Planning developed an integrated assessment process for safety assurance of development proposals, which are potentially hazardous (NSW, 2011). The process entails three stages:

- Preliminary screening
- Risk classification and prioritisation
- Risk analysis and assessment.

The Preliminary Hazard Analysis (PHA) is referenced to Hazardous Industry Planning Advisory Paper No 6 Hazard Analysis (NSW, 2011) and determines the suitability of a site to accommodate a proposed development by understanding the hazards and risks. Once identified, hazards and risks associated with a proposed development are compared with established criteria as recommended in Hazardous Industry Planning Advisory Paper No 4 Risk Criteria for Land Use Safety Planning (NSW, 2011).

2. Site and process description

2.1 Site location and description

The Proposal Site is located in the small suburb of Loxford in the Hunter Valley region of New South Wales, approximately three kilometres (km) north of the town of Kurri Kurri, approximately 30 km west of Newcastle CBD and 125 km north of Sydney (see Figure 2.1).

The Proposal Site forms part of the now decommissioned Kurri Kurri aluminium smelter site which ceased operation in late 2012 and was permanently closed in 2014. The existing Kurri Kurri aluminium smelter property is being sub-divided into allotment for a future industrial estate and the Proposal Site will be largely rectangular in shape and flat. The Proposal Site is seen in Figure 2.2.

The natural gas supply to the Proposal Site would be via a new gas lateral pipeline (to be completed under a separate EIS approval by a third party proponent), originating from the existing Jemena JGN North Trunk gas transmission pipeline between Sydney and Newcastle. There are no natural gas bulk storage tanks at the Proposal Site. The third party proponent is responsible for the design, approvals, construction and operation the gas lateral pipeline and GRS.

2.2 Surrounding land uses

2.2.1 Land use overview

The Proposal Site is to be located within an industrial estate, anticipated to have both general and heavy industrial operations. Apart from the former Kurri Kurri aluminium smelter, there are no other established businesses within the proposed industrial estate at present. Unoccupied rural landscape as bushland extends from the north-east, across north and north-west of the Proposal Site. West of the Proposal Site is a special purpose infrastructure site – a containment cell for waste from the former Kurri Kurri aluminium smelter.

Figure 2.3 displays the proposed rezoning plan for the area incorporating the industrial estate development on the existing Kurri Kurri aluminium smelter site.

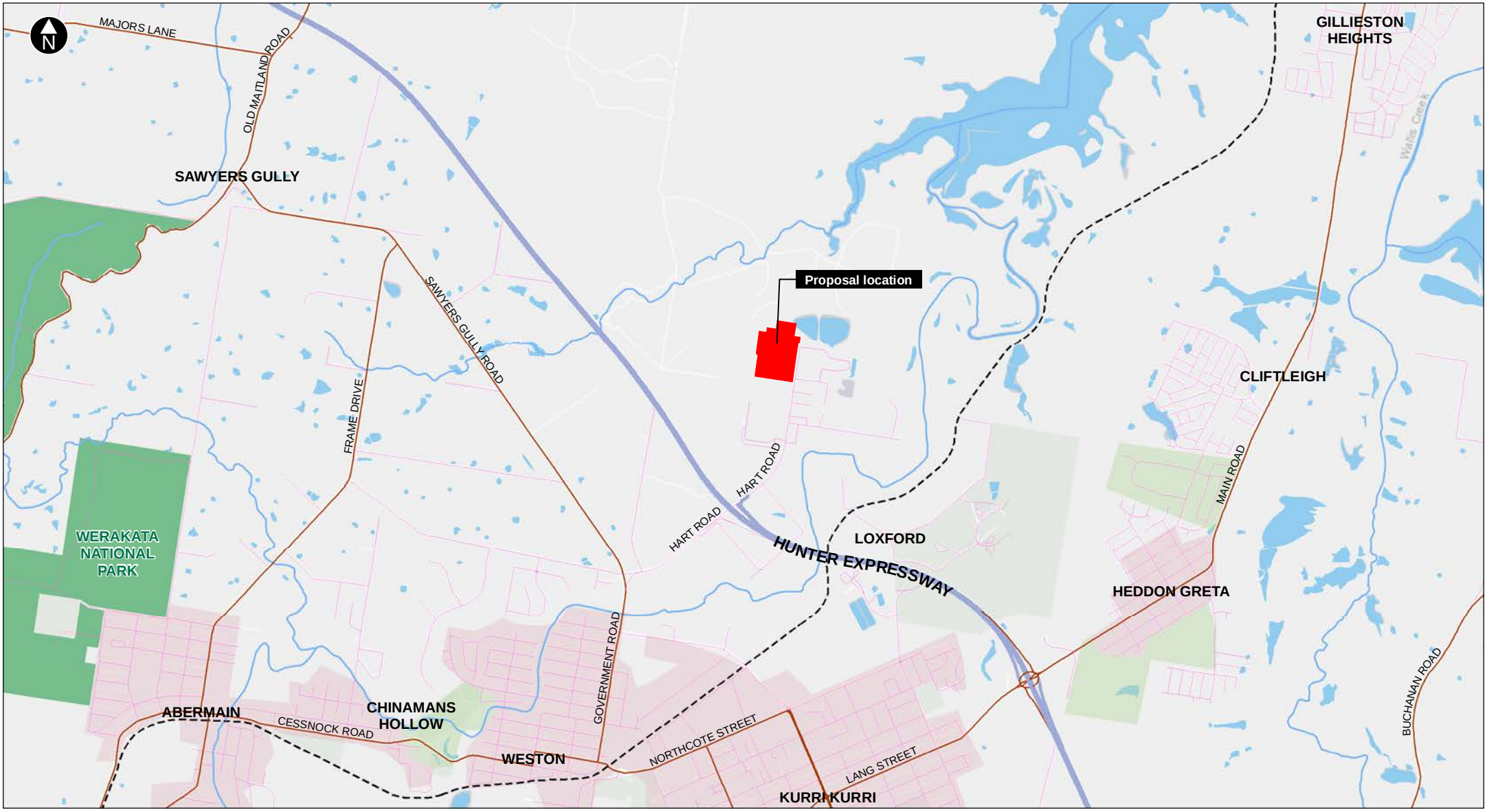
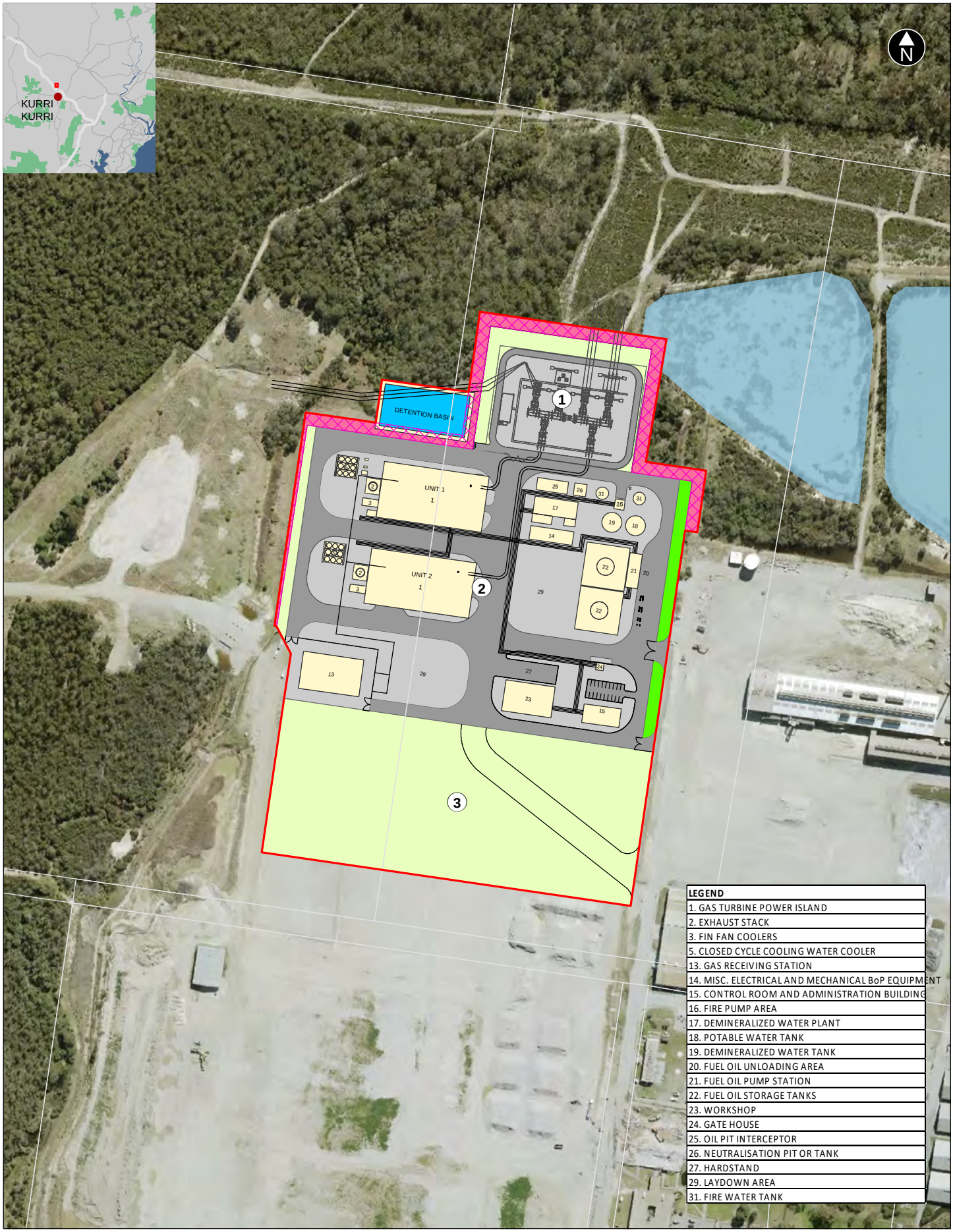


Figure 2-1 Proposal location (regional)



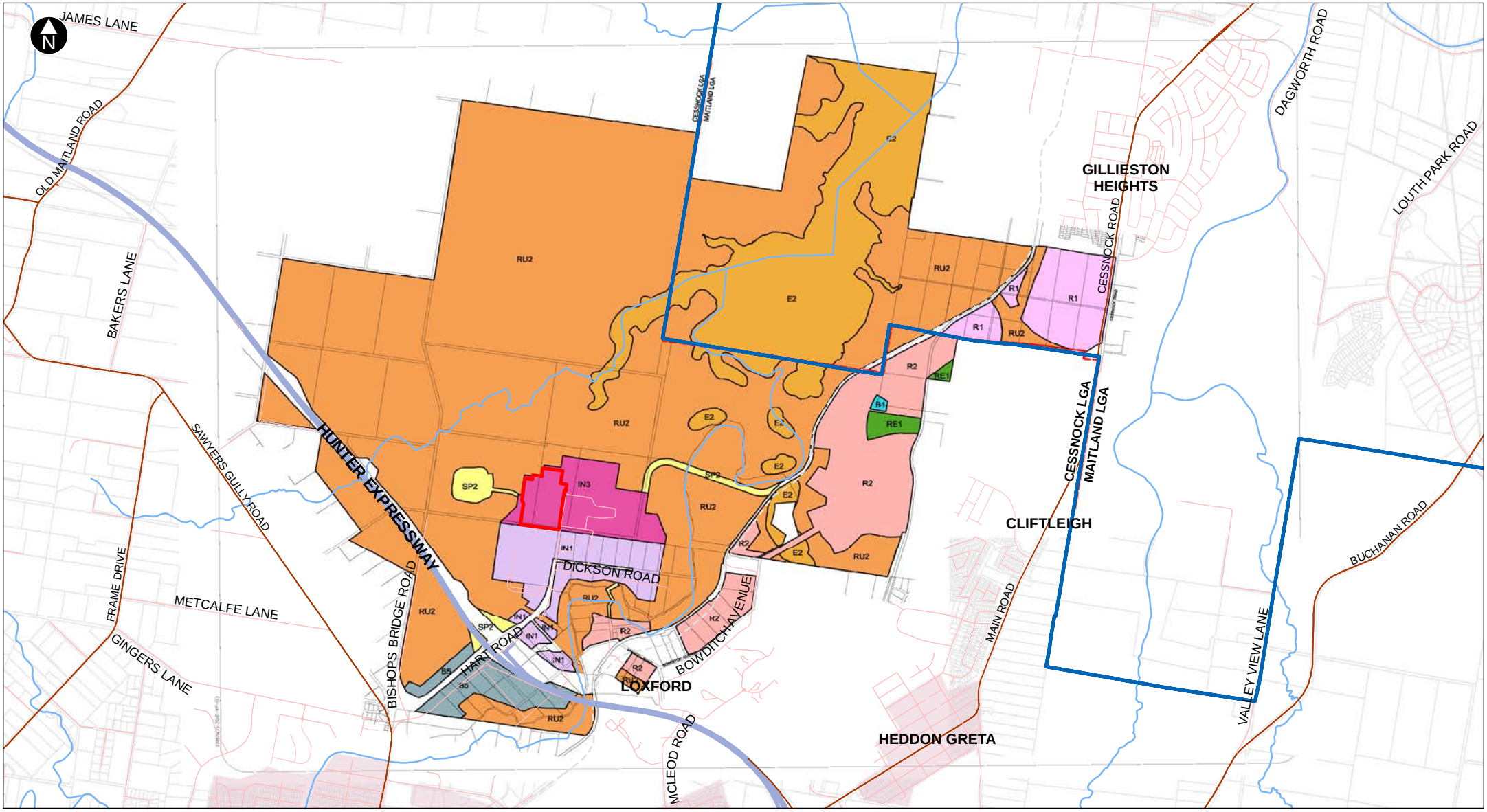
Proposal Site
Asset protection zone
Detention basin
Sealed roadway
Crushed rock
Landscaping
Grass / Road base
Existing waterbodies
Existing cadastre
1 Proposed Switchyard Area
2 Proposed Plant Area
3 Proposed Buffer Area

0 100 200 m

1:4,000 at A4
GDA2020 MGA Zone 56

Data sources:
Jacobs
Metromap (Aerometrex) 2020
NSW Spatial Services

Figure 2-2 Proposal Site Layout



Proposal Site
Urban areas
Cadastre
Motorway
Main roads
Roads
Railway
Local Government Area

B1	NEIGHBOURHOOD CENTRE (1.19ha)
B5	BUSINESS DEVELOPMENT (33.20ha)
E2	ENVIRONMENTAL CONSERVATION (268.51ha)
IN1	GENERAL INDUSTRIAL (65.73ha)
IN3	HEAVY INDUSTRIAL (53.48ha)
R1	GENERAL RESIDENTIAL (56.57ha)
R2	LOW DENSITY RESIDENTIAL (137.22ha)
RE1	PUBLIC RECREATION (8.54ha)
RU2	RURAL LANDSCAPE (1246.75ha)
SP2	SPECIAL PURPOSE INFRASTUCTURE (12.77ha)

0 1 2 km

1:40,000 at A4

GDA2020 MGA56

Source: McCloy Group, December 2020
Note: Subject to Planning Approval and subject to change.
This image has been georeferenced to this location.
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Figure 2-3 Hydro Kurri Kurri rezoning concept master plan

snowy hydro renewable energy Jacobs

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Created by : AA | QA by : KI

2.2.2 Residential and sensitive land use

Applying SEPP33 (NSW, 2011) refers to two land use groupings: (a) Residential and sensitive land use; and (b) Other land use (including rural, commercial and industrial). There are no residential or sensitive land use proximate to the Proposal Site. The type of industrial operations at the neighbouring lots within the proposed Industrial Estate[1] are not defined at the time of writing this report, but the proposed zoning is Heavy Industrial and General Industrial land uses. The closest residential zoned land is the suburban areas of Kurri Kurri, located approximately three km south and south-west of the Proposal Site. Further residential areas at Heddon Greta and Cliftleigh are situated approximately 2.5 km to the east of the Proposal Site. There are some sparse rural residential properties south and south-east of the Proposal Site, the nearest being located on Dawes Avenue, Loxford which is approximately 1.15 km south-east of the Proposal Site.

2.2.3 Populations at risk

Three populations external to the Proposal Site are considered for risk analysis purposes:

- Industrial Estate occupants, at < 0.2 km distance
- Rural Residential occupants, at 1.15 km distance
- General/Low Density Residential, at > 2.5 km distance.

Table 2.1 presents the population density estimates for the three risk populations.

Table 2.1: Risk Population Density Estimates

Risk Population	Population Density Estimate	Basis of Estimate and Assumptions
Industrial Estate	150.0 persons / km^2 [1.50/ha]	Allow 300 occupants[2] over $2km^2$
Rural Residential	4.8 persons / km^2 [0.05/ha]	Loxford area. Allow 50[3] occupants over 10.5 km^2
Urban Residential	1185.1 persons / km^2 [11.85/ha]	Kurri Kurri area. 6044[4] occupants over 5.1 km^2

The Industrial Estate occupants are expected to have principally indoor/daytime occupancy; Rural Residential occupants are expected to have outdoor occupancy, mainly day-time but also across night-time periods; and Urban Resident occupants are expected to have more night-time indoor occupancy.

2.3 Summary of design and operation

The proposed power station will have a nominal output of up to approximately 750 MW, from a two industrial F-Class Open Cycle Gas Turbines. The final power station output will be dependent on the eventual gas turbine model selected. The following are some other key Proposal parameters:

- The Proposal is intended to be operational by the end of 2023, with the first unit potentially commencing operations by August 2023
- The gas turbines will primarily be fired on natural gas with diesel as a backup fuel:
  - The natural gas would be supplied from a new gas lateral pipeline to be developed by a third partly proponent and will be connected into the existing Jemena JGN North Trunk gas transmission pipeline between Sydney and Newcastle

[1] Industrial Estate being developed on the Hydro Aluminium Kurri Kurri aluminium smelter site. Unverified estimate. Equates to 0.000150.persons / m^2.
[2] Estimated occupants, assume principally daytime workers.
[3] Estimated rural residential occupants with 24hr/365day occupation. Equates to 0.000005.persons / m^2
[4] https://en.wikipedia.org/wiki/Kurri_Kurri,_New_South_Wales. Equates to 0.001185.persons / m^2

  - Diesel fuel would be supplied by single or B-Double road tankers[5] and would be stored on the Proposal Site in two bunded bulk fuel storage tanks, each nominally 1.75 ML. The size of the diesel bulk fuel storage tanks has been based on the largest gas turbine consumption rate and this may reduce depending on the eventual gas turbine selected for the Proposal.
- The power station generators' step-up transformers will be located within the power station boundary and will step up the generator voltage to 132 kV for the connection to the National Electricity Market (NEM) at the proposed connecting 132 kV electrical switchyard
- The connecting 132 kV electrical switchyard will eventually be operated by Ausgrid as the local network service provider. Existing 132 kV transmission lines exit the switchyard and connect into the Kurri Kurri Zone Substation and the Newcastle Terminal Station.

2.4 Operating hours and staffing

The Proponent is seeking approval for the operation of the power station with a capacity factor[6] of up to 10 percent on natural gas and up to 2 percent on diesel. However, this is dependent upon market conditions and the actual plant operation capacity factor is likely to be in the order of two percent.

The power station will be fully automated, with operations, control and monitoring to be performed from Snowy Hydro's existing remote-control facility in Cooma, NSW and/or the Proposal Site. Local control of the power station is able to be taken as required. The electrical switchyard will also be designed to be fully automated and is expected to be largely unmanned during operation.

Approximately 10 permanent local staff will be in attendance during business hours and respond to callouts as required outside of business hours. Additional maintenance staff and contractors will be present during large gas turbine maintenance events, being up to approximately 50 personnel.

2.5 Meteorological summary

The meteorological profile of the Loxford area was estimated by the Cessnock Airport automatic weather station (AWS). Table 2.2 presents the summary weather profile for the region and Appendix C presents the average annual wind rose diagram.

Table 2.2: Annual Weather Data – Cessnock Airport AWS

Weather Metric	Data
Mean daily maximum temperature (°C)	24.3
Mean daily minimum temperature (°C)	10.5
Mean annual rainfall (mm)	729.4
Mean 3pm temperature (°C)	22.8
Mean 3pm relative humidity (%)	49
Mean 3pm wind speed (km/h)	16.9
Indicative dominant 3pm wind direction	E [15%] SE [20%] NE [20%] refer Appendix C

[5] B-Double diesel tanker volume is approximately 50Kl and delivery count to replenish is estimated at 6 per day, but averaging 3 occasions per year.
[6] The capacity factor is the proportion of actual energy generated per year (expressed as MWh) compared with the total energy that could have been produced if operating at full load for every hour of the year (expressed as MWh).

3. Study methodology

3.1 Multi-level risk assessment

The former NSW Department of Planning's Multi-Level Risk Assessment Guidelines (NSW, 2011) presents a stepwise assessment method to determine if a proposed industrial development poses significant risk to the safety of surrounding land use. The Guidelines outline three levels:

- Preliminary screening
- Risk classification and prioritisation
- Risk analysis and assessment.

The Guidelines set out criteria for using the results of the preliminary screening, and risk classification and prioritisation steps to determine which of three levels of further analysis is appropriate:

- Level 1 is an essentially qualitative approach based on comprehensive hazard identification to demonstrate that the activity does not pose a significant off-site risk
- Level 2 supplements the qualitative analysis by sufficiently quantifying the main risk contributors to show that risk criteria will not be exceeded
- Level 3 is a full quantitative analysis.

3.2 Preliminary screening

The Multi-Level Risk Assessment (NSW, 2011) describes a preliminary screening process applied to exclude those developments which do not pose significant risk. Applying SEPP 33 Guideline (NSW, 2011) lists categories of industries with the potential for off-site offensive impacts.

The NSW Environmental Planning and Assessment Regulations (2000), Schedule 3 definition of potential offensive industry includes:

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

As the proposed power station will have a nominal output of up to approximately 750 MW, it is therefore deemed as a potentially offensive industry development. This triggers the requirement to include assessment of risk of hazards impacting on neighbouring land use and occupants.

3.3 Risk analysis method determination

The required level of risk analysis should be applied per HIPAP[7] No. 6 – Hazard Analysis (NSW, 2011) as follows in Table 3.1.

Table 3.1: Risk Analysis Method (after NSW, 2011)

Harm potential	Risk analysis method
Not Potentially Hazardous	No Analysis
Non-Serious Harm Potential	Qualitative Analysis
Medium Harm Potential	Semi-Quantitative Analysis
High Harm Potential	Quantitative Analysis

[7] HIPAP: Hazardous Industry Planning Advisory Papers

3.4 Risk criteria

HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011) provides risk criteria to evaluate the physical magnitude of a given risk and community concerns over risks that are imposed rather than voluntarily accepted. Risk criterion consider:

- Individual risk – which considers the acceptability of a particular level of risk to an exposed individual
- Societal risk – which takes into account society's aversion to accidents which can result in multiple fatalities.

Underpinning the risk criteria are the key principles that:

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

3.4.1 Individual risk criteria

Individual risk criteria are suggested for fatality, injury, and property damage. In the case of fatality, the criteria differentiate between the various types of land use, acknowledging the need to protect the more vulnerable members of the community.

Individual fatality risk

Individual Fatality Risk is the risk of death to a person at a particular point of risk exposure, assuming the subject is at the point of risk exposure 24 hours per day, 365 days per year. Table 3.2 provides the former Department of Planning (NSW, 2011) individual fatal risk banding by land use.

Table 3.2: Individual Fatality Risk Criteria (after NSW, 2011)

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

Individual injury risk

Individual Injury Risk criteria enables assessment in terms of levels of effects that may cause injury to people but will not necessarily cause fatality. HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011) provides risk criteria to evaluate injuries resulting from:

- Heat radiation
- Explosion overpressure
- Toxic exposure.

Table 3.3 presents individual injury risk and associated risk criteria.

Table 3.3: Individual Injury Risk Criteria (after NSW, 2011)

Injury Risk Event	Risk Criteria (injuries per million per year)
Heat Radiation [4.7 kW/m^2][8]	50
Explosion Overpressure [7 kPa][8]	50
Exposure to Toxic Gas/Smoke/Dust [Serious Injury on Short-Term Exposure]	10
Exposure to Toxic Gas/Smoke/Dust [Irritation Injury on Exposure]	50
Industrial Applications	50

Property damage / secondary incident propagation

Hazardous industry developments must account for the potential of an accident at the installation causing damage to buildings and propagating to neighbouring industrial operations and possibly initiating further incidents. HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011) provides risk criteria to evaluate property damage resulting from:

- Heat radiation
- Explosion overpressure.

Table 3.4 presents property damage risk and associated risk criteria.

Table 3.4: Property Damage Risk Criteria (after NSW, 2011)

Property Damage Risk Event	Risk Criteria (property damage per million per year)
Heat Radiation [23 kW/m^2][9]	50
Explosion Overpressure [14 kPa][10]	50

3.4.2 Societal risk criteria

Societal risk criteria are recommended, based on the ALARP (as low as reasonably practicable) principle. Qualitative criteria are also suggested for risks to the environment. HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011) provides risk criteria to evaluate societal tolerance to industrial accidents.

[8] Residential risk recipients
[9] Industrial [Potentially Hazardous] risk recipients

4. Hazard identification

4.1 Hazardous chemicals and dangerous goods

Hazardous chemicals are substances, mixtures and articles that can pose a significant risk to health and safety if not managed correctly. They may have health hazards, physical hazards or both in a work health and safety context. Dangerous Goods are hazardous chemical substances that are corrosive, flammable, combustible, explosive, oxidising or water-reactive or have other hazardous properties. Dangerous Goods can cause explosions or fires, serious injury, death and large-scale damage associated with handling, transport and storage context.

4.1.1 Hazardous chemicals: power station

For the purpose of the Hazard and Risk Assessment, hazardous chemical risks are analysed with reference to land use safety planning impact. While it is anticipated that the Proposal development will handle, transport and store minor quantities of hazardous chemicals / dangerous goods, the risks associated with these is more relevant to the work health and safety context and are not considered for this analysis. Table 4.1 presents the list of hazardous chemicals that may reasonably be on site either within equipment or during maintenance and operation of the Proposal.

Table 4.1: Typical Operation and Maintenance Chemical Inventory

Chemical	Risk Context	Risk Management
Nitrogen (N2) Sulphur hexafluoride (SF6) Acetone (C3H6O) Aerosols (propellant) Acids, hydrochloric acid (HCl) or sulphuric acid (H2SO4) Caustic, sodium hydroxide (NaOH) Chlorine remover, e.g. Sodium bisulphate Biocide, e.g. DNBPA based solution Anti-scalant Anti-foam Fire suppression foam Vegetation control, e.g. glyphosate (C3H6NO5P) Hydrocarbons such as transformer oil, lubricating oil and grease.	Minor quantities for operational and maintenance purposes.	Handling storage and transport safeguards are to statutory, code and standard requirements.

In addition to minor quantities of hazardous chemicals for operation and maintenance, Table 4.2 presents the main hazardous chemicals / dangerous goods as fuel (see Appendix C) associated with the Proposal.

Table 4.2: Principal Hazardous Chemicals

Hazardous Chemical	Description	CAS RN / UNID	DG Class	Pressure/Volume/Method
Natural Gas: Methane 93 mol% Ethane 6 mol% Other 1 mol%	Invisible, highly flammable gas which forms explosive mixtures in air.	8006-14-2 / 1971	ADG7 Class 2.1 Flammable Gas	Approximately 38 bar(g) to 47 bar(g) delivered pressure / up to approximately 152 t/hr / pipeline
Diesel Fuel: Low Sulphur	Combustible hydrocarbon liquid fuel.	68334-30-5 / 3082	ADG7 Class C1 Combustible Liquid	Approximately 3.5 ML [2 x 1.75 ML Bulk Diesel Storage Tanks] / B-Double Road Transport

Table 4.3 presents the proposed major chemical risk summary.

Table 4.3: Chemical Risk Summary

Chemical	Risk Context	Risk Management
Natural Gas Fuel	Major quantities for operational purposes. Manifest and Placard quantity. Potentially hazardous industry	Handling and transport [pipeline] safeguards are to statutory, code and standard requirements. Land use safety planning.
Diesel Fuel	Major quantities for operational purposes. Manifest and Placard quantity. Potentially hazardous industry	Handling, storage and transport [road] safeguards are to statutory, code and standard requirements. Land use safety planning.

4.1.2 Fuel delivery and storage infrastructure

Natural gas fuel

Natural gas will be supplied to the Proposal Site by a gas lateral[10] pipeline. The pipeline will be buried below ground level within an easement and will be connected to the GRS at the Proposal Site.

The power station plant within the Proposal Site will not incorporate gas compression equipment. The delivery pressure provided by the gas lateral is assumed to be enough for the gas turbine allowing for some pressure loss in the interconnecting pipeline. Pipeline and valve sizing (including in the GRS) are to consider static and dynamic pressure control requirements during gas turbine start, stop and upset conditions. All on-site piping will be located within trenches and certain sections above ground and be accessible for maintenance.

[10] The gas lateral pipeline is outside the scope of the Proposal

Diesel fuel

Diesel fuel will be delivered to the Proposal Site by B-Double road transport vehicles and unloaded at the proposed unloading station, within the Proposal Site, by unloading pumps located in a bunded facility which will transfer the diesel to two approximate 1.75 ML nominal bulk fuel storage tanks. The tanks would be in a bund which will have a nominal net capacity of 110 per cent of the largest tank capacity (as per the requirements of AS 1940).

4.1.3 Other storage infrastructure

The Proposal will also incorporate other non-hazardous bulk storage tank infrastructure on the Proposal Site including for demineralised water [approximately 1 x 1.6 ML], firefighting water [approximately 2 x 0.5ML] and potable water [approximately 1 x 1.6 ML].

4.2 External and interfacing hazards

The PHA considered external hazards capable of impacting on the proposed operation or compounding risks associated with operational hazards. There is currently no data to analyse external and interfacing hazards of future industrial applications on neighbouring lots at the Industrial Estate. Bushfire hazards are creditable external and interfacing hazard and are addressed in a separate supporting report to the EIS.

4.3 Operational hazards

A Hazard and Risk Workshop was undertaken during this assessment. The Hazard and Risk Workshop sought input from the Proponent, the Industrial Estate Developer and designers to identify general operational hazards with potential land use and environmental impacts. The output was prepared as a hazard table permitting screening for relevance to land-use safety impacts.

4.3.1 Major hazard events

The Proponent's Major Accident Event analysis has identified four risks:

- Gas Supply Failure causing uncontrolled release of flammable gas from power station gas line or in gas turbine enclosure
- Gas Turbine Failure causing uncontrolled release of rotating parts or projectiles from the gas turbine[11]
- Above Ground Transformer Fire causing uncontrolled release of electrical energy from above-ground transformers leading to fire or explosion[12]
- High Voltage Generator Failure causing uncontrolled release of kinetic energy from generator motor equipment leading to fire, explosion, or catastrophic failure[13].

Of the identified major hazard events, the impacts from Gas Supply Failure releasing flammable gas may pose the highest risk to surrounding land use safety. Gas Turbine Failure, Above Ground Transformer Fire and High Voltage Generator Failure hazard scenarios are likely to be operational and limited to on-site risk exposures.

[11] Gas turbine failures including destructive release are most likely to have localised and contained impact causing reduced performance, severe damage to the turbine and significant cost (**Rajabinezhad et al, 2020; Abad et al, 2013; Ghasemian, 2017).**

[12] Transformer oil classified as an ADGC Class 9 miscellaneous, is a process chemical for electrical transformers. Transformer oil is "stored in process" as a closed circuit system, per transformer. Primary electrical fire risk in transformers arise from component failure and then either internal electrical arcing and/or external flashover. In turn heat is generated associated with initial fuel as combustible materials, then transformer oil may react expanding its storage containment, spilling to initiate a secondary fire event. Guide for Transformer Fire Safety Practices (Conseil International des Grands Réseaux Electriques CIGRE, 2012) report that fire events are primarily localised to the affected transformer unit with a low, but not negligible risk.

[13] Maughan (2013) suggests major destruction at the failure location due to burning and arcing damage in generator failure.

5. Supplementary risk analysis

There are two infrastructure items relevant to the Proposal which are proposed to be owned and operated by a third party. These are:

- Gas lateral pipeline
- Gas receiving station.

NSW Department of Planning Industry and Environment (DPIE) recognise that the gas lateral pipeline (including the GRS) will be subject to a separate EIS within the critical State Significant Infrastructure declaration. While the third party will assess the Hazards and Risks associated with the gas lateral pipeline and GRS, the GRS is also included as part of this Proposal PHA due to the potential contribution to risk in terms of land use safety planning.

5.1 Gas Lateral Pipeline

The gas lateral pipeline will be designed, constructed, operated and maintained by a third party. The gas lateral pipeline will comprise a high-pressure pipeline in the order of 15-20 km in length and which is subject to NSW Pipelines Act 1967. Planning approval for the gas lateral pipeline will be sought by the pipeline proponent, and for this reason, the gas lateral pipeline risk will be analysed independently and does not form part of this analysis.

5.2 Gas Receiving Station

The GRS will also be the third party's asset and responsibility, located in a separate compound within the Proposal Site. The risk associated with the GRS will be included as a component of the gas lateral pipeline.

Functionally, the GRS is situated within the Proposal Site and therefore could affect the cumulative risk profile of the Proposal. For this reason, the risks associated with the GRS have been considered in the context of the Proposal PHA[14].

The GRS forms the tie-in to the Proponent's power station, and the risk analysis follows the method previously described in Section 3 of this report.

5.2.1 Assumptions

At the time of this risk analysis the design of the GRS was at a preliminary design stage, providing only general specification and sizing information. In situations where such information could impact on the risk analysis, assumptions have been made and as such are intentionally conservative.

5.2.2 Location and Surrounding Land Use

The GRS compound is proposed to be located in the south-west corner of the power station area, in a controlled access compound within the Proposal Site. Immediately west is unoccupied rural landscape and to the north is the power station, then rural landscape. To the east is planned general industrial zoning; to the south of the GRS is the power station noise buffer area of the Proposal Site, and then further planned general industrial zoning.

5.2.3 Design and Operation

The GRS includes gas metering, pressure regulation, heating stations, potential pigging facilities (to clean and inspect the gas pipeline) and potential provision for flaring.

[14] Noting that the scope of the Hazard and Risk Assessment cannot and does not infer responsibility for hazards and risks associated with the Gas Receiving Station.

Table 5.1 provides a summary of design information including assumptions. This information is at a conceptual level as design of the GRS has not yet commenced in detail.

Table 5.1: Summary of Gas Receiving Station Design [including assumptions]

Element	Design Specification / Assumption
Operational	Allows for 100% on basis that the GRS is an on-demand system.
Maximum Estimated Operating Pressure	14.0 MPa(g) [Estimate]
Operating Pressure	4.0-7.0 MPa(g)
Operating Temperatures	15 – 30 °C [Estimate]
Upstream Operating Pressure	7.0 to 14.0 MPa(g) [Estimate]
Downstream Operating Pressure	<= 4.0 MPa(g)
Design Standard	AS 2885.0 Pipeline – Gas and Liquid Petroleum AS 1210 – Pressure Vessels AS 4041 – Pressure Piping ASME B16.5 – Pipes and Flanged Fittings
Safeguards and Controls	Safety valves / Pressure-relief devices will be fitted to the equipment
Security	Separate, locked access-restricted compound within the power station boundary
Location Classification AS2885.6	Industrial (I) – General Industrial

5.2.4 Risk Criteria

Refer to Section 3.4 of this report.

5.2.5 Identified Hazards

Properties of natural gas are presented in Section 4.1.1. Table 5.2 describes the principal hazard associated with the GRS.

Table 5.2: Gas Receiving Station

Hazard Reference	Description
Plant Process Area	Gas receiving station
Phase of Proposal likely to occur	Operation
Risk Description	Potential for loss of control of natural gas supply at GRS, leading to release of flammable gas, fire or explosion at the GRS.
Cause	GRS asset unplanned change, failure, malfunction, or damage. External event impacting or causing unplanned operational change to GRS operation. Human factor event impacting or causing unplanned operational change to GRS operation. Secondary event/s associated with the primary GRS fire or explosion event.

Hazard Reference	Description
Consequence	Hazardous Chemical [natural gas] release to environment. Equipment damage and cost. GRS fire. GRS explosion and shrapnel projection/damage. Fire transferred to directly injure people, damage other project equipment or external property/environment. Explosion and GRS shrapnel projection transferred to directly injure people, damage other project equipment or external property/environment.
Control/ Treatment [if provided]	GRS pressure management and protective system/s. GRS safety, integrity, and reliability protection design. GRS security compound. Power Station CCTV and boundary security. Environmental controls and natural gas release management. Fire detection and suppression system/s. Personnel access restriction. Emergency response.
Impact Assessment / Recommendations	Operational impacts. Could impact nearby industrial land use. Could impact the environment.
Potential Offsite Impacts	Yes

6. Hazard screening

6.1 Hazard quantity screening

Applying SEPP 33 – Hazardous and Offensive Development Application Guidelines (NSW, 2011) provides a risk screening method to determine potentially hazardous development.

6.1.1 Natural gas, Flammable Gas Class 2.1

For the hazard screening purposes:

- Pressurised natural gas is an Australian Dangerous Goods Code (AGDC) Class 2.1 Flammable Gas
- From section 4.1.1 the natural gas is delivered to the power station's gas delivery network from the GRS at up to approximately 152 t/hr and may be held in process in the GRS and within the power station piping in below ground delivery pipework and above ground pipework and equipment
- A design estimate of 1.3 tonne of ADGC 2.1[15] pressurised natural gas could be held in process systems and equipment on the Proposal Site. This comprises of:
  - Approximately 550 kg in underground non-storage pipework
  - Approximately 100 kg in above ground non-storage pipework and equipment
  - Approximately 650 kg in process at the GRS.

Figure 6.1 shows the heat radiation effects for various quantities of natural gas. For the estimated 1,300 kg of pressurised natural gas held on the Proposal Site, it can be seen that sensitive receptors should be at least 50 m away. From section 2.2.1. the nearest sensitive receptors are:

- Rural residential properties on Dawes Avenue and Bowditch Road at Loxford at approximately 1.15 km to the south-east of the power station.
- Residential zoned land is the suburban areas of Kurri Kurri, located approximately three km south and south-west of the Proposal Site and residential areas at Heddon Greta and Cliftleigh are situated approximately 2.5 km to the east.

Therefore, no sensitive receptors are predicted to be impacted by heat radiation effects.

From Figure 6.1 for the estimated 1,300 kg of pressurised natural gas held on the Proposal site, other landuses (such as industrial, rural landscape and special purpose infrastructure) should be at least 35 m away. Table 6.1 presents the approximate distance from the nearest pressurised gas system to the Proposal Site property boundary.

Table 6.1: Distance to Proposal Site Boundary

Proposal System	Boundary	Relevance	Approximate Distance to Proposal Site boundary (m)
Power station underground non-storage pipework and above ground non-storage pipework and equipment	Northern	Faces other landuse (Rural Landscape - bushland)	60
Power station underground non-storage pipework and above ground non-storage pipework and equipment Gas receiving station	Eastern	Faces other landuse (future Industrial)	150 250

[15] Per Applying SEPP33 Hazardous and Offensive Development Application Guideline Table 1: This Class 2.1 excludes LPG.

Proposal System	Boundary	Relevance	Approximate Distance to Proposal Site boundary (m)
Gas receiving station	Southern	Faces other landuse (future Industrial)	130
Power station underground non-storage pipework and above ground non-storage pipework and equipment	Western	Faces other landuse (Rural Landscape - bushland)	10 to 20

The minimum distance to other landuses is met for all the future neighbouring industrial land use both to the east and south of the Proposal Site.

However, the minimum distance of the Proposal Site boundary from both the power station underground non-storage pipework and above ground non-storage pipework (and certain equipment within the power station) as well as from the GRS towards the western boundary is not met. Therefore, the Proposal is considered potentially hazardous (NSW, 2011) due to the inadequate boundary distance to the Rural Landscape - bushland.

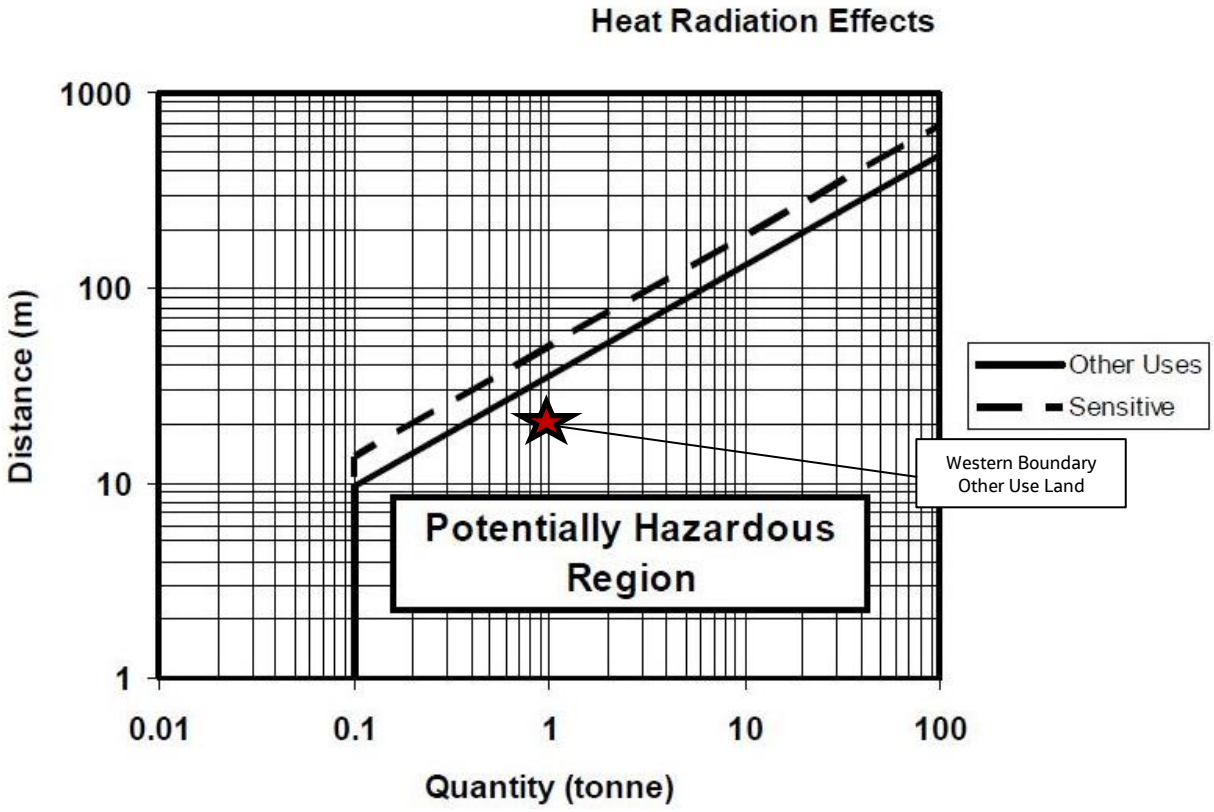

Figure 6.1: Class 2.1 Flammable Gas Pressurised (after Figure 6, NSW 2011)

6.1.2 Diesel, Combustible Liquid (Diesel) Class C1

For the Proposal, diesel as a ADGC Class C1 combustible liquid class would be stored in two approximate 1.75 ML nominal bulk fuel installation storage tanks within a bunded area as per the AS1940 requirements. The volume of diesel stored at the Proposal Site will trigger the requirement to notify WorkCover NSW and comply with statutory manifest requirements[16] for hazardous chemicals. There are no flammable liquids[17] proposed to be stored at the diesel bulk fuel storage tanks. As such, the criteria is not applicable for stored diesel.

6.2 Hazard transportation screening

Applying SEPP 33 – Hazardous and Offensive Development Application Guidelines (NSW, 2011) provides guidance to screen risk associated with transportation of dangerous goods having the potential to classify an industrial activity as potentially hazardous. Figure 6.2 displays the Transport Screening Thresholds from this reference. For the Proposal:

- Natural Gas Class 2.1 flammable gas will not be transported by road
- Diesel Class C1 combustible liquid will be transported by road, but Class C1 is not considered in the screening method
- Miscellaneous Dangerous Goods Class 9 will be transported by road, but will be minor quantities.

Diesel fuel will be transported to the Proposal Site by road in approximate 50 kL, B-Double road tankers. An estimate of approximately six vehicle movements (six in and six out) could enter the Proposal Site per day, allowing 42 deliveries per week if needing to fill up the diesel storage tanks (however the weekly and annual criteria should not be exceeded). In the absence of Class C1 threshold, using Class 9 criteria in Figure 6.2, the transport of diesel or misc. dangerous goods (separate and combined) will fall below the threshold, therefore need not be considered in the PHA (NSW, 2011).

	Vehicle Movements		**Minimum quantity***	
	Cumulative	Peak	**per load (tonne)**	
Class	Annual *or*	Weekly	Bulk	Packages
1	see note	see note	see note	
2.1	>500	>30	2	5
2.3	>100	>6	1	2
3PGI	>500	>30	1	1
3PGII	>750	>45	3	10
3PGIII	>1000	>60	10	no limit
4.1	>200	>12	1	2
4.2	>100	>3	2	5
4.3	>200	>12	5	10
5	>500	>30	2	5
6.1	all	all	1	3
6.2	see note	see note	see note	
7	see note	see note	see note	
8	>500	>30	2	5
9	>1000	>60	no limit	

Figure 6.2: Transportation Screening Threshold (after Table 2, NSW 2011)

[16] Work Health and Safety Regulations (NSW, 2011)
[17] Flammable materials include Class 3PGI, II or III flammable liquids.

6.2.1 Other potential land use impacts and risks

Section 3.2 of this report has established that this Proposal is categorised as a potentially offensive industry. As a consequence, broader environmental impacts on surrounding land use are to be reviewed, analysed, and reported. To avoid repetition, the required technical studies form detailed sections of the EIS and include the analysis and management of the associated risks.

6.3 Screening threshold assessment summary

For storage and handling of Dangerous Goods Class 2.1, the Proposal is considered to be potentially hazardous in terms of the stored dangerous goods quantity and the distance threshold to the western boundary which adjoins Rural Landscape Bushland. The Proposal does not exceed the storage and handling threshold for Dangerous Goods Class C1, nor the dangerous goods transportation threshold regarding ADGC Class C1 and/or Class 9.

7. Preliminary hazard analysis

7.1 Identified major hazardous event risks

From the hazard identification processes, the principal hazard identified with potential for off-site impacts is:

- Gas Supply Failure causing uncontrolled release of flammable gas from power station gas line or in gas turbine enclosure.

This hazard is predicated on unplanned, uncontrolled gas release associated with an ignition source leading to fire or explosion. This event may stem from failure of various control systems within the power station's pressurised gas handling systems and equipment. In addition, a failure event of the high pressure third party GRS is considered. Table 7.1 presents the breakdown of a range of gas supply failure scenarios.

Table 7.1: Gas Supply Failure Events

Failure Event	System/Systems	Pressure	Mass (Stored in Process)	Sensitive Use Distance (m) Population Density	Other Use Distance (m) Population Density
Failure of Above / Underground Distribution Pipeline and Equipment within the power station	[per Unit] Above / Underground Distribution Pipeline Network and Gas Generator	<= 4.0 MPa(g)	650 kg	1150 m Rural Residential 0.05 persons/ha	<=150 m General Industry 1.50 persons/ha
Failure of gas receiving station (GRS)	Gas Lateral Connection, GRS and Distribution System Connection	7.0 to 14.0 MPa(g)	650 kg	1150 m Rural Residential 0.05 persons/ha	<=130 m General Industry[18] 1.50 persons/ha[19]

7.2 Consequence analysis

Consequences from a flammable gas fire at the Proposal Site will be dependent on release volume and duration. The hazard may present as fire with thermal damage [heat radiation] potential or explosion with blast pressure damage [over-pressure] potential.

7.2.1 Heat radiation criteria

Heat radiation is dependent on intensity of heat source, distance from the source, duration of exposure and the sensitivity of the risk recipient. DPIE in HIPAP 4 Risk Criteria for Land Use Safety Planning (NSW, 2011) provides examples of consequence banding for Heat Radiation exposures. Figure 7.1 presents the guidance on heat radiation effects on people and property.

[18] Future prospect to rezone to Heavy Industry.
[19] Estimate of Future Industrial Estate persons during business hours.

Heat Radiation (kW/m^2)	Effect
1 .2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 1 5-20 seconds and injury after 30 seconds' exposure (at least second degree burns will occur)
12.6	• Significant chance of fatality for extended exposure. High chance of injury • Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
23	• Likely fatality for extended exposure and chance of fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved or failure would occur
35	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of fatality for people exposed instantaneously

Figure 7.1: Indicative Heat Radiation Effects (after NSW, 2011)

The human risk criteria is recommended as: Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m^2 at a frequency of more than 50 chances in a million per year.

From Figure 7.1 the built environment [structures] risk criteria is recommended as: Incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations should not exceed a risk of 50 in a million per year for the 23 kW/m^2 heat flux level.

7.2.2 Explosion overpressure criteria

Damaging effect from explosions are associated with the intensity and rate of travel impacting [displacing] people and structures. Figure 7.2 presents the guidance on explosion overpressure effects on people and property from HIPAP 4 Risk Criteria for Land Use Safety Planning (NSW, 2011).

Explosion Overpressure	Effect
3.5 kPa (0.5 psi)	• 90% glass breakage • No fatality and very low probability of injury
7 kPa (1 psi)	• Damage to internal partitions and joinery but can be repaired • Probability of injury is 10%. No fatality
14 kPa (2 psi)	• House uninhabitable and badly cracked
21 kPa (3 psi)	• Reinforced structures distort • Storage tanks fail • 20% chance of fatality to a person in a building
35 kPa (5 psi)	• House uninhabitable • Wagons and plants items overturned • Threshold of eardrum damage • 50% chance of fatality for a person in a building and 1 5% chance of fatality for a person in the open
70 kPa (10 psi)	• Threshold of lung damage • 100% chance of fatality for a person in a building or in the open • Complete demolition of houses

Figure 7.2: Indicative Explosion Overpressure Effects (after NSW, 2011)

From Figure 7.2, the explosion overpressure risk criteria is recommended as: Incident explosion overpressure at residential and sensitive use areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year.

7.3 Risk screening and classification

7.3.1 Focussed description

The main power station equipment will be positioned approximately 150 m from its boundary adjoining similar zoned industry allotment. The two open cycle gas turbine units, pipework and GRS are proposed to be grouped on the western side of the Proposal Site. The nearest sensitive land use to the Proposal Site is currently zoned rural residential and this is located at approximately 1.15 km from the Proposal Site. The nearest proposed industrial zoned land use structures will be approximately 150 m distance from the hazard being considered.

Inventory analysis established the following dangerous goods class proposed in the development:

- Class 2.1 Flammable Gas [pressurised natural gas]
- Class C1 Combustible Liquid [diesel fuel]
- Class 9 Miscellaneous Chemicals.

There is no bulk gas storage tank for Class 2.1 Flammable Gas on the Proposal Site. The natural gas inventory is as "stored in process" in its delivery pipework and gas turbine equipment aggregating to an estimated Proposal Site quantity of approximately 1,300 kg. This quantity is stored across three subcomponents[20] and the maximum quantity in any one subcomponent is approximately 650 kg. Natural gas is delivered to the Proposal Site by a third party gas lateral pipeline and there is no transportation by road.

Diesel fuel, Class C1 Combustible Liquid, will be stored in two, bunded 1.75 ML nominal bulk fuel storage tanks. Diesel and miscellaneous chemicals are delivered by road transport.

[20] (a) GRS; (b) Underground gas delivery pipework; (c) above ground gas delivery and equipment.

Class 9 Miscellaneous Chemicals are in minor quantities. Transformer oil is in minor quantities, stored in process.

7.3.2 Risk estimation

The risk of external consequence is estimated based on the approximate 1,300 kg of Class 2.1 flammable gas using International Atomic Energy Agency (IAEA,1996) Classification of Substances by Effect Categories method. The method considers toxicity effect, vapour / flammability effect and explosion effect. Consideration is given to dangerous goods type and class, quantity, impact range and at-risk population exposure adjusted for distribution and anticipated risk mitigation. Appendix B presents reference data supporting the analysis. Table 7.2 presents the analysis and findings.

Table 7.2: Consequence Analysis

Analysis Reference	Result	Comment
IAEA Table IV(a) Classification of Substance by Effects Reference #13 Flammable Gas, pressurised >25 bar	For 1 to 5 tonnes, the effect is inconsequential.	For this class, effects may be consequential, but respectively require the following minimum[21] class 2.1 quantities: CIII (toxicity) 5,000 kg CII (vapour release/flammability) 10,000 kg CI (explosion) 50,000 kg
IAEA Table V Maximum Distance and Effect Area	For 1 to 5 tonnes, the effect over distance and area, while unspecified will be less than the baseline for classification C.	For 1 tonne of class 2.1 flammable gas, the hazard impact distance is forecast as: < 50 m. The hazard impact area by consequence type is forecast as: <3 ha for toxicity <1.5 ha for vapour release/flammability <0.3 ha for explosion
IAEA Table VI Population Density	For 1 to 5 tonnes, the effect is inconsequential.	As indicated above, are not likely to extend beyond the proposed power station boundary. Off-site land use risk populations are unlikely to be exposed
IAEA Table VII Population Correction Factor	N/A	
IAEA Table VIII Mitigation Correction Factor	N/A	

Based on the above result, the screening of the quantity of approximately 1,300 kg of class 2.1 flammable gas stored in process indicates that while hazardous, the land use safety risk would be classified as Non-serious Harm Potential.

7.3.3 Determining risk analysis method

Referring to Section 2.5, Table 3.1 the risk classification and prioritisation assessment indicates that the off-site risks are potentially hazardous, categorised as Non-serious Harm Potential, therefore semi-quantitative and qualitative levels of analysis are not required. However, on consultation with representative of the NSW Department of Planning, Industry and Environment, additional semi-quantitative analysis was included to model risks associated with the dynamic properties of class 2.1 flammable gas major hazard event at the proposed power station.

[21] Indicative minimum of the minimum – maximum range.

8. Risk analysis

8.1 Hazard identification

8.1.1 Stakeholder consultation

The Hazard and Risk Assessment sourced information via a stakeholder consultation workshop, directly from the Proponent and data used during the preliminary design phase of the Proposal. The information used during preliminary screening included:

- Local planning and property use information
- Preliminary design information and drawings
- Operation and maintenance process and risk management descriptions
- Hazardous Chemicals and Dangerous Goods inventories
- Proposal Site inspection.

8.1.2 Hazard and risk workshop

The Hazard and Risk Assessment provides input to the environmental impact statement (EIS). The objectives of the Hazard and Risk Workshop were to:

- Develop an initial risk profile of the Proposal by high level hazard identification (HAZID) review of the development design, operating characteristics, land use and potential environmental aspects and impacts
- Undertake a Preliminary Hazard Analysis (PHA), covering aspects of the Proposal which may impose public risks, to be prepared consistent with Hazardous Industry Planning Advisory Paper No. 6 – Guidelines of Hazard Analysis and Multilevel Risk Assessment (DPE, 2011)
- Review and assess the risks from the Proposal to the criteria set out in Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning (DPE, 2011).

The Hazard and Risk Workshop was held on 9 December 2020. The workshop was facilitated online via Microsoft Teams. The purpose of the Hazard and Risk Workshop was to identify credible major hazards associated with the operation of the Proposal and external risks impacting on the operator or compounding operational hazards. Identified hazards were recorded and screened as a Hazard Table see Appendix A.

8.1.3 Other risks

There are additional environmental risks with potential to impact land use which are addressed by separate technical reports in the EIS. These include:

- Exhaust plume rise/ aviation
- Bushfire
- Water quality
- Air quality
- Noise and vibration
- Other environmental management impacts.

The technical studies specifically detail the source and nature of relevant hazards, monitoring, assessments, and treatments to manage the risk to acceptable and/or tolerable levels.

8.2 Hazard scenario risk assessment

Table 8.1 presents the potential risk scenarios that could be associated with an open cycle gas turbine power station operation.

Table 8.1: Hazard Event Scenarios

Failure Event	Failure Factor/s	Cause	Consequence	Mitigations
Failure of gas receiving station (GRS)	Catastrophic failure or leak from GRS pressured cell, flange, valve, or other sub-element	Corrosion / Failure Impact / Penetration Mechanical damage External fire	Gas Release [with no ignition] Flash Fire Jet Fire Explosion	Secured Compound Design Piping to AS2885 Excess flow valve, non-return valve and remote shutdown[22] Ops Inspection Program Preventive Maintenance Control of ignition sources Fire Fighting System Workforce competency and authorities.
	Catastrophic failure or leak from gas supply pipeline	Corrosion / Failure Impact / Penetration Mechanical damage External fire	Gas Release [with no ignition] Flash Fire Jet Fire Explosion	
	Equipment overpressure	Equipment design failure Pressure regulation failure Human Error	Gas Release [with no ignition] Flash Fire Jet Fire Explosion	
Failure of underground gas distribution pipeline	Catastrophic failure or leak from delivery pipeline, flange, valve, or other sub-element	Corrosion Impact / Penetration Mechanical damage External fire	Gas Release [with no ignition] Flash Fire Jet Fire Explosion	CCTV and Site Security Design Piping to AS2885 Excess flow valve, non-return valve and remote shutdown Ops Inspection Program Preventive Maintenance Control of ignition sources Fire Fighting System Workforce competency and authorities.
	Pipeline overpressure	Equipment design failure Pressure regulation failure Human Error	Gas Release [with no ignition] Flash Fire Jet Fire Explosion	
Failure of above ground gas distribution piping and equipment	Catastrophic failure or leak from delivery pipeline, flange, valve, or other sub-element	Corrosion Impact / Penetration Mechanical damage External fire	Gas Release [with no ignition] Flash Fire Jet Fire Explosion	CCTV and Site Security Design Piping to AS2885 Excess flow valve, non-return valve and remote shutdown Ops Inspection Program Preventive Maintenance Control of ignition sources Fire Fighting System Workforce competency and authorities.
	Pipeline overpressure	Equipment design failure Pressure regulation failure Human Error	Gas Release [with no ignition] Flash Fire Jet Fire Explosion	

[22] May include Slam-Shut Valve controls, however this should be confirmed at detailed design phase.

Failure Event	Failure Factor/s	Cause	Consequence	Mitigations
	Generator malfunction	Equipment design failure Operating system failure Control system failure Human Error	Gas Release [with no ignition] Flash Fire Jet Fire Explosion	
Failure of diesel storage and diesel distribution	Catastrophic failure or leak from diesel tank, diesel distribution piping, flange, valve, or other sub-element	Equipment design failure Operating system failure Control system failure Human Error	Diesel release [to bund] Spill and land/water contamination Diesel release to wastewater system Diesel fire Environment damage	CCTV and Site Security Design Tank to AS1692 Design Process AS1940 Excess flow valve, non-return valve and remote shutdown Segregation, Containment and Spill Management Ops Inspection Program Preventive Maintenance Control of ignition sources Spill management Fire Fighting System Wastewater Management Workforce competency and authorities Emergency Response
Failure of Diesel Transport and unloading	Catastrophic failure or leak of diesel during transportation or off-loading, or other sub-element	Equipment design failure Operating system failure Control system failure Vehicle Accident / Fire Human Error	Diesel release [to containment] Diesel release to wastewater system Diesel fire Environment damage	CCTV and Site Security Regulated / Licensed Fuel Transport Unloading Facilities to AS1940 Excess flow valve, non-return valve and remote shutdown Segregation, Containment and Spill Management Ops Inspection Program Preventive Maintenance Control of ignition sources Fire Fighting System Wastewater Management Workforce competency and authorities Procurement of competent and licensed transport companies Emergency Response

Failure Event	Failure Factor/s	Cause	Consequence	Mitigations
Failure of Gas Turbine	Mechanical failure at turbine or another sub-element	Equipment design failure Operating system failure Control system failure Accidental Damage Gas fire/explosion Human Error	Uncontrolled release of rotating parts or projectiles from the gas turbine resulting in localised primary damage	CCTV and Site Security Design Turbine to AS ISO 21789 SCADA and remote shutdown Ops Inspection Program Preventive and Condition-based Maintenance Control of ignition sources Gas and Heat Detection Fire Fighting System Workforce training and competency Emergency response plans
Failure of HV Generator	Mechanical or system failure at High Voltage Generator or another sub-element	Equipment design failure Operating system failure Control system failure Accidental Damage Human Error	Uncontrolled release of electrical energy from an HV generator resulting in localised primary damage that may include fire, explosion or catastrophic failure.	CCTV and Site Security Design Transformer to AS 2067 SCADA and remote shutdown Ops Inspection Program Preventive and condition-based Maintenance Control of ignition sources Heat Detection Fire Fighting System Workforce competency and authorities Emergency Response
Above Ground Transformer Fire / Explosion	Mechanical or system failure at transformer or another sub-element	Equipment design failure Operating system failure Control system failure Accidental Damage Transformer Oil Release and Secondary Fire Human Error	Uncontrolled release of kinetic energy from an above ground transformer resulting in localised primary damage and secondary fire / explosion	CCTV and Site Security Design Transformer to AS/NZS 60076 SCADA and remote shutdown Ops Inspection Program Preventive Maintenance Control of ignition sources Fire Fighting System Explosion protection Workforce competency and authorities
Operation Noise	Emission of acoustic energy from mechanical equipment or another sub-element	Equipment design failure Operating system failure Control system failure Accidental Damage	Emission of noise with environmental impact.	Ops Inspection Program Preventive Maintenance Control of noise sources Noise monitoring program Workforce competency and authorities

Failure Event	Failure Factor/s	Cause	Consequence	Mitigations
Operation Air Quality	Emission of process exhaust from power generation or another sub-element	Equipment design failure Operating system failure Control system failure Accidental Damage	Emission of exhaust fume and vapour with air quality and environmental impact.	Ops Inspection Program Preventive Maintenance Control of exhaust sources Exhaust emission and exhaust plume monitoring program Workforce competency and authorities
Uncontrolled release of contaminated water	Emission of untreated, contaminated water.	Equipment design failure Operating system failure Control system failure Accidental Damage	Emission of contaminated water with environmental impact.	Ops Inspection Program Preventive Maintenance Control of waste waster Wastewater monitoring program Workforce competency and authorities

A credible risk assessment with controls in place for the hazards identified in Table 8.1 is presented in Appendix D.

8.3 Semi-Quantitative Risk Analysis

Section 3.4 describes the risk criteria from HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011) used to evaluate the physical magnitude of major event risks. These criteria span personal harm, property damage and social impact.

8.3.1 Major Hazard Events

This Risk Analysis focusses principally on the ADGC Class 2.1 flammable gas supply failure events at the proposed power station as presented in Figure 7.1. These are underground and above ground pipework systems within the Proposal Site with a forecast line pressure of <= 4.0 MPa(g). This hazard event scenario refers to the low-pressure pipe system associated with the gas turbine (abbreviated as "LP@GT").

Section 5 recognises the GRS operated by a third party and subject to a separate EIS as an external risk with potential to increase the cumulative risk profile for the proposed Proposal Site. This is an above ground system with an indicative pressure of <= 14.0 MPa(g). This hazard event scenario refers to the high-pressure GRS system (abbreviated as "HP@GRS").

The analysis considers two initiating events to release gas from the respective systems: (a) Full pipe diameter rupture; and, (b) 3" hole rupture.

8.3.2 Assumptions and Limitations

Risk analysis for the low-pressure pipe system associated with the gas turbine is limited to information provided in the basis of design from the proponent at preliminary design stage.

Risk analysis for the high-pressure GRS system is based on guidance information from the third-party supplier. Thus, should be treated as indicative but deferring to the third-party supplier's information and risk analysis for reliance.

The ignition of gas release is instantaneous for jet-fire [heat radiation modelling] and delayed for gas cloud [blast overpressure modelling]

8.3.3 Consequence Model

The ALOHA (Areal Locations of Hazardous Atmospheres) software model has been developed jointly by the US National Oceanic Atmospheric Administration (NOAA) and the US Environmental Protection Agency (EPA). The program has been used to model gas supply system rupture, gas dispersion and ignition events, then the consequence predictions for thermal radiation and (explosion) blast overpressure. Table 8.2 summarise the hazard event scenarios modelled, while the ALOHA model inputs, assumptions and full results are included in Appendix F.

Table 8.2: Hazard Event Scenarios Modelled in ALOHA

Event	Units	HP @ GRS		LP @ GT	
Rupture size	-	Full-Bore	3"	Full-Bore	3"
Pipe Inner Diameter	mm	300		200	
Pipe Pressure	kPag	14,000		4,000	
Initial Gas Temp (ambient)	°C	22.8		22.8	
Estimated Rupture Flow, Calculated	kg/s	970	110	130	40

Table 8.3 presents ALOHA model setting adjustments.

Table 8.3: ALOHA Model Variable Settings

Variable	Applied Setting	Assumption/s
Location	Loxford NSW	Specific site location
Temperature/Humidity	22.8° C / 49%	Cessnock Airport Weather Station: Mean temperature/humidity at 3pm
Wind	10 m/s [jet fire] 1 m/s [explosion]	Conservative estimate promoting heat radiation potential. Conservative estimate promoting gas explosive potential.
Landscape	Congested	Conservative estimate promoting gas dispersion.
Gas Source	Unbroken end is closed	Supply is limited by slam shut valve systems.
Ground Roughness	50 cm	Conservative estimate promoting gas dispersion.
Pipe Temperature	22.8	Ambient temperature used.

8.3.4 Thermal Radiation Analysis

Table 8.4 presents the results of the ALOHA thermal radiation analysis. Referring to the risk criteria from HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011), the ALOHA analysis indicates that consequences associated with high-pressure, full-bore rupture fire would be experienced within the Proposal Site boundary, and may extend to slightly outside the Proposal Site boundary (but only with extended exposure period). The results also indicated that there could be some consequences potentially resulting in pain or injury across neighbouring industrial land use areas to a radius distance of approximately 255m from the GRS.

High-pressure, 3" rupture heat radiation consequences would not extend beyond the Proposal Site boundary, except for the western boundary adjoining rural bushland.

All low-pressure rupture heat radiation consequences would be limited to within the Proposal Site boundary.

The analysis indicated that residential land use at 1.15km would not be impacted.

Table 8.4: ALOHA Model Thermal Radiation Results

Event	Units	HP @ GRS		LP @ GT	
Rupture Size	-	Full-Bore	3"	Full-Bore	3"
Rupture Flow, ALOHA Modelled	kg/s	967	107	122	30
Maximum Burn Rate	kg/s	1,667	108	213	31
23 kW/m² Radiation Radius	m	120	41	45	23
12.6 kW/m² Radiation Radius	m	159	55	60	30
4.7 kW/m² Radiation Radius	m	255	89	96	49

8.3.5 Explosion Overpressure Analysis

Table 8.5 presents the results of the ALOHA overpressure analysis. Referring to the risk criteria from HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011) the ALOHA analysis indicates that consequences associated with high-pressure, full-bore rupture blast overpressure event could be experienced at a radius distance of approximately 250m from the GRS, therefore with the potential to impact the site and neighbouring industrial land use areas.

High-pressure, 3" rupture blast overpressure consequences would not extend beyond the Proposal Site boundary, except for the western boundary adjoining rural bushland.

All low-pressure rupture overpressure consequences would be limited to within the Proposal Site boundary.

The analysis indicated that residential land use would not be impacted.

Table 8.5: ALOHA Model Overpressure Results

Event	Units	HP @ GRS		LP @ GT	
Rupture Size	-	Full-Bore	3"	Full-Bore	3"
Total Mass Emission (ALOHA)	kg	5,640	1,340	1,220	770
21 kPa Overpressure Radius	m	214	107	83	66
14 kPa Overpressure Radius	m	220	111	91	73
7 kPa Overpressure Radius	m	250	131	118	95

8.3.6 Consequence Frequency Analysis

The 11th edition of the European Gas Pipeline Incident Data Group (EGIG, 2020) is an appropriate source of gas pipeline performance, reliability and incident data. Data is documented from European Gas Transmission Utilities spanning 1970 to 2019. Data for 1411 incidents can be described from consequence type by secondary event and initiating event.

Table 8.6 presents the secondary failure frequency for pipeline size 11 inch <= diameter <17 inch for pipe failure resulting in pipeline rupture or hole.

Table 8.6: Secondary Failure Frequency (After EGIC, 2020, Table 6)

	Secondary Failure Frequency
Rupture	0.013 per 1000 km.yr
Hole	0.017 per 1000 km.yr

Historically only 5.2% of recorded gas releases ignite. Table 8.7 presents the percentage of releases from pipeline rupture or hole that have resulted in ignition.

Table 8.7: Ignition Percentage (After EGIC, 2020, Table 7)

	Percentage of Releases with Ignition
Rupture <=16"	9.8%
Hole	2.2%

EGIC (2020) presents data from 1,411 gas pipeline incidents during the period 1970 to 2019. Of these, only two incidents resulted in fatalities among the public. Table 8.8 presents the incident breakdown by injury and fatalities per group.

Table 8.8: Percentage of accidents of groups involved in pipeline incidents (After EGIC, 2020, Figure 54)

	Worker	Person Causing	Fire Fighting	Public
Injuries	0.07%	0.57%	0.14%	0.28%
Fatalities	0.07%	0.43%	0.07%	0.14%

The consequence frequency of injury or fatality to members of the public from ignited gas release is equal to the Secondary Event multiplied by the Ignition Release multiplied by the Public Impact.

Table 8.9: Consequence Frequency

	Type of Consequence	Secondary Event	Ignition Release	Public Impact	Consequence Frequency (per 1000 km)
Rupture	Injuries	0.013	0.098	0.0028	3.57×10^{-6} per year
	Fatalities	0.013	0.098	0.0014	1.78×10^{-6} per year
Hole	Injuries	0.017	0.022	0.0028	1.05×10^{-6} per year
	Fatalities	0.017	0.022	0.0014	0.52×10^{-6} per year

Accounting for the length of pipeline within the Proposal Site, which is in the order of hundreds of metres rather than a 1000 km, the above consequence frequency is reduced by orders of magnitude.

Property damage risks (thermal radiation and blast overpressure) carry the same profile of secondary events and release ignition therefore are expected to have similar or lower consequence frequency.

8.3.7 Risk Criteria Assessment

The above semi-quantitative analysis has demonstrated that there is very low risk of a low-pressure GT pipework system damage event with a secondary release ignition occurring. Further, with the occurrence of such event, consequences are not expected to extend outside the Proposal Site boundaries.

A supplementary risk analysis has been included to cover the high-pressure GRS system, operated by the third-party gas supplier, due to it being situated within the Proposal Site. Similarly, there is a very low risk of damage event with a secondary release ignition occurring. However, the analysis suggests that consequences could extend past the power station perimeter to adjoining industrial land-use allotments, but consequences will not impact on residential or sensitive land-use.

Tables 8.10, 8.11 and 8.12 reflect the assessment of the proposed power station by the HIPAP Paper No 4 – Risk Criteria for Land Use Safety Planning (NSW, 2011) land-use risk criteria.

Table 8.10: Individual Injury Risk Criteria (after NSW, 2011)

Injury Risk Event	Risk Criteria (injuries per million per year)	Criteria Assessment
Heat Radiation [4.7 kW/m^2] – residential and sensitive land-use	50	Outside Consequence Zone
Explosion Overpressure [7 kPa] – residential and sensitive land-use	50	Outside Consequence Zone
Industrial Applications	50	Criteria Satisfied

Table 8.11: Individual Fatality Risk Criteria (after NSW, 2011)

Land Use	Risk Criteria (fatal injuries per million per year)	Criteria Assessment
Hospitals, schools, child-care facilities, old age housing	0.5	Outside Consequence Zone
Residential, hotels, motels, tourist resorts	1	Outside Consequence Zone
Commercial developments including retail centres, offices and entertainment	5	Outside Consequence Zone
Sporting complexes and active open space	10	Outside Consequence Zone
Industrial Applications	50	Criteria Satisfied

Table 8.12: Property Damage Risk Criteria (after NSW, 2011)

Property Damage Risk Event	Risk Criteria (property damage per million per year)	Criteria Assessment
Heat Radiation [23 kW/m^2] – industrial / hazardous installation zoning	50	Criteria Satisfied
Explosion Overpressure [14 kPa] – industrial / hazardous installation zoning	50	Criteria Satisfied

The social risk level of multiple fatalities is deemed mitigated ALARP essentially by event likelihood, controls, containment of risk consequences, separation distance to sensitive land uses and low population density.

8.4 Hazard controls and risk management

At this preliminary stage of design, the Proponent has considered and proposed a number of hazard and risk controls to benefit safety and mitigate harm. In summary these include:

- Location of the Proposal in a proposed heavy/ general industry zoned land package on the edge of a future industrial estate
- Positioning of the Proposal Site adjoining undeveloped rural bushland and future industrial land uses
- Positioning of the Proposal Site remote to existing sensitive land uses
- Positioning of the OCGTs and GRS within the Proposal Site to provide maximum distance to future industrial land uses
- Provision of an additional and significant buffer zone extending south from the power station boundary
- Minimising dangerous goods and hazardous chemical transport, storage and handling at the Proposal Site
- Planning for security, including on-site facilities used by third party gas supplier
- Consideration of safety and environmental management requirements in the selection and design of processes and equipment including but not limited to:
  - Natural gas supply and distribution
  - Diesel transportation, storage and distribution
  - Electricity protection and distribution
  - Pressure management, performance monitoring and leak/fault detection
  - Process control and isolation systems
  - Preventive maintenance
  - Safety and environmental management systems
  - Environmental protection and emission monitoring
  - Emergency preparedness and response
  - Staff competencies and authorisation.

9. Conclusions

The Hazard and Risk Assessment has consulted stakeholders and referenced relevant information and data to identify hazards associated with the Proposal development. Risks associated with the hazards were considered in the context of land use safety criteria based on guidance from State Environmental Planning Policy No.33 (SEPP 33) Hazardous and Offensive Development and applicable Hazardous Industry Planning Advisory Papers (HIPAP).

The Proposal will exceed the electricity generation nominal energy output threshold and is therefore deemed as a potentially offensive industry development.

The assessment of risk of hazards impacting on neighbouring land use, particularly the nearest rural residential property located at a distance of approximately1.15 km from the Proposal Site and future, but non-defined, heavy industry land use adjoining boundaries south and east of the Proposal Site.

In accordance with the SEARs assessment method, the Proposal is assessed to be a potential hazardous industry based on the volume of dangerous goods / hazardous chemical proposed to be stored within the Proposal Site. This determination is attributed to the volume of approximately 1,300 kg of natural gas fuel stored in the process exceeding the threshold based on ADGC Class 2.1 dangerous goods (natural gas) quantity stored in terms of the distance to the Proposal Site boundary. The threshold does not apply to Class C1 (diesel).

The assessment threshold for transportation by vehicle movements of dangerous goods is not exceeded for Class C1 (diesel) and/or Class 9 (miscellaneous chemicals). This threshold assessment does not apply to Class 2.1 as it is delivered via pipeline, not road transport.

The preliminary hazard analysis based on the proposed power station, inclusive of the third party's GRS, flammable gas inventory quantity by mass of approximately 1,300 kg of natural gas could have localised Proposal Site impacts but would have inconsequential off-site impacts. On conservative estimates, the Proposal Site inventory quantity by mass of Class 2.1 natural gas would have to increase considerably to produce off-site toxicity (CIII), vaporisation/flammability (CII) and explosion (CI) impacts at the nearest rural residential property.

Additional semi-quantitative consequence analysis of the Class 2.1 flammable gas hazards using the ALOHA modelling software indicated that the low-pressure gas turbine (GT) gas supply pipework (ie the power station gas infrastructure) is unlikely to generate an ignited gas release event having thermal radiation or blast overpressure consequences much beyond the power station site perimeter except for a small area along the western boundary adjoining rural bushland.

Supplementary risk analysis of the high-pressure (third-party designed, owned and operated) GRS indicated that there is risk of ignited gas release event where thermal radiation and blast overpressure consequences would extend to neighbouring industrial land-use allotments, but not to any residential or sensitive land-use zones.

In addition to flammable gas fire and explosion, the preliminary hazard analysis considered and assessed a broad range of credible major hazard events, operational hazards and environmental impacts. No unusual risks have been identified that cannot be mitigated through the application of good industry practice, safety in design processes and operating practices. The Proponent has a long history of power generation and has developed and operates similar gas fired power stations across different Australian jurisdictions. Snowy Hydro have demonstrated systems to manage risks to satisfy enterprise and industry standards and to comply with statutory requirements.

The Hazard and Risk Assessment concludes that the proposed power station, inclusive of the potential contribution to risk associated with the third party's GRS, is a potentially hazardous industry, but satisfies the Risk Criteria for Land Use Safety Planning (NSW, 2012) including the proposed neighbouring industrial landuses.

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Appendix A. Hazard Table – Identified Hazards

The following table presents the outputs from a Risk Workshop undertaken on the 9th December 2020.

ID	Plant or Process Area	Phase of Project likely to occur	Risk Description	Cause	Consequence	Control/ Treatment [if provided]	Impact Assessment / Recommendations	Potential Offsite Impacts
SH_KK-001	Above Power Islands	Operation	Potential for environmental air quality standards exceedance from stack exhaust affecting human health.	Unplanned plant operational performance and emission transfer to human recipients.	Human health impact. Environmental contamination impact (fallout).	Plant performance design [exhaust emissions] Stack exhaust emission monitoring program.	May impact with excessive and prolonged gas/particulate emission exceedance.	Yes
SH_KK-002	Above Power Islands	Operation	Potential for environmental air quality standards exceedance from stack exhaust affecting air traffic.	Stack and plume emissions in close proximity to airfields and flight paths. Note: Proximity of project to airfields: Newcastle Airport -30 km Cessnock Airport – 13 km Maitland Airport – 9 km	Airspace restriction resulting in flight paths modification Low-level flight risks from stack and exhaust causing loss of performance of aircraft [TBC]. Aircraft incident.	Stack plume clearance maintained by existing CASA flight airspace restriction [Hydro Aluminium airspace restriction continuity]	Should not impact subject to CASA flight airspace adherence.	No
SH_KK-003	Above Power Islands	Operation	Potential for aircraft [fixed wing, helicopter, or ultra-light] entering restricted airspace and loss of control resulting in crash at site.	Aircraft operating within or close to restricted airspace. Unspecified and unplanned loss of control of aircraft and aircraft incident above or at project site. Note: Proximity of project to airfields: Newcastle Airport -30 km Cessnock Airport – 13 km Maitland Airport – 9 km	Unrelated aircraft incident. Project equipment damage. Associated consequential events [minor to catastrophic].	Site clearance maintained by existing CASA flight airspace restriction [Hydro Aluminium airspace restriction continuity]	Should not impact subject to CASA flight airspace adherence.	No
SH_KK-004	SH Propoal Site	Construction	Potential for aircraft [fixed wing, helicopter, or ultra-light] entering restricted airspace and loss of control resulting in crash at site.	Refer Operational: SH_KK-003 Aircraft operating within or close to restricted airspace. Unspecified and unplanned loss of control of aircraft and aircraft incident above or at project site.	Unrelated aircraft incident. Project equipment damage. Associated consequential events [minor to catastrophic].	Site clearance maintained by existing CASA flight airspace restriction [Hydro Aluminium airspace restriction continuity]	Should not impact subject to CASA flight airspace adherence.	No
SH_KK-005	Industrial Operations adjacent to Project Site	Operation	Potential [limited] impacts to adjacent industrial properties. Potential [undefined] impacts from adjacent industrial properties.	General zoning and intended industrial land use are known. Specific hazards and sensitivities are undefined. There are no known adjacent industrial applications likely to influence the hazard and risk profile of the project.	Specific hazards and risks are undefined. Assumed as general industrial land use.	Boundary separation.	Should not impact or be impacted by near industrial land use.	No
SH_KK-006	Loxford, adjacent to TAFE along Bowditch Road	Operation	Potential noise impacts to nearest residential receivers along Dawes Ave and Bowditch Rd at Loxford	Inadequate management of noise from the project resulting in noise emission exceedance during the operation.	Potential complaints from residents. DA condition/legislation noncompliance. Prosecution and corrective orders.	Operation noise emission limits. Environmental noise monitoring program.	May impact with excessive and repeated noise emission exceedance.	Yes
SH_KK-007	Loxford, adjacent to TAFE along Bowditch Road	Construction	Potential Noise impacts to nearest residential receivers along Dawes Ave and Bowditch Rd at Loxford	Refer Operational: SH_KK-006 Inadequate management of noise from the project resulting in noise emission exceedance during the construction. Failure to adhere to construction working time [out of hours] restrictions.	Potential complaints from residents. DA condition/legislation noncompliance. Construction interruption delay. Prosecution and corrective orders.	Operation noise emission limits. Construction noise generation/working hour restriction. Environmental noise monitoring program.	May impact with excessive and repeated noise emission exceedance.	Yes
SH_KK-008	Local External Roads	Operation	Potential traffic incidents and associated traffic noise impacts to residential receivers along roads during operation.	Inadequate management of project traffic and associated noise impacts from the project during operation.	Potential complaints from residents, noncompliance with relevant legislation. Road vehicle / traffic incident/s.	Operation Traffic Management Plan.	May impact local road users.	Yes
SH_KK-009	Local roads	Construction	Potential increased heavy traffic incidents and associated traffic noise impacts to residential receivers along roads during construction.	Refer Operational: SH_KK-008 Inadequate management of construction related traffic and noise impacts from the project during construction.	Potential complaints from residents, noncompliance with relevant legislation. Road vehicle / traffic incident/s.	Construction Traffic Management Plan.	May impact local road users.	Yes

ID	Plant or Process Area	Phase of Project likely to occur	Risk Description	Cause	Consequence	Control/ Treatment [if provided]	Impact Assessment / Recommendations	Potential Offsite Impacts
SH_KK-010	Development Waste Material Relocation Haul Roads across Site; and, Construction zone clashes at Hart Rd and Dixon Rd,	Operation	Potential increased heavy traffic / light vehicle incidents at Haul Road crossing during operation until the completion of waste material transfer.	Ongoing haulage of hazardous waste from site (Dixon Rd Stockpile) via the designated Haul Road continuing during operation. General road and Haul Road traffic interaction at crossing points.	Light vehicle / Haul vehicle traffic incident/s. Pedestrian worker / Haul vehicle traffic incident/s.	Operation Traffic Management Plan. Construction Traffic Management Plan.	Operational impacts.	No
SH_KK-011	Development Waste Material Relocation Haul Roads across Site; and, Construction zone clashes at Hart Rd and Dixon Rd,	Construction	Potential increased heavy traffic / light vehicle incidents at Haul Road crossing during operation until the completion of waste material transfer.	Refer Operational: SH_KK-010 Ongoing haulage of hazardous waste from site (Dixon Rd Stockpile) via the designated Haul Road continuing during operation. General road and Haul Road traffic interaction at crossing points.	Light vehicle / Haul vehicle traffic incident/s. Pedestrian worker / Haul vehicle traffic incident/s.	Operation Traffic Management Plan. Construction Traffic Management Plan.	Operational impacts.	No
SH_KK-012	Development Site Waste Material Relocation Haul Roads across Site	Operation	Potential for hazardous material contamination disbursement and worker exposure during transfer from waste stockpiles [temporary] to containment cell [permanent storage]. Hazardous materials include [but my not be limited to]: - Asbestos Containing Material [ACM]; - Spent Pot Lining [SPL] materials; - Leachate contaminated soil and materials; - Hydrocarbon contaminated soil and materials.	Airborne particles being emitted and transferred to exposed workers during haulage of waste from stockpiles to the containment cell.	Health risks to project operation and construction workers.	Containment Cell Management Plan and Procedures.	Operational impacts.	No
SH_KK-013	Development Site Waste Material Relocation Haul Roads across Site	Construction	Potential for hazardous material contamination disbursement and worker exposure during transfer from waste stockpiles [temporary] to containment cell [permanent storage]. Hazardous materials include [but my not be limited to]: - Asbestos Containing Material [ACM]; - Spent Pot Lining [SPL] materials; - Leachate contaminated soil and materials; - Hydrocarbon contaminated soil and materials.	Refer Operational: SH_KK-012 Airborne particles being emitted and transferred to exposed workers during haulage of waste from stockpiles to the containment cell.	Health risks to project operation and construction workers.	Containment Cell Management Plan and Procedures.	Operational impacts.	No

ID	Plant or Process Area	Phase of Project likely to occur	Risk Description	Cause	Consequence	Control/ Treatment [if provided]	Impact Assessment / Recommendations	Potential Offsite Impacts
SH_KK-014	Transformers	Operation	Potential for electrical event or condition contributing to uncontrolled release of electrical energy leading to fire or explosion of above ground transformer.	Transformer Asset unplanned change, failure, malfunction, or damage. External event impacting or causing unplanned operational change to Transformer Operation. Human factor event impacting or causing unplanned operational change to Transformer Operation. Secondary Event/s associated with the primary transformer fire or explosion event.	Hazardous Chemical Spill of transformer oil to environment. Equipment damage and cost. Transformer fire. Transformer explosion and transformer shrapnel projection/damage. Fire transferred to directly injure people, damage other project equipment or external property/environment. Explosion and transformer shrapnel projection transferred to directly injure people, damage other project equipment or external property/environment.	Electrical protective system/s. Transformer safety, integrity, and reliability protection design. Environmental controls and spill management. Fire detection and suppression system/s. Transformer enclosure walls [non blast-resistant rated]. Personnel access restriction. Emergency response.	Operational impacts. Could impact the environment.	No
SH_KK-015	Gas Supply Line/System or Gas Turbine	Operation	Potential for loss of control of natural gas supply to gas turbine burner enclosure, leading to release of flammable gas, fire, or explosion at the gas line or in the burner header in gas turbine enclosure.	Gas Supply Line/System and/or Liquid Fuel Supply Line Asset unplanned change, failure, malfunction, or damage. Gas Turbine Burner Asset unplanned change, failure, malfunction, or damage. External event impacting or causing unplanned operational change to Gas Supply or Gas Turbine Operation. Human factor event impacting or causing unplanned operational change to Gas Supply or Gas Turbine Operation. Secondary Event/s associated with the primary Gas Supply or Gas Turbine fire or explosion event.	Hazardous Chemical [natural gas] release to environment. Equipment damage and cost. Gas Supply, Liquid Fuel Supply Line or Gas Turbine fire. Gas Supply, Liquid Fuel Supply Line or Gas Turbine explosion and shrapnel projection/damage. Fire transferred to directly injure people, damage other project equipment or external property/environment. Explosion and Gas Supply or Gas Turbine shrapnel projection transferred to directly injure people, damage other project equipment or external property/environment.	Gas supply line protective system/s. Gas Supply and Gas Turbine safety, integrity and reliability protection design. Liquid Fuel Supply Line protective system/s. Liquid Fuel Supply Line and Gas Turbine safety, integrity and reliability protection design. Environmental controls and natural gas release management. Fire detection and suppression system/s. Control Room enclosure walls [fire-resistant rated]. Personnel access restriction. Emergency response.	Operational impacts. Could impact near industrial land use. Could impact the environment.	Yes
SH_KK-016	High Voltage Electrical Generator	Operation	Potential for loss of control and release of kinetic energy from generator/motor equipment leading to fire, explosion, or catastrophic failure.	Electrical Generator Asset unplanned change, failure, malfunction, or damage. External event impacting or causing unplanned operational change to Electrical Generator Operation. Human factor event impacting or causing unplanned operational change to Electrical Generator Operation. Secondary Event/s associated with the primary Electrical Generator fire or explosion event.	Hazardous Smoke/Fume release to environment. Equipment damage and cost. Arc Flash/Pressure Wave, Electro-Magnetic Radiation and Non-Life Sustaining Atmosphere exposure. Electrical Generator/Motor Equipment fire. Electrical Generator/Motor Equipment explosion and shrapnel projection/damage. Fire transferred to directly injure people, damage other project equipment or external property/environment. Explosion and Electrical Generator/Motor Equipment shrapnel projection transferred to directly injure people, damage other project equipment or external property/environment.	Electrical Generator/Motor Equipment protective system/s. Electrical Generator/Motor Equipment safety, integrity and reliability protection design. Voltage [AVR] and Electrical Control management system/s. Fire detection and suppression system/s. Pressure Venting [pressure vent valves] System/s. Control Room enclosure walls [fire-resistant rated]. Personnel access restriction. Emergency response.	Operational impacts. Could impact the environment.	No

ID	Plant or Process Area	Phase of Project likely to occur	Risk Description	Cause	Consequence	Control/ Treatment [if provided]	Impact Assessment / Recommendations	Potential Offsite Impacts
SH_KK-017	Gas Turbine	Operation	Potential for loss of control and release of rotating parts or projectiles from the gas turbine leading to fire, explosion, or catastrophic failure.	Gas Turbine Asset unplanned change, failure, malfunction, or damage. External event impacting or causing unplanned operational change to Gas Turbine Operation. Human factor event impacting or causing unplanned operational change to Gas Turbine Operation. Secondary Event/s associated with the primary Gas Turbine fire or explosion event.	Hazardous Smoke/Fume release to environment. Equipment damage and cost. Gas Turbine fire. Gas Turbine explosion and shrapnel projection/damage. Fire transferred to directly injure people, damage other project equipment or external property/environment. Explosion and Gas Turbine shrapnel projection transferred to directly injure people, damage other project equipment or external property/environment.	Gas Turbine and Fuel [Gas/Diesel] Supply Systems protective system/s. Gas Turbine and Fuel [Gas/Diesel] Supply Systems safety, integrity and reliability protection design. Fire detection and suppression system/s. Gas Turbine Ventilation System/s. Control Room enclosure walls [fire-resistant rated]. Personnel access restriction. Emergency response.	Operational impacts. Could impact the environment.	No
SH_KK-018	Gas Receiving Station	Operation	Potential for loss of control of natural gas supply to GRS, leading to release of flammable gas, fire or explosion at the GRS.	GRS Asset unplanned change, failure, malfunction, or damage. External event impacting or causing unplanned operational change to GRS Operation. Human factor event impacting or causing unplanned operational change to GRS Operation. Secondary Event/s associated with the primary GRS fire or explosion event.	Hazardous Chemical [natural gas] release to environment. Equipment damage and cost. GRS fire. GRS explosion and shrapnel projection/damage. Fire transferred to directly injure people, damage other project equipment or external property/environment. Explosion and GRS shrapnel projection transferred to directly injure people, damage other project equipment or external property/environment.	GRS protective system/s. GRS safety, integrity, and reliability protection design. Environmental controls and natural gas release management. Fire detection and suppression system/s. Personnel access restriction. Emergency response.	Operational impacts. Could impact near industrial land use. Could impact the environment.	Yes
SH_KK-019	Air Intakes	Operation	Potential for unplanned release of pressure leading to structural damage and/or failure of Air Intake Unit.	Air Intake Unit, Implosion Relief Panel/s unplanned change, failure, malfunction, or damage. Failure to inspect/test Implosion Relief Panel/s.	Air Intake implosion and shrapnel projection/damage. Implosion and Air Intake shrapnel projection transferred to directly injure people, damage other project equipment or external property/environment.	Air Intake safety, integrity, and reliability protection design. Gas Turbine Ventilation System/s. Air Intake Implosion Relief Panel inspection and maintenance.	Operational impacts.	No
SH_KK-020	Exhaust Stacks	Operation	Potential for separation and jettison of Exhaust Stack building fabric [cladding], ash/embers under exhaust plume pressure leading to injury to people or damage to plant/property resulting from falling object/s.	Exhaust Stack building fabric unplanned change, failure, malfunction, or damage. Hot ash/embers. Failure to inspect and maintain Exhaust Stack building fabric.	Exhaust Stack building fabric projection/damage. Cladding and other falling objects or hot embers transferred to directly injure people, damage other project equipment or external property/environment.	Exhaust Stack safety, integrity, and reliability protection design. Exhaust Stack inspection and maintenance.	Operational impacts.	No
SH_KK-021	Switch Yard	Operation	Potential for uncontrolled release of electrical energy from earth grid through the ground around property boundary.	Inadequate earthing and bonding system. Breach or failure of earthing and bonding grid.	Electrical shock, electrocution, or injury to people at/near Switch Yard perimeter. Equipment damage at/near Switch Yard perimeter. Operation interruption, delay, and cost.	Switch Yard earing and bonding protective system/s. Switch Yard Station safety, integrity, and reliability protection design. Earthing grid is located at least 2m from fence line. Both grid and fence to be independently grounded.	Operational impacts. Unlikely to impact near industrial land use.	No
SH_KK-022	Switch Yard - Grid Connection	Operation	Potential for miscommunication or misunderstanding between Snowy Hydro and Ausgrid leading to various incident scenarios.	Human factors associated with shared high risk operating space.	Various injury to worker. Various equipment damage. Various supply connection interruptions. Operation interruption, delay, and cost.	Switch Yard management system and procedures. Agreed SH/Ausgrid Switch Yard protocol.	Operational impacts.	No

ID	Plant or Process Area	Phase of Project likely to occur	Risk Description	Cause	Consequence	Control/ Treatment [if provided]	Impact Assessment / Recommendations	Potential Offsite Impacts
SH_KK-023	Diesel Fuel Transport	Operation	Potential for loss of containment and unplanned release of diesel fuel leading to ground and/or water environmental contamination during Diesel Fuel transport and unloading.	Inadequate transportation, storage, handling and use of diesel fuel. Diesel [uploading] pump unplanned change, failure, malfunction, or damage. Human factor event causing release of diesel waste / spillage to storm water system.	Hazardous Chemical [diesel fuel] release to environment. Environment damage and cost. Prosecution and reputation damage.	Hazardous Chemical Management System Wastewater Management System Diesel Fuel Storage Management System	Could impact the environment.	Yes
SH_KK-024	Diesel Fuel Storage	Operation	Potential for loss of containment and unplanned release of diesel fuel leading to ground and/or water environmental contamination at Diesel Fuel from bulk fuel storage facility [including bund] or Diesel Supply Lines.	Inadequate transportation, storage, handling and use of diesel fuel. Diesel Tank and Bund unplanned change, failure, malfunction, or damage. Human factor event causing release of diesel waste / spillage to storm water system.	Hazardous Chemical [diesel fuel] release to environment. Environment damage and cost. Prosecution and reputation damage.	Hazardous Chemical Management System Wastewater Management System Diesel Fuel Storage Management System	Could impact the environment.	Yes
SH_KK-025	Diesel Fuel Storage	Operation	Potential for loss of containment of PFOS/PFAS containing firefighting foam leading to ground and/or ground water environmental contamination at Diesel Storage facility.	Inadequate transportation, storage, handling and use of PFOS/PFAS containing firefighting foam. Diesel Tank [containment] Bund unplanned change, failure, malfunction, or damage. Human factor event causing use of PFOS/PFAS containing firefighting foam at incorrect location.	Hazardous Chemical [PFOS/PFAS] release to environment. Environment damage and cost. Prosecution and reputation damage.	Hazardous Chemical Management System Use of alternative non-PFAS firefighting foam	Could impact near ground water use. Could impact the environment.	Yes
SH_KK-026	Demineralised / Potable Water Storage	Operation	Potential for loss of containment and unplanned release of water from Bulk Water Storage Facilities leading to minor local flooding and/or ground erosion.	Water Tank unplanned change, failure, malfunction, or damage. Human factor event causing release of water from storage tank.	Non-Hazardous Chemical [demineralised] release to environment. Minor local flooding and/or erosion.	Wastewater Management System Water Storage Management System	Unlikely to impact the environment.	No
SH_KK-027	Site Wide	Operation	Potential for breach of site security and unauthorised entry to Proposal Site by unauthorised person, livestock, and fauna.	Boundary breach, unauthorised access/occupation or trespass or theft to site during operation. Unplanned [mistaken] entry.	Injury to occupying people, livestock, or other fauna. Equipment damage. Equipment/Property theft. Operation interruption, delay, and cost.	Security Management System. Permanent boundary fence with secured entry points. 24/7 back to base CCTV surveillance.	Operational impacts.	No
SH_KK-028	Site Wide	Construction	Potential for breach of site security and unauthorised entry to Proposal Site by unauthorised person, livestock, and fauna.	Refer Operational: SH_KK-027 Boundary breach, unauthorised access/occupation or trespass or theft to site during construction. Unplanned [mistaken] entry.	Injury to occupying people, livestock, or other fauna. Equipment damage. Equipment/Property theft. Construction interruption, delay, and cost.	Construction Security Management System. Temporary construction fence with limited secured entry points. Out of hours security service surveillance.	Operational impacts.	No
SH_KK-029	Site Wide	Operation	Potential for breach of site security and unauthorised entry to Proposal Site by unauthorised person with criminal intent or political motivation.	Unauthorised access/occupation by person or vehicle to site during operation for purpose of anti-social behaviour, vandalism, arson, terrorism actions.	Injury to occupying people or workers. Major equipment damage. Operation disruption and cost.	Security Management System. Permanent boundary fence with secured entry points. 24/7 back to base CCTV surveillance.	Operational impacts.	No
SH_KK-030	Site Wide	Construction	Potential for breach of site security and unauthorised entry to Proposal Site by unauthorised person with criminal intent or political motivation.	Refer Operational: SH_KK-029 Unauthorised access/occupation by person or vehicle to site during construction for purpose of anti-social behaviour, vandalism, arson, terrorism actions.	Injury to occupying people or workers. Major equipment damage. Operation disruption and cost.	Construction Security Management System. Temporary construction fence with limited secured entry points. Out of hours security service surveillance.	Operational impacts.	No
SH_KK-031	Site Wide	Operation	Potential for extreme weather events (bushfire, earthquake, flooding) impacting the project or leading to worker injury during operation.	Extreme weather events Bushfire events	Worker injury. Equipment damage. Project operation interruption and costs.	Extreme weather event protocol and procedures. Weatherproof the project plant and equipment.	Operational impacts.	No
SH_KK-032	Site Wide	Construction	Extreme weather events (bushfire, earthquake, flooding) impacting the project or leading to worker injury during construction.	Refer Operational: SH_KK-031 Extreme weather events Bushfire events	Worker injury. Equipment damage. Project operation interruption and costs.	Extreme weather event protocol and procedures. Weatherproof the project plant and equipment.	Operational impacts.	No

Appendix B. Classification of Substances by Effect Categories

IAEA Table IV(a): Classification of Substances by Effect Categories

Ref. No.	Type of substance	Description of substance	Activity	Quantity (t)								
				0.2-1	1-5	5-10	10-50	50-200	200-1000	1000-5000	5000-10000	>10000
1	Flammable liquid	Vapour pressure <0.3 bar at 20℃	Storage with tank pit	-	-	-	-		AI	BI	BI	CI
2			Pipeline	-	-	-	-	-	-	-	-	-
3			Other	-	-	-	AI	BI	CI	DII	X	X
4		Vapour Pressure 0.3 bar at 20℃	Storage with tank pit	-	-	-	-	-	BI	CII	CII	DII
6			Other	-	-	-	BII	CII	DII	E II	X	X
7	Flammable gas	Liquefied by pressure	Rail, road, overground storage	-	AI	BI	C I	D I	E I	X	X	X
9			Other	-	BII	CIII	CIII	DIII	E III	X	X	X
10		Liquefied by cooling	Storage with tank pit	-	-	-	-	-	BI	CII	CII	DII
11			Other		-	-	BII	CII	DII	E II	X	X
13		Under pressure > 25 bar: high toxicity	Storage of cylinders (25-100kg)	-	-	CIII	CII	CI	CI	X	X	X
14	Explosive	In bulk (causing single explosion)		AI	BI	BI	CI	CI	DI	X	X	X
15		In packages (e.g. shells)		BIII	BIII	CIII	CI	CI	DI	X	X	X
16	Toxic liquid	Low toxicity	Storage with tank pit	-	-	-	-		A II	A II	B II	C III
17			Other	-	-	-	A III	A II	B II	C II	C II	C II
18		Medium toxicity	Storage with tank pit	-	-	-	A III	B III	D III	E III	F III	F III
21			Other	-	BII	C III	D III	E III	F III	F III	X	X
22		High toxicity	Storage with tank pit	-	-	A II	B III	C III	E III	F III	G III	G III
25			Other	BII	CII	D III	E III	F III	F III	G III	X	X
26		Very high toxicity	Storage with tank pit	AII	BII	C III	E III	F III	G III	G III	H III	H III
29			Other	CIII	DIII	E III	F III	G III	H III	H III	X	X
30	Toxic gas	Liquefied by pressure: low toxicity		AII	BII	B II	CIII	C II	DIII	D III	D III	E III
31		medium toxicity		BII	CII	C II	DIII	E III	F III	F III	G III	H III
32		high toxicity		CII	DIII	E III	E III	F III	G III	G III	X	X
33		very high toxicity		DIII	EIII	F III	G III	G III	H III	.	X	X
34		extreme toxicity		EIII	FIII	G III	H III	H III	X	X	X	X
35		Liquefied by cooling: low toxicity	In the case of activities on water	-	-	-	A II	A II	B II	B II	C II	DIII
36		medium toxicity	use 30-34 instead of 35-39	-	AII	B II	C II	D III	D III	E III	F III	G III
37		high toxicity		BII	CII	D III	E III	E III	F III	F III	G III	H III
38		very high toxicity		DIII	EIII	F III	F III	G III	G III	X	X	X
39		extreme toxicity		EIII	FIII	G III	H III	H III	X	X	X	X

***Note**: For flammable liquids in underground tanks, the quantity should be divided by 5 and the substance treated as 'other' i.e. Refs 3 or 6.*

***Symbols**: 'X' means the combination of that substance and that amount does not usually exist in practice. It is suggested that a full QRA should be carried out in any such case. '-' means that the effects are small enough to be ignored.*

IAEA Table V: Effect Categories: Maximum Distance and Area of Effect (A)

Effect distance (m)		Effect area category (ha)		
Category	Max. Distance (m)	I	II	III
A	0-25	0.2	0.1	0.02
B	25-50	0.8	0:4	0.1
C	50-100	3	1.5	0.3
D	100-200	12	6	1
E	200-500	80	40	8
F	500-1000	-	-	30
G	1000-3000	-	-	300
H	3000-10 000	-	-	1000

IAEA Table VI: Population Density (d)

Description of the area	Density (persons/ha)
Farmland, scattered houses	5
Individual dwellings	10
Village, quiet residential area	20
Residential area	40
Busy residential area	80
Urban area, shopping centres, centre of city	160

IAEA Table VII: Population Correction Factor (f_A)

Effect area	Populated fraction (%) of circular area				
Category	100%	50%	20%	10%	5%
I	1	0.6	0.2	0.1	0.05
II	1	1	0.4	0.2	0.1
III	1	1	1	1	1

IAEA Table VIII: Correction Factor for Mitigation (f_m)

Substances (reference numbers)	Factor
Flammables (1-12)	1
Flammables (13)	0.1
Explosives (14, 15)	1
Toxic liquid (16-29, 43-46)	0.05
Toxic gas (30-34, 37-39, 40-42)	0.1
Toxic gas (35-36)	0.05

Appendix C. Cessnock Airport Automatic Weather Station: Windrose

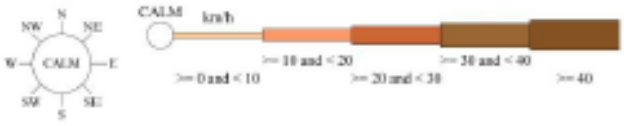
Rose of Wind direction versus Wind speed in km/h (01 Oct 1968 to 10 Aug 2020)

Custom times selected, refer to attached note for details

CESSNOCK AIRPORT AWS

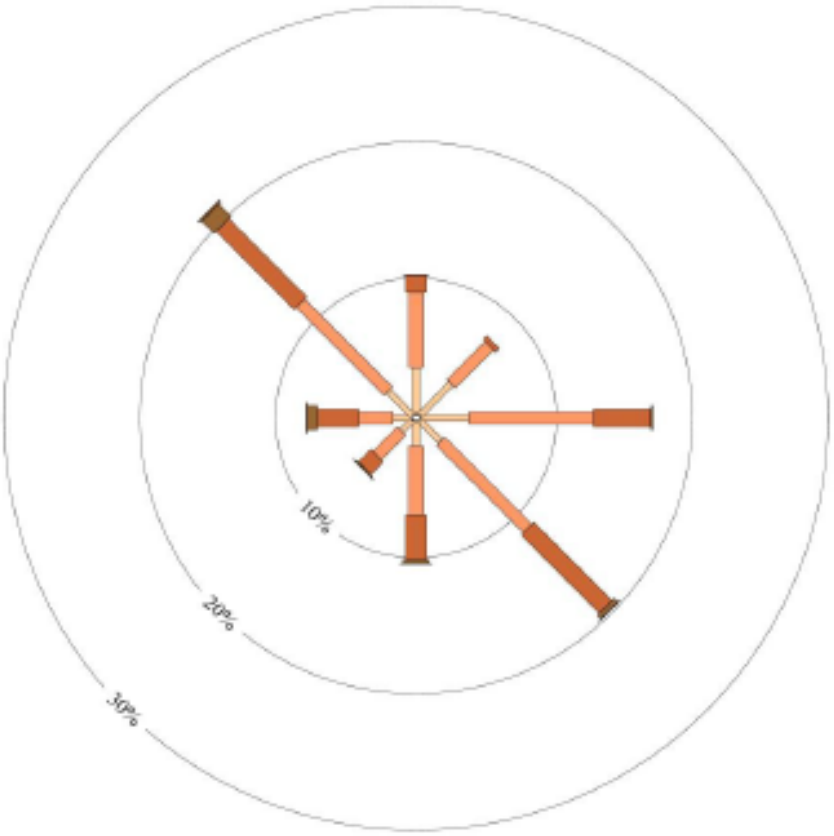
Site No: 061260 • Opened Jun 1968 • Still Open • Latitude: -32.7886° • Longitude: 151.3377° • Elevation 61m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
10126 Total Observations

Calm 1%



TCZANNUAL Page 1

Appendix D. Hazard Likelihood and Consequence Assessment

Table D.1: Risk Estimates for Hazard Events

Failure Event	Outcome	Context	Impact	Likelihood	Consequence	Risk Estimate[23]
Failure of Gas Receiving Station (GRS)	Gas Release [with no ignition]	On-Site	Human Health	Rare	Medium	Low
		Off-Site	Negligible [odour event]	-	-	-
	Flash Fire	On-Site	Human Health Property Damage	Rare	High	Medium
		Off-Site	Negligible [secondary fire]	-	-	-
	Jet Fire	On-Site	Human Health Property Damage	Rare	High	Medium
		Off-Site	Negligible [secondary fire]	-	-	-
	Explosion	On-Site	Human Health Property Damage	Rare	Very High	Medium
		Off-Site	Negligible [secondary noise]	-	-	-
Failure of Underground Distribution Pipeline	Gas Release [with no ignition]	On-Site	Human Health	Rare	Low	Low
		Off-Site	Negligible [odour event]	-	-	-
	Fire	On-Site	Human Health Property Damage	Rare	Low	Low
		Off-Site	Negligible [secondary fire]	-	-	-
	Explosion	On-Site	Human Health Property Damage	Rare	High	Medium
		Off-Site	Negligible [secondary fire]	-	-	-
Failure of Above Ground Distribution Pipeline and Equipment	Gas Release [with no ignition]	On-Site	Human Health	Rare	Low	Low
		Off-Site	Negligible [odour event]	-	-	-
	Fire	On-Site	Human Health Property Damage	Rare	Medium	Low
		Off-Site	Negligible [secondary fire]	-	-	-
	Explosion	On-Site	Human Health Property Damage	Rare	High	Medium
		Off-Site	Negligible [secondary fire]	-	-	-

[23] Referenced to: Risk Management Toolkit for NSW Public Sector Agencies.

Failure Event	Outcome	Context	Impact	Likelihood	Consequence	Risk Estimate[23]
Failure of Diesel Storage and Delivery Pipelines	Diesel release [to bund]	On-Site	Product Loss [economic]	Rare	High	Medium
		Off-Site	Negligible [Nil]	-	-	-
Failure of Diesel Transport	Diesel release to wastewater system	On-Site	Property Damage	Possible	Low	Low
		Off-Site	Negligible [Nil]	-	-	-
	Diesel release to environment	On-Site	Environmental Damage	Rare	High	Medium
		Off-Site	Environmental Damage [secondary bund failure]	Rare	High	Medium
	Diesel fire [as secondary event]	On-Site	Human Health Property Damage	Rare	Very High	Medium
		Off-Site	Human Health [smoke / odour event[24]]	Rare	Medium	Low
Failure of Gas Turbine	Uncontrolled release of rotating parts or projectiles	On-Site	Human Health Property Damage	Rare	High	Medium
		Off-Site	Negligible	-	-	-
Failure of HV Generator	Uncontrolled release of electrical energy	On-Site	Human Health Property Damage	Rare	High	Medium
		Off-Site	Negligible	-	-	-
Above Ground Transformer Fire	Uncontrolled release of kinetic energy	On-Site	Human Health Property Damage	Rare	High	Medium
		Off-Site	Negligible	-	-	-

[24] Acute, short term exposure to smoke for duration of uncontrolled secondary fire event.

Appendix E. Fuel Specification

Table E.1: Typical natural gas fuel specification

Parameter	Value	Comments
Natural gas	As per AS 4564	Originating from various east coast Australian supplies
Minimum expected pressure	40 bar.g	
Maximum expected pressure	70 bar.g	
Wobbe Index	46.0 ML/m3 (min) 52.0 MJ/m3 (max)	As per AS 4564 Table 3.1
Higher Heating Value	42.3 MJ/m3 (max)	As per AS 4564 Table 3.1
Oxygen	0.2 mol% (max)	As per AS 4564 Table 3.1
Hydrogen Sulphide	5.7 mg/m3	As per AS 4564 Table 3.1
Total Sulphur	50 mg/m3	As per AS 4564 Table 3.1
Water Content	Dewpoint 0°C at the highest MAOP in the relevant transmission system (in any case, no more than 112.0 mg/m3)	As per AS 4564 Table 3.1
Hydrocarbon Dewpoint	2.0°C at 3500 kPag (max)	As per AS 4564 Table 3.1
Total Inert Gases	7.0 mol% (max)	As per AS 4564 Table 3.1
Oil	20 mL/TJ (max)	As per AS 4564 Table 3.1

NOTES:

1) m^3 means 1 cubic metre of dry gas at the standard conditions (see Clause 1.5.9 of AS 4564).
2) mol% means the mole faction of gas expressed as a percentage.
3) The sulphur level upstream of the point(s) of addition of odorant needs to be such as to allow for any increase due to the odorant.
4) The hydrocarbon dewpoint limit is intended to ensure that condensation, and in particular retrograde condensation, does not occur to an excessive extent.
5) *Higher heating value*: For the previous edition of this Standard it was expected that for all practical gases available, or likely to be available commercially, higher heating values would be in the range of 37 to 42 MJ/m3 and no limit was specified. A normative maximum limit has now been included in this edition.
6) *Relative density*: It is expected that for all practical gases available, or likely to be available commercially, relative density values would be in the range of 0.55 to 0.70.
7) For applications such as natural gas vehicles requiring compression to higher pressure than the maximum transmission pressure it may be necessary to use a gas dryer to remove moisture from the gas to prevent liquid water or hydrate formation.

Table E.2: Typical diesel fuel specification

Parameter	Value	Comments
Diesel	Extra Low Sulphur Diesel	Compliance to Australian Fuel Standard Determination 2019 The performance guarantee fuel conditions are specified in the Power Island Technical Specification
Sulphur	<10 mg/kg	Compliance with Australian Fuel Standard Determination 2019

Appendix F. Aloha Modelling

F.1 MAJOR HAZARDOUS EVENTS

Two principle locations for a major event were assessed, the first on the site boundary at the gas receiving station, and the second central to the facility near the proposed gas turbines. A moderate 3" rupture and worst-case full-bore rupture of the gas pipeline at these locations were reviewed. The gas release associated with each rupture type and location was calculated as well as the sum of the static and dynamic sources. The static source considers the gas within the local section of pipe at the time of the rupture. The dynamic source considers the gas which will flow into the local system before it can be isolated by automated valving operations.

The dynamic flow was calculated using a steady state hydraulic model in FluidFlow (Version 3) by Flite Software Ltd. The full-bore and 3" rupture holes were incorporated by using a branch at the nominated locations (i.e. at the GRS and the gas turbine). Realistically, the rupture flow would reduce as the shutdown valve is activated and closes, however a continuous steady state rupture flow for 5 seconds was assumed which is considered to be a conservative analysis for the total discharge.

Table F.1: Major event scenario – Summary

Location	**High-pressure piping at gas receiving station**		**Buried reduced pressure piping near gas turbines**	
MAOP	14 MPa		4 MPa	
Pipe Description	2x 300NB x 40m		300NB x 175m, 200NB x 150m	
Failure type	Full-bore rupture	3" rupture	Full-bore rupture	3" rupture
Static Gas Mass	650 kg		550 kg	
Dynamic Gas Flow (5s duration)	4,850 kg	550 kg	650 kg	200 kg
Total Gas Emission	4,850 kg	1,340 kg	1,220 kg	770 kg

Instantaneous ignition resulting in a jet fire and delayed ignition causing a vapour cloud explosion have been evaluated for all rupture locations and types.

F.2 CONSEQUENCE MODELLING

Consequence modelling for the major hazardous events was performed using the ALOHA software (Version 5.4.7) from the CAMEO software system developed by the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA) of the Unites States. The software was used to model the plume dispersion, and determine the specific heat radiation and over-pressure consequences related to each of the major hazardous event scenarios. The key model inputs used for all scenarios are provided below.

Table F.2: Modelling parameters - summary

Parameter	Input	Default parameter	Justification
Chemical	Methane (pure), ALOHA library	n/a	Nearest option. Actual gas expected to be >90% methane by volume (Originating from various east coast Australian supplies)
Source type	Gas pipeline: smooth-walled, temperature equal to ambient.	Unchanged	ALOHA models dynamic flow and burn rate to produce threat zone outputs. Smooth walled and low temperature produced conservative (high) flow rates.
Air	Temperature: 22.8 °C, Humidity: 49 %	n/a	Average 3pm conditions for project site.
Wind speed	Adjusted for each ignition type to provide worst case. 3m measurement height	n/a	Range of 1 m/s to 10 m/s reviewed (3pm average is 4.69 m/s). Most conservative case selected.
Stability Class	No override.	Unchanged	Adjusted by ALOHA based on wind speed input.
Inversion	No inversion height	Unchanged	No better data available.
Cloud cover	5 (partly cloudy)	Unchanged	No better data available.
Surface roughness	z_0 = 0.5 m	z_0 = 0.03 m (open country) or z_0 = 1 m (urban or forest)	Built-up environment around installation, roughness aligns with space containing numerous obstacles.

The source pressure, rupture size and ignition and ignition type were set to match the scenarios described in Table F.1. Other scenario-specific inputs are shown below. The pipe lengths modelled in ALOHA were setup to achieve the gas emission event. These pipe lengths do not reflect the concept design lengths but are used to determine a similar amount of gas to be released.

Table F.3: Consequence scenario modelling – summary

Ignition	Scenarios	Model setup
Instant (jet fire)	Full-bore rupture at GRS (14 MPa) 3" rupture at GRS (14 MPa) Full-bore rupture at GT (4 MPa) 3" rupture at GT (4 MPa)	Source/pipeline modelled to extend peak emission duration > 1 minute (see note) 10 m/s wind speed Vertical flame direction (default) to match methane dispersion and combustion characteristics
Delayed (blast)	Full-bore rupture at GRS (14 MPa) 3" rupture at GRS (14 MPa) Full-bore rupture at GT (4 MPa) 3" rupture at GT (4 MPa)	Closed pipeline with length adjusted to match calculated mass emission 1 m/s wind speed Ignited by spark or flame, at an unknown time to provide the full envelope of possible blast outcomes before the emission cloud is dispersed to below 60% LEL Level of congestion set to "congested" to allow for local areas of turbulence (mixing) in the flame front and higher resultant blast pressure

Notes

1. ALOHA uses source strength averaging used to expedite threat zone modelling. The total mass emission for scenarios within instantaneous ignition was scaled to prolong the peak emission rate to at least one minute. Full-bore ruptures were modelled as being connected to an infinite gas source with a pipe length of 200x the nominal bore to negate flow transition effects, while 3" ruptures were modelled with an extended pipeline length (to 30 km).

- Connection to an infinite source via minimum pipeline length of 200 x ID used to mimic maximum emission rate for thermal radiation from full-bore rupture. Maximum pipeline length (30km, closed end) used to mimic maximum emission rate for a 3" rupture
- Total mass emissions for overpressure and ignition scenario based on dynamic response over 5-second period, pipeline length (closed end) adjusted to match
- Pipe sizing (inner diameter) has been based on nominal bore
- High congestion assumed for overpressure blast, which increases the shockwave pressure due to greater turbulence (and hence mixing) at the flame front
- With the exception of wind speed, all atmospheric inputs are 3pm average for the site or ALOHA defaults.

F.3 RESULTS

F.3.1 Thermal Radiation

Table F.4: Thermal radiation results summary

Location	Units	HP @ GRS		LP @ GT	
Rupture size		**Full-Bore**	**3"**	**Full-Bore**	**3"**
Pipe Inner Diameter	mm	300		200	
Pipe Pressure	kPag	14,000		4,000	
Initial Gas Temp (ambient)	°C	22.8		22.8	
Rupture Flow, Calculated	kg/s	970	110	130	40
Rupture Flow, Modelled	kg/s	967	107	122	30
Maximum Burn Rate	kg/s	1,667	108	213	31
23 kW/m² Radiation Radius	m	120	41	45	23
12.7 kW/m² Radiation Radius	m	159	55	60	30
4.7 kW/m² Radiation Radius	m	255	89	96	49

*10 m/s wind speed assumed for all cases

Text Summary

```
SITE DATA:
  Location: LOXFORD NSW, AUSTRALIA
  Building Air Exchanges Per Hour: 2.00 (unsheltered single storied)
  Time: April 9, 2021  1219 hours ST (user specified)

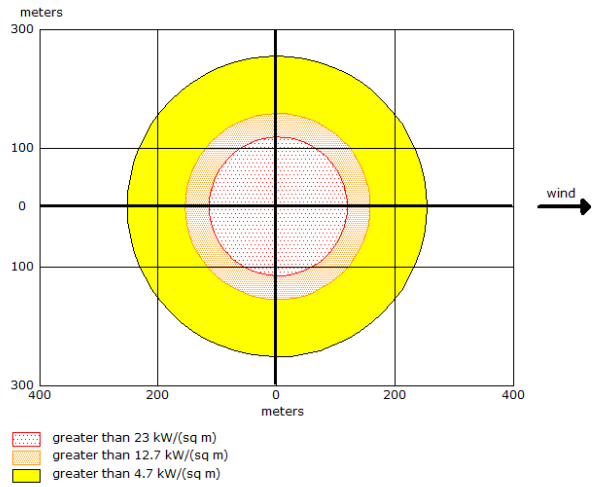
CHEMICAL DATA:
  Chemical Name: METHANE
  CAS Number: 74-82-8                    Molecular Weight: 16.04 g/mol
  PAC-1: 65000 ppm   PAC-2: 230000 ppm   PAC-3: 400000 ppm
  LEL: 50000 ppm     UEL: 150000 ppm
  Ambient Boiling Point: -161.5° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 10 meters/second from NE at 3 meters
  Ground Roughness: 50 centimeters       Cloud Cover: 5 tenths
  Air Temperature: 22.8° C               Stability Class: D
  No Inversion Height                    Relative Humidity: 49%

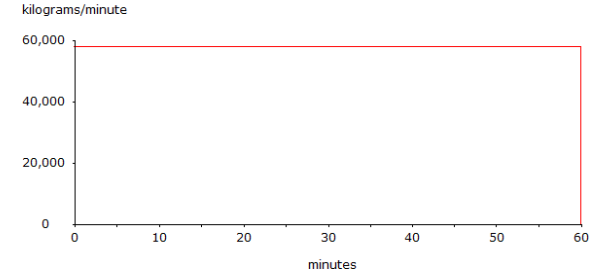
SOURCE STRENGTH:
  Flammable gas is burning as it escapes from pipe
  Pipe Diameter: 30 centimeters          Pipe Length: 60 meters
  Unbroken end of the pipe is connected to an infinite source
  Pipe Roughness: smooth                 Hole Area: 707 sq cm
  Pipe Press: 139.169 atmospheres        Pipe Temperature: 22.8° C
  Max Flame Length: 37 meters
  Burn Duration: ALOHA limited the duration to 1 hour
  Max Burn Rate: 100,000 kilograms/min
  Total Amount Burned: 3,465,142 kilograms

THREAT ZONE:
  Threat Modeled: Thermal radiation from jet fire
  Red    : 120 meters --- (23 kW/(sq m))
  Orange: 159 meters --- (12.7 kW/(sq m))
  Yellow: 255 meters --- (4.7 kW/(sq m))
```

Thermal Radiation Threat Zone



Source Strength (Burn Rate)



Text Summary

```
SITE DATA:
  Location: LOXFORD NSW, AUSTRALIA
  Building Air Exchanges Per Hour: 2.00 (unsheltered single storied)
  Time: April 9, 2021  1219 hours ST (user specified)

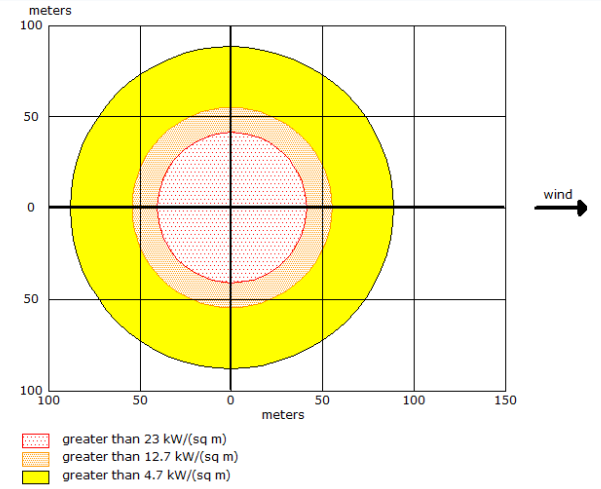
CHEMICAL DATA:
  Chemical Name: METHANE
  CAS Number: 74-82-8                    Molecular Weight: 16.04 g/mol
  PAC-1: 65000 ppm   PAC-2: 230000 ppm   PAC-3: 400000 ppm
  LEL: 50000 ppm     UEL: 150000 ppm
  Ambient Boiling Point: -161.5° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 10 meters/second from NE at 3 meters
  Ground Roughness: 50 centimeters       Cloud Cover: 5 tenths
  Air Temperature: 22.8° C               Stability Class: D
  No Inversion Height                    Relative Humidity: 49%

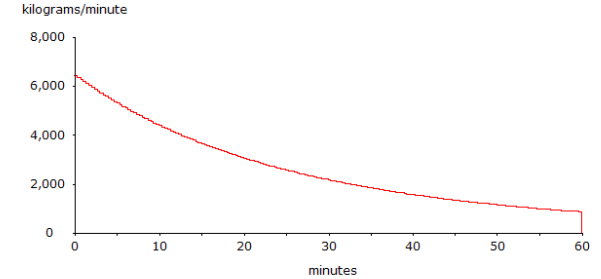
SOURCE STRENGTH:
  Flammable gas is burning as it escapes from pipe
  Pipe Diameter: 30 centimeters          Pipe Length: 30000 meters
  Unbroken end of the pipe is closed off
  Pipe Roughness: smooth                 Hole Area: 45.6 sq cm
  Pipe Press: 139.169 atmospheres        Pipe Temperature: 22.8° C
  Max Flame Length: 7 meters
  Burn Duration: ALOHA limited the duration to 1 hour
  Max Burn Rate: 6,470 kilograms/min
  Total Amount Burned: 159,043 kilograms

THREAT ZONE:
  Threat Modeled: Thermal radiation from jet fire
  Red    : 41 meters --- (23 kW/(sq m))
  Orange: 55 meters --- (12.7 kW/(sq m))
  Yellow: 89 meters --- (4.7 kW/(sq m))
```

Thermal Radiation Threat Zone



Source Strength (Burn Rate)



Text Summary

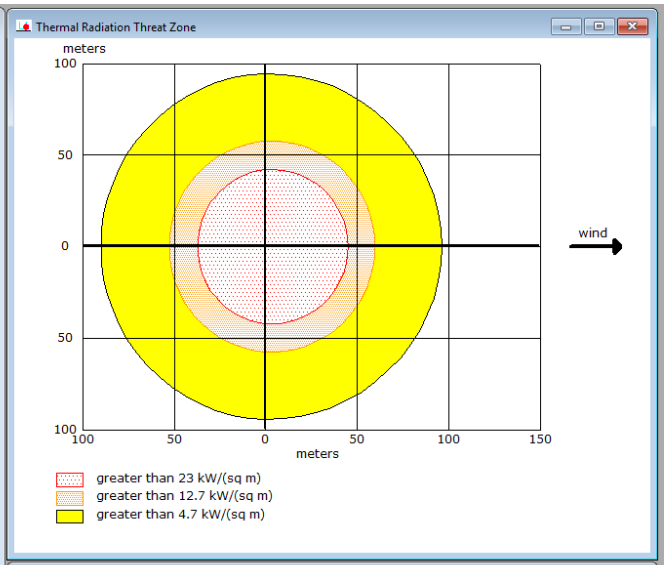
```
SITE DATA:
  Location: LOXFORD NSW, AUSTRALIA
  Building Air Exchanges Per Hour: 2.00 (unsheltered single storied)
  Time: April 9, 2021  1219 hours ST (user specified)

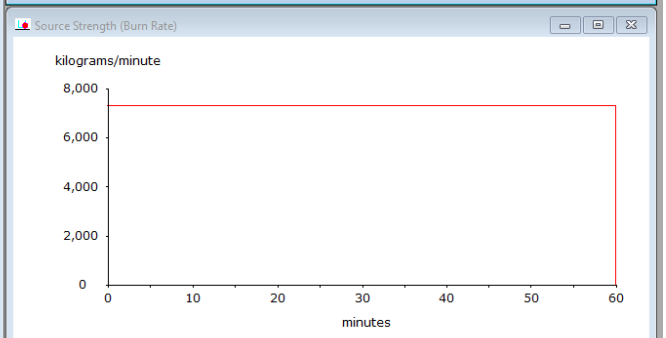
CHEMICAL DATA:
  Chemical Name: METHANE
  CAS Number: 74-82-8                    Molecular Weight: 16.04 g/mol
  PAC-1: 65000 ppm   PAC-2: 230000 ppm   PAC-3: 400000 ppm
  LEL: 50000 ppm     UEL: 150000 ppm
  Ambient Boiling Point: -161.5° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 10 meters/second from NE at 3 meters
  Ground Roughness: 50 centimeters       Cloud Cover: 5 tenths
  Air Temperature: 22.8° C               Stability Class: D
  No Inversion Height                    Relative Humidity: 49%

SOURCE STRENGTH:
  Flammable gas is burning as it escapes from pipe
  Pipe Diameter: 20 centimeters          Pipe Length: 40 meters
  Unbroken end of the pipe is connected to an infinite source
  Pipe Roughness: smooth                 Hole Area: 314 sq cm
  Pipe Press: 40.477 atmospheres         Pipe Temperature: 22.8° C
  Max Flame Length: 22 meters
  Burn Duration: ALOHA limited the duration to 1 hour
  Max Burn Rate: 12,800 kilograms/min
  Total Amount Burned: 437,505 kilograms

THREAT ZONE:
  Threat Modeled: Thermal radiation from jet fire
  Red    : 45 meters --- (23 kW/(sq m))
  Orange: 60 meters --- (12.7 kW/(sq m))
  Yellow: 96 meters --- (4.7 kW/(sq m))
```





Text Summary

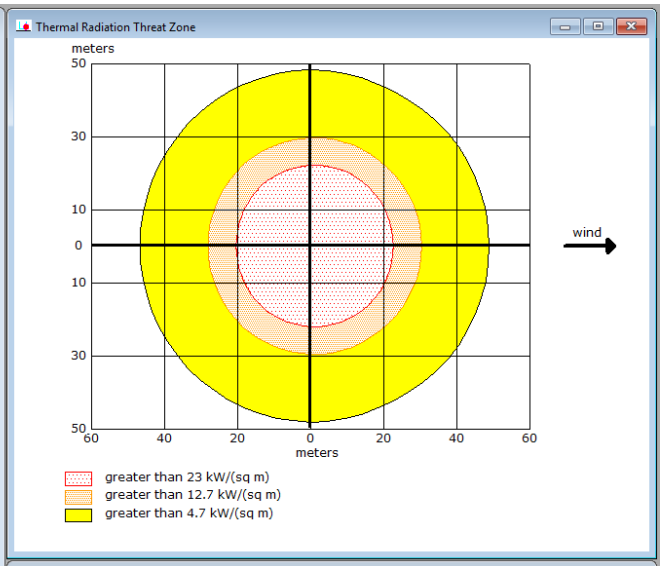
```
SITE DATA:
  Location: LOXFORD NSW, AUSTRALIA
  Building Air Exchanges Per Hour: 2.00 (unsheltered single storied)
  Time: April 9, 2021  1219 hours ST (user specified)

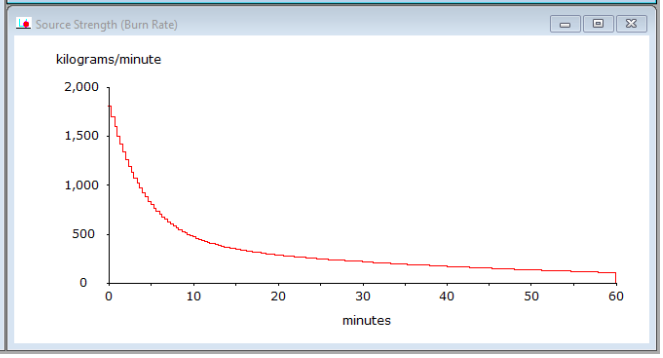
CHEMICAL DATA:
  Chemical Name: METHANE
  CAS Number: 74-82-8                    Molecular Weight: 16.04 g/mol
  PAC-1: 65000 ppm   PAC-2: 230000 ppm   PAC-3: 400000 ppm
  LEL: 50000 ppm     UEL: 150000 ppm
  Ambient Boiling Point: -161.5° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 10 meters/second from NE at 3 meters
  Ground Roughness: 50 centimeters       Cloud Cover: 5 tenths
  Air Temperature: 22.8° C               Stability Class: D
  No Inversion Height                    Relative Humidity: 49%

SOURCE STRENGTH:
  Flammable gas is burning as it escapes from pipe
  Pipe Diameter: 20 centimeters          Pipe Length: 30000 meters
  Unbroken end of the pipe is closed off
  Pipe Roughness: smooth                 Hole Area: 45.6 sq cm
  Pipe Press: 40.477 atmospheres         Pipe Temperature: 22.8° C
  Max Flame Length: 7 meters
  Burn Duration: ALOHA limited the duration to 1 hour
  Max Burn Rate: 1,860 kilograms/min
  Total Amount Burned: 20,073 kilograms

THREAT ZONE:
  Threat Modeled: Thermal radiation from jet fire
  Red    : 23 meters --- (23 kW/(sq m))
  Orange: 30 meters --- (12.7 kW/(sq m))
  Yellow: 49 meters --- (4.7 kW/(sq m))
```





F.3.2 Overpressure and subsequent ignition

Table F.5: Summary of overpressure results

Location	Units	HP @ GRS		LP @ GT	
Rupture size		**Full-Bore**	**3"**	**Full-Bore**	**3"**
Pipe Inner Diameter	mm	300		200	
Pipe Pressure	kPag	14,000		4,000	
Initial Gas Temp (amb.)	°C	22.8		22.8	
Total Mass Emission (Calculated)	kg	5,640	1,340	1,220	770
21.1 kPa Shockwave Radius	m	214	107	83	66
14 kPa Shockwave Radius	m	220	111	91	73
7 kPa Shockwave Radius	m	250	131	118	95

*1 m/s wind speed assumed for all cases

**21.1 kPa represents the maximum shockwave pressure as modelled

Text Summary

```
SITE DATA:
  Location: LOXFORD NSW, AUSTRALIA
  Building Air Exchanges Per Hour: 0.27 (unsheltered single storied)
  Time: April 9, 2021  1219 hours ST (user specified)

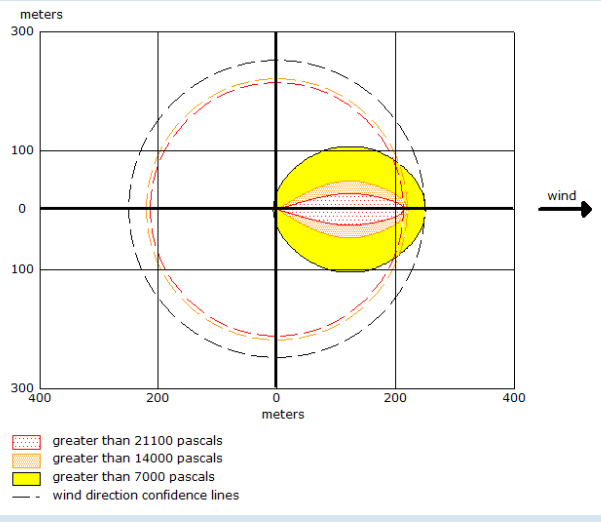
CHEMICAL DATA:
  Chemical Name: METHANE
  CAS Number: 74-82-8                    Molecular Weight: 16.04 g/mol
  PAC-1: 65000 ppm   PAC-2: 230000 ppm   PAC-3: 400000 ppm
  LEL: 50000 ppm     UEL: 150000 ppm
  Ambient Boiling Point: -161.5° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 1 meters/second from NE at 3 meters
  Ground Roughness: 50 centimeters       Cloud Cover: 5 tenths
  Air Temperature: 22.8° C               Stability Class: B
  No Inversion Height                    Relative Humidity: 49%

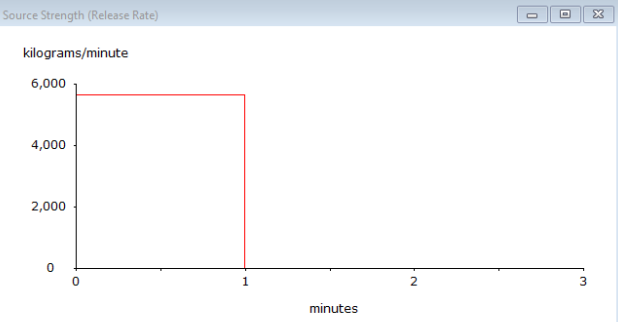
SOURCE STRENGTH:
  Flammable gas escaping from pipe (not burning)
  Pipe Diameter: 30 centimeters          Pipe Length: 874 meters
  Unbroken end of the pipe is closed off
  Pipe Roughness: smooth                 Hole Area: 707 sq cm
  Pipe Press: 139.169 atmospheres        Pipe Temperature: 22.8° C
  Release Duration: 2 minutes
  Max Average Sustained Release Rate: 5,630 kilograms/min
     (averaged over a minute or more)
  Total Amount Released: 5,639 kilograms

THREAT ZONE:
  Threat Modeled: Overpressure (blast force) from vapor cloud explosion
  Type of Ignition: ignited by spark or flame
  Level of Congestion: congested
  Model Run: Gaussian
  Red    : 214 meters --- (21100 pascals)
  Orange: 220 meters --- (14000 pascals)
  Yellow: 250 meters --- (7000 pascals)
```

Overpressure (Blast Force) Threat Zone



Source Strength (Release Rate)



Text Summary

```
SITE DATA:
  Location: LOXFORD NSW, AUSTRALIA
  Building Air Exchanges Per Hour: 0.27 (unsheltered single storied)
  Time: April 9, 2021  1219 hours ST (user specified)

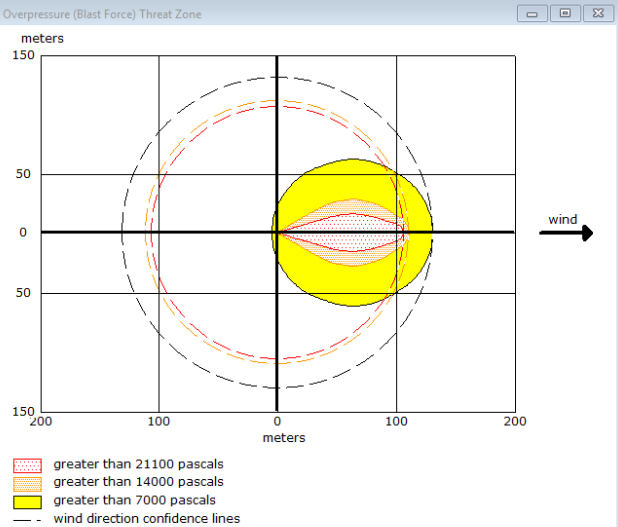
CHEMICAL DATA:
  Chemical Name: METHANE
  CAS Number: 74-82-8                    Molecular Weight: 16.04 g/mol
  PAC-1: 65000 ppm   PAC-2: 230000 ppm   PAC-3: 400000 ppm
  LEL: 50000 ppm     UEL: 150000 ppm
  Ambient Boiling Point: -161.5° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 1 meters/second from NE at 3 meters
  Ground Roughness: 50 centimeters       Cloud Cover: 5 tenths
  Air Temperature: 22.8° C               Stability Class: B
  No Inversion Height                    Relative Humidity: 49%

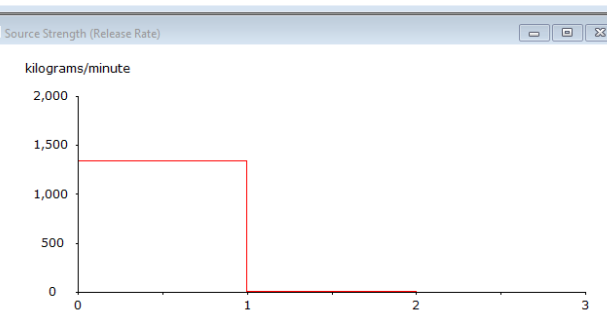
SOURCE STRENGTH:
  Flammable gas escaping from pipe (not burning)
  Pipe Diameter: 30 centimeters          Pipe Length: 208 meters
  Unbroken end of the pipe is closed off
  Pipe Roughness: smooth                 Hole Area: 45.6 sq cm
  Pipe Press: 139.169 atmospheres        Pipe Temperature: 22.8° C
  Release Duration: 2 minutes
  Max Average Sustained Release Rate: 1,330 kilograms/min
     (averaged over a minute or more)
  Total Amount Released: 1,342 kilograms

THREAT ZONE:
  Threat Modeled: Overpressure (blast force) from vapor cloud explosion
  Type of Ignition: ignited by spark or flame
  Level of Congestion: congested
  Model Run: Gaussian
  Red    : 107 meters --- (21100 pascals)
  Orange: 111 meters --- (14000 pascals)
  Yellow: 131 meters --- (7000 pascals)
```

Overpressure (Blast Force) Threat Zone



Source Strength (Release Rate)



Text Summary

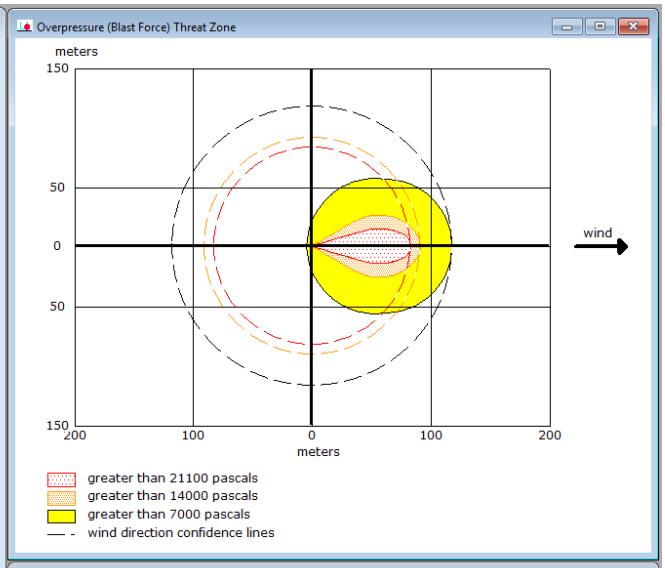
```
SITE DATA:
  Location: LOXFORD NSW, AUSTRALIA
  Building Air Exchanges Per Hour: 0.27 (unsheltered single storied)
  Time: April 9, 2021  1219 hours ST (user specified)

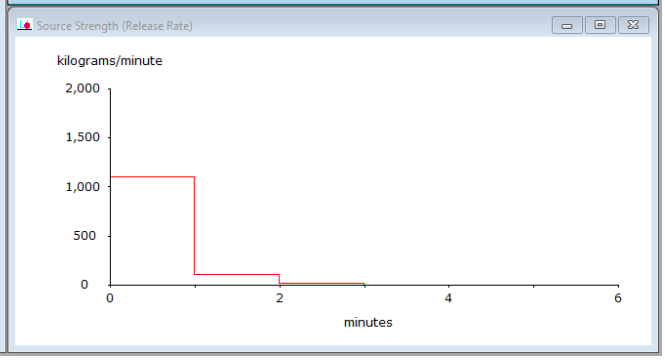
CHEMICAL DATA:
  Chemical Name: METHANE
  CAS Number: 74-82-8                    Molecular Weight: 16.04 g/mol
  PAC-1: 65000 ppm   PAC-2: 230000 ppm   PAC-3: 400000 ppm
  LEL: 50000 ppm     UEL: 150000 ppm
  Ambient Boiling Point: -161.5° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 1 meters/second from NE at 3 meters
  Ground Roughness: 50 centimeters       Cloud Cover: 5 tenths
  Air Temperature: 22.8° C               Stability Class: B
  No Inversion Height                    Relative Humidity: 49%

SOURCE STRENGTH:
  Flammable gas escaping from pipe (not burning)
  Pipe Diameter: 20 centimeters          Pipe Length: 1489 meters
  Unbroken end of the pipe is closed off
  Pipe Roughness: smooth                 Hole Area: 314 sq cm
  Pipe Press: 40.477 atmospheres         Pipe Temperature: 22.8° C
  Release Duration: 5 minutes
  Max Average Sustained Release Rate: 1,100 kilograms/min
     (averaged over a minute or more)
  Total Amount Released: 1,220 kilograms

THREAT ZONE:
  Threat Modeled: Overpressure (blast force) from vapor cloud explosion
  Type of Ignition: ignited by spark or flame
  Level of Congestion: congested
  Model Run: Gaussian
  Red    : 83 meters --- (21100 pascals)
  Orange: 91 meters --- (14000 pascals)
  Yellow: 118 meters --- (7000 pascals)
```





Text Summary

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SITE DATA:
  Location: LOXFORD NSW, AUSTRALIA
  Building Air Exchanges Per Hour: 0.27 (unsheltered single storied)
  Time: April 9, 2021  1219 hours ST (user specified)

CHEMICAL DATA:
  Chemical Name: METHANE
  CAS Number: 74-82-8                    Molecular Weight: 16.04 g/mol
  PAC-1: 65000 ppm   PAC-2: 230000 ppm   PAC-3: 400000 ppm
  LEL: 50000 ppm     UEL: 150000 ppm
  Ambient Boiling Point: -161.5° C
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 1 meters/second from NE at 3 meters
  Ground Roughness: 50 centimeters       Cloud Cover: 5 tenths
  Air Temperature: 22.8° C               Stability Class: B
  No Inversion Height                    Relative Humidity: 49%

SOURCE STRENGTH:
  Flammable gas escaping from pipe (not burning)
  Pipe Diameter: 20 centimeters          Pipe Length: 940 meters
  Unbroken end of the pipe is closed off
  Pipe Roughness: smooth                 Hole Area: 45.6 sq cm
  Pipe Press: 40.477 atmospheres         Pipe Temperature: 22.8° C
  Release Duration: 5 minutes
  Max Average Sustained Release Rate: 697 kilograms/min
     (averaged over a minute or more)
  Total Amount Released: 770 kilograms

THREAT ZONE:
  Threat Modeled: Overpressure (blast force) from vapor cloud explosion
  Type of Ignition: ignited by spark or flame
  Level of Congestion: congested
  Model Run: Gaussian
  Red    : 66 meters --- (21100 pascals)
  Orange: 73 meters --- (14000 pascals)
  Yellow: 95 meters --- (7000 pascals)
```