





Culcairn to Wagga Wagga Gas Pipeline

MOD 1 Uranquinty Compressor Station - Preliminary Hazard Analysis

APA Group

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Executive Summary

The proposed modification

East Australian Pipeline Pty Ltd, part of APA Group (APA), own and operate the Culcairn to Wagga Wagga Pipeline, an 88 km natural gas pipeline extending from Wagga Wagga in the Wagga Wagga local government area (LGA) to Culcairn in the Greater Hume Shire LGA in NSW. The Culcairn to Wagga Wagga pipeline interconnects with the Moomba to Wilton Pipeline which extends approximately 1,300 km between Moomba in South Australia to Wilton in NSW. The Culcairn to Wagga Wagga Pipeline is authorised by Pipeline Licence No. 23 (PL23) and SSI-65512969. The pipeline forms part of APA's East Coast Grid of gas transmission pipelines.

APA seeks to construct the Uranquinty Compressor Station (UCS) as part of Stage 3 of APA's East Coast Grid Expansion Plan (the proposed modification). The UCS would be located in Uranquinty, NSW along Uranquinty Cross Road within the Wagga Wagga LGA on land owned by APA (Lot 781 DP 878179, the 'proposed site') (refer to Figure 1.1).

The construction and operation of the UCS, the decommissioning of infrastructure and rehabilitation of land is being sought through a modification (Modification 1) to the SSI-65512969 approval under Section 5.25 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), referred to as 'the proposed modification' in the Modification Report.

This report

This report includes a description of the proposed modification, summary of dangerous goods (DGs) used on site, identification of DGs expected to be transported, handled, and stored on the proposed site, risk screening of DGs as per the State Environmental Planning Policy (Resilience and Hazards) 2021 requirements, and an assessment that reviews potential hazards that may arise during the construction, operation, maintenance, decommissioning and rehabilitation of the development.

A Preliminary Hazard Analysis (PHA) was deemed necessary for the proposed modification. The Level 3 PHA was conducted as a quantitative desktop study and systematically identified any potential off-site impacts and mitigation measures to eliminate, or control identified hazards.

The PHA was undertaken in accordance with *Hazardous Industry Planning Advisory Paper No 6 – Guidelines for Hazard Analysis* (HIPAP No 6) (Department of Planning, 2011a), which lists the process required for undertaking a PHA, and *Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning* (HIPAP No 4) (Department of Planning, 2011b) which sets out risk criteria for industries that are considered potentially hazardous to comply with.

Impacts from the proposed modification during operation

The loss of containment of natural gas from the pipeline and compression station were identified risks during operation, which may result in off-site impacts on people, property, or the biophysical environment. Flammable releases are not expected during the construction phase, and planned flammable releases during the commissioning, maintenance and decommissioning phases have not been assessed as any potential offsite impacts from these activities would be managed using controls. The operational phase loss of containment risk was assessed using the risk modelling software Safeti version 9.0 and compared against the Hazardous Industry Planning and Advisory Paper (HIPAP) No. 4 risk criteria.

The results of the quantitative risk assessment identified that the cumulative off-site fatality risk results for the project complies with the individual and societal risk criteria outlined in HIPAP No. 4 and are therefore considered broadly acceptable. There is negligible risk to the nearest sensitive land users, which are located more than 900 m away. Members of the public using Uranquinty Cross Road would be temporarily exposed to a risk equivalent to the HIPAP No. 4 specified "sporting complex and active open space" risk criteria for the duration of the time they are passing the site.

The following recommendations have been identified from this study:

- Develop a control philosophy for the UCS
- Any new equipment should have procedures developed for their safe operation to prevent injury to people.
- Provide protection of above ground facilities from inadvertent or deliberate acts, which may cause damage to the exposed equipment and piping e.g., security fencing to prevent vandalism and barriers to prevent vehicle collision where adjacent to roads, as per the *Security of Critical Infrastructure Act 2018* requirements.
- Prepare an update to the existing Safety Management Study for the Culcairn to Wagga Wagga Pipeline to incorporate the UCS in accordance with AS 2885 (Australian Standard for Pipelines - Gas & Liquid Petroleum), including a Hazard and Operability (HAZOP) study. This should include assessment that the pipeline and UCS will have adequate over-pressure and over- and under-temperature protection.
- Implement an appropriate Asset Lifecycle Plan for the UCS, which includes site checks and maintenance regimes
- Communicate to Origin Energy and neighbouring lots that may be developed in the future the risk of injury to onsite personnel, and implement appropriate safeguards, such as Emergency Response Plans, at the neighbouring facilities.
- Hazardous Area Classification, including review of potential ignition sources on site, and selection of appropriately rated electrical equipment to manage the potential ignition sources.

The hazard identification and analysis demonstrate that the modification can be designed, constructed, and operated in a manner that will meet the relevant regulations, standards and policies and minimise hazardous impact to the public.

Any changes to the assumptions used in this report should result in a review of the screening and PHA process and update as required. This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.3 and the assumptions and qualifications contained throughout the report.

Glossary and abbreviations

Abbreviation	Description
APA	APA Group
CSMP	Construction Safety Management Plan
DG	Dangerous Good(s)
DNV	Det Norske Veritas
DoP	(NSW) Department of Planning
EIS	Environmental Impact Statement
FBR	Full bore rupture
GHD	GHD Pty Ltd
HAZID	Hazard Identification
HAZOP	Hazard and Operability
HIPAP	(NSW) Hazardous Industry Planning Advisory Paper
HV	High Voltage
IBC	Intermediate Bulk Container
LFL	Lower Flammability Limit
NSW	New South Wales
Pfat	Probability of fatality
PHA	Preliminary Hazard Analysis
PL	Pipeline License
QRA	Quantitative Risk Assessment
Safeti	Software for the assessment of fire, explosion and toxic impacts
SDV	Shutdown Valve
SEPP	SEPP (Resilience and Hazards), formerly called State Environmental Planning Policy No. 33 – Hazardous and Offensive Development
SMS	Safety Management Study
TNO	The Netherlands Organisation
UCS	Uranquinty Compressor station
UPS	Uranquinty Power Station
UFL	Upper Flammable Limit
VFD	Variable Frequency Drive

Contents

Glossary and abbreviations	iii
1. Introduction	1
1.1 Overview	1
1.2 Purpose of this report	1
1.3 Scope and limitations	1
1.4 Structure of this report	2
1.5 Summary of the modification	2
1.6 Modelling software	7
1.7 Assumptions	7
2. Legislative and policy context	8
2.1 State Environmental Planning Policy (Resilience and Hazards) 2021	8
2.2 Multi-level risk assessment	8
2.3 Hazardous Industry Planning Advisory Papers	9
3. Methodology	11
3.1 Hazard identification	11
3.2 Preliminary hazard analysis	12
4. Risk screening	16
4.1 Dangerous goods and hazardous materials screening	16
4.2 Summary of risk screening results	19
5. Hazard identification and management	20
5.1 Hazard identification (HAZID)	20
6. Preliminary Hazard Analysis	25
6.1 Summary of hazard scenarios	25
6.2 Consequence and risk modelling results	25
7. Conclusions	39
8. Recommendations	40
9. References	41

Table index

Table 1.1	Identified offsite receivers	5
Table 3.1	Heat radiation criteria	13
Table 3.2	Overpressure criteria	13
Table 3.3	Individual fatality risk criteria	14
Table 3.4	Individual injury risk criteria	14
Table 3.5	Property damage criteria	15
Table 4.1	Construction related Dangerous Goods volumes and thresholds	16
Table 4.2	Operations Dangerous Goods volumes and thresholds	17

Table 5.1	Identified hazards for the YW158 compressor station and pipeline take-offs	21
Table 6.1	Summary of hazardous scenarios for assessment	25
Table 6.2	Modelling inputs	26
Table 6.3	Summary of jet fire radiation consequence distances	27
Table 6.4	Summary of flash fire consequence distances	30
Table 6.5	Summary of explosion overpressure consequence distances	34
Table 6.6	Fireball scenario – distances to thermal radiation intensity levels	34
Table 7.1	HIPAP 4 risk criteria compliance	39
Table D.1	Scenario 1: Jet Fire Results	1
Table D.2	Scenario 1: Flash Fire Results	2
Table D.4	Scenario 2: Jet Fire Results	3
Table D.5	Scenario 2: Flash Fire Results	4
Table D.7	Scenario 3: Jet Fire Results	5
Table D.8	Scenario 3: Flash Fire Results	6
Table D.10	Scenario 4: Jet Fire Results	7
Table D.11	Scenario 4: Flash Fire Results	8
Table E.1	Wind classes and directions	11
Table E.2	Wind Speeds and direction probabilities	12

Figure index

Figure 1.1	Site layout	4
Figure 1.2	Sensitive receivers	6
Figure 2.1	Multi-level risk assessment approach (NSW Department of Planning, 2011)	9
Figure 3.1	Risk assessment flowchart	12
Figure 6.1	Scenario 1: Pipeline take off piping to compressor, full bore rupture – Jet fire effect zone, 4.6D weather condition	28
Figure 6.2	Scenario 2: Compressor and inlet piping, full bore rupture – Jet fire effect zone, 1.6F weather condition	29
Figure 6.3	Scenario 3: Compressor outlet piping, full bore rupture – Jet fire effect zone, 1.6F weather condition	29
Figure 6.4	Scenario 4: Compressor discharge piping to pipeline take off, full bore rupture – Jet fire effect zone, 5.1D weather condition	30
Figure 6.5	Scenario 1: Pipeline take off piping to compressor, full bore rupture – Flash fire effect zone, 5.1D weather condition	31
Figure 6.6	Scenario 2: Compressor and inlet piping, full bore rupture – Flash fire effect zone, 5.1D weather condition	32
Figure 6.7	Scenario 3: Compressor outlet piping, full bore rupture – Flash fire effect zone, 5.1D weather condition	32
Figure 6.8	Scenario 4: Compressor discharge piping to pipeline take off, full bore rupture – Flash fire effect zone, 5.1D weather condition	33
Figure 6.9	Scenario 2: Compressor and inlet piping, full bore rupture – Flash fire cloud side view, 5.1D weather condition	33
Figure 6.10	Fireball scenario, full bore rupture – 4.7 kW/m ² effect zone, 1.6/F weather condition	35
Figure 6.11	Fireball scenario, full bore rupture – 35 kW/m ² effect zone, 1.6/F weather condition	35
Figure 6.12	Individual fatality risk contours	36

Figure 6.13	Individual fatality risk contours – close-up of site	36
Figure 6.14	Individual Injury risk contour	37
Figure 6.15	Property damage risk contour	38

Appendices

Appendix A	Site Layout
Appendix B	Methane Safety Data Sheet
Appendix C	Assumptions Register
Appendix D	Consequence Modelling Results
Appendix E	Site Meteorological Data

1. Introduction

1.1 Overview

East Australian Pipeline Pty Ltd, part of APA Group (APA), own and operate the Culcairn to Wagga Wagga Pipeline, an 88 km natural gas pipeline extending from Wagga Wagga in the Wagga Wagga local government area (LGA) to Culcairn in the Greater Hume Shire LGA in NSW (the project). The Culcairn to Wagga Wagga pipeline interconnects with the Moomba to Wilton Pipeline which extends approximately 1,300 km between Moomba in South Australia to Wilton in NSW.

The Culcairn to Wagga Wagga Pipeline is authorised by Pipeline Licence No. 23 (PL23) and SSI-65512969. The pipeline forms part of APA's East Coast Grid of gas transmission pipelines.

APA is proposing an expansion of gas transportation capacity within its East Coast Grid linking Queensland to southern states of Australia. This is in response to forecasted potential supply issues during the winter months. To achieve expansion of the East Coast Grid and build capacity to move more gas to address shortfalls, the construction of a compressor station on the Culcairn to Wagga Wagga Pipeline is proposed.

APA seeks to construct the Uranquinty Compressor Station (UCS) as part of Stage 3 of APA's East Coast Grid Expansion Plan (the proposed modification). The UCS would be located in Uranquinty, NSW along Uranquinty Cross Road within the Wagga Wagga LGA on land owned by APA (Lot 781 DP 878179).

The construction and operation of the UCS, the decommissioning of infrastructure and rehabilitation of land is being sought through a modification (Modification 1) to the SSI-65512969 approval under Section 5.25 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), referred to as 'the proposed modification'.

Further details on the proposed modification are provided in the Culcairn to Wagga Gas Pipeline Modification 1 – Uranquinty Compressor Station Report.

1.2 Purpose of this report

This report has been prepared to:

- Assess the hazard and risk impacts for the proposed UCS in terms of the potential impact on the surrounding land use in accordance with the approach outlined in the Department of Planning, Housing and Infrastructure (DPHI) *Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis* (HIPAP No 6) (DoP, 2011a)
- Determine whether the risk posed by the modification complies with the risk criteria outlined in the DPHI *Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning* (HIPAP No 4) (DoP, 2011b).
- Identify risk reduction options such that the risk is reduced so far as is reasonably practicable.

The scope of work for the proposed modification requires consideration of hazards and risks related to proximity to other facilities and ongoing land use. To satisfy this requirement, a Preliminary Hazard Analysis (PHA) has been undertaken.

This PHA has been undertaken to support the Modification Report for Modification 1 and should be read in conjunction with that report and all other supporting studies.

1.3 Scope and limitations

The scope of this report includes the UCS. Excluded is any identification or assessment of hazards and risks associated with current operational activities beyond the proposed modification. The assessment focuses on risks to surrounding populations and excludes assessment of onsite risk.

Additionally, this report has been prepared by GHD for APA Group and may only be used and relied on by APA Group for the purpose agreed between GHD and APA Group as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than APA Group arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer to Section 1.6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by APA Group and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

It must be recognised that a quantitative risk assessment (QRA) is one tool to assist decision making and not a substitute for suitably experienced and competent engineering input. Due to limitations of input data and Safeti¹ model detail/programming limits, the results of a QRA are approximate and reflect the constraints of the input data, assumptions, and model rule sets. The conclusions of a QRA are therefore sensitive to variations in the inputs or modelling assumptions. This is an unavoidable limitation of the technique. This study is reliant on the ability of the Safeti software to correctly model the data and settings for this exercise. GHD have not conducted an independent verification of the software and disclaims any responsibility for the performance of the Safeti program.

1.4 Structure of this report

The report is structured as follows:

- Section 1: provides an introduction to the modification and the assessment
- Section 2: describes the legislative context for the assessment
- Section 3: describes the methodology for the assessment
- Sections 4, 5 and 6: assess the impacts of all stages of the modification and describes mitigation measures for the impacts
- Sections 7 and 8: presents the conclusions and recommendations.

1.5 Summary of the modification

1.5.1 Location

The site for the proposed modification is identified as Lot 781 / DP 878179 in Uranquinty, NSW on land owned by APA, located within the Wagga Wagga LGA (the proposed site). The proposed site is adjacent to the Uranquinty Power Station (constructed in 2008 and commissioned in 2009) which is owned and operated by Origin Energy. The proposed site is about 4.6 ha in size and located approximately 3.2 km north-west of the town of Uranquinty, NSW. The major access to the proposed site is via Uranquinty Cross Road. An existing access road is present within the proposed site which also provides access to the metering station.

The Uranquinty Power Station is located adjacent to the eastern boundary of the proposed site. Ancillary infrastructure for the power station runs along the eastern boundary of the proposed site which connects to the Uranquinty Power Station. The proposed site location is presented in Figure 1.1.

¹ Software for the Assessment of Flammable, Explosive and Toxic Impact

1.5.2 The proposed modification

The proposed modification will include the construction of:

- An electric driven compressor unit
- Lubricating oil system (inclusive of lube oil cooler)
- Compressor inlet / scrubber
- Air cooled heat exchangers
- Electrical house for high voltage switchgear
- Variable Frequency Drive (VFD)
- VFD cooler
- Isolation transformer
- Electrical substation and high voltage HV power transmission lines to substation
- Air compressors and receivers
- Nitrogen generation
- Associated piping, electrical equipment, instrumentation and controls
- Station attenuated vent
- Control building housing the automated control systems and communications
- Back up diesel generator
- Septic tank system
- Security fences
- Access and support facilities.

The Uranquinty Power Station is located adjacent to the proposed site on the north-east corner. This power station can be operated manned or remotely with up to 6 personnel working on-site (Origin, 2022, Table 2.3). There is also an Australian Gas Network (AGN) fenced compound which shares a border with the UCS. The site layout is shown in more detail in Figure 1.1.

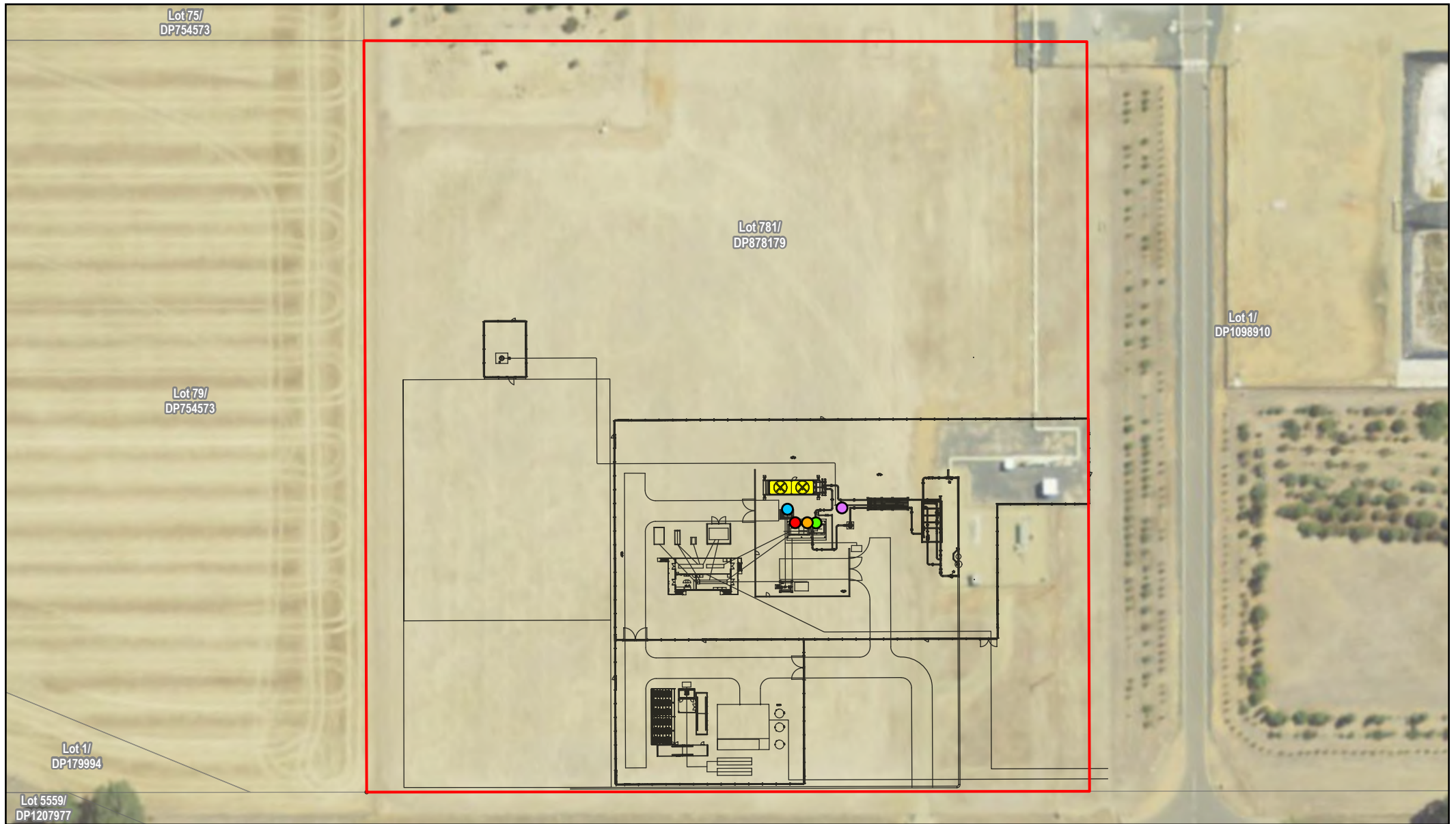
Construction of the UCS is scheduled to begin in the second half of 2026 subject to approval of Modification 1. The construction of UCS would take approximately 12 months, followed by approximately three months of commissioning. Once completed, UCS will have a design life of approximately 25 years.

The construction of UCS will require an average workforce of 40, with a peak of 65 personnel over the 12-month period (including commissioning). Mobilisation and demobilisation of the workforce will likely be from the nearest airport (i.e., Wagga Wagga). The workforce will commute to site each day as there is not proposed to be an on-site temporary workers' accommodation camp over the construction timeframe.

Construction is expected to require a daily total of 32 heavy vehicle movements and 66 light vehicle movements. The major road to access the proposed site is via Uranquinty Cross Road. An existing access road is present within the proposed site which provides access to the APA owned metering station for the Culcairn to Wagga pipeline (metering station) infrastructure (refer to Figure 1.1). The proposed site will be rehabilitated progressively as construction activities are completed.

The UCS is designed to operate remotely without onsite staff for most of its working life. It would be operated remotely from APA's control centre in Brisbane and can operate up to 24 hours per day, seven days per week. It is anticipated that the compressor will operate intermittently depending upon gas demand throughout the year.

The decommissioning phase will likely involve removal of infrastructure followed by rehabilitation of temporary disturbance areas back to their original state, which may include filling excavated areas. The proposed site will be fully rehabilitated following decommissioning of the UCS at the end of its design life, estimated at around 25 years.



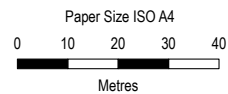
LEGEND

- Proposed site
- After cooler
- Lot
- Site layout

Noise sources

- Anti-Surge valve
- Compressor
- Gearbox

- Lube Oil Cooler
- Motor



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55



**East Australian Pipeline Pty Ltd
Culcairn to Wagga Wagga Gas Pipeline –
MOD 1 Uranquinty Compressor Station
Preliminary Hazard Analysis**

Site layout

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Date **29/07/2025**

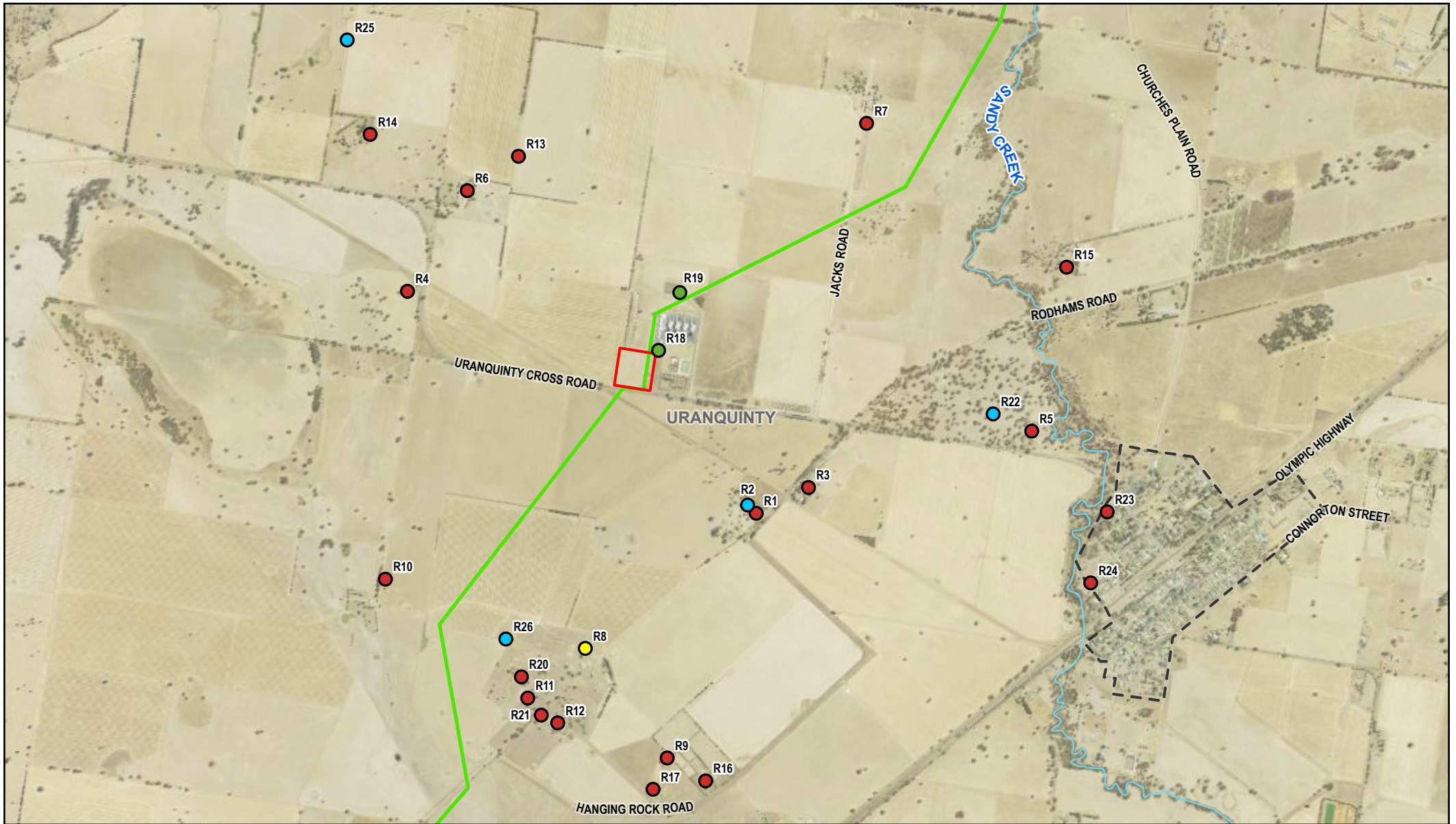
FIGURE 1.1

1.5.3 Offsite receptors

The Air Quality Assessment for the proposed modification identified nearby sensitive receivers. The nearest residential offsite receiver is more than 900 m from the proposed site. A list of sensitive receivers is summarised in Table 1.1 and shown on Figure 1.2.

Table 1.1 *Identified offsite receivers*

ID	Description	Distance from site (m)	Direction from site
R1	Residential	924	Southeast
R2	Primary production (Shed)	855	Southeast
R3	Residential	1,055	Southeast
R4	Residential	1,283	West
R5	Residential	2,197	East
R6	Residential	1,286	Northwest
R7	Residential	1,803	Northeast
R8	Commercial	1,530	South
R9	Residential	2,124	South
R10	Residential	1,738	Southwest
R11	Residential	1,880	South
R12	Residential	1,984	South
R13	Residential	1,274	Northwest
R14	Residential	1,920	Northwest
R15	Residential	2,414	Northeast
R16	Residential	2,276	South
R17	Residential	2,303	South
R18	Industrial	29	North
R19	Industrial	383	North
R20	Residential	1,773	South
R21	Residential	1,957	South
R22	Primary production (Shed)	1,961	East
R23	Residential	2,717	East
R24	Residential	2,765	East
R25	Primary production (Shed)	2,402	Northwest
R26	Primary production (Shed)	1,598	Southwest



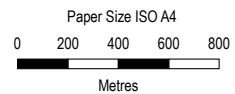
LEGEND

- Proposed site
- Uranquinty township

- ~ Waterway
- Culcairn to Wagga Wagga pipeline

Sensitive receivers

- Commercial
- Industrial
- Residential
- Shed



Map Projection: Transverse Mercator
 Horizontal Datum: GDA 1994
 Grid: GDA 1994 MGA Zone 55



East Australian Pipeline Pty Ltd
Culcairn to Wagga Wagga Gas Pipeline
- MOD 1 Uranquinty Compressor Station
Preliminary Hazard Analysis
Sensitive receivers

Project No. **12614690**
 Revision No. **0**
 Date **10/06/2025**

FIGURE 1.2

1.6 Modelling software

The consequence modelling and quantitative risk analysis (QRA) was performed using Det Norske Veritas (DNV) Safeti Version 9.0 (DNV, 2024).

Safeti is recognized as the industry standard for process hazard analysis inclusive of flammable, fire, explosion, and toxic hazards. It is used to estimate, understand, and visualize the effects from loss of containment scenarios.

1.7 Assumptions

Specific assumptions for the PHA were recorded and agreed during the study and are provided in Appendix C.

Further assumptions have been made in the preparation of this report:

- All plant and equipment items will be designed, installed and operated in accordance with appropriate Australian Standards, codes, and guidelines.
- All equipment and systems are designed to be inherently safe.
- All equipment is maintained and operated as designed.

Any changes to the assumptions used in this report should result in a review of the PHA and update as required.

2. Legislative and policy context

2.1 State Environmental Planning Policy (Resilience and Hazards) 2021

Chapter 3 of the State Environmental Planning Policy (Resilience and Hazards) 2021 (Resilience and Hazards SEPP) provides planning provisions to manage hazardous and offensive development. The proposed modification is considered a 'potentially hazardous industry', which means:

a development for the purposes of any industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality -

(a) to human health, life, or property, or

(b) to the biophysical environment,

and includes a hazardous industry and a hazardous storage establishment.

Section 3.11 of the Resilience and Hazards SEPP provides that the proponent of a potentially hazardous facility must undertake a PHA in accordance with the current circulars or guidelines published by the Department of Planning.

The *Applying SEPP 33: Hazardous and Offensive Development Application Guidelines* (DoP, 2011c) provides the process for assessing if developments are potentially hazardous or offensive, including threshold levels that trigger the potentially hazardous or offensive status. *Applying SEPP 33* (DoP, 2011c) is the main guidance document that has been followed for this PHA.

2.2 Multi-level risk assessment

In implementing its requirements for risk assessment, the NSW DPHI advocates an approach where the level and extent of the analysis should reflect the nature, scale and location of each development.

The *Multi-level Risk Assessment* (DoP, 2011d) provides guidance in determining the appropriate level of risk assessment which is summarised in Figure 2.1. These guidelines are intended to assist in carrying out and evaluating risk assessments at an appropriate level. The principles in the guidelines may be used when considering risks from new facilities or risks from existing facilities.

The level of risk assessment required is determined by the potential for harm:

- A Level 1 assessment (qualitative) is applicable if the level of harm is significant but not serious.
- A Level 2 assessment (semi-quantitative) can be justified for certain scenarios / events having a potential medium level of harm if the societal risk estimates fall within the middle So Far As Is Reasonably Practical zone and the frequency of risk contributors having offsite consequences is relatively low.
- A Level 3 (quantitative) assessment is required if there is a high potential of harm.

A level 3 quantitative assessment approach has been applied for this PHA.

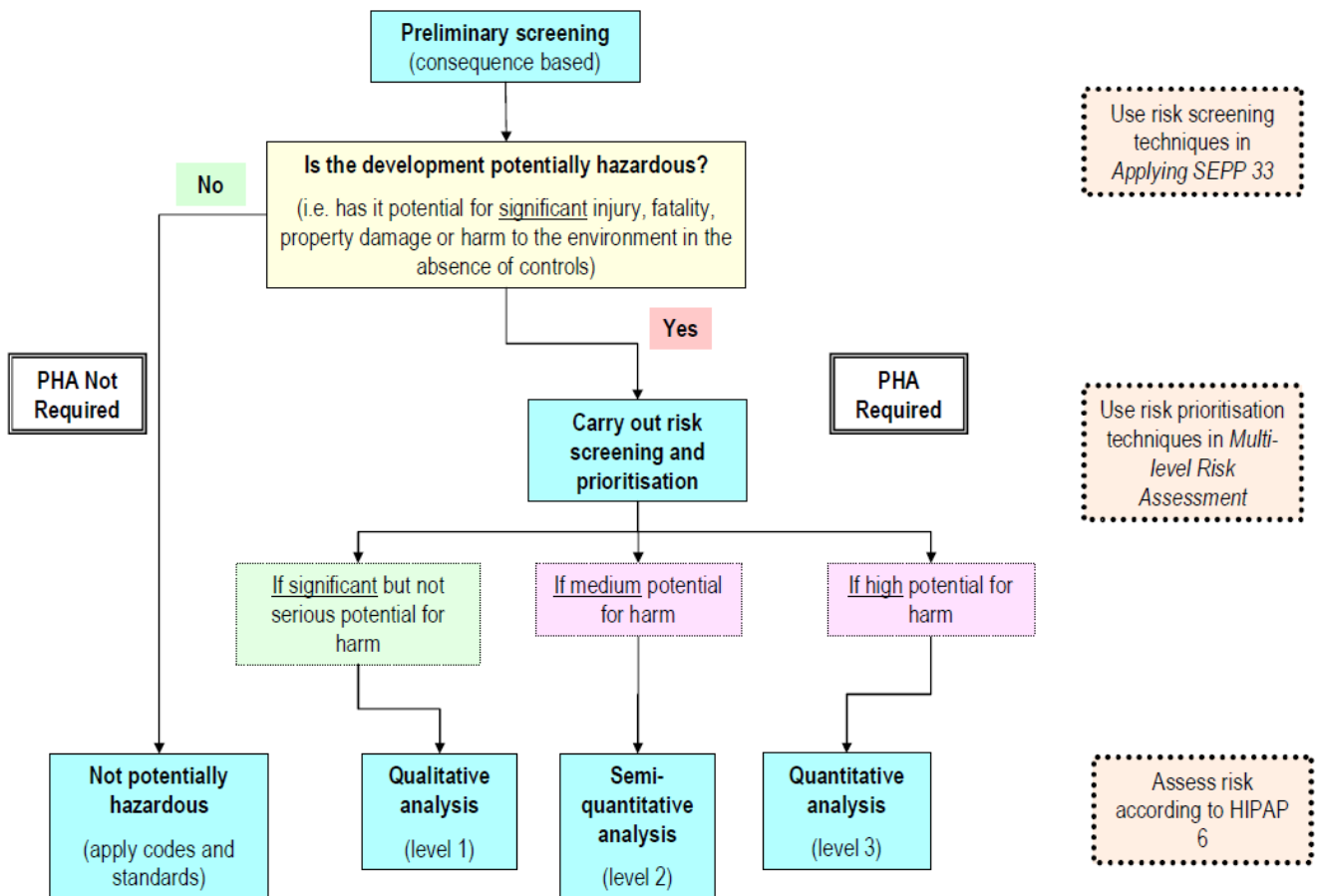


Figure 2.1 Multi-level risk assessment approach (NSW Department of Planning, 2011)

2.3 Hazardous Industry Planning Advisory Papers

HIPAP No 6 (DoP, 2011a) lists the process required for undertaking a PHA.

HIPAP No 4 (DoP, 2011b) sets out risk criteria for industries that are considered hazardous to comply with. These are discussed in Section 3.2.1.

These guidelines are described below, including their relevance to the assessment undertaken.

Hazardous Industry Planning Advisory Paper No. 6 – Hazard Analysis

HIPAP No. 6 explains the hazard analysis process, provides guidance on the general approach recommended for hazard analysis, and details the requirements for a PHA.

When the risk assessment method required is quantitative, HIPAP No. 6 specifies that:

- Appropriate modelling tools should be used to calculate the consequences of all events determined by the preliminary assessment to have the potential for harmful off-site effects.
- There should be an estimate of likelihood for each event confirmed by the consequence modelling to have significant off-site effects, using appropriate failure data and techniques, such as fault and event trees.
- There should be an indicative estimate of the off-site risk, taking into account the cumulative impact of multiple events.
- The study must demonstrate that all relevant numerical risk criteria would be met (specified in HIPAP No. 4).

Section 3 outlines how the requirements of HIPAP No. 6 have been applied in the PHA for both the qualitative and quantitative risk assessments completed.

Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Planning

HIPAP No. 4 provides risk criteria to be considered when assessing the acceptability of potentially hazardous development. The relevant HIPAP No. 4 criteria are provided in Section 3.2.1.

Following completion of the risk assessment in accordance with HIPAP No. 6 (below), the results of the risk assessment are compared with the criteria to determine compliance. In cases of non-compliance against the HIPAP No. 4 criteria, controls are needed to reduce the risk to acceptable levels.

3. Methodology

The risk screening process concentrates on the storage of specific dangerous goods (DG) classes that have the potential for significant off-site effects. Specifically, the assessment involves the identification of classes and quantities of all DGs to be used, stored, or produced on-site with an indication of storage locations. The quantities of DGs are then assessed against the *Applying SEPP 33* (DoP, 2011c) threshold quantities. If any of the *Applying SEPP 33* (DoP, 2011c) threshold quantities are exceeded, then further assessment is required. If the threshold is not exceeded, the assessment concludes at the risk screening.

Environmental hazards and risks related to air emissions, dust, noise, vibration, soil, waste and water quality are excluded from this assessment, as they are addressed by other technical reports and chapters for the proposed modification.

Similarly, transport hazards are not included in the assessment, except for those involving dangerous goods. Potential traffic and transport risks and impacts, and measures that would be implemented to manage these risks are addressed in the Traffic and Transport Assessment undertaken for the proposed modification.

A Bushfire Assessment has been undertaken for the proposed modification.

3.1 Hazard identification

Following screening, *Applying SEPP 33* (DoP, 2011c) requires a determination of whether the proposed modification poses significant risk or offence. This requires identification of potential hazards to highlight any risks associated with the interaction of the proposed modification (as a whole) with the surrounding environment (i.e., a systematic process to identify any potential off-site impacts).

The Hazard Identification (HAZID) process is a desktop assessment and involves documenting possible events that could lead to a possible off-site incident. The assessment then lists the potential causes of the incident, as well as identification of operational and organisational safeguards to prevent the incidents from occurring or mitigate their impact. The HAZID process identifies the scenarios relevant to the PHA, should it be required.

3.2 Preliminary hazard analysis

The PHA identifies the potential hazards, analyses these hazards in terms of their impact to people and the environment and their likelihood of occurrence, quantifies the resulting risk to surrounding land users and assesses the risk to demonstrate that the proposed modification will not impose an unacceptable level of risk. The assessment is performed using a quantitative risk assessment (QRA) approach, as summarised in Figure 3.1.

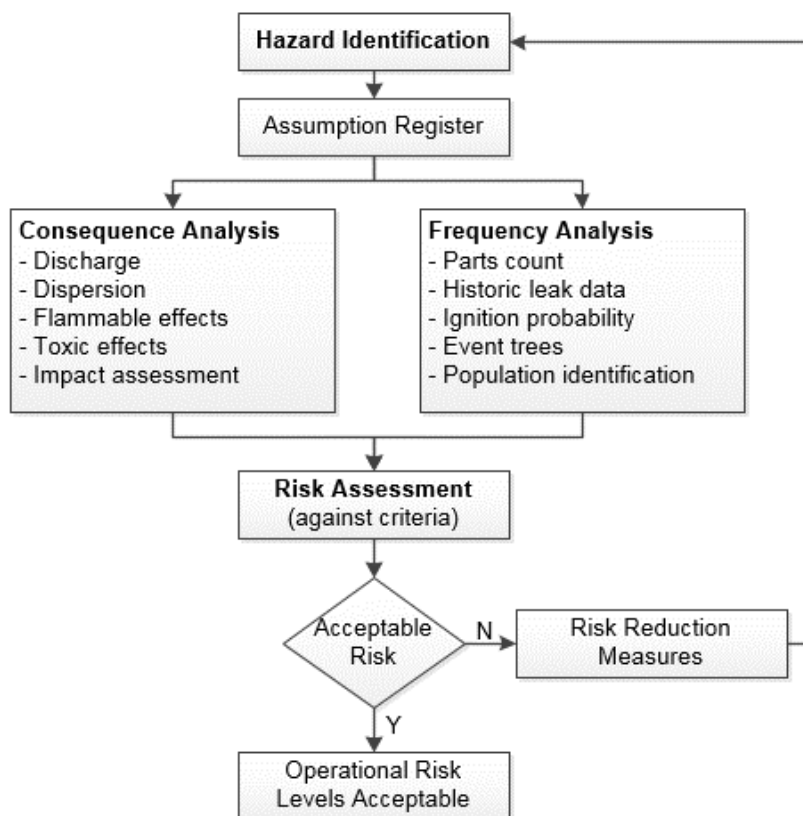


Figure 3.1 Risk assessment flowchart

3.2.1 Relevant risk criteria

The identification of hazards and the quantification of risks outside the boundaries of a potentially hazardous development, and assessment of that risk in terms of the nature of land uses in the vicinity provide the basis for compatible land use safety planning. The following criteria is used as the basis to draw meaningful conclusions from the risk assessment. Individual fatality or injury risk measures represent the likelihood of a specified level of harm at a specified location. No account is taken of whether or not anyone is actually present at that location. (HIPAP 6, Section 7.2)

3.2.1.1 Risk determination

The risk associated with flammable effects are determined using a probit approach based on flammable consequences. In this method a dose is calculated based on the radiation level and duration of exposure. Then the dose is converted to a probability of fatality using the probit function. Within the 35 kW/m² heat radiation contour, the probability of fatality is assumed to be 100 percent regardless of exposure duration, based on the HIPAP heat radiation effects.

The vulnerability relationship for death due to thermal radiation was sourced from the TNO Green Book (TNO, 1992) and is characterised by the following probit equation:

$$Pr = -36.38 + 2.56(Q^{4/3}t)$$

Here:

- Pr is the probit that corresponds to the likelihood of death (-)
- Q represents the level of heat radiation (W/m²)
- t is the duration of exposure (s).

The probability of fatality (Pfat) for heat radiation is influenced by the level of thermal radiation and the length of exposure. This study utilised an exposure time of 20 seconds.

The criteria for injury and escalation to neighbouring potentially hazardous installations were established at a thermal radiation of 4.7 kW/m² and 23 kW/m² respectively, aligning with the description of this level in HIPAP 6 (DoP, 2011a).

3.2.1.2 Heat radiation criteria

The effects of various heat radiation levels are summarised in Table 3.1 as per HIPAP No. 4 (DoP, 2011b). The heat radiation levels reported in this assessment include 4.7 kW/m², 7.3 kW/m², 12.6 kW/m², 23 kW/m² and 35 kW/m².

Table 3.1 Heat radiation criteria

Heat radiation (kW/m ²)	Effect
4.7	– Will cause pain in 15 to 20 seconds and injury after 30 seconds' exposure (at least second degree burns will occur)
7.3	– 1% probability of fatality (based on probit equation)
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

3.2.1.3 Overpressure criteria

The effects of various overpressure levels are summarised in Table 3.2 as per the NSW HIPAP No. 4 (DoP, 2011b). These four overpressure levels are calculated in this assessment, to the extent that they occur for each scenario.

Table 3.2 Overpressure criteria

Explosion overpressure (kPa)	Effect
7	Damage to internal partitions and joinery but can be repaired. Probability of injury is 10%. No fatality.
14	House inhabitable and badly cracked.
21	Reinforced structures distort. Storage tanks fail. 20% chance of fatality to a person in a building.
35	House uninhabitable. Wagons and plants items overturned. Threshold of eardrum damage. 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open.

Explosion overpressure (kPa)	Effect
70	Threshold of lung damage. 100% chance of fatality for a person in a building or in the open Complete demolition of houses

3.2.1.4 Individual risk criteria

Individual risk is a measure of the risk to an individual continuously exposed at a specific location within the effect zone of a hazardous incident. The individual risk criteria listed in Table 3.3 are suggested in HIPAP 4 (DoP, 2011b). The risk level represents the frequency at which the relevant exposure type should not be exceeded.

Table 3.3 Individual fatality risk criteria

Risk levels (individual fatality risk per year)	Land-use	Limit of exposure at the following locations
0.5×10^{-6}	Sensitive	Hospitals, child-care facilities, and old age housing
1×10^{-6}	Residential	Residential developments and places of continuous occupancy such as hotels and tourist resorts
5×10^{-6}	Commercial	Commercial developments, including offices, retail centres and entertainment centres
10×10^{-6}	Recreational	Sporting complexes and active open space areas
50×10^{-6}	Industrial	Target for site boundary

3.2.1.5 Injury risk criteria

Relying entirely upon fatality risk criteria may not account for the factors such as societies' concern about risk of injury and that fatality risk levels may not entirely reflect variations in people's vulnerability to risk. Some people may be affected at a lower level of hazard exposure than others. So, it is appropriate to consider injury risk criteria (i.e., levels of effects that may cause injury to people but will not necessarily cause fatality).

The NSW HIPAP 4 (DoP, 2011b) injury risk criteria for heat radiation and explosion overpressure are stated in Table 3.4.

Table 3.4 Individual injury risk criteria

Risk levels (individual injury risk per year)	Type
50×10^{-6}	<ul style="list-style-type: none"> - Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m^2 - Incident explosion overpressure at residential and sensitive use areas should not exceed 7 kPa

3.2.1.6 Property damage criteria

The NSW HIPAP 4 (DoP, 2011b) also includes the risk of property damage and accident propagation, which considers the potential of an accident at the installation causing damage to buildings and propagating to a neighbouring industrial operation and hence initiating further hazardous incidents.

A heat radiation level of 23 kW/m^2 as the result of fire incidents at a hazardous plant may affect a neighbouring installation to the extent that unprotected steel can suffer thermal stress that may cause structural failure (see Table 3.1). This may trigger a hazardous event unless protection measures are adopted.

The NSW HIPAP 4 (DoP, 2011b) property damage risk criteria for heat radiation and explosion overpressure are stated in Table 3.5.

Table 3.5 Property damage criteria

Risk levels (property damage risk per year)	Type
50 x 10 ⁻⁶	<ul style="list-style-type: none"> <li data-bbox="456 280 1514 338">– Incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations should not exceed 23 kW/m² <li data-bbox="456 342 1514 398">– Incident explosion overpressure at neighbouring hazardous installations or at land zoned to accommodate such installations should not exceed 14 kPa.

4. Risk screening

4.1 Dangerous goods and hazardous materials screening

Hazardous materials may be used throughout the life of the proposed modification, including dangerous goods and non-dangerous goods. The storage and handling of dangerous goods and hazardous materials have the potential to impact the surrounding community and environment if leaks and spills occur, resulting in the potential contamination of air, soils, surface water and/or groundwater.

A list of materials potentially associated with the construction and operation of the modification are summarised in Section 4.1.1 and 4.1.2 respectively.

4.1.1 Construction

This section describes the storage, handling and transport of dangerous goods and hazardous materials during construction of the proposed modification.

The dangerous goods that may be used during construction are listed in Table 4.1. These are compared to the storage and transport thresholds in *Applying SEPP 33* (DoP, 2011c). These thresholds represent the maximum amounts of various dangerous goods that can be stored or transported to and from a proposed site without causing a significant risk to off-site receptors.

In general, low volumes of dangerous goods would be stored in designated storage areas as per the requirements of the safety data sheets.

Table 4.1 Construction related Dangerous Goods volumes and thresholds

Dangerous good	Australian Dangerous Good Code Class (Note 1)	Storage method	Applying SEPP 33 thresholds		
			Storage volume	Minimum distance from sensitive receptors	Transport (weekly)
Petrol	C1; 3 PG III	20 L drums	Greater than 5 t if stored with other Class 3 flammable liquids	5 m	N/A if not transported with Class 3 dangerous goods
Diesel	C1 (Note 2)	10,000 L Tank, equating to 8.5 tonnes.	Greater than 5 t if stored with other Class 3 flammable liquids	5 m	N/A if not transported with Class 3 dangerous goods
Lubricating and hydraulic oils and greases	C2	20 L drums	N/A	N/A	N/A if not transported with Class 3 dangerous goods
Cement	N/A	Bags or pallets	N/A	N/A	Not subject to thresholds
Acetylene	2.1	Cylinders (up to 55 kg)	Greater than 100 kg	15 m	2 t, 30 times per week
Epoxy glue	3 PG III	Small containers	Greater than 5 t	5 m	10 t, 60 times per week
Premix concrete	N/A	Bags or pallets	N/A	N/A	Not subject to thresholds
Shotcrete accelerator	3 PG III	1,000 L intermediate bulk containers (IBCs)	Greater than 5 t	5 m	3 t, 45 times per week

Dangerous good	Australian Dangerous Good Code Class (Note 1)	Storage method	Applying SEPP 33 thresholds		
			Storage volume	Minimum distance from sensitive receptors	Transport (weekly)
Acids	8 PG II	1,000 L IBCs	Greater than 25 t	N/A	2 t, 30 times per week
Bases	8 PG II	1,000 L IBCs	Greater than 25 t	N/A	2 t, 30 times per week
Disinfectant	8 PG II	500 L IBCs	Greater than 50 t	N/A	2 t, 30 times per week

Notes

1. "C" denotes the "class" of the dangerous good, and "PG" denotes the "packing group" of the dangerous good, in accordance with the Australian Dangerous Goods Code (2024a).
2. Diesel is classified as C1 if not stored with other Class 3 flammable liquids, and classified as 3PGIII if stored with other Class 3 flammable liquids. It is not proposed to store diesel near other Class 3 flammable liquids, but it is currently adjacent to the fence line next to cultivated lot.

Construction of the proposed modification will be handled by the construction contractor and any quantities of dangerous goods stored or transported to the site, such as diesel storage for on-site power generators, will be covered in the Construction Safety Management Plan (CSMP).

Any storage or handling of diesel during the construction phase will be undertaken in accordance with AS1940:2017: The storage and handling of flammable liquids, and the requirements of WorkSafe NSW.

Based on the above quantities of materials, the proposed modification does not pose a significant offsite risk during the construction phase and quantitative assessment of construction related loss of containment risks are not required as per Resilience and Hazards SEPP requirements.

4.1.2 Operation

This section describes any impacts that may cause hazards or risk during operation of the proposed modification.

In general, the only dangerous good would be the natural gas (predominantly methane) flowing through the compressor station, as listed in Table 4.2. A number of other hazardous materials and dangerous goods would be used for compressor station maintenance activities, however, the volumes required would still be much smaller than the volumes required for construction.

Table 4.2 Operations Dangerous Goods volumes and thresholds

Material	Material properties	Anticipated Flowrate / Storage Volume	Description of use
Natural gas (methane) UN 1971 Class 2.1	Natural gas is considered a hazardous substance. It predominantly consists of methane. Material properties are discussed in further detail in Section 4.1.2.1.	Up to 232 kSm ³ /hr	The Culcairn to Wagga Pipeline currently operates at a forward haul capacity up to 232 kilo standard cubic meters per hour (kSm ³ /hr). Natural gas will be present during commissioning and operations.
Lubrication oils	Class C2 combustible liquids.	20 L drums or IBCs	Compressor electric motor lubrication. Centrifugal gas compressor lubrication. There is no SEPP 33 threshold for either storage volume or minimum distance from sensitive receptor for Class 2 combustible liquids.

Natural gas (methane) is the only hazardous material in significant quantities that would pose a potential risk to nearby people, property, or the biophysical environment during the operation phase.

Within the compressor inlet piping, compressor outlet piping, and associated equipment, there is approximately 530 kg of natural gas, which exceeds the Resilience and Hazards SEPP threshold of 100 kg for Class 2.1 DGs. This quantity does not include the piping to and from the Culcairn to Wagga Wagga pipeline, which would result in an even larger quantity of natural gas in the facility. This triggers the need for a quantitative PHA. Refer to Appendix C for details on the inventory calculation.

Hazards introduced as a result of natural gas are discussed in further detail in Section 4.1.2.1, and Safety Data Sheet is provided in Appendix B.

4.1.2.1 Natural gas properties

The predominant source of hazard from the modification is associated with the potential for a loss of containment of natural gas. This would generally only have the potential to cause injury or damage if there was ignition, which resulted in a fire or explosion (when in a confined area).

Natural gas in the Culcairn to Wagga Wagga pipeline, consists predominantly of methane (around 98%), with less than 0.1% ethane and 0.3% carbon dioxide (CO₂). Methane is an odourless, non-toxic, and non-corrosive gas and is lighter than air at temperatures greater than minus 110°C. On release in the open the non-ignited gas tends to disperse rapidly. Commercial natural gas is generally odourised to aid in leak detection.

The lower flammability limit of pure methane is 5% and the upper flammability limit is 15%. This means that if the concentration of methane in air is less than 5%, the gas mixture is too diluted to burn and if it is greater than 15% there is not enough oxygen for it to burn. The auto-ignition point for methane is 580°C. This is the minimum temperature required for methane gas to ignite in air without a spark or flame being present.

Methane is non-toxic, posing only an asphyxiation hazard. Asphyxia is a possibility if the oxygen concentration in the atmosphere is less than 19.5%. Due to its buoyancy, a release of natural gas in the open would not typically present an asphyxiation hazard.

4.1.2.2 Fire and explosion factors

The factors involved in natural gas releases leading to fire or explosion are:

- The pipeline or associated equipment must fail such that a release of gas occurs. There are several possible causes of failure including corrosion and damage by external sources.
- The released material must form a flammable mixture between the lower and upper flammability limits described above.
- The released material must come into contact with an ignition source. In some cases, this may be heat or sparks generated by mechanical damage, non-flame proof equipment, vehicles, or open flames.
- Depending on the conditions of the release including the volume of natural gas and how rapidly it ignites, the event may be a jet fire, a flash fire, fireball or a vapour cloud explosion.
- For there to be a safety risk, people must be present within the harmful range (consequence effect distance) of the fire or explosion. How close the people are to the release will determine whether any injuries or fatalities result.

More information about these risks is provided below.

4.1.2.2.1 Jet Fire

A jet fire risk is present as there is pressurised flammable gas. Jet fires result from the immediate ignition of the escaping fluid. Turbulence evoked by pressurised fluid escape entrains ambient oxygen and could create a mixture that lies within the methane's flammability limits. The modelling software does not consider the effect of any obstructions that may be present, so the software models it as an unimpeded jet fire.

4.1.2.2.2 Vapour Cloud Explosion

A vapour cloud explosion is an explosion occurring after the release of a large quantity of flammable gas, which ignites following the formation of a flammable cloud within the upper and lower flammable limits in a confined area causing a damaging pressure wave.

A typical blast overpressure comprises several events, not all occurring simultaneously. Firstly, there is overpressure associated with the expansion of vapor upon release of the material and secondly, there is an accompanying increase in pressure resulting from the combustion/ignition of the material released.

The above is typically referred to as a delayed explosion and its occurrence downwind from the release location are highly dependent on prevailing weather conditions at the time of the release.

4.1.2.2.3 Flash Fire

If a gas release does not ignite immediately, a gas cloud may form which could find an ignition source distant from the release location leading to a flash fire or vapour cloud explosion. A flash fire is a slow deflagration of an unconfined, unobstructed gas cloud producing negligible overpressure. Thermal effects are the main hazard, as flash fires typically have a heat flux of approximately 84kW/m² for a duration of approximately 3 seconds.

Unlike a vapour cloud explosion, the negligible overpressure created does not accelerate the flame front and thus energy released from the combustion does not take the form of an explosive blast and consequent overpressure blast wave, which normally causes the majority of the damage.

Flash fire risks can only be expected from highly flammable materials or flammable materials heated significantly above ambient temperature to near or above their boiling point. Flash fire results are typically represented in cloud distances to the UFL and to the LFL. It is typically assumed that 100% fatality occurs within the LFL envelope, and 0.5 LFL represents the maximum distance in which a flammable cloud could be ignited.

4.1.2.2.4 Fireball

A fireball may be formed from the instantaneous flashing of superheated material due to the catastrophic failure of a storage container or pipeline creating an expanding cloud of material. A fireball is created if this cloud is ignited, often from the flame source that caused the initial vessel failure. The surface emissive powers typically associated with fireballs are high (250 to 350 kW/m²). Due to buoyancy of the hot gases, the burning cloud typically rises and becomes more spherical in shape.

4.2 Summary of risk screening results

The results of the dangerous goods screening indicate that the proposed modification exceeds the thresholds in the Resilience and Hazards SEPP requirements and is therefore considered a 'potentially hazardous industry'. This triggers the requirement for a Level 3 PHA quantitative assessment, included within the following sections.

Any change to the separation distance, the proposed design or increase in DG inventories will require a review of this assessment.

5. Hazard identification and management

5.1 Hazard identification (HAZID)

The HAZID for the proposed modification is shown in Table 5.1.

The HAZID was conducted as a desktop study based on the provided design documentation and focused specifically on the operational activities resulting from the proposed modification. Typical control measures are also outlined in Table 5.1 and are required to ensure the risk scenarios that were identified are controlled to an acceptable level.

The first step in the HAZID involved identifying the hazardous materials within the process systems associated with the compressor station to be considered in the PHA.

For the compressor station the only hazardous substance of interest is natural gas; other substances used at the site would not result in significant consequences if released, as determined in the risk screening in Section 4.

As described in Section 4.1.2.1, natural gas at the compressor station contains mainly methane, which is flammable between 5% and 15% by volume and is a simple asphyxiant. On release, the gas tends to rise as it has a lower density than air at ambient conditions. Loss of containment of natural gas from the compressor station may result in fires, in the event of ignition.

In undertaking the HAZID, a number of assumptions were made, as listed in Section 1.7.

Table 5.1 Identified hazards for the YW158 compressor station and pipeline take-offs

Area	Hazard Scenario	Causes/Threats	Consequences	Typical Control Measures	Assess in PHA?	Comments
Compressor station	Release of natural gas during commissioning or operation from the compressor inlet and outlet piping between the compressor isolation valves and the compressor.	<ul style="list-style-type: none"> – Corrosion – Mechanical failure (e.g., flange/gasket leak) – Overpressure – Maintenance error – Physical impact 	<p>If ignited, a jet/flash fire would occur, resulting in equipment damage and potentially:</p> <ul style="list-style-type: none"> – injury/fatality of personnel (if present) – injury to third parties (if present in the vicinity) – property damage. <p>An explosion is not considered to be a realistic consequence due to the lack of confinement and very low level of congestion at the compressor station.</p>	<ul style="list-style-type: none"> – Asset integrity: This includes the durability of compression equipment, considering factors such as corrosion allowance, stress analysis of pipes, the distance between the equipment and existing pipeline infrastructure, equipment orientation, external paintwork, and quality control measures like ensuring the tightness of flange bolts, conducting hydrotests, checking for leaks during pressurisation, and maintaining a minimal level of confinement/congestion. – Preventative maintenance and inspection: This involves conducting regular inspections of the equipment while it's in service, testing Emergency Shutdown systems, and calibrating instruments. – Trained personnel and operating procedures: Ensuring that operators are well-trained and that operating procedures are in place. – Secure compressor station: Maintaining a secure environment around the gas compressor station. – Remote monitoring: Implementing remote monitoring of pressure and flow, including the detection of low pressure. – Emergency shutdown system: Having an independent safety Programmable Logic Controller (PLC) for critical process safety items, such as overpressure events. – Fire and gas detection: Installing fire and gas detection systems around the compressor, local equipment room, and microturbines area. – Emergency response: Establishing emergency response procedures. 	Yes	Clean natural gas with low corrosive potential.

Area	Hazard Scenario	Causes/Threats	Consequences	Typical Control Measures	Assess in PHA?	Comments
Pipeline Connections (outside of compressor train isolation valves)	Release of natural gas during construction, commissioning or operation from above ground piping from pipeline take-offs to compressor inlet/outlet isolation valves	<ul style="list-style-type: none"> - Corrosion - Mechanical failure (e.g., flange/gasket leak) - Overpressure - Maintenance error - Physical impact 	<p>If ignited, a jet/flash fire would occur, resulting in equipment damage and potentially:</p> <ul style="list-style-type: none"> - injury/fatality of personnel (if present) - injury to third parties (if present in the vicinity) - property damage. <p>Fireball resulting from full bore rupture.</p> <p>An explosion is not considered to be a realistic consequence due to the lack of confinement and very low level of congestion at the compressor station and near the pipeline.</p>	<ul style="list-style-type: none"> - Asset integrity: This includes the durability of compression equipment, considering factors such as corrosion allowance, stress analysis of pipes, the distance between the equipment and existing pipeline infrastructure, equipment orientation, external paintwork, and quality control measures like ensuring the tightness of flange bolts, conducting hydrotests, checking for leaks during pressurisation, and maintaining a minimal level of confinement/congestion. - Preventative maintenance and inspection: This involves conducting regular inspections of the equipment while it's in service, testing Emergency Shutdown systems, and calibrating instruments. - Trained personnel and operating procedures: Ensuring that operators are well-trained and that operating procedures are in place. - Secure compressor station: Maintaining a secure environment around the gas compressor station and pipeline take-offs. - Remote monitoring: Implementing remote monitoring of pressure and flow in the WWP pipeline. - Emergency response: Establishing emergency response procedures. 	Yes	Clean natural gas with low corrosive potential.

Area	Hazard Scenario	Causes/Threats	Consequences	Typical Control Measures	Assess in PHA?	Comments
Compressor station	Vehicle related incident during construction, operation and maintenance	<ul style="list-style-type: none"> Increased vehicle movements in the local area with the potential for driver error, poor visibility 	Interaction between project related vehicle and public resulting in injury or fatality	<ul style="list-style-type: none"> Design of site accessway in accordance with relevant road design standards to allow for safe access and egress. Compliance with local road rules including licenses for all project personnel. Traffic management plan for peak periods of interaction with public road users, including delivery or large equipment and traffic control as required. 	No	Traffic impacts were assessed separately in the Traffic Impact Assessment and found that the modification would not have any significant impact on road network operations
Compressor station	Loss of containment of dangerous goods or hazardous materials during construction or operation e.g. petrol, diesel, lubricants (excluding natural gas)	<ul style="list-style-type: none"> Spills while handling Failure of storage system / containers 	<p>Environmental contamination</p> <p>If flammable material is ignited, there is potential for fire with injury to nearby personnel or property damage</p> <p>If hazardous material is released, there is potential for skin irritation, eye & respiratory tract damage if contact occurs with nearby personnel</p>	<ul style="list-style-type: none"> Storage and handling of each material as per the safety data sheet including original containers, dedicated storage areas. Use of appropriate PPE. Spill kits available. Trained Personnel and Operating Procedures: Ensuring that operators are well-trained and that operating procedures are in place. 	No	As determined by the screening process, there are no materials other than natural gas in quantities that require further assessment

Area	Hazard Scenario	Causes/Threats	Consequences	Typical Control Measures	Assess in PHA?	Comments
Removal of existing pipeline take off to UPS	Loss of containment of dangerous goods or hazardous materials (natural gas) during demolition and decommissioning	<ul style="list-style-type: none"> – Leakage during / after hot works 	<p>If ignited, a jet/flash fire would occur, resulting in equipment damage and potentially:</p> <ul style="list-style-type: none"> – injury/fatality of personnel (if present) – injury to third parties (if present in the vicinity) – property damage. <p>An explosion is not considered to be a realistic consequence due to the lack of confinement and very low level of congestion in the pipeline connection area.</p>	<ul style="list-style-type: none"> – Trained personnel and construction procedures: Ensuring that construction workers are well-trained and that hot work procedures are in place. – Emergency response: Establishing emergency response procedures. 	No – see comments	While not specifically covered by this PHA, leaks and full-bore rupture of the pipeline during operation are considered, and consequences from those scenarios will also be applicable to this hazard scenario.

6. Preliminary Hazard Analysis

6.1 Summary of hazard scenarios

Scenarios were chosen as worst case scenarios, with potential for jet fire impingement on or flash fire engulfment of onsite operations, construction and maintenance workforce, nearby equipment, and off-site receptors including people on Uranquinty Cross Road and at the Uranquinty Power Station. Causes of these scenarios may be due to external interference e.g., vehicle impact or corrosion, pressure fatigue in pipe etc, as discussed in Table 5.1.

The five scenarios listed in Table 6.1 were carried forward from the HAZID phase of the study for consequence analysis and risk assessment.

Table 6.1 Summary of hazardous scenarios for assessment

Scenario #	Description
Scenario 1	Release of natural gas from the DN400 piping and header between the pipeline take-off manual isolation valve and the compressor suction inlet isolation valve (SDV 7621).
Scenario 2	Release of natural gas from the DN350 piping between the compressor package inlet isolation valve (SDV 7621) and the compressor
Scenario 3	Release of natural gas from the DN350 piping between the compressor and the compressor package outlet SDV 7641
Scenario 4	Release of natural gas from the DN400 header and piping between the compressor package discharge isolation valve (SDV 7641) and the pipeline take-off manual isolation valve
Scenario 5	The full bore rupture cases for scenarios 1 to 4 may cause a fireball. This is modelled as a standalone scenario in Safeti, due to the limitations of the modelling software.

Full details of the model input parameters are provided in the Assumptions Register in Appendix C, including release scenarios and weather conditions. The resulting Safeti modelling outputs are presented in Section 6.2.

6.2 Consequence and risk modelling results

6.2.1 Modelling inputs

Full details for the relevant modelling input parameters are provided in the Assumption Register in Appendix C and weather information in Appendix E.

The hole sizes and corresponding leak frequencies used for the consequence and risk modelling for each of the scenarios are presented below in Table 6.2.

All releases were modelled as horizontal, and the full-bore ruptures (FBR) were modelled as the largest pipe diameter within the section. For hole sizes 2 mm and 6 mm, the leaks were modelled as steady state release while hole sizes between 22 mm and FBR were modelled as time varying releases to accommodate the large release and quick drop of pressure.

The leak locations for each scenario were chosen based on locations closest to the power station to represent the worst-case consequence and risk outcomes to the nearest offsite receptors. The height of interest for all consequences is 1.5 m, as per the modelling assumptions presented in Appendix C.

Table 6.2 Modelling inputs

ID	Scenario title	Scenario description	Process conditions		Hole size (mm)	Release frequency (p.a.)
			Pressure (kPag)	Temperature (°C)		
1	Piping from pipeline take-off to compressor suction inlet isolation valve, including inlet header (DN400)	Release of natural gas from the DN400 piping and header between the pipeline take-off manual isolation valve and the compressor suction inlet isolation valve.	8,101	21	2	1.37 x 10 ⁻³
					6	6.21 x 10 ⁻⁴
					22	2.95 x 10 ⁻⁴
					85	4.98 x 10 ⁻⁵
					Full bore rupture	8.57 x 10 ⁻⁵
2	Compressor inlet piping from inlet isolation valve and gas compressor (DN350)	Release of natural gas from the DN350 piping between the compressor package inlet isolation valve (SDV) and the compressor	8,101	21	2	1.31 x 10 ⁻³
					6	5.92 x 10 ⁻⁴
					22	2.74 x 10 ⁻⁴
					85	3.35 x 10 ⁻⁵
					Full bore rupture	1.40 x 10 ⁻⁴
3	Compressor outlet piping to isolation valve (DN350)	Release of natural gas from the DN350 piping between the compressor and the compressor package outlet SDV	9,150	55	2	2.65 x 10 ⁻³
					6	1.14 x 10 ⁻³
					22	5.02 x 10 ⁻⁴
					85	7.95 x 10 ⁻⁵
					Full bore rupture	1.04 x 10 ⁻⁴
4	Piping from compressor discharge isolation valve to pipeline take-off, including outlet header (DN400)	Release of natural gas from the DN400 header and piping between the compressor package discharge isolation valve and the pipeline take-off manual isolation valve	10,300	55	2	2.06 x 10 ⁻³
					6	9.22 x 10 ⁻⁴
					22	4.29 x 10 ⁻⁴
					85	5.92 x 10 ⁻⁵
					Full bore rupture	1.30 x 10 ⁻⁴
5	Fireball	The full bore rupture cases for scenarios 1 to 4 may cause a fireball. This is modelled as a standalone scenario in SAFETI, due to the limitations of the modelling software.	10,300 (Note: Model does not use pressure for this scenario)	55	N/A Fireball evaluation is based on released inventory	4.6 x 10 ⁻⁴

6.2.1.1 Modelling approach

For this PHA, a conservative approach to the consequence and risk modelling was taken. This allows a margin of error and provides confidence that if the conservative model complies with the nominated risk criteria, then the development will also comply.

In addition to applying conservative assumptions to the whole risk assessment, the event frequency calculation was especially conservative. For the event frequency calculation, a “parts count” approach was used, where industry event data is used to estimate the frequency of leaks with a variety of hole sizes on piping of numerous sizes and a range of equipment. This includes piping lengths and fittings including flanges, elbows, tees, valves, and instrument fittings of all sizes. The parts count conducted for this project took leak frequencies for all pipe sizes and applied them all to the largest pipe size in that section (i.e., DN400 for Scenario 1 and 4, and DN350 for Scenario 2 and 3). This effectively over-estimates the frequency of larger leaks of larger piping.

6.2.2 Consequence modelling results

Consequence modelling results are reported at downwind distances from the release location and at the levels outlined in Section 3.2.1.

The assessment has been performed for all weather conditions described in Appendix E. Results for all weather conditions are presented in the tables in Appendix D, however, contours overlayed onto the site layout maps are only presented for the worst-case weather condition for that scenario i.e., the weather condition producing the greatest downwind distance to thermal radiation or overpressure level.

A summary of the results is presented in the following sub sections, highlighting worst-case rupture scenarios and the associated worst-case weather conditions.

6.2.2.1 Jet fire

Jet fires resulting from both immediate and delayed ignition were generated for the four scenarios. For all scenarios and all weather conditions, the jet fires that were immediately ignited resulted in larger distances and hence are presented in Table 6.3 for the corresponding worst-case weather conditions, noting that different weather conditions generally do not have a large impact on jet fire results. Full jet fire consequence modelling results for all immediate ignition cases are provided in Appendix D.

Table 6.3 Summary of jet fire radiation consequence distances

ID	Scenario	Worst weather condition	Distance downwind to intensity level 1 (4.7 kW/m ²) [m]	Distance downwind to intensity level 2 (7.3 kW/m ²) [m]	Distance downwind to intensity level 3 (12.6 kW/m ²) [m]	Distance downwind to intensity level 4 (23 kW/m ²) [m]	Distance downwind to intensity level 5 (35 kW/m ²) [m]
Scenario 1 - Piping from pipeline take-off to compressor suction inlet isolation valve, including inlet header (DN400)							
1.1	2mm hole	All	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
1.2	6 mm hole	3.6/C	8.1	7.8	7.5	7.3	7.3
1.3	22 mm hole	5.1/D	36.3	33.6	31	28.6	27.3
1.4	85 mm hole	5.1/D	111.5	100.8	90.2	80.9	75.5
1.5	513 mm hole (FBR)	4.6/D	228.8	203.9	178.9	156.8	142.9
Scenario 2 - Compressor inlet piping from inlet isolation valve and gas compressor (DN350)							
2.1	2 mm hole	1.6/F	2.8	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
2.2	6 mm hole	3.6/C	9.0	8.7	8.3	8.1	8.0
2.3	22 mm hole	4.6/D	35.9	33.2	30.6	28.3	27.0
2.4	85 mm hole	5.1/D	139.0	125.2	111.5	99.3	91.9
2.5	316 mm hole (FBR)	1.6/F	412.4	358.3	303.3	258.5	236.0
Scenario 3 - Compressor outlet piping to isolation valve (DN350)							
3.1	2 mm hole	1.6/F	2.6	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
3.2	6 mm hole	3.6/C	9.0	8.7	8.4	8.1	8.0
3.3	22 mm hole	5.1/D	35.7	33.1	30.5	28.2	26.9

3.4	85 mm hole	5.1/D	140.2	126.3	112.4	100.3	93.0
3.5	316 mm hole (FBR)	1.6/F	407.1	354.8	301.7	257.7	236.2
Scenario 4 - Piping from compressor discharge isolation valve to pipeline take-off, including outlet header (DN400)							
4.1	2 mm hole	1.6/F	2.7	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
4.2	6 mm hole	3.6/C	8.9	8.6	8.3	8.0	8.0
4.3	22 mm hole	5.1/D	40.5	37.5	34.4	31.8	30.2
4.4	85 mm hole	5.1/D	123.6	111.7	99.8	89.4	83.3
4.5	513 mm hole (FBR)	5.1/D	246.9	220.3	193.7	170.2	155.6

The full-bore rupture scenario presents the worst-case jet fire for all modelled scenarios. The D categories and 1.6/F weather conditions typically represent the worst-case weather for FBR jet fire results across the various release scenarios.

The worst heat radiation contours, which occur in the full bore rupture cases, for Scenarios 1, 2, 3 and 4 overlaid on the site layout map are shown in Figure 6.1, Figure 6.2, Figure 6.3 and Figure 6.4 respectively.

The circular contours presented in these figures show the total effect zone, which represents the jet fire distance achieved by the worst-case weather conditions for all event rotations. The shape of the worst-case contour for any particular wind direction would fall within the contour and would be influenced by the wind direction. Given the effect zone of these contours there is potential for a jet fire to result in the ignition of trees located to the north west and east of the site. Peak heat fluxes around 20kW/m² have the ability to ignite a tree around 2 m high, this is impacted by additional factors such as moisture content of the tree (Fire Safety Journal, 2023).

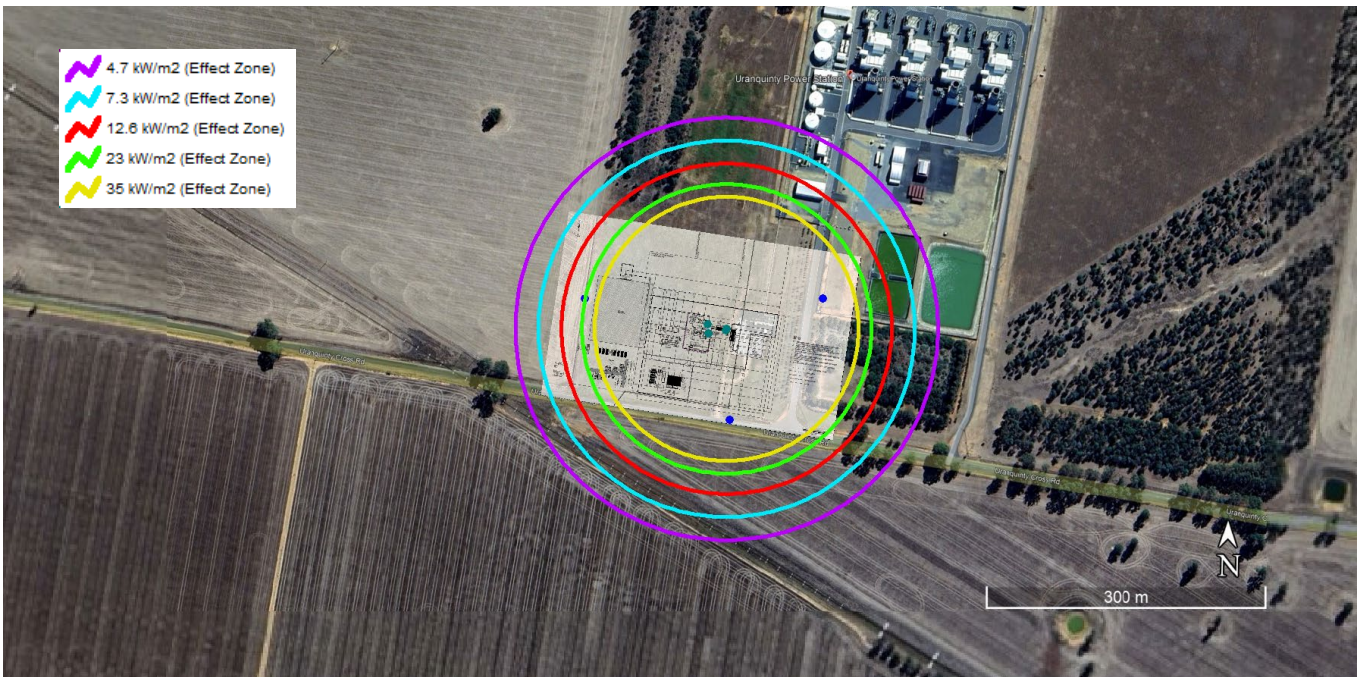


Figure 6.1 Scenario 1: Pipeline take off piping to compressor, full bore rupture – Jet fire effect zone, 4.6D weather condition



Figure 6.2 Scenario 2: Compressor and inlet piping, full bore rupture – Jet fire effect zone, 1.6F weather condition

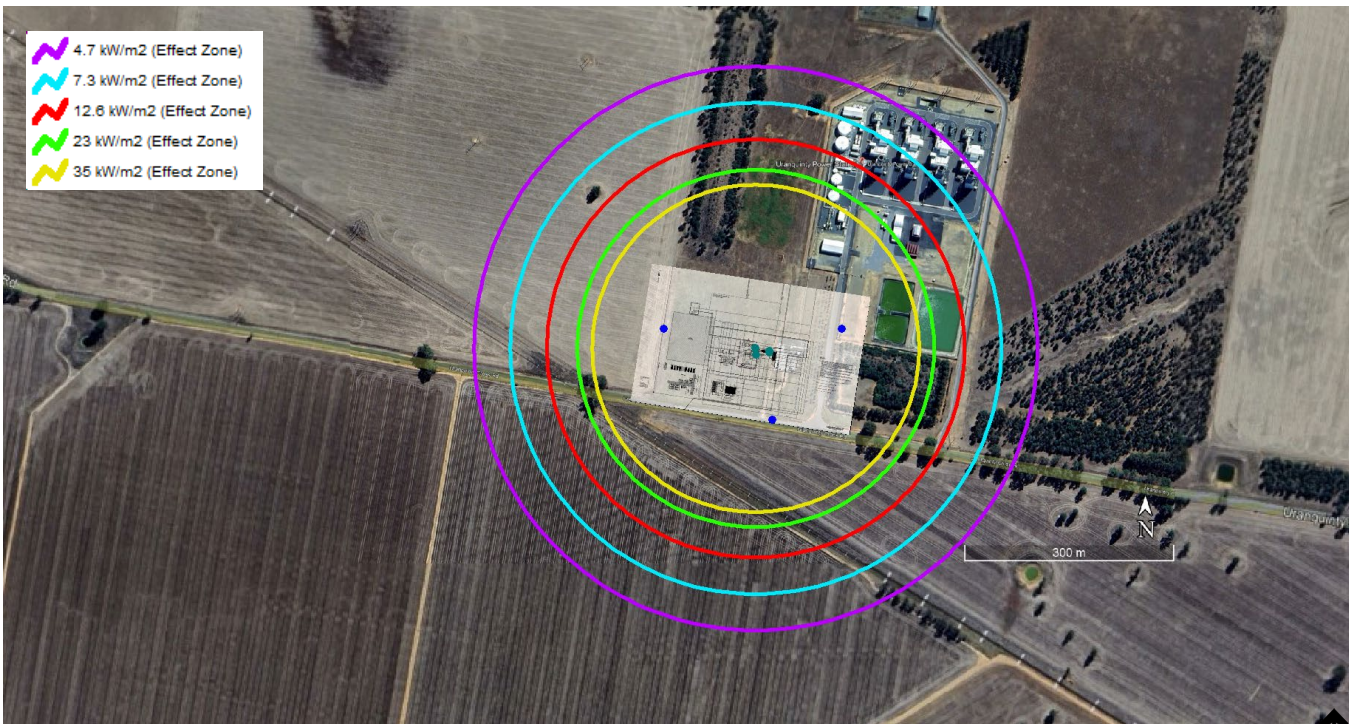


Figure 6.3 Scenario 3: Compressor outlet piping, full bore rupture – Jet fire effect zone, 1.6F weather condition



Figure 6.4 Scenario 4: Compressor discharge piping to pipeline take off, full bore rupture – Jet fire effect zone, 5.1D weather condition

6.2.2.2 Flash fire

Flash fire results for a representative worst-case weather condition are presented in Table 6.4. It is typically assumed that 100% fatality occurs within the LFL envelope, and 50% LFL represents the maximum distance in which a flammable cloud could be ignited. Full consequence modelling results are provided in Appendix D.

Table 6.4 Summary of flash fire consequence distances

ID	Scenario	Worst weather condition	Distance downwind to LFL [m]	Distance downwind to 50% LFL [m]
Scenario 1 - Piping from pipeline take-off to compressor suction inlet isolation valve, including inlet header (DN400)				
1.1	2 mm hole	N/A	N/A	N/A
1.2	6 mm hole	N/A	N/A	N/A
1.3	22 mm hole	1.6/F	14.9	36.9
1.4	85 mm hole	1.6/F	63.9	146.9
1.5	513 mm hole (FBR)	5.1/D	156.0	334.5
Scenario 2 - Compressor inlet piping from inlet isolation valve and gas compressor (DN350)				
2.1	2 mm hole	N/A	N/A	N/A
2.2	6 mm hole	N/A	N/A	N/A
2.3	22 mm hole	1.6/F	15.1	37.5
2.4	85 mm hole	1.6/F	88.3	199.4
2.5	316 mm hole (FBR)	5.1/D	371.6	882.0
Scenario 3 - Compressor outlet piping to isolation valve (DN350)				
3.1	2 mm hole	N/A	N/A	N/A
3.2	6 mm hole	N/A	N/A	N/A
3.3	22 mm hole	1.6/F	14.5	36.2
3.4	85 mm hole	1.6/F	85.5	194.5

ID	Scenario	Worst weather condition	Distance downwind to LFL [m]	Distance downwind to 50% LFL [m]
3.5	316 mm hole (FBR)	5.1/D	352.3	855.0
Scenario 4 - Piping from compressor discharge isolation valve to pipeline take-off, including outlet header (DN400)				
4.1	2 mm hole	N/A	N/A	N/A
4.2	6 mm hole	N/A	N/A	N/A
4.3	22 mm hole	1.6/F	16.9	41.2
4.4	85 mm hole	1.6/F	70.9	157.6
4.5	513 mm hole (FBR)	5.1/D	163.5	316.0

The full-bore rupture case presents the worst-case flash fire consequence for all scenarios. The 5.1/D weather condition typically represents the worst-case weather for FBR flash fire results across the various release scenarios.

The worst flash fire LFL (50,000 ppm, shown in blue) and 50% LFL contours (25,000 ppm, shown in green), being for the full bore rupture cases for Scenarios 1, 2, 3 and 4 overlaid onto the site layout map are shown in Figure 6.5, Figure 6.6, Figure 6.7 and Figure 6.8 respectively.

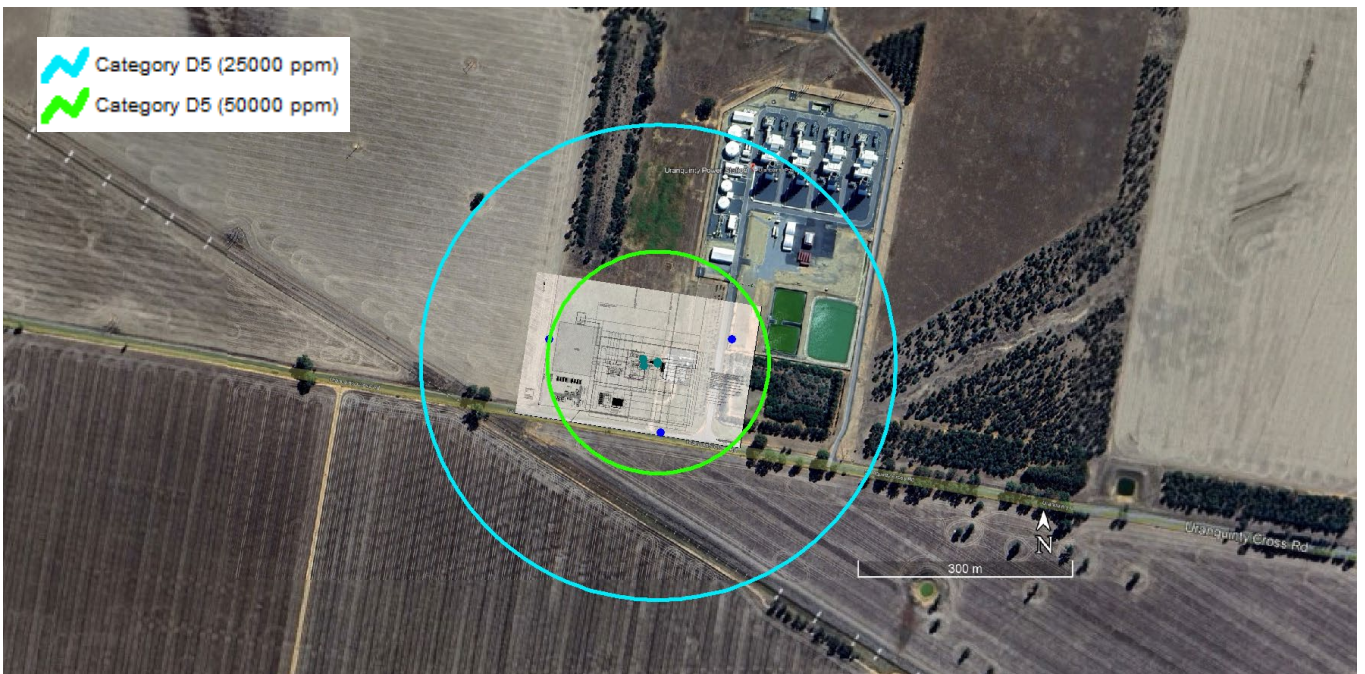


Figure 6.5 Scenario 1: Pipeline take off piping to compressor, full bore rupture – Flash fire effect zone, 5.1D weather condition



Figure 6.6 Scenario 2: Compressor and inlet piping, full bore rupture – Flash fire effect zone, 5.1D weather condition

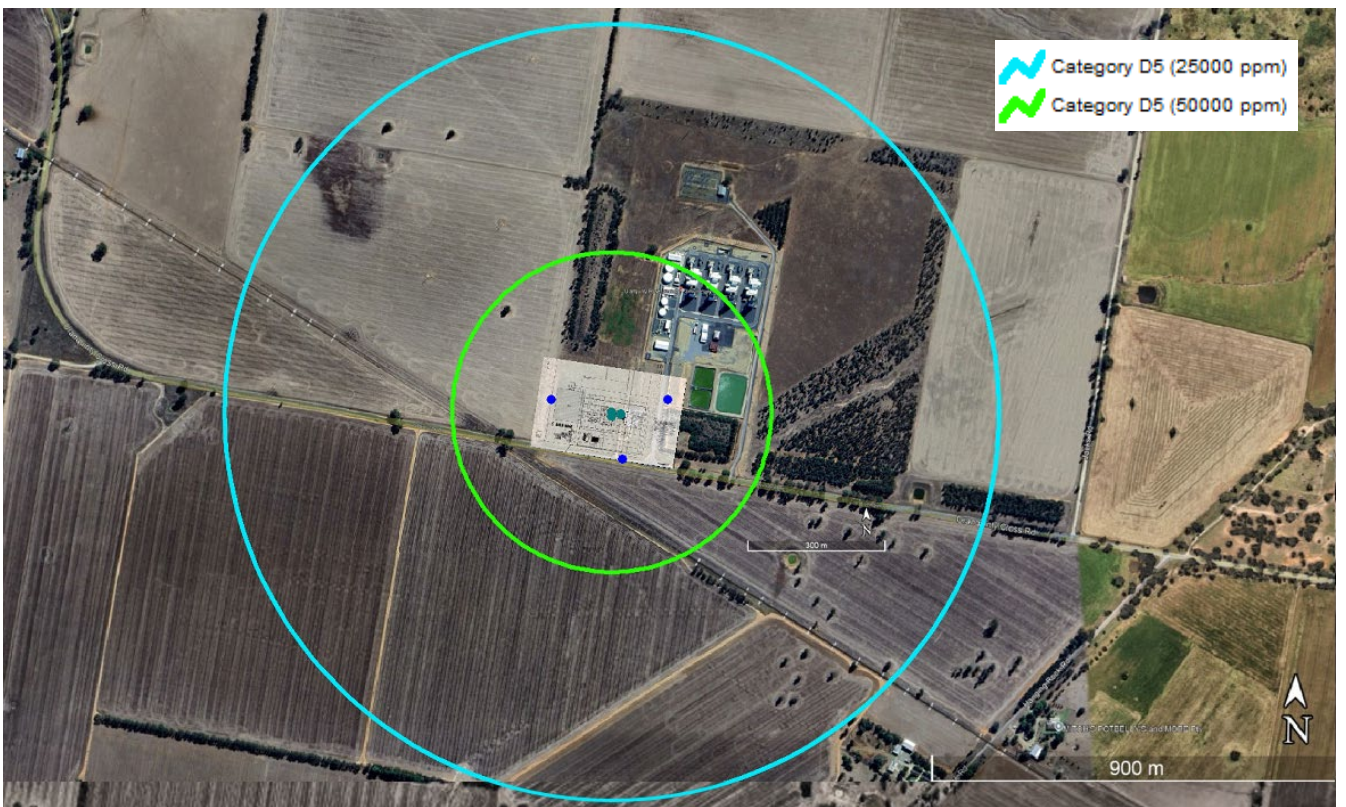


Figure 6.7 Scenario 3: Compressor outlet piping, full bore rupture – Flash fire effect zone, 5.1D weather condition



Figure 6.8 Scenario 4: Compressor discharge piping to pipeline take off, full bore rupture – Flash fire effect zone, 5.1D weather condition

Figure 6.9 shows the side view of the flash fire resulting from the full bore rupture case for Scenario 2, compressor and inlet piping, for the 5.1D weather condition, which corresponds to the farthest extent of the various dispersion contours.

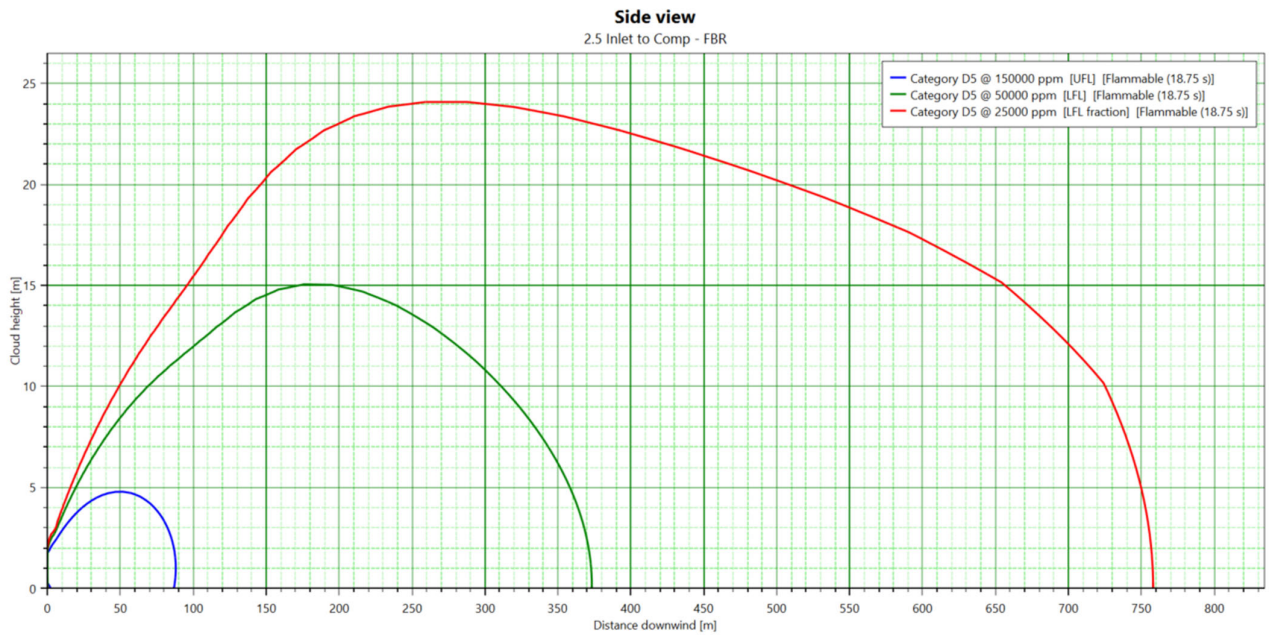


Figure 6.9 Scenario 2: Compressor and inlet piping, full bore rupture – Flash fire cloud side view, 5.1D weather condition

6.2.2.3 Explosion overpressure

The modelling showed that there are no scenarios that resulted in a potential explosion overpressure. This was expected due to the open layout and subsequent lack of confinement of the flammable gas. The consequence results are shown in Table 6.5.

Table 6.5 Summary of explosion overpressure consequence distances

ID	Scenario	Worst weather condition	Distance to overpressure level 1 (7kPa) [m]	Distance to overpressure level 2 (14kPa) [m]	Distance to overpressure level 3 (21kPa) [m]	Distance to overpressure level 4 (35kPa) [m]
1	1. Piping from pipeline take-off to compressor suction inlet isolation valve, including inlet header	All	Not reached	Not reached	Not reached	Not reached
2	2. Compressor inlet piping from inlet isolation valve and gas compressor	All	Not reached	Not reached	Not reached	Not reached
3	3. Compressor outlet piping to isolation valve	All	Not reached	Not reached	Not reached	Not reached
4	4. Piping from compressor discharge isolation valve to pipeline take-off, including outlet header	All	Not reached	Not reached	Not reached	Not reached

6.2.2.4 Fireball

A separate model is required for the fireball scenario, and hence one fireball scenario was generated to represent the full-bore rupture fireball risk and consequences for all four pipe sections. The release was located as close as possible to the Uranquinty Power Station to represent the worst fireball consequences for offsite receptors. Further information on the fireball scenario inputs can be found in Appendix C.

Fireball results are generated for all weather conditions and are presented in Table 6.6. While the results for all weather conditions analysed are very similar, weather category 1.6/F resulted in the longest distances to each thermal radiation intensity level assessed. The intensity levels of 4.7 kW/m² and 35 kW/m² for the weather category of 1.6/F are shown in are shown on Figure 6.10 and Figure 6.11 respectively.

Table 6.6 Fireball scenario – distances to thermal radiation intensity levels

Scenario	Weather	Fireball diameter [m]	Distance downwind to intensity level 1 (4.7 kW/m ²) [m]	Distance downwind to intensity level 2 (7.3 kW/m ²) [m]	Distance downwind to intensity level 3 (12.6 kW/m ²) [m]	Distance downwind to intensity level 4 (23 kW/m ²) [m]	Distance downwind to intensity level 5 (35 kW/m ²) [m]
Fireball Scenario (FBR)	3.6/C	39.3	152.7	123.5	94.7	70.2	56.6
	5.1/D	39.3	154.2	124.7	95.5	70.8	57.0
	4.6/D	39.3	154.2	124.7	95.5	70.8	57.0
	1.6/F	39.3	156.4	126.4	96.7	71.6	57.7
	3.5/E	39.3	155.3	125.5	96.1	71.2	57.4



Figure 6.10 Fireball scenario, full bore rupture – 4.7 kW/m² effect zone, 1.6/F weather condition



Figure 6.11 Fireball scenario, full bore rupture – 35 kW/m² effect zone, 1.6/F weather condition

6.2.3 Risk modelling results

Risk modelling has been completed to determine if the cumulative risk of all the potential scenarios meets the HIPAP 4 (DoP, 2011b) risk criteria as required by the proposed modification.

6.2.3.1 Individual fatality risk results

The cumulative individual fatality risk for the proposed modification is shown in Figure 6.12, with a magnified version showing the detail of the risk of the site in Figure 6.13.



Figure 6.12 Individual fatality risk contours

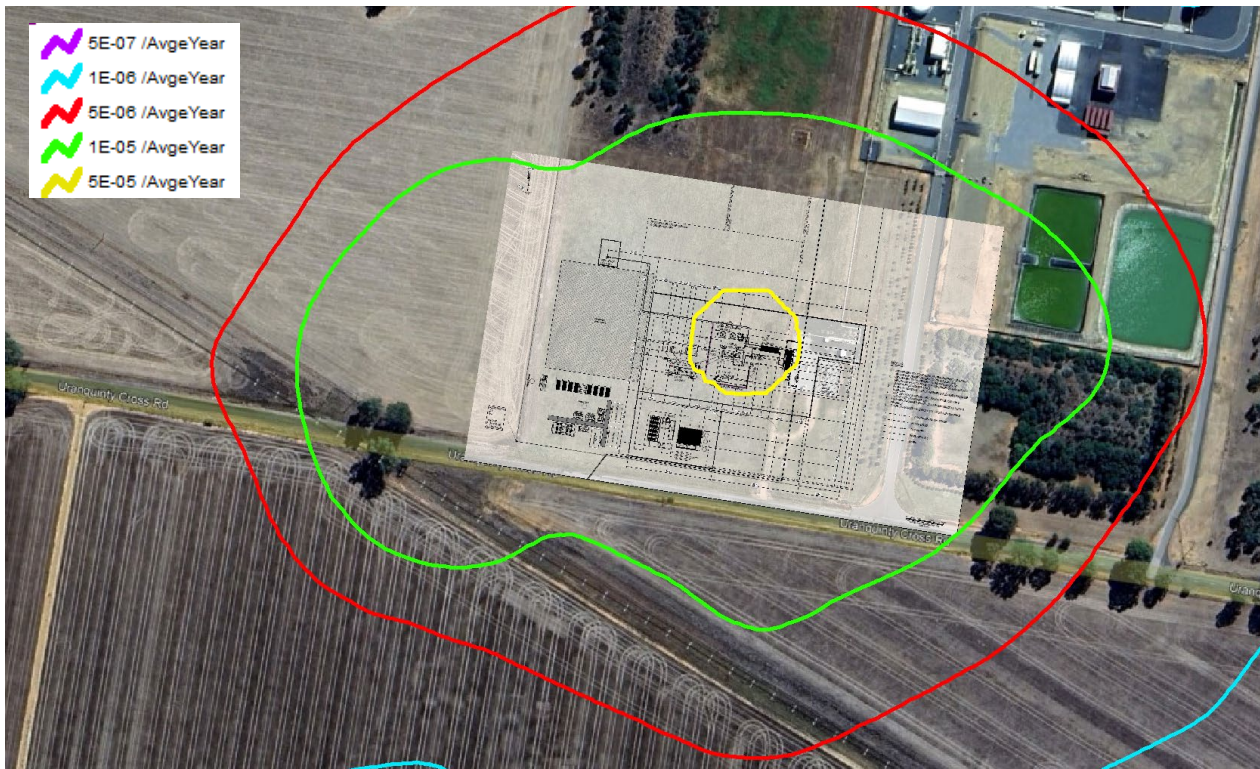


Figure 6.13 Individual fatality risk contours – close-up of site

Figure 6.12 shows the risk levels for individual fatalities for the majority of land use criteria were found to extend beyond the site boundary. The following summarises the results against the HIPAP 4 criteria:

- Sensitive dwellings such as hospitals, schools, child-care facilities, and old age housing developments should not be exposed to individual fatality risk levels in excess of half in a million per year (5×10^{-7} per year, shown in purple). Even though the 5×10^{-7} risk contour extends beyond the site boundary, this criterion is met as there are no sensitive dwellings in the vicinity of the site.
- Residential developments and places of continuous occupancy, such as hotels and tourist resorts, should not be exposed to individual fatality risk levels in excess of one in a million per year (1×10^{-6} per year, shown in blue). Even though the 1×10^{-6} risk contour extends beyond the site boundary, this criterion is met as the nearest residential development is greater than 900 m from the site.
- Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres should not be exposed to individual fatality risk levels in excess of five in a million per year (5×10^{-6} per year, shown in red). This criterion is met as there are no commercial developments in the vicinity of the site.
- Sporting complexes and active open space areas should not be exposed to individual fatality risk levels in excess of ten in a million per year (1×10^{-5} per year, shown in green). This criterion is met as there are no sporting complexes in the vicinity of the site.
- Individual fatality risk levels for industrial sites at levels of 50 in a million per year (5×10^{-5} per year, shown in yellow) should, as a target, be contained within the boundaries of the site where applicable. This criterion is met as this risk level is wholly within the site boundaries and does not encroach onto the neighbouring power station and AGN fenced compound (refer to Figure 6.13).

Figure 6.12 indicates that the risk contour for commercial developments (5×10^{-6} per year, shown in red) encroaches onto the Uranquinty Power Station, AGN compound, and neighbouring lots 79 and 1, which are currently unoccupied. This risk should be communicated to Origin Energy and appropriate safeguards such as Emergency Response Plans or other mitigation measures to protect against potential hazards should be implemented at the UPS. Similarly, if the unoccupied lots nearby are developed in the future, the risks need to be communicated, and appropriate mitigation measures should be implemented.

Transient receptors traversing Uranquinty Cross Road may be temporarily exposed to a risk of fatality up to 10×10^{-6} per year as they pass by the facilities. This is the equivalent HIPAP No. 4 risk criteria for sporting complexes and active open space areas and would be considered acceptable for a transient population passing by.

6.2.3.2 Individual injury risk

The cumulative individual injury risk for the proposed modification is shown in Figure 6.14.



Figure 6.14 Individual Injury risk contour

Figure 6.14 shows the cumulative 5×10^{-5} per year contour does not reach any of the sensitive receptors listed in Section 1.5.3. A portion of the risk contour encroaches onto the AGN fenced compound shown in light blue. While personnel working in this area are exposed to greater than the cumulative individual injury risk criterion in HIPAP 4, this area is considered industrial and the HIPAP 4 injury risk criterion only applies to sensitive and residential receptors, so this does not impose any land use restrictions. The metering station is also unmanned and would only be accessed for occasional maintenance.

6.2.3.3 Property damage risk

The cumulative property damage risk for the proposed modification is shown in Figure 6.15.



Figure 6.15 Property damage risk contour

The relevant property damage risk criterion from HIPAP 4 is based on the 23 kW/m^2 heat flux level not exceeding 5×10^{-5} per year. The cumulative 5×10^{-5} per year property damage risk contour for this thermal radiation level is localised to within the compressor station site and does not extend to the neighbouring UPS or AGN compound.

Therefore, the HIPAP 4 criteria for property damage is met.

6.2.3.4 Societal risk

Societal risk criteria particularly focus on situations where multiple fatalities could occur, and as such is only meaningful to consider address when there is a significant population in the vicinity of a potentially hazardous industry. The NSW HIPAP 4 (DoP, 2011b) provides indicative societal risk criteria to be considered for such developments, even if the individual risk criteria are met. However, as there is no significant population around the proposed site, societal risk has not been calculated for this study.

7. Conclusions

The HAZID identified five scenarios that may involve the loss of containment of natural gas at the proposed site.

Risks to people and property were assessed using modelling techniques to determine if the modification meets the HIPAP 4 risk criteria. A summary of the risk assessment results against the relevant HIPAP 4 criteria is provided in Table 7.1.

Although there is a potential for offsite fatality from multiple sources, the risk from the proposed modification, being installation of the UCS, is below the HIPAP 4 risk criteria for offsite personnel.

Table 7.1 HIPAP 4 risk criteria compliance

Risk Category	Offsite Receptor Exposure Type	Maximum tolerable annual risk	Complies with HIPAP 4
Fatality	Hospitals, schools, child-care facilities, and old age housing developments	Half in a million (0.5×10^{-6} per year)	Yes
Fatality	Residential developments and places of continuous occupancy (hotels/resorts)	One in a million (1×10^{-6} per year)	Yes
Fatality	Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants, and entertainment centres	Five in a million (5×10^{-6} per year)	Yes
Fatality	Sporting complexes and active open space areas	Ten in a million (10×10^{-6} per year)	Yes
Fatality	Industrial sites	Fifty in a million (50×10^{-6} per year)	Yes
Injury	4.7 kW/m ² incident heat flux radiation at offsite residential and sensitive use areas	Fifty in a million (50×10^{-6} per year)	Yes
Property damage	23 kW/m ² incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations	Fifty in a million (50×10^{-6} per year)	Yes

Any changes to the assumptions used in this report should result in a review and update of the screening, HAZID, consequence and risk modelling processes.

8. Recommendations

During the hazard analysis presented in Section 6, a number of controls have been identified to manage the risk of loss of containment through prevention or mitigation of the events. Arising from this analysis, some key recommendations for the modification include:

- Develop a control philosophy for the UCS.
- New equipment should have procedures developed for their safe operation to prevent injury to people
- Provide protection of above ground facilities from inadvertent or deliberate acts, which may cause damage to the exposed equipment and piping e.g., security fencing to prevent vandalism and barriers to prevent vehicle collision where adjacent to roads, as per the *Security of Critical Infrastructure Act 2018* requirements.
- Prepare an update to the existing Safety Management Study for the Culcairn to Wagga Wagga Pipeline to incorporate the UCS in accordance with AS2885, including a Hazard and Operability (HAZOP) study. This should include assessment that the pipeline and UCS will have adequate over-pressure and over- and under-temperature protection.
- Implement an appropriate asset lifecycle plan for the UCS, which includes site checks and maintenance regimes.
- Communicate to Origin Energy and neighbouring lots that may be developed in the future the risk of injury to onsite personnel, and implement appropriate safeguards, such as Emergency Response Plans, at the neighbouring facilities.
- Hazardous Area nomination, including review of potential ignition sources on site, and selection of appropriately rated electrical equipment to manage the potential ignition sources.
- Liaise with local emergency services with regards to management of vegetation located within jet fire contours.

9. References

National Transport Commission (2024a). Australian Dangerous Goods Code, Edition 7.9

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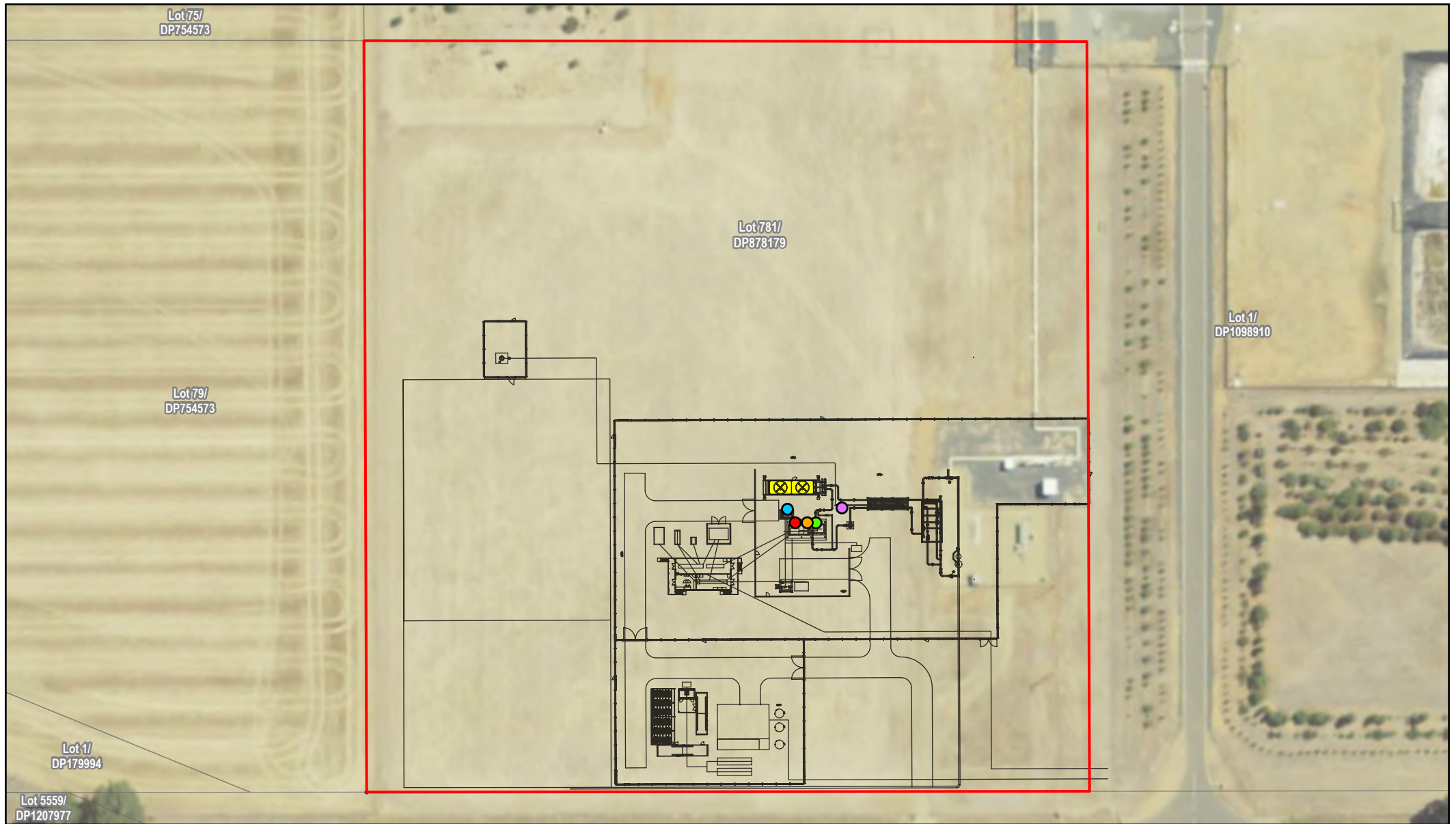
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TNO Institute of Environmental Sciences (1992). Green Book: Method of determination for possible damage to people and objects resulting from the release of hazardous materials, 1st ed.

Appendices

Appendix A

Site Layout



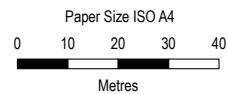
LEGEND

- Proposed site
- After cooler
- Lot
- Site layout

Noise sources

- Anti-Surge valve
- Compressor
- Gearbox

- Lube Oil Cooler
- Motor



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55



**East Australian Pipeline Pty Ltd
Culcairn to Wagga Wagga Gas Pipeline –
MOD 1 Uranquinty Compressor Station
Preliminary Hazard Analysis**

Site layout

Project No. **12614690**
Revision No. **0**
Date **29/07/2025**

FIGURE 1.1

Appendix B

Methane Safety Data Sheet

SAFETY DATA SHEET

Version 6.3
Revision Date 19.12.2024
Print Date 11.02.2025

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifiers

Product name : Methane

Product Number : 295477
Brand : Aldrich
CAS-No. : 74-82-8

1.2 Other means of identification

No data available

1.3 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : For R&D use only. Not for pharmaceutical, household or other uses.

1.4 Details of the supplier of the safety data sheet

Company : Merck Life Science Pty Ltd
Ground Floor, Building 1, 885 Mountain Highway
BAYSWATER VIC 3153
AUSTRALIA

Telephone : +61 1800 800 097
E-mail address : customersupport.anz@merckgroup.com

1.5 Emergency telephone

Emergency Phone # : Free call (24/7): 1800 862 115
Int'l (24/7): +61 2 9037 2994
(CHEMTREC)

SECTION 2: Hazards identification

2.1 GHS Classification

Flammable gases (Category 1), H220
Gases under pressure (Compressed gas), H280

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram



Signal Word : Danger

Hazard Statements

H220 : Extremely flammable gas.
H280 : Contains gas under pressure; may explode if heated.

Precautionary Statements

Prevention

P210 : Keep away from heat/ sparks/ open flames/ hot surfaces. No

	smoking.
Response P377	Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
P381	Eliminate all ignition sources if safe to do so.
Storage P410 + P403	Protect from sunlight. Store in a well-ventilated place.

2.3 Other hazards

May displace oxygen and cause rapid suffocation.

SECTION 3: Composition/information on ingredients

Substance / Mixture : Substance

3.1 Substances

Formula : CH₄
Molecular weight : 16.04 g/mol
CAS-No. : 74-82-8
EC-No. : 200-812-7
Index-No. : 601-001-00-4

No components need to be disclosed according to the applicable regulations.

For the full text of the H-Statements mentioned in this Section, see Section 16.

SECTION 4: First aid measures

4.1 Description of first-aid measures

General advice

Show this material safety data sheet to the doctor in attendance.

If inhaled

After inhalation: fresh air.

In case of skin contact

In case of skin contact: Take off immediately all contaminated clothing. Rinse skin with water/ shower.

In case of eye contact

After eye contact: rinse out with plenty of water. Remove contact lenses.

If swallowed

After swallowing: make victim drink water (two glasses at most). Consult doctor if feeling unwell.

4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed

No data available

SECTION 5: Firefighting measures

5.1 Extinguishing media

Suitable extinguishing media

Water Foam Carbon dioxide (CO₂) Dry powder

Unsuitable extinguishing media

For this substance/mixture no limitations of extinguishing agents are given.

5.2 Special hazards arising from the substance or mixture

Carbon oxides

Combustible.

Pay attention to flashback.

Development of hazardous combustion gases or vapours possible in the event of fire.

5.3 Advice for firefighters

In the event of fire, wear self-contained breathing apparatus.

5.4 Further information

Remove container from danger zone and cool with water.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

Advice for non-emergency personnel: Do not breathe gas. Avoid substance contact.

Ensure adequate ventilation. Evacuate the danger area, observe emergency procedures, consult an expert.

For personal protection see section 8.

6.2 Environmental precautions

No special precautionary measures necessary.

6.3 Methods and materials for containment and cleaning up

Observe possible material restrictions (see sections 7 and 10). Stop flow of gas, move leaking cylinder to open air if without risk.

6.4 Reference to other sections

For disposal see section 13.

SECTION 7: Handling and storage

7.1 Precautions for safe handling

Advice on protection against fire and explosion

Keep away from open flames, hot surfaces and sources of ignition.

Hygiene measures

Change contaminated clothing. Wash hands after working with substance.

For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Storage conditions

Tightly closed. Keep away from combustible materials and sources of ignition.

Contents under pressure.

Storage class

Storage class (TRGS 510): 2A: Gases

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.3 no other specific uses are stipulated.

SECTION 8: Exposure controls/personal protection

8.1 Control parameters

Ingredients with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Methane	74-82-8	TWA	0.1 mg/m ³	Australia. Workplace Exposure Standards for Airborne Contaminants.

8.2 Exposure controls

Appropriate engineering controls

Change contaminated clothing. Wash hands after working with substance.

Personal protective equipment

Eye/face protection

Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU). Safety glasses

Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

The selected protective gloves have to satisfy the specifications of Regulation (EU) 2016/425 and the standard EN 374 derived from it.

Full contact

Material: Fluorinated rubber

Minimum layer thickness: 0.7 mm

Break through time: 480 min

Material tested: Vitoject® (KCL 890 / Aldrich Z677698, Size M)

Splash contact

Material: Nitrile rubber

Minimum layer thickness: 0.4 mm

Break through time: 60 min

Material tested: Camatril® (KCL 730 / Aldrich Z677442, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374

If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the EC approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection

Flame retardant antistatic protective clothing.

Respiratory protection

required when vapours/mists are generated. Our recommendations on filtering respiratory protection are based on the following standards: DIN EN 143, DIN 14387 and other accompanying standards relating to the used respiratory protection system.

Control of environmental exposure

No special precautionary measures necessary.

SECTION 9: Physical and chemical properties

9.1 Information on basic physical and chemical properties

- | | |
|---|--|
| a) Physical state | gaseous |
| b) Color | colorless |
| c) Odor | odorless |
| d) Melting point/freezing point | Melting point/ range: -183 °C - lit. |
| e) Initial boiling point and boiling range | -161 °C - lit. |
| f) Flammability (solid, gas) | No data available |
| g) Upper/lower flammability or explosive limits | Upper explosion limit: 15 %(V)
Lower explosion limit: 5 %(V) |
| h) Flash point | -188 °C - closed cup |
| i) Autoignition temperature | No data available |
| j) Decomposition temperature | No data available |
| k) pH | No data available |
| l) Viscosity | Viscosity, kinematic: No data available
Viscosity, dynamic: No data available |
| m) Water solubility | 24.4 g/l at 25 °C |
| n) Partition coefficient: n-octanol/water | log Pow: 1.09 - Bioaccumulation is not expected., (ECHA) |
| o) Vapor pressure | 45,200 hPa at -83 °C |
| p) Density | 0.716 g/cm ³ at 25 °C - lit. |
| Relative density | No data available |
| q) Relative vapor density | No data available |
| r) Particle characteristics | No data available |
| s) Explosive properties | No data available |
| t) Oxidizing properties | none |

9.2 Other safety information

- | | |
|------------------------|--------------------|
| Relative vapor density | 0.55 - (Air = 1.0) |
|------------------------|--------------------|

SECTION 10: Stability and reactivity

10.1 Reactivity

No data available

10.2 Chemical stability

The product is chemically stable under standard ambient conditions (room temperature) .

10.3 Possibility of hazardous reactions

No data available

10.4 Conditions to avoid

no information available

10.5 Incompatible materials

Strong oxidizing agents

10.6 Hazardous decomposition products

In the event of fire: see section 5

SECTION 11: Toxicological information

11.1 Information on toxicological effects

Acute toxicity

Oral: No data available

Inhalation: No data available

Dermal: No data available

Skin corrosion/irritation

No data available

Serious eye damage/eye irritation

No data available

Respiratory or skin sensitization

No data available

Germ cell mutagenicity

Test Type: Ames test

Test system: Salmonella typhimurium

Metabolic activation: with and without metabolic activation

Method: OECD Test Guideline 471

Result: negative

Test Type: Chromosome aberration test in vitro

Test system: Human lymphocytes

Metabolic activation: with and without metabolic activation

Method: OECD Test Guideline 473

Result: negative

Carcinogenicity

No data available

Reproductive toxicity

No data available

Specific target organ toxicity - single exposure

No data available

Specific target organ toxicity - repeated exposure

No data available

Aspiration hazard

No data available

11.2 Additional Information

RTECS: PA1490000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

SECTION 12: Ecological information

12.1 Toxicity

No data available

12.2 Persistence and degradability

No data available

12.3 Bioaccumulative potential

No data available

12.4 Mobility in soil

No data available

12.5 Results of PBT and vPvB assessment

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Endocrine disrupting properties

No data available

12.7 Other adverse effects

No data available

SECTION 13: Disposal considerations

13.1 Waste treatment methods

Product

Waste material must be disposed of in accordance with the national and local regulations. Leave chemicals in original containers. No mixing with other waste. Handle uncleaned containers like the product itself. Pressurised gas bottle: dispose of only in empty condition!

SECTION 14: Transport information

14.1 UN number

ADR/RID: 1971

IMDG: 1971

IATA-DGR: 1971

14.2 UN proper shipping name

ADR/RID: METHANE, COMPRESSED

IMDG: METHANE, COMPRESSED

IATA-DGR: Methane, compressed

Passenger Aircraft: Not permitted for transport

14.3 Transport hazard class(es)

ADR/RID: 2.1

IMDG: 2.1

IATA-DGR: 2.1

14.4 Packaging group

ADR/RID: -

IMDG: -

IATA-DGR: -

14.5 Environmental hazards

ADR/RID: no

IMDG Marine pollutant: no

IATA-DGR: no

Aldrich- 295477

Page 7 of 8

The life science business of Merck operates as MilliporeSigma in the US and Canada



14.6 Special precautions for user

None

14.7 Incompatible materials

Strong oxidizing agents

Other regulations

Hazchem Code : 2SE

SECTION 15: Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Therapeutic Goods (Poisons Standard) : No poison schedule number
Instrument allocated

SECTION 16: Other information

Full text of H-Statements referred to under sections 2 and 3.

H220 Extremely flammable gas.
H280 Contains gas under pressure; may explode if heated.

Further information

The information is believed to be correct but is not exhaustive and will be used solely as a guideline, which is based on current knowledge of the chemical substance or mixture and is applicable to appropriate safety precautions for the product. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

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Appendix C

Assumptions Register

Technical Memorandum

19 August 2025

To	APA	Email	
From	Megan Hardy, Teresa Weatherill	Project No.	12614690
Project Name	Culcairn to Wagga Gas Pipeline - MOD1 Uranquinty Compressor Station		
Subject	Consequence Modelling Assumptions Register, July 2025 Layout Update, Rev C		

1. Introduction

The objective of this memorandum is to provide the basis for the consequence and risk modelling that will be performed by GHD for the Preliminary Hazard Analysis (PHA) to support the proposed Modification 1 to the Culcairn to Wagga Gas Pipeline. This modification consists of the addition of a new compressor station at Uranquinty, on land adjacent to the existing Uranquinty Power Station (UPS) and the existing Main Line Valve (MLV) and UPS take-off station. This memorandum is to be reviewed by APA to confirm their preferences for the basis of modelling where required. The agreed basis will be transferred into the PHA report, together with the results and recommendations from the assessment.

1.1 Scope and limitations

1.1.1 Scope

The scope is to update the Rev B PHA to support the proposed Modification 1 to the Culcairn to Wagga Gas Pipeline, being the new Uranquinty Compressor Station (UCS) using the revised layout, P&IDs and other updated site information. The PHA will include a Quantitative Risk Assessment (QRA) of loss of containment events, with reference to the Hazardous Industry Planning Advisory Papers (HIPAPs) No. 6: Hazard Analysis¹ and No. 4: Risk Criteria for Land Use Safety Planning².

The QRA will be modelled in DNV's PHAST software version 9.0.

1.1.2 Limitations

This technical memorandum has been prepared by GHD for APA. It is not prepared as, and is not represented to be, a deliverable suitable for reliance by any person for any purpose. It is not intended for circulation or incorporation into other documents. The matters discussed in this memorandum are limited to those specifically detailed in the memorandum and are subject to any limitations or assumptions specially set out.

¹ NSW Department of Planning, "HIPAP No.6 - Guidelines for Hazard Analysis," 2011.

² NSW Department of Planning, "HIPAP No.4 - Risk Criteria for Land Use Planning," 2011.

2. Release cases inputs and assumptions

Table 1 outlines the release cases which represent the loss of containment scenarios for the UCS.

Table 1 Summary of release cases

No.	Scenario description	Comments/Rationale
Scenario 1	Release of natural gas from the DN400 piping and header between the pipeline take-off manual isolation valve (V-200) and the compressor suction inlet isolation valve (SDV 7621)	<ul style="list-style-type: none"> – Scenario chosen as there is a large inventory in this section, and it requires manual isolation if there is a release. There is potential for jet fire impingement on onsite operators / maintainers, nearby equipment, and off-site personnel. – Causes of this scenario may be due to external interference e.g., vehicle impact; corrosion; or pressure fatigue in pipe etc.
Scenario 2	Release of natural gas from the DN350 piping between the compressor package inlet isolation valve (SDV 7621) and the compressor	<ul style="list-style-type: none"> – Scenario chosen as typical of the compressor inlet line, with potential for jet fire impingement on onsite operators / maintainers, nearby equipment, and (potentially) off-site personnel. – Causes of this scenario may be due to external interference e.g., vehicle impact; corrosion; or pressure fatigue in pipe etc.
Scenario 3	Release of natural gas from the DN350 piping between the compressor and the compressor package outlet SDV 7641	<ul style="list-style-type: none"> – Scenario chosen as typical of the compressor discharge line, with potential for jet fire impingement on onsite operators / maintainers, nearby equipment, and (potentially) off-site personnel. – Causes of this scenario may be due to external interference e.g., vehicle impact; corrosion; or pressure fatigue in pipe etc.
Scenario 4	Release of natural gas from the DN400 header and piping between the compressor package discharge isolation valve and the pipeline take-off manual isolation valve (V-300)	<ul style="list-style-type: none"> – Scenario chosen as gas is at high pressure and this section has a large inventory, which requires manual isolation if there is a release. There is potential for jet fire impingement on onsite operators / maintainers, nearby equipment, and off-site personnel. – Causes of this scenario may be due to external interference e.g., vehicle impact; corrosion; or pressure fatigue in pipe etc.
Scenario 5	Fireball scenario	<ul style="list-style-type: none"> – The full bore rupture cases for scenarios 1 to 4 may cause a fireball. This is modelled as a standalone scenario, due to the limitations of the modelling software.

The general modelling parameters to be applied to all release cases are outlined in Table 2.

Table 2 General modelling parameters

Description	Assumption	Reference / Comment
General Inputs		
Location	15km south-west of Wagga Wagga, NSW	Approximate location as per Uranquinty Power Station Environmental Management Plan (UPS-ENV-PLN-001)
Release location	Outdoor release, over land	
Release height	1 m	Assumed height of release, approximately equivalent to pipe rack height
Type of release	Leak release	Release flowrates from small bore leaks will be constant during the period of interest. Release flowrates from larger holes will vary with time, after the source of the release is isolated.
Height of interest	1.5 m	Used for reporting of results and represents the average height of a typical person
Surface roughness	1 m	Regular, large obstacle coverage Representing the infrastructure present on the site e.g., vessels, pipes, etc. (affects the turbulence in the air as it reaches the release)
Composition	Natural Gas, Methane ~97.8 %, modelled as 100% methane to be conservative	As per APA Process Design Specification, 24023-SP-Q-001_0.3, Table 6: Design Gas composition Natural gas from Moomba and/or the Victorian Transmission System Note – The composition will be modelled as 100% methane to be conservative
Angle of leak	Horizontal	Represents the worst-case release direction which would result in largest jet fire impingement onto personnel or nearby equipment
Ignition probability	Ignition model no. 5 - small plant gas LPG (gas or LPG release from small onshore plant)	Ignition probabilities for this study were derived based on the International Association of Oil & Gas Producers ignition probability information, which is based on plant size, plant type and release rate. ³
Surface Temperature	Taken to be the same as the ambient air temperature	The surface temperature can be higher or lower than the ambient air temperature at any particular time, depending on a number of factors, including time of day, time of year, cloud cover etc. As the correlation between average surface temperature and average ambient temperature is not known, they are assumed to be the same.

³ Reference: International Association of Oil & Gas Producers Risk Assessment Data Directory Report No. 434-06 Ignition Probabilities, 2019.

Description	Assumption	Reference / Comment
Solar Radiation	1.0 kW/m ²	Typical value used for thermal radiation analysis, and as per APA EDP, Plume Dispersion and Radiation Analysis, 530-EDP-Q-005, Section 4.2.2, Rev 2 (2019). Included in consequences modelling for daytime weather categories.
Weather Conditions	Refer to Table 4 below	Calculated from Wagga Wagga AMO BoM station climate data

These weather conditions provide a representative view of the site for day and night. Weather data used as assumptions is measured from the nearest Bureau of Meteorology (BoM) station to the project site.

Table 3 *Nearest BoM station to the project site*

Station Name	Station BoM ID	Latitude	Longitude	Elevation	Distance to Project Site
WAGGA WAGGA AMO	072150	35.16° S	147.46° E	212 m	22.73 km

Table 4 *Wagga Wagga AMO Wind Classes average conditions*

Wind Class	C	D	D	F	E
Stability	Unstable	Fast	Moderate	Low	Weak Stable
Wind Speed (m/s)	3.6	5.1	4.6	1.6	3.5
Temperature (C)	20	16	16	10	13
Mixing Height	1090	532	349	232	169
Time of Day	Daytime	Daytime	Daytime	Nighttime	Nighttime
Summer (Min) Mean 3PM Relative Humidity	29 %				
Winter (Max) Mean 9AM Relative Humidity	88 %				

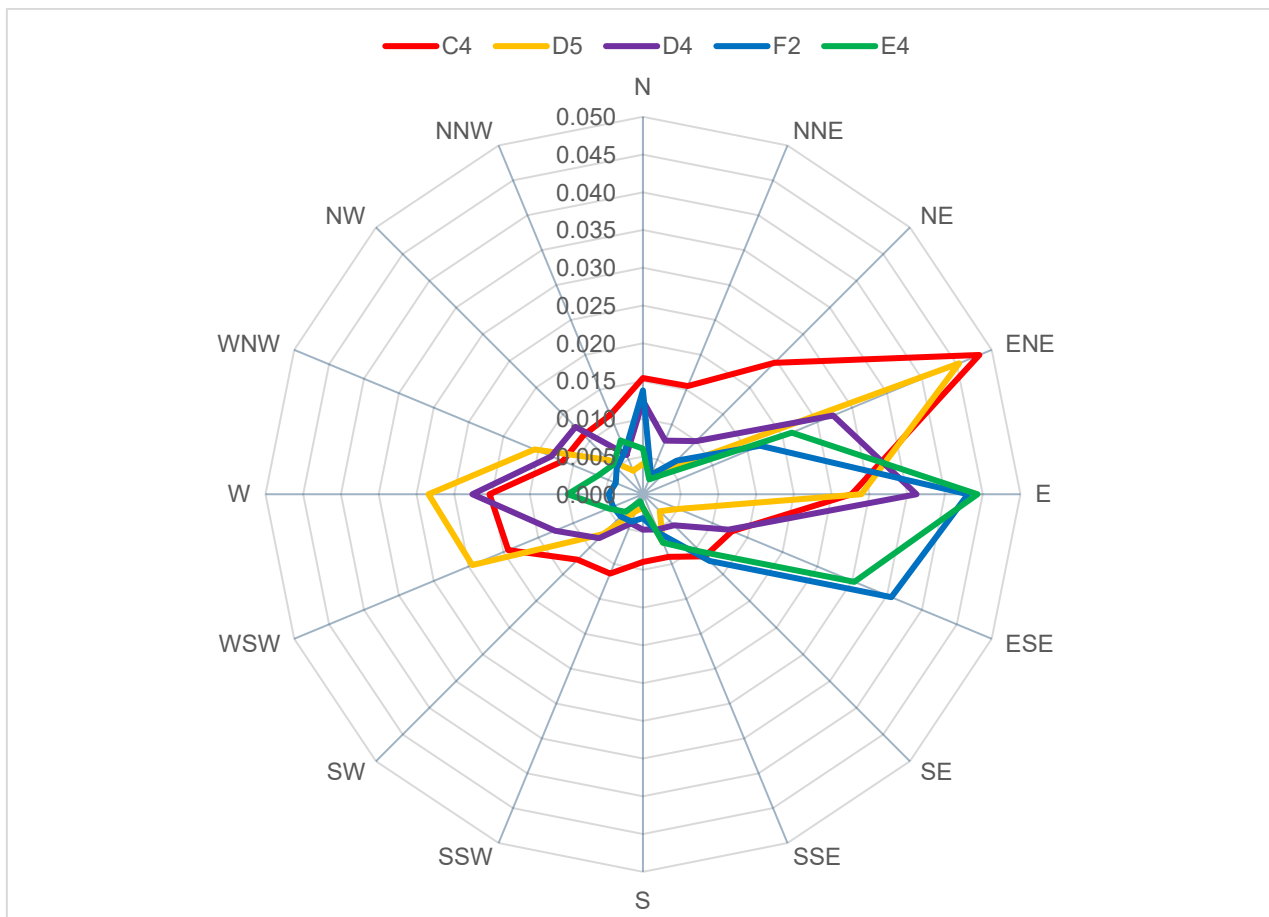


Figure 1: Directions and Wind Classes probability chart

Table 5 Modelled Weather Conditions

Wind speed and class	Stability and weather description
3.6/C	Moderately unstable – Very windy/sunny or overcast/light wind
5.1/D	Neutral – Little sun and high wind or overcast/windy night
4.6/D	Neutral – Little sun and high wind or overcast/windy night
1.6/F	Stable – Night with moderate clouds and light moderate winds
3.5/E	Moderately stable – Less overcast and less windy night compared to D

The inputs and assumptions for the release cases are outlined in Table 6.

Leak frequencies for the four isolatable sections of the compressor station will be estimated by combining historical leak frequency data compiled by the International Association of Oil and Gas Producers (IOGP)⁴ and a high-level parts count of piping, valves and fittings within the station, which will be compiled from the Schematic for the YW158 Uranquinty Compressor Station (24023-DWG-Q-0001.01 Rev 0.2) for line sizes, valves and fittings, and the Navisworks 3D piping model of the Uranquinty Compressor Station provided by APA for pipe run lengths (WWP.URAN-CLM-A-0003 (DRAFT)).

The modelling of scenarios one and four is based on 100% on-line time, as these sections are not isolated from the pipeline, which is always pressured. Scenarios 2 and 3 are modelled based on 120 days of operating time. The compressor within this station is expected to operate for a maximum of 100 days per

⁴ Reference: International Association of Oil & Gas Producers, "Risk Assessment Data Directory – Report 434-01, Process Release Frequencies, " 2019

year, but a contingency of an additional 20 days has been included to account for the time the compressor package between the inlet and outlet shutdown valves will be left in Pressurised Hold mode.

In reality, the closure of the compressor shutdown valves would reduce the equivalent hole size used for the full bore rupture case of Scenario 4 for the period when the compressor is isolated, as gas could only flow into the leak from downstream. This would result in two scenario 4 full bore rupture cases, one for when the compressor shutdown valves are open and one for when the compressor shutdown valves are closed. This nuance was not included in the risk calculations, i.e., the equivalent hole size is calculated in PHAST assuming the hole can be fed from both upstream and downstream 100% of the time.

The lengths of the larger piping diameters (being piping with nominal diameters larger than DN100) were mostly removed from the leak frequency calculation for FBR in all scenarios, as there is a very low likelihood of larger pipes experiencing FBR due to their increased robustness. For each pipe size larger than DN100, 2 m of pipe length were retained in the leak frequency calculation to account for piping adjacent to nozzles, as this is the most likely area to experience a FBR.

The leak frequencies are calculated based on the current station configuration of one compressor unit installed. Provisions are available in the design for a future installation of a second compressor, however is not included in this study as per APA's advice due to the very low likelihood of future compressor installation.

Table 6 Release case inputs and assumptions

Description	Units	Assumption	Reference / Comment
Scenario 1: Release of natural gas from the DN400 piping and header between the pipeline take-off manual isolation valve and the compressor suction inlet isolation valve (SDV 7621).			
Model / Scenario		Pipeline / leak	This scenario draws gas from the pipeline until it is manually isolated, and hence has a constant release rate during the period of interest.
Hole diameter	mm	2 6 22 85 Full bore rupture	Geometric mean diameter of hole size ranges given in IOGP 434-01 ⁵ , except full bore rupture, which is discussed below.
Material		100% CH ₄	Material predominantly CH ₄ , as per Table 2
Maximum Operating Pressure	kPag	8,101	Compressor duty point maximum suction pressure as per the Table 9 (Section 5.1) of the Process Design Specification (24023-SP-Q-001_0.4).
Line Temperature	°C	21	Maximum pipeline gas (ground) temperature taken to be the same as the summer station suction pressure, as per Table 7 (Section 4.2) of the Process Design Specification (24023-SP-Q-001_0.4).
Line size and schedule	mm	DN400 Schedule 80 ID = 363.5	As per the Uranquinty Compressor Station Schematic (24023-DWG-Q-0001.01, Rev 0.2) Schedule 80 as per APA Pipe Spec A09C04. DN400 internal diameter = 406.4 – 2x21.44 = 363.5
Hole diameter (full bore rupture)		Calculated	Piping full bore rupture, when connected to a pipeline, is modelled using an equivalent hole size of two (2) x the piping internal cross

⁵ Reference: International Association of Oil & Gas Producers, "Risk Assessment Data Directory – Report 434-01, Process Release Frequencies, " 2019

Description	Units	Assumption	Reference / Comment
			section area – and this equivalent diameter for this hole size is calculated in PHAST.
Length of pipe	m	10,000	A long pipe to approximate a large inventory of gas that allows for a steady flow without affecting the jet fire outcomes. There is no automatic isolation between this piping section and the pipeline, so it will be continuously fed from the pipeline until it is manually isolated.
Flowrate		Calculated	Flowrate is calculated in PHAST based on inventory, gas upstream conditions and hole size. A discharge coefficient (Cd) of 1.0 is used to be conservative.
Given time used for flowrate calculation	seconds	30	In line with the requirements of AS2885 for leaks fed by a pipeline, as per APA requirements.
Scenario 2: Release of natural gas from the DN350 piping between the compressor inlet isolation valve (SDV) and the compressor			
Model / Scenario		Pressure vessel / leak	This small pipe section is modelled as a pressure vessel. This scenario has a constant release rate until the gas inventory is exhausted.
Hole sizes	mm	2 6 22 85 Full bore rupture	Geometric mean diameter of hole size ranges given in IOGP 434-01 ⁶ , except full bore rupture, which is discussed below.
Material		100% CH ₄	Material predominantly CH ₄ , as per Table 2
Maximum Operating Pressure	kPag	8,101	Compressor duty point maximum suction pressure as per the Process Design Specification Process Design Specification Table 9 (Section 5.1) of the Process Design Specification (24023-SP-Q-001_0.4).
Line Temperature	°C	21	Maximum pipeline gas (ground) temperature taken to be the same as the summer station suction pressure, as per Table 7 (Section 4.2) of the Process Design Specification (24023-SP-Q-001_0.4).
Line size and schedule	mm	DN350 Schedule 80 ID = 316.5	As per the Uranquinty Compressor Station Schematic (24023-DWG-Q-0001.01, Rev 0.2) Schedule 80 as per APA Pipe Spec A09C04. DN350 internal diameter = 355.6 – 2x19.55 = 316.5. This is the line size for which the leaks and rupture were modelled. Other piping sections of different diameters are included in the volume inventory.
Hole diameter (full bore rupture)	mm	316.5	The ID of the DN350 piping. The check valve on the compressor discharge prevents the release from being fed from both directions.
Inventory (Volume released)	m ³	800	Calculated based on an estimated pipe length of 101 m (including inlet scrubber) plus 10

⁶ Reference: International Association of Oil & Gas Producers, "Risk Assessment Data Directory – Report 434-01, Process Release Frequencies, " 2019

Description	Units	Assumption	Reference / Comment
			minutes of flow at the design flowrate. It is assumed that it would take 10 minutes for the release to be detected and for the compressor suction piping to be isolated in the event of a full bore rupture. This scenario includes pipe lengths of various line sizes which have been considered in the inventory calculation. APA has advised that, while the suction and discharge PAL/PALL will stop the compressor in event of low low pressure, the SDVs do not close automatically.
Flowrate		Calculated	Flowrate is calculated in PHAST based on inventory, gas upstream conditions and hole size. A discharge coefficient (Cd) of 1.0 is used to be conservative.
Scenario 3: Release of natural gas from the DN350 piping between the compressor and the compressor package outlet SDV			
Model / Scenario		Pressure vessel / leak	This small pipe section is modelled as a pressure vessel. This scenario has a constant release rate until the gas inventory is exhausted.
Hole sizes	mm	2 6 22 85 Full bore rupture	Geometric mean diameter of hole size ranges given in IOGP 434-01 ⁷ , except full bore rupture, which is discussed below.
Material		100% CH ₄	Material predominantly CH ₄ , as per Table 2
Maximum Operating Pressure	kPag	9,150	Compressor duty point maximum discharge pressure as per the Process Design Specification Table 10 (Section 5.2) of the Process Design Specification (24023-SP-Q-001_0.4)
Line Temperature	°C	55	APA has advised compressor discharge TAHH is set at 55 °C as per Process Design Specification Table 7 (Section 4.2) of the Process Design Specification (24023-SP-Q-001_0.4).
Line size and schedule	mm	DN350 Schedule 80 ID = 316.5	As per the Uranquinty Compressor Station Schematic (24023-DWG-Q-0001.01, Rev 0.2) Schedule 80 as per APA Pipe Spec A09C04. DN350 internal diameter = 355.6 – 2x19.55 = 316.5.
Hole diameter (full bore rupture)	mm	316.5	The ID of the DN350 piping. The check valve on the compressor discharge prevents the release from being fed from downstream.
Inventory (volume released)	m ³	724	Calculated based on an estimated pipe length of 106 m (including air cooler) plus 10 minutes of flow at the design flowrate. It is assumed that it would take 10 minutes for the release to be detected and for the compressor discharge piping to be isolated in the event of a full bore rupture. This scenario

⁷ Reference: International Association of Oil & Gas Producers, "Risk Assessment Data Directory – Report 434-01, Process Release Frequencies, " 2019

Description	Units	Assumption	Reference / Comment
			includes pipe lengths of various line sizes which have been considered in the inventory calculation. APA has advised that, while the suction and discharge PAL/PALL will stop the compressor in event of low low pressure, the SDVs do not close automatically.
Flowrate		Calculated	Flowrate is calculated in PHAST based on inventory, gas upstream conditions and hole size. A discharge coefficient (Cd) of 1.0 is used to be conservative.
Scenario 4: Release of natural gas from the DN400 header and piping between the compressor package discharge isolation valve and the pipeline take-off manual isolation valve			
Model / Scenario		Pipeline / leak	This scenario draws gas from the pipeline until it is manually isolated, and hence has a constant release rate during the period of interest.
Hole sizes	mm	2 6 22 85 Full bore rupture	Geometric mean diameter of hole size ranges given in IOGP 434-01 ⁸ , except full bore rupture, which is discussed below.
Material		100% CH ₄	Material predominantly CH ₄ , as per Table 2
Maximum Operating Pressure	kPag	10,300	Compressor duty point maximum discharge pressure as per the Process Design Specification Table 10 (Section 5.2) of the Process Design Specification (24023-SP-Q-001_0.4) plus an additional safety factor.
Line Temperature	°C	55	APA has advised compressor discharge TAHH is set to 55 °C. Refer to Process Design Specification Table 7 (Section 4.2) of the Process Design Specification (24023-SP-Q-001_0.4).
Line size and schedule	mm	DN400 Schedule 80 ID = 363.5	As per the Uranquinty Compressor Station Schematic (24023-DWG-Q-0001.01, Rev 0.2) Schedule 80 as per APA Pipe Spec A09C04. DN400 Internal Diameter = 406.4 – 2x21.44 = 363.5
Hole diameter (full bore rupture)		Calculated	Piping full bore rupture, when connected to a pipeline, is modelled using an equivalent hole size of two (2) x the piping internal cross section area – and this equivalent diameter for this hole size is calculated in PHAST. While there is a check valve on the compressor discharge, it does not prevent this release (which is downstream of the check valve) from being fed from both directions.
Length of pipe	m	10,000	A long pipeline to approximate a large inventory of gas that allows for a steady flow without affecting the jet fire outcomes. There is no automatic isolation between this piping section and the pipeline, so it will be

⁸ Reference: International Association of Oil & Gas Producers, "Risk Assessment Data Directory – Report 434-01, Process Release Frequencies, " 2019

Description	Units	Assumption	Reference / Comment
			continuously fed from the pipeline until it is manually isolated.
Flowrate		Calculated	Flowrate is calculated in PHAST based on inventory, gas upstream conditions and hole size. A discharge coefficient (Cd) of 1.0 is used to be conservative.
Given time used for flowrate calculation	seconds	30	In line with the requirements of AS2885 for leaks fed by a pipeline, as per APA requirements.

Due to the limitations of the software, the fireball scenario is modelled separately. A single fireball scenario will be modelled to represent the risks and consequences of all four FBR scenarios. The inputs of the fireball scenario are listed below.

Description	Units	Assumption	Reference / Comment
Model / Scenario		Fireball	Standalone fireball model within PHAST
Material		100% CH ₄	Material predominantly CH ₄ , as per Table 2
Released Mass	kg	311	This is based on the initial mass of gas in the piping section. This mass was calculated based on the scenario with the largest volumetric inventory, scenario three. The volumetric inventory of 5.5m ³ was multiplied with the density of the gas, 56.55 kg/m ³ .
Event Frequency		4.6 x 10 ⁻⁴	Calculated using event tree analysis and has an initiating frequency that is the summation of leak frequencies of all four FBR scenarios.

3. Consequence and Risk Criteria

Since natural gas is flammable, lighter than air and not toxic, the consequence modelling results will be presented at the heat radiation and explosion overpressure thresholds required by HIPAP 4² requirements. Toxic criteria are excluded as they are not applicable to methane. The consequence endpoints are shown in Table 7 and Table 8.

Table 7 Thermal radiation consequence thresholds

Level (kW/m ²)	Impact (based on HIPAP 6 ¹)	Usage in study
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds exposure	Threshold level for injury
7.3		1% probability of fatality (based on probit equation)
12.6	Significant chance of fatality for extended exposure. High chance of injury.	32% probability of fatality (based on probit equation)
23	Likely fatality for extended exposure and chance of fatality for instantaneous exposure. Unprotected steel will reach thermal stress temperatures which can cause failures.	95% probability of fatality (based on probit equation) Threshold level for escalation to neighbouring potentially hazardous installations or at land zoned to accommodate such installations

Level (kW/m ²)	Impact (based on HIPAP 6 ¹)	Usage in study
35	Cellulosic material will pilot ignite within one minute's exposure. Significant chance of fatality for people exposed instantaneously	Critical Radiation Intensity - 100% probability of fatality (based on probit equation)
Within flash fire	Flashfire envelope based on 50% lower flammable limit (0.5 LFL) contour	100% probability of fatality assumed

Table 8 Overpressure consequence thresholds

Overpressure endpoint	Effect
7 kPa	Damage to internal partitions and joinery but can be repaired. Probability of injury is 10%. No fatality.
14 kPa	House inhabitable and badly cracked.
21 kPa	Reinforced structures distort. Storage tanks fail. 20% chance of fatality to a person in a building.
35 kPa	House uninhabitable. Wagons and plants items overturned. Threshold of eardrum damage. 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open.
70 kPa	Threshold of lung damage. 100% chance of fatality for a person in a building or in the open Complete demolition of houses

HIPAP 4² provides quantitative risk criteria for fatality, injury and property damage, which are described in Table 9, Table 10, and Table 11 respectively.

HIPAP 4² provides indicative societal risk criteria for when there is significant population around a potentially hazardous facility. There is no significant offsite population around the compressor station, therefore societal risk criteria are excluded as they are not applicable to this study.

Table 9 Individual fatality risk criteria

Risk levels (individual fatality risk per year)	Land-Use	Limit of exposure at the following locations
0.5×10^{-6}	Sensitive	Hospitals, child-care facilities, and old age housing.
1×10^{-6}	Residential	Residential developments and places of continuous occupancy such as hotels and tourist resorts.
5×10^{-6}	Commercial	Commercial developments, including offices, retail centres and entertainment centres.
10×10^{-6}	Recreational	Sporting complexes and active open space areas.
50×10^{-6}	Industrial	Target for site boundary

Table 10 Individual injury risk criteria

Risk levels (individual injury risk per year)	Type
50×10^{-6}	Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m² .
50×10^{-6}	Incident explosion overpressure at residential and sensitive use areas should not exceed 7 kPa .

Table 11 Property damage criteria

Risk levels (Property damage risk per year)	Type
50 x 10 ⁻⁶	Incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations should not exceed 23 kW/m² .
50 x 10 ⁻⁶	Incident explosion overpressure at neighbouring potentially hazardous installations or at land zoned to accommodate such installations should not exceed 14 kPa .

The nearest residential or commercial offsite receptor is more than 900 m from the site, as summarised in Table 12 and shown in Figure 2.

Table 12 Offsite Receptors proximity to project site

ID	Description	Distance from site	Direction from site
R1	Potential dwelling	900 metres	South East
R2	Potential dwelling	1.0 km	South East
R3	Potential dwelling	1.38 km	North West
R4	Potential dwelling	2.19 km	East
R5	Potential dwelling	1.78 km	North East
R6	Potential dwelling	2.16 km	South
C1	Commercial receptor	1.0 km	South East
C2	Commercial receptor	2.14 km	North West
C3	Commercial receptor	1.54 km	South



Figure 2 Location of Nearby Off-site receptors

This Technical Memorandum is provided as an interim output under our agreement with APT Management Services Pty Limited. It is provided to foster discussion in relation to technical matters associated with the project and should not be relied upon in any way.

There are two neighbouring potentially hazardous installations, being the adjacent Uranquinty Power Station (UPS) and the AGN Fenced Compound. The power station can be operated manned, with up to 6 personnel working on-site, or operated remotely. The AGN Fenced Compound is operated remotely.

Appendix D

Consequence Modelling Results

D-1 Consequence Modelling Results

D-1-1 Scenario 1: Piping from pipeline take-off to compressor suction inlet isolation valve, including inlet header (DN400)

Jet fire Results

The distance downwind to the defined radiation levels for jet fire at the selected height of interest (1.5m) are shown in Table D.1.

Table D.1 Scenario 1: Jet Fire Results

ID	Scenario	Weather condition	Flame length [m]	Distance downwind to intensity level 1 (4.7 kW/m ²) [m]	Distance downwind to intensity level 2 (7.3 kW/m ²) [m]	Distance downwind to intensity level 3 (12.6 kW/m ²) [m]	Distance downwind to intensity level 4 (23 kW/m ²) [m]	Distance downwind to intensity level 5 (35 kW/m ²) [m]
1.1	2mm hole	All	2.6	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
1.2	6 mm hole	3.6/C	6.8	8.1	7.8	7.5	7.3	7.3
		5.1/D	6.8	7.9	7.7	7.4	7.2	7.2
		4.6/D	6.8	8.0	7.7	7.5	7.2	7.2
		1.6/F	6.7	8.1	7.8	7.5	7.3	7.2
		3.5/E	6.8	8.0	7.7	7.5	7.2	7.2
1.3	22 mm hole	3.6/C	24.3	36.6	33.8	31.0	28.6	27.2
		5.1/D	24.4	36.3	33.6	31.0	28.6	27.3
		4.6/D	24.3	36.3	33.6	31.0	28.6	27.2
		1.6/F	23.5	36.7	33.8	30.8	28.2	26.7
		3.5/E	24.0	36.5	33.7	30.9	28.4	27.0
1.4	85 mm hole	3.6/C	63.3	111.5	100.6	89.6	79.9	74.1
		5.1/D	64.3	111.5	100.8	90.2	80.9	75.5
		4.6/D	63.8	111.6	100.8	90.0	80.6	75.0
		1.6/F	60.5	111.4	99.7	88.1	77.8	71.5
		3.5/E	62.5	111.7	100.5	89.4	79.6	73.8
1.5	513 mm hole (FBR)	3.6/C	119.0	228.7	203.4	177.9	155.1	140.8
		5.1/D	121.0	228.8	204.1	179.5	88.3	87.9
		4.6/D	120.1	228.8	203.9	178.9	156.8	142.9
		1.6/F	114.0	228.9	202.2	175.2	151.0	135.4
		3.5/E	117.7	229.0	203.3	177.6	154.6	140.4

Flash fire results

The distance downwind to the defined flammable gas concentration levels at the selected height of interest (1.5m) are shown in Table D.2.

Table D.2 Scenario 1: Flash Fire Results

ID	Scenario	Weather	Distance downwind to LFL [m] at height of interest	Distance downwind to 50% LFL [m] at height of interest
1.1	2 mm hole	All	N/A	N/A
1.2	6 mm hole	All	N/A	N/A
1.3	22 mm hole	3.6/C	13.0	36.3
		5.1/D	12.6	36.2
		4.6/D	12.8	36.4
		1.6/F	14.9	36.9
		3.5/E	13.8	37.1
1.4	85 mm hole	3.6/C	61.0	154.4
		5.1/D	61.8	160.5
		4.6/D	61.6	158.2
		1.6/F	63.9	146.9
		3.5/E	62.8	155.9
1.5	513 mm hole (FBR)	3.6/C	154.1	322.9
		5.1/D	156.0	334.5
		4.6/D	154.9	331.0
		1.6/F	148.0	274.5
		3.5/E	155.0	309.4

Explosion results

The distance downwind to the defined intensity levels for explosion at the selected height of interest (1.5m) are shown in Table D.13.

Table D.3 Scenario 1: Explosion Results

ID	Scenario	Weather	Distance downwind to intensity level 1 (7kPa) [m]	Distance downwind to intensity level 2 (14kPa) [m]	Distance downwind to intensity level 3 (21kPa) [m]	Distance downwind to intensity level 4 (35kPa) [m]
1.1	2 mm hole	All	Not reached	Not reached	Not reached	Not reached
1.2	6 mm hole	All	Not reached	Not reached	Not reached	Not reached
1.3	22 mm hole	All	Not reached	Not reached	Not reached	Not reached
1.4	85 mm hole	All	Not reached	Not reached	Not reached	Not reached
1.5	513 mm hole (FBR)	All	Not reached	Not reached	Not reached	Not reached

D-1-2 Scenario 2: Compressor inlet piping from inlet isolation valve and gas compressor (DN350)

Jet fire results

The distance downwind to the defined radiation levels for jet fire at the selected height of interest (1.5m) are shown in Table D.4.

Table D.4 Scenario 2: Jet Fire Results

ID	Scenario	Weather	Flame length [m]	Distance downwind to intensity level 1 (4.7 kW/m ²) [m]	Distance downwind to intensity level 2 (7.3 kW/m ²) [m]	Distance downwind to intensity level 3 (12.6 kW/m ²) [m]	Distance downwind to intensity level 4 (23 kW/m ²) [m]	Distance downwind to intensity level 5 (35 kW/m ²) [m]
2.1	2 mm hole	3.6/C	2.9	2.7	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		5.1/D	2.9	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		4.6/D	2.9	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		1.6/F	2.8	2.8	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		3.5/E	2.8	2.7	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
2.2	6 mm hole	3.6/C	7.5	9.0	8.7	8.3	8.1	8.0
		5.1/D	7.5	8.8	8.5	8.2	8.0	8.0
		4.6/D	7.5	8.9	8.6	8.3	8.0	8.0
		1.6/F	7.4	9.0	8.7	8.3	8.0	7.9
		3.5/E	7.4	8.9	8.6	8.3	8.0	7.9
2.3	22mm hole	3.6/C	24.1	36.1	33.4	30.6	28.2	26.7
		5.1/D	24.3	35.9	33.2	30.6	28.3	27.0
		4.6/D	24.2	35.9	33.2	30.6	28.2	26.8
		1.6/F	23.2	36.2	33.2	30.2	27.6	26.1
		3.5/E	23.8	36.0	33.2	30.4	28.0	26.5
2.4	85mm hole	3.6/C	77.2	139.0	124.7	110.4	97.6	89.6
		5.1/D	78.7	139.0	125.2	111.5	99.3	91.9
		4.6/D	78.1	139.2	125.2	111.2	98.8	91.2
		1.6/F	73.7	140.6	125.1	109.5	95.6	86.9
		3.5/E	76.3	139.8	125.2	110.6	97.6	89.6
2.5	316mm hole (FBR)	3.6/C	190.5	405.8	355.3	304.1	257.2	235.1
		5.1/D	192.9	403.8	355.0	305.8	261.6	234.9
		4.6/D	191.7	405.0	355.5	305.4	260.3	235.1
		1.6/F	183.8	412.4	358.3	303.3	258.5	236.0

ID	Scenario	Weather	Flame length [m]	Distance downwind to intensity level 1 (4.7 kW/m ²) [m]	Distance downwind to intensity level 2 (7.3 kW/m ²) [m]	Distance downwind to intensity level 3 (12.6 kW/m ²) [m]	Distance downwind to intensity level 4 (23 kW/m ²) [m]	Distance downwind to intensity level 5 (35 kW/m ²) [m]
		3.5/E	188.4	408.2	356.9	304.9	257.7	235.6

Flash fire results

The distance downwind to the defined flammable gas concentration levels at the selected height of interest (1.5m) are shown in Table D.5.

Table D.5 Scenario 2: Flash Fire Results

ID	Scenario	Weather	Distance downwind to LFL [m] at height of interest	Distance downwind to 50% LFL [m] at height of interest
2.1	2 mm hole	All	N/A	N/A
2.2	6 mm hole	All	N/A	N/A
2.3	22 mm hole	3.6/C	13.1	36.6
		5.1/D	12.6	36.5
		4.6/D	12.9	36.8
		1.6/F	15.1	37.5
		3.5/E	13.9	37.7
2.4	85 mm hole	3.6/C	85.3	213.8
		5.1/D	86.8	223.4
		4.6/D	86.4	219.4
		1.6/F	88.3	199.4
		3.5/E	87.6	214.2
2.5	316 mm hole (FBR)	3.6/C	363.5	847.5
		5.1/D	371.6	882.0
		4.6/D	367.4	857.7
		1.6/F	334.5	592.7
		3.5/E	367.3	743.4

Explosion results

The distance downwind to the defined intensity levels for explosion at the selected height of interest (1.5m) are shown in Table D.16.

Table D.6 Scenario 2: Explosion Results

ID	Scenario	Weather	Distance downwind to intensity level 1 (7kPa) [m]	Distance downwind to intensity level 2 (14kPa) [m]	Distance downwind to intensity level 3 (21kPa) [m]	Distance downwind to intensity level 4 (35kPa) [m]
2.1	2mm hole	All	Not reachable	Not reachable	Not reachable	Not reachable
2.2	6 mm hole	All	Not reachable	Not reachable	Not reachable	Not reachable
2.3	22mm hole	All	Not reachable	Not reachable	Not reachable	Not reachable
2.4	85mm hole	All	Not reachable	Not reachable	Not reachable	Not reachable
2.5	316mm hole (FBR)	All	Not reachable	Not reachable	Not reachable	Not reachable

D-1-3 Scenario 3: Compressor outlet piping to isolation valve (DN350)

Jet fire results

The distance downwind to the defined radiation levels for jet fire at the selected height of interest (1.5 m) are shown in Table D.7.

Table D.7 Scenario 3: Jet Fire Results

ID	Scenario	Weather	Flame length [m]	Distance downwind to intensity level 1 (4.7 kW/m ²) [m]	Distance downwind to intensity level 2 (7.3 kW/m ²) [m]	Distance downwind to intensity level 3 (12.6 kW/m ²) [m]	Distance downwind to intensity level 4 (23 kW/m ²) [m]	Distance downwind to intensity level 5 (35 kW/m ²) [m]
3.1	2mm hole	3.6/C	2.9	2.9	2.4	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		5.1/D	2.8	2.8	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		4.6/D	2.8	2.8	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		1.6/F	2.8	2.9	2.7	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		3.5/E	2.8	2.9	2.6	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
3.2	6mm hole	3.6/C	7.5	9.0	8.7	8.4	8.1	8.0
		5.1/D	7.5	8.8	8.5	8.2	8.0	8.0
		4.6/D	7.5	8.8	8.6	8.3	8.0	8.0
		1.6/F	7.4	9.0	8.7	8.3	8.0	7.9
		3.5/E	7.5	8.9	8.6	8.3	8.0	7.9
3.3	22mm hole	3.6/C	23.9	36.0	33.3	30.5	28.2	26.8
		5.1/D	24.1	35.7	33.1	30.5	28.2	26.9
		4.6/D	24.0	35.7	33.1	30.5	28.2	26.8
		1.6/F	23.2	36.1	33.2	30.3	27.8	26.3
		3.5/E	23.6	35.9	33.1	30.4	28.0	26.6
3.4	85mm hole	3.6/C	77.5	140.1	125.8	111.5	98.9	91.1
		5.1/D	78.8	140.2	126.3	112.4	100.3	93.0
		4.6/D	78.2	140.3	126.2	112.2	99.8	92.4
		1.6/F	74.1	139.9	124.7	109.6	96.1	87.8
		3.5/E	76.6	140.3	125.7	111.2	98.5	90.7

ID	Scenario	Weather	Flame length [m]	Distance downwind to intensity level 1 (4.7 kW/m ²) [m]	Distance downwind to intensity level 2 (7.3 kW/m ²) [m]	Distance downwind to intensity level 3 (12.6 kW/m ²) [m]	Distance downwind to intensity level 4 (23 kW/m ²) [m]	Distance downwind to intensity level 5 (35 kW/m ²) [m]
3.5	316mm hole (FBR)	3.6/C	191.1	402.2	353.0	303.1	257.6	235.7
		5.1/D	193.6	401.4	353.5	305.3	262.0	235.8
		4.6/D	192.4	402.1	353.7	304.7	260.7	235.9
		1.6/F	184.3	407.1	354.8	301.7	257.7	236.2
		3.5/E	189.1	404.4	354.4	303.9	258.0	236.1

Flash fire results

The distance downwind to the defined flammable gas concentration levels at the selected height of interest (1.5m) are shown in Table D.8.

Table D.8 Scenario 3: Flash Fire Results

ID	Scenario	Weather	Distance downwind to LFL [m] at height of interest	Distance downwind to 50% LFL [m] at height of interest
3.1	2 mm hole	All	N/A	N/A
3.2	6 mm hole	All	N/A	N/A
3.3	22 mm hole	3.6/C	12.6	35.5
		5.1/D	12.2	35.4
		4.6/D	12.5	35.6
		1.6/F	14.5	36.2
		3.5/E	13.5	36.3
3.4	85 mm hole	3.6/C	82.1	206.1
		5.1/D	83.5	215.0
		4.6/D	83.0	211.5
		1.6/F	85.5	194.5
		3.5/E	84.3	207.8
3.5	316 mm hole (FBR)	3.6/C	345.7	827.5
		5.1/D	352.3	855.0
		4.6/D	348.3	832.3
		1.6/F	320.0	573.2
		3.5/E	349.6	721.9

Explosion results

The distance downwind to the defined intensity levels for explosion at the selected height of interest (1.5m) are shown in Table D.19.

Table D.9 Scenario 3: Explosion Results

ID	Scenario	Weather	Distance downwind to intensity level 1 (7kPa) [m]	Distance downwind to intensity level 2 (14kPa) [m]	Distance downwind to intensity level 3 (21kPa) [m]	Distance downwind to intensity level 4 (35kPa) [m]
3.1	2mm hole	All	Not reached	Not reached	Not reached	Not reached
3.2	6mm hole	All	Not reached	Not reached	Not reached	Not reached
3.3	22mm hole	All	Not reached	Not reached	Not reached	Not reached
3.4	85mm hole	All	Not reached	Not reached	Not reached	Not reached
3.5	316mm hole (FBR)	All	Not reached	Not reached	Not reached	Not reached

D-1-4 Scenario 4: Piping from compressor discharge isolation valve to pipeline take-off, including outlet header (DN400)

Jet fire results

The distance downwind to the defined radiation levels for jet fire at the selected height of interest (1.5m) are shown in Table D.10.

Table D.10 Scenario 4: Jet Fire Results

ID	Scenario	Weather	Flame length [m]	Distance downwind to intensity level 1 (4.7 kW/m ²) [m]	Distance downwind to intensity level 2 (7.3 kW/m ²) [m]	Distance downwind to intensity level 3 (12.6 kW/m ²) [m]	Distance downwind to intensity level 4 (23 kW/m ²) [m]	Distance downwind to intensity level 5 (35 kW/m ²) [m]
4.1	2mm hole	3.6/C	2.8	2.5	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		5.1/D	2.8	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		4.6/D	2.8	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		1.6/F	2.8	2.7	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
		3.5/E	2.8	2.5	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest
4.2	6mm hole	3.6/C	7.5	8.9	8.6	8.3	8.0	8.0
		5.1/D	7.4	8.7	8.5	8.2	7.9	7.9
		4.6/D	7.4	8.8	8.5	8.2	8.0	7.9
		1.6/F	7.4	8.9	8.6	8.3	8.0	7.8
		3.5/E	7.4	8.8	8.5	8.2	8.0	7.9
4.3	22mm hole	3.6/C	26.6	40.9	37.7	34.5	31.7	30.1
		5.1/D	26.7	40.5	37.5	34.4	31.8	30.2
		4.6/D	26.6	40.6	37.5	34.4	31.7	30.2
		1.6/F	25.8	41.1	37.7	34.3	31.4	29.6

ID	Scenario	Weather	Flame length [m]	Distance downwind to intensity level 1 (4.7 kW/m ²) [m]	Distance downwind to intensity level 2 (7.3 kW/m ²) [m]	Distance downwind to intensity level 3 (12.6 kW/m ²) [m]	Distance downwind to intensity level 4 (23 kW/m ²) [m]	Distance downwind to intensity level 5 (35 kW/m ²) [m]
		3.5/E	26.2	40.8	37.6	34.4	31.6	29.9
4.4	85mm hole	3.6/C	69.8	123.7	111.5	99.3	88.5	82.0
		5.1/D	70.8	123.6	111.7	99.8	89.4	83.3
		4.6/D	70.3	123.6	111.5	99.5	89.0	82.8
		1.6/F	66.9	123.0	110.2	97.3	86.0	79.1
		3.5/E	69.0	123.3	111.0	98.7	87.9	81.4
4.5	513mm hole (FBR)	3.6/C	128.6	246.7	219.5	192.1	167.7	152.3
		5.1/D	130.5	246.9	220.3	193.7	170.2	155.6
		4.6/D	129.6	246.9	220.1	193.2	169.3	154.7
		1.6/F	123.4	246.7	218.2	189.4	163.6	146.9
		3.5/E	127.1	247.0	219.4	191.8	167.2	151.9

Flash fire results

The distance downwind to the defined flammable gas concentration levels at the selected height of interest (1.5m) are shown in Table D.11.

Table D.11 Scenario 4: Flash Fire Results

ID	Scenario	Weather	Distance downwind to LFL [m] at height of interest	Distance downwind to 50% LFL [m] at height of interest
4.1	2mm hole	3.6/C	N/A	N/A
4.2	6mm hole	3.6/C	N/A	N/A
24.3	22mm hole	3.6/C	15.1	41.1
		5.1/D	14.7	41.1
		4.6/D	14.9	41.3
		1.6/F	16.9	41.2
		3.5/E	15.9	41.7
4.4	85mm hole	3.6/C	68.5	170.8
		5.1/D	69.3	175.0
		4.6/D	69.1	172.8
		1.6/F	70.9	157.6
		3.5/E	70.2	169.0
4.5	513mm hole (FBR)	3.6/C	161.3	303.1
		5.1/D	163.5	316.0
		4.6/D	162.4	313.2
		1.6/F	150.5	259.9
		3.5/E	160.9	291.5

Explosion results

The distance downwind to the defined intensity levels for explosion at the selected height of interest (1.5m) are shown in Table D.112.

Table D.12 Scenario 4: Explosion Results

ID	Scenario	Weather	Distance downwind to intensity level 1 (7kPa) [m]	Distance downwind to intensity level 2 (14kPa) [m]	Distance downwind to intensity level 3 (21kPa) [m]	Distance downwind to intensity level 4 (35kPa) [m]
4.1	2 mm hole	All	Not reached	Not reached	Not reached	Not reached
4.2	6 mm hole	All	Not reached	Not reached	Not reached	Not reached
4.3	22 mm hole	All	Not reached	Not reached	Not reached	Not reached
4.4	85 mm hole	All	Not reached	Not reached	Not reached	Not reached
4.5	513 mm hole (FBR)	All	Not reached	Not reached	Not reached	Not reached

Appendix E

Site Meteorological Data

Wind and Stability Risk Analysis Data

Project: 12614690

Input met file: Observations from Wagga Wagga AWS, Mixing height from TAPM

Table E.1 Wind classes and directions

Class number	Directions/ Wind Classes (m/s)	Unstable (A/B/C, all wind speeds)	Mod D (D, WS <5.0 m/s)	Fast D (D, WS>5.0 m/s)	E: Weak stable (all speeds)	F: strong stable (all speeds)	Totals
1	N	122	98	32	48	109	409
2	NNE	123	61	25	17	22	248
3	NE	195	79	37	29	50	390
4	ENE	382	216	359	169	133	1259
5	E	219	287	229	351	341	1427
6	ESE	101	97	40	240	282	760
7	SE	92	46	25	85	99	347
8	SSE	71	40	55	55	44	265
9	S	71	37	14	14	25	161
10	SSW	90	33	19	8	31	181
11	SW	97	65	59	26	33	280
12	WSW	153	100	194	39	34	520
13	W	161	179	225	79	36	680
14	WNW	91	104	123	51	31	400
15	NW	88	100	51	44	39	322
16	NNW	90	45	27	61	49	272
Sub-totals		2146	1587	1514	1316	1358	7921

Table E.2 Wind Speeds and direction probabilities

Directions/ Wind classes (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WN W	NW	NNW	Total
C4	0.015	0.016	0.025	0.048	0.028	0.013	0.012	0.009	0.009	0.011	0.012	0.019	0.020	0.011	0.011	0.011	0.271
D6	0.004	0.003	0.005	0.045	0.029	0.005	0.003	0.007	0.002	0.002	0.007	0.024	0.028	0.016	0.006	0.003	0.191
D3	0.012	0.008	0.010	0.027	0.036	0.012	0.006	0.005	0.005	0.004	0.008	0.013	0.023	0.013	0.013	0.006	0.200
F2	0.014	0.003	0.006	0.017	0.043	0.036	0.013	0.006	0.003	0.004	0.004	0.004	0.005	0.004	0.005	0.006	0.171
E4	0.006	0.002	0.004	0.021	0.044	0.030	0.011	0.007	0.002	0.001	0.003	0.005	0.010	0.006	0.006	0.008	0.166
Totals	0.052	0.031	0.049	0.159	0.180	0.096	0.044	0.033	0.020	0.023	0.035	0.066	0.086	0.051	0.041	0.034	1.000

