HALSTON

APPENDIX 4.2

CONSEQUENCE STUDY REPORT

COMAH SUPPORT FOR PROJECT COOLPOWRA

Consequence Study Report

Halston Environmental and Planning Limited

Rev. 1
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Abbreviations

AGI	Above Ground Installation
AIS	Air Insulated Switchgear
ALARP	As Low as Reasonably Practicable
CFD	Computational Fluid Dynamics
CIA	Chemical Industries Association
DAL	Dimensioning Accidental Load
FBR	Full Bore Rupture
GIS	Gas Insulated Switchgear
GNI	Gas Networks Ireland
HCRD	Hydrocarbon Leak Frequency Database
HSE	Health and Safety Executive
IOGP	International Association of Oil and Gas Producers
LDES	Long Duration Energy Storage
LFL	Lower Flammability Limit
OCGT	Open Cycle Gas-Fired Generators
PFD	Process Flow Diagram
QRA	Quantitative Risk Assessment
UG	Underground

1 EXECUTIVE SUMMARY

1.1 Background

The aim of Project Coolpowra is to design, develop, and expand Ireland's 400kV transmission system to improve the reliability, resilience, and efficiency of the electricity supply, supporting the transition to greener energy. It facilitates the integration of renewable energy sources, aligning with Ireland's goals to reduce greenhouse gas emissions and combat climate change.

This study has conducted a preliminary consequence modelling, which by its nature, results in typically **worst-case hazard contours**. In order to provide context to the results, a semi-quantitative risk assessment has been carried out based on DNVs experience in assessing similar industrial facilities.

1.2 Conclusions

The consequences derived have been both for small 5 mm releases and full bore/catastrophic releases. There are no notable consequences for any small leak scenario, except for the firewater tanker locations. Given the high flash point of diesel, it is difficult to ignite and this is reflected by the low likelihoods associated with the ignited diesel scenarios in the risk assessment.

The following conclusions are made from this study:

- **Risk**: None of the risks associated with the facility are considered intolerable. A high-level semi-quantitative risk assessment has not highlighted any serious concerns at this point, and given that further risk assessment studies are planned for further stages of the project (detailed design), it is likely that all risks will be demonstrated to be tolerable.
  - **Off-site risk:** No natural gas or diesel hazards have been identified with the potential to impact off-site populations. Given the proposed safeguards and control measures associated with the long duration energy storage (LDES) compound (including fire water application, spacing, and inert gas application), a full scale LDES compound fire, which may have the potential to result in smoke passing the site boundary, is considered unlikely.
- **Consequence Results:** Consequence modelling results are considered representative of worst-case scenarios. Still, no off-site impacts have been identified during the consequence modelling. Furthermore, a full risk-based study (such as a quantitative risk assessment, QRA, to be undertaken in detailed design) is likely to demonstrate that the safety risk from the proposed facility is tolerable both on and off-site.
  - **Pool Fires:** In the highly unlikely event of a catastrophic rupture of a diesel road tanker resulting in a pool fire, the thermal radiation intensity is at levels sufficient to cause multiple fatalities at the administration/control building. Furthermore, there is potential for fuel tank pool fires to escalate to the adjacent tanks, or to cause catastrophic damage to the fire water tanks.
  - **Jet Fires:** There is potential for the 37.5 kW/m^2 contours to extend across a large section of the facility, which suggests that there is potential for escalation due to jet fires associated with the natural gas system on-site. There is also potential for personnel situated outside (e.g. walking between areas of the site) to be fatally injured from natural gas jet fires. There is also potential (based on unmitigated risk) for escalation of jet fires originating in the AGI or on-site pipeline to the LDES compound, however given the protective systems at the LDES compound, a compound-wide fire is considered unlikely.
  - **Fireballs:** The hazard contours associated with fireballs are relatively large, however these are short lived events and therefore do not contribute greatly to escalation, and the likelihood of a fireball has been deemed improbable over the lifetime of the facility.

- **Flash Fires:** Flash fires can have far reaching effects; however, cloud shapes can be seen to be much smaller than the entire cloud envelope. The ½ LFL cloud can impact the majority of the site such that muster points could be considered compromised.
- **LDES System:** The safety risk posed by LDES systems must not be underestimated, and there is potential for very large fires should propagation between containers occur. Should an LDES fire be contained to a single container (as is likely the case given the protective measures proposed for the facility), there is potential for localised asset damage and safety risk to first responders.
- **Off-site impacts:** Natural gas and fuel oil consequence modelling has highlighted no particular concerns to third-party buildings or properties outside of the site boundary. In the unlikely event that a large-scale LDES compound fire occurs, with the fire propagating across multiple containers, there is potential for off-site impacts from smoke and evolved gases.

1.3 Recommendations

The following recommendations are made:

1. Consider fire protection strategies for the tanker unloading and fuel oil storage areas, which could include separate bunds for each storage tank, deluge (sprinkler) systems, and/or foam application on confirmation of a fire. Also consider relocation of the fire water tanks to a location away from all flammable inventories to ensure they are not impacted by fire events.
2. There is currently potential two occupied buildings (security and administration/control building) to be within the 37.5 kW/m^2 hazard ranges associated with jet fires and pool fires. If possible, Halston Lumcloom should consider relocating these buildings to an area outside all hazard contours – which would be considered an inherently safe solution.
3. Ensure any muster points are located outside of the ½ LFL clouds, as shown in Section 5.4.
4. If possible, the spacing between the natural gas-containing systems and the LDES compound should be increased to reduce the likelihood of a natural gas jet fire escalating to a large-scale battery fire, which could potentially have off-site impacts.
5. Undertake further risk assessments in later design stages and review the input data and assumptions. This should primarily address any uncertainties or assumptions in process information, as these will be more accurately defined as the design progresses. Particular attention should be given to fire and explosion risk within the LDES compound - ensuring and demonstrating that all applicable design standards have been followed to minimise the risk associated with stored electrical energy.

Note, these recommendations aim to further reduce any risk associated with Project Coolpowra, however other risk reduction measures may be deemed more appropriate as the design develops

2 INTRODUCTION

Halston Lumcloon Energy is designing, developing, and expanding Ireland's 400kV transmission system to improve the reliability, resilience, and efficiency of the electricity supply, supporting the transition to greener energy. It facilitates the integration of renewable energy sources, aligning with Ireland's goals to reduce greenhouse gas emissions and combat climate change.

Halston have developed a proposal, which consists of units such as reserve gas-fired generators, Gas Insulated Switchgear Substations, long duration energy storage batteries and more. The first site for application of the plant concept is a facility in Ireland, and the modules and components are designed for use with gas oil. Natural gas is present in the underground pipelines and equipment associated with integration into Gas Network Ireland's network.

2.1 Study Scope

The study covers:

- Quantitatively model a set of identified major accident hazards, at a level of detail commensurate with the design data currently available.
- Both full bore pipework ruptures and catastrophic vessel ruptures are modelled, as well as smaller (5mm diameter) leaks, giving an indication as to the likely extent of hazard ranges associated with the project.
- Risk to people and asset in terms of flammable leak major accident hazards (i.e. potential fire and explosion loads to the plant itself and surrounding facilities) will be assessed at a high level to give an early indication of the risk profile of the facility.

The following aspects are excluded from the study scope:

- Risk during construction, commissioning or other phases not representing normal operation of the facilities.
- Risks to the environment and of business interruption / remediation / reputation.

2.2 Study Objectives

The objectives of the report are:

- Conduct a high-level risk study (consequence modelling and semi-quantitative risk assessment) to highlight any preliminary siting or layout concerns for the facility based on the current layout.
- To understand the potential risk exposure of site personnel, key buildings, offsite populations, and other siting aspects.

3 DESCRIPTION AND STUDY BASIS

The assumptions for this study were derived from the project description and discussion with project team members, which are summarised below:

The key inputs defining the design as modelled in this study are:

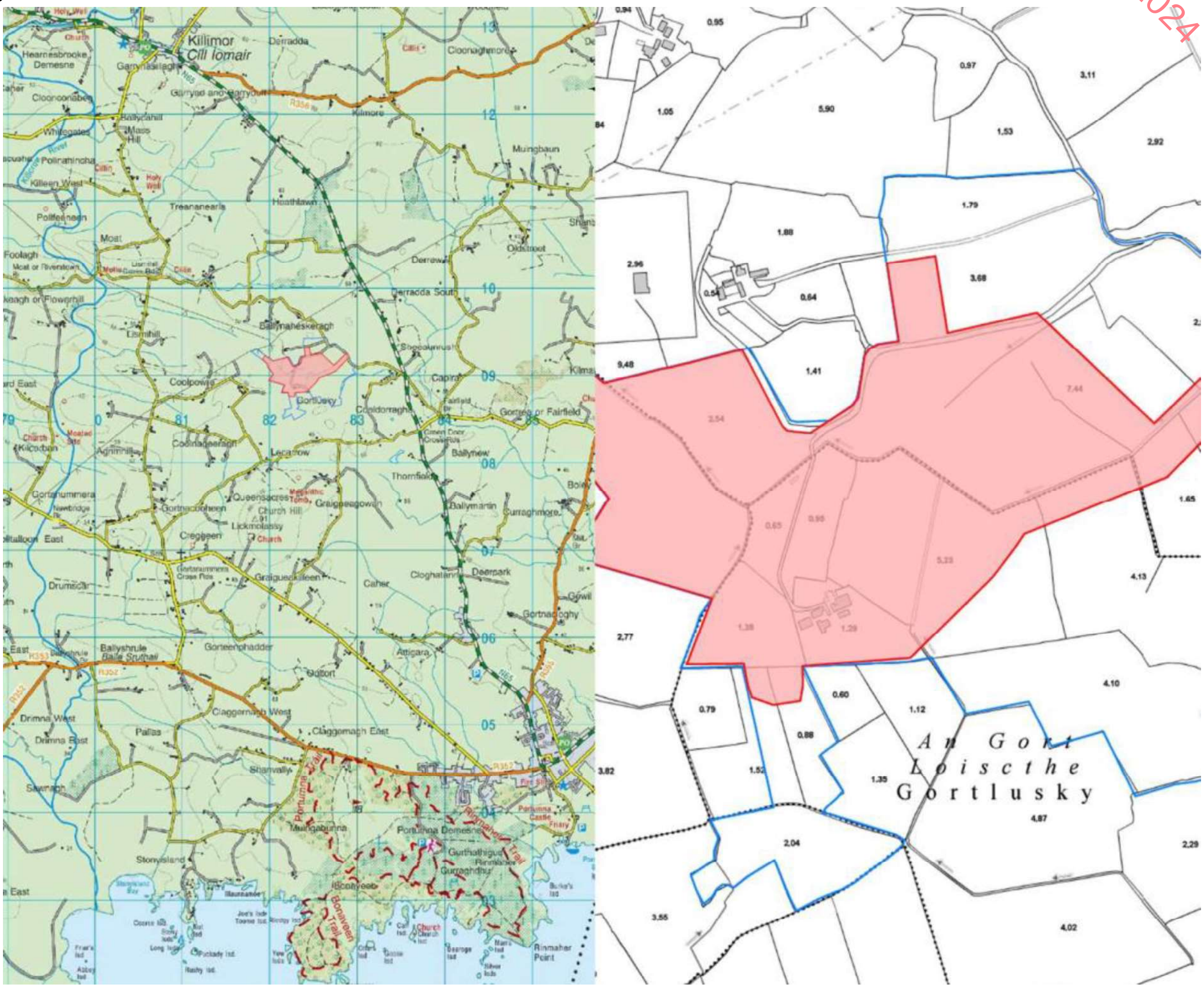
- Process details are given by the Project Description document /1/ and discussion with the project team
- The overall process structure and major equipment items are given by the Project Description /1/.

Other data provided by Halston, and public information sources provide underlying basis for the study modelling as discussed in the remainder of this section.

3.1 Site Location

The proposed development is located approximately 4km north of Portumna and 3.1km south of Killimor. Lands within the development site boundary are in agricultural use and include a farmhouse and outbuildings which will be demolished. The proposed lands are situated at an elevation of c. 51-54m AOD and are accessed by road via the N65 (National Road) and the L8763 (local road). The N65 connects the towns of Loughrea and Portumna. The proposed development will be located adjacent to, and south of, the existing operational 400kV AIS electricity substation (Oldstreet).

Figure 3-1 Location of the Halston Plant



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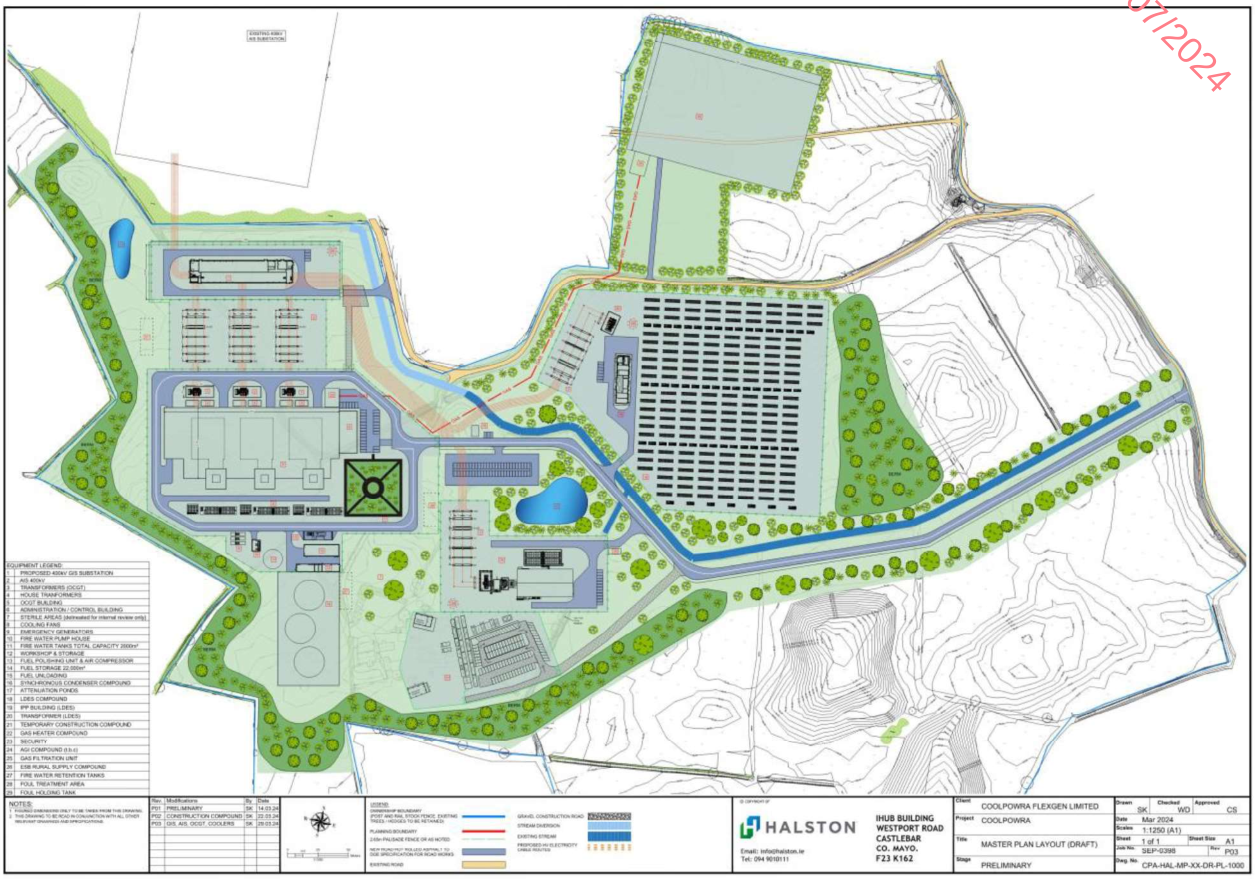
3.2 Site Layout

The facility layout shown in Figure 3-2 is used as the basis for this study.

Figure 3-2 Layout of the Halston Site



3.3 Process Description

The plant processing equipment within the scope of this study is defined within Table 3-1. Note that not all of these items present hazards that form part of the consequence modelling.

Table 3-1 Summary of The Plant Processing Equipment and Systems

System	Description
Reserve Gas-Fired Generator	Three OCGT units, 1,125 MW (3 x 375 MW) Output will connect to the electricity system via the gas insulated switchgear (GIS).
Under Ground Gas Pipeline	Delivers gas to proposed AGI on site. Operating at pressures of 16 bar or higher, established by Gas Networks Ireland (GNI) through separate planning application at the time of this report. Around 400m run-length across the site in zig-zag formation.
Gas Insulated Switchgear (GIS) Substation	Forms part of the Electricity Transmission System. Two-storey building positioned and secured within a palisaded fenced compound. The proposed GIS will upgrade and replace the existing air insulated switchgear (AIS) substation with a new gas GIS substation at Oldstreet. The GIS substation will facilitate connection of the reserve gas fired generator and ESS to the existing node on the transmission network thereby securing energy supply into the future
Energy Storage System Energy – Grid Stability	LDES with 200 MW / 800 MWh Output. Synchronous Condenser with 400 MVA output. Both connect to electricity system via the GIS. The technology is designed to complement and support the reserve gas fired generator by providing zero carbon, instantaneous power and balancing power to the grid.
Diesel Storage Tanks	Three vessels containing gas oil, with a gross maximum inventory of 22,000 m^3.
Diesel Road Tanker	Located between the OCGT units and the diesel storage tanks, assumed to have an internal capacity
Grid Connection AGI	Connects to the main gas pipeline run by Gas Networks Ireland
Diesel Transfer Pumps	For safe delivery of diesel from tanks to process.
Foul Holding Tank	For use with the foul treatment area

3.4 Ambient Conditions

It is necessary to define certain meteorological constants as inputs to the consequence modelling. These values are summarised in Table 3-2, based typical values for facilities located in the United Kingdom.

Table 3-2 Meteorological Parameters

Parameter	Value	Notes and References
Atmospheric Temperature	10°C	Based on average annual temperatures.
Relative Humidity	70%	Typical annual average for Ireland.
Surface Temperature	10°C	Taken to be the same as atmospheric temperature

The contribution of solar flux to thermal radiation is not accounted for risks from fires (as is typical for these studies).

Those parameters above which are not based on any available site/ project specific data source are assumed values, selected based on experience or using model defaults, with the intention of providing the most appropriate modelling results whilst still taking a conservative approach so as not to underestimate any of the risk levels.

4 METHODOLOGY

The outline methodology to be adopted for this preliminary consequence modelling shown in Figure 4-1 and is described in more detail in in the following sections.

Figure 4-1 Simplified QRA Methodology Flowchart

4.1 Software

DNV Phast software v9.0 is used to carry out the study. A summary of global modelling parameters to be applied in the study are provided in Table 4-1. Other values not mentioned in this document can be assumed to remain as default settings in the software.

Table 4-1 General Phast Parameters to be Used for Modelling

Parameter	Value	Notes
Software version	V9.0	Latest version
Height of interest	1 m	Population is assumed to be located at ground level with a receptor height of 1 m (equal to release height); this applies to the whole population identified for the study.
Default leak direction for above-ground releases	Horizontal impinged	Releases from any containerised equipment are considered as impinged. Modelling all releases as horizontal is somewhat conservative, however is typical practice for QRA studies.
Default release elevation	1.5 m	Typical standard value representing 'head height'
Surface Type	Concrete	
Surface Roughness	183 mm	Affects the turbulence in the air reaching the release source and is related to effective average obstacle height over the terrain. 183 mm is the Phast default and is suitable for occasional large obstacles, and is selected as the site has neither open, flat terrain (typically assigned a value of 30 mm), nor a significantly built-up area (typically assigned a value of 500 mm or more) in close proximity to the site.
Flammable averaging time	18.75 sec	Phast default value for flammable dispersion.
Flammable vapour cloud extent allowing ignition	Lower Flammability Limit (LFL)	Effects are calculated at effect height rather than the default cloud centreline height (affects buoyant cloud delayed ignition risk)

4.2 Failure Cases

Normal operating conditions for each failure case have been assumed, namely pressure, temperature, and operating flowrate.

Table 4-2 Operating parameters and parameters assumed for modelling.

Vessel/Equipment	Parameter	Value used
Diesel Storage Tanks	Temperature	20 °C
Diesel Storage Tanks	Volume inventory (per tank)	7333.3 m3
Diesel Road Tanker	Pressure	Atmospheric
Diesel Road Tanker	Temperature	20 °C
Diesel Road Tanker	Volume inventory	40 m^3
Diesel Transfer Pumps	Pressure	2 barg
Diesel Transfer Pumps	Temperature	20 °C
Diesel Transfer Pumps	Maximum Diameter	6 inches (full bore)
Diesel Transfer Pumps	Flow Rate	0.5 kg/s
Grid Connection AGI	Pressure	25 barg
Grid Connection AGI	Temperature	20 °C
Grid Connection AGI	Maximum Diameter	6 inches (full bore)
Gas Pipeline	Pressure	16 barg
Gas Pipeline	Temperature	20 °C

4.2.1 Leak Sizes

A range of representative leak sizes has been modelled as shown in Table 4-3.

Table 4-3 Representative Leak Sizes Modelled

Leak Size Name	Representative Hole Diameter (mm)	Hole Size Range for Frequency Analysis (mm)
Medium Leak	5	3-10
Full-Bore Rupture (FBR)	Line Size	Residual from total frequency for component

Additionally, catastrophic rupture of all vessels has been modelled, which is representative of vessel failure e.g. due to vehicle impact of mechanical defects.

4.2.2 Locations

A single representative leak location is defined per failure case, based on the plot plans and information provided.

The gas pipeline was modelled as an extended line source with potential leak locations along the pipeline length, however only the worst-case results are reported in this document.

4.3 Consequence Analysis

This section outlines the approach to be used for consequence modelling analysis.

4.3.1 Process Fluid Compositions

Some key assumptions have been made when defining the process fluid compositions to be modelled:

- The natural gas feed is assumed to be 100% methane.
- Secondary fuel oil (gas oil) is modelled as diesel.

4.3.2 Discharge

The discharge parameters have been determined within Phast on the basis of the defined failure case parameters (pressure, temperature). Where releases occur downstream of equipment such as a pump or compressor, the release rate will typically be driven by the normal flow rate of the section in forward flow. Therefore, the release rates are capped at a maximum of 150% of the inflow rate.

Detection and isolation are not modelled at this stage.

4.3.3 Dispersion

Releases have been modelled with a "horizontal" release direction, accounting for the open nature of the facility, with limited opportunity for direct impingement to adjacent equipment.

A default representative release height of 1.5 m applies for all failure cases, as is typical QRA practice.

4.3.4 Fire Modelling

Standard Phast models for flash fires and fireballs are used.

4.3.5 Explosion Modelling

Explosions are assumed to have the potential to occur where a vapour cloud with concentration within the flammable range is ignited and there is simultaneously a mechanism to accelerate the flame front. Such explosion scenarios require delayed ignition of the vapour cloud.

The potential detonation of natural gas in the open (i.e. outside areas of congestion/confinement) is not considered credible, and therefore a single area of congestion has been defined in the model, this being the Transformers shown by location 20 in Figure 3-2.

The approach to modelling a vapour cloud explosion (VCE) associated with a flammable cloud interacting with these transformers is to calculate the mass of methane associated with filling the transformer area with a stoichiometric mixture of methane in air, in this case approximately 80 kg of methane, and assuming ignition in the centre of this location. All explosion results outlined in this report are based on an explosion in this transformer compound.

4.3.6 Ignition Modelling

For the sake of consequence modelling, it is always assumed that the natural gas and secondary fuel (diesel) are ignited and the worst-case results are presented in Section 5. In reality, diesel is difficult to ignite - having a flash point of between 52 and 96ºC, it is classified as 'combustible' rather than 'flammable'. This means that diesel is not readily ignited with a naked flame and requires sustained energy input (or atomisation) for it to ignite.

As a result, although the consequences of a diesel fire can appear severe, the likelihood of this event occurring can be considered less than for a more readily ignitable fluid (such as petrol or gases such as natural gas). This is reflected in the high-level risk assessment presented in Section 6.

4.3.7 Long Duration Energy Storage Modelling

DNV are currently unable to model fires associated with battery energy storage systems (BESSs), however a qualitative assessment is undertaken for the likely impacts of BESS fires, based on DNVs experience in risk assessment of these systems.

4.4 Vulnerability Criteria

This section covers the integration of the consequence and frequency modelling to provide risk estimates for human receptors. The vulnerability criteria in Table 4-4 are for information only and provide context to the choice of hazard levels reported in this document.

Table 4-4 Vulnerability Criteria

Hazard	Effect Threshold (model ≥ threshold)	Fatality Probability				Notes
		Outdoor	Indoor CIA 4*	Indoor CIA 3*	Indoor CIA 2*	
Flash fire	LFL	100%	50%	20%	20%	DNV internal guidance.
Jet fire	4.7 kW/m^2	0%	0%	0%	0%	4.7 kW/m^2 is considered the 'safe limit' for on-site personnel. 6.3 kW/m^2 is considered the point at which escape routes are considered impaired. 37.5 kW/m^2 is considered the point at which process equipment can sustain damage.
	6.3 kW/m^2	0%	0%	0%	0%	
	12.5 kW/m^2	50%	25%	25%	25%	
	37.5 kW/m^2	100%	100%	50%	50%	
Fireball	4 kW/m^2	0%	0%	0%	0%	0% at lower radiation thresholds to account for the short exposure duration.
	12.5 kW/m^2	0%	0%	0%	0%	
	37.5 kW/m^2	100%	100%	50%	50%	
Pool fire	4 kW/m^2	0%	0%	0%	0%	4.7 kW/m^2 is considered the 'safe limit' for on-site personnel. 6.3 kW/m^2 is considered the point at which escape routes are considered impaired. 37.5 kW/m^2 is considered the point at which process equipment can sustain damage.
	12.5 kW/m^2	50%	25%	25%	25%	
	37.5 kW/m^2	100%	100%	50%	50%	
Explosion overpressure (side-on)	0.07 bar	0%	3%	2%	0%	Linearly interpolated between thresholds. 0% below lowest threshold. Outdoors represents people adjacent to buildings. Indoors from IOGP /11/ based on Chemical Industries Association (CIA) guidance.
	0.14 bar	0%	15%	8%	3%	
	0.35 bar	30%	90%	55%	70%	
	0.5 bar	100%	100%	65%	80%	
Toxicity	-	-	-	-	-	No toxic components have been identified for this study.

Note*: CIA4: 'Portacabin' type timber construction, single storey, CIA3: Typical domestic building: two-storey, brick, walls, timber floors, CIA2: Typical office block: four storey, concrete frame and roof, brick block wall panels.

4.5 Tolerability of Risk

The Health and Safety Authority (HSA) in Ireland follow a similar approach to the Health and Safety Executive (HSE) in the United Kingdom in respect to tolerability of risk, and the ALARP principle (Ref /12/). Risks can be designated into one of three categories:

a) **Broadly Acceptable**, whereby the individual risk is calculated to be below 1x10^{-6} per year. As long as it can be demonstrated that good practice has been followed in terms of management of these risks, no further action is required.

b) **Tolerable if ALARP.** Individual risk calculated to lie between 1x10^{-6} and 1x10^{-3} /1x10^{-4} for on-site and off-site populations respectively are considered tolerable if it can be demonstrated that further risk reductions are not practicable. In practice, this would mean demonstrating that further risk mitigation measures could not be justified in terms of cost (monetary or time/effort) against the level of risk reduction gained.

c) **Intolerable**. If the risk is found to exceed $1x10^{-3}$ /$1x10^{-4}$ for on-site and off-site populations respectively, risk reduction measures must be implemented regardless of cost, to bring the risk into the Tolerable if ALARP region before operation can continue.

Note, the quantitative figures outlined above are typically the outcome of a full QRA. This is outside the scope of the scope of this document given the early stage of the project however a QRA is planned for detailed design. The risk ranking matrix used in this semi-quantitative assessment aims to map the identified hazards across the three categories listed above.

5 CONSEQUENCE ASSESSMENT

Note, these results are for consequences only and do not consider the likelihood of the initial release, ignition probability, or any other conditional modifiers such as occupancy. They are necessarily coarse given the relatively early design maturity, and it is likely that any risk results derived during detailed design will give less severe contours.

5.1 Pool Fire Thermal Radiation

The thermal radiation consequence contours representing all diesel pool fires (irrespective of duration) are shown in Figure 5-1 to Figure 5-6. It can be seen from the shape of the contours that:

- The control room is located outside of all pool fire contours for all scenarios except for the catastrophic rupture of the Diesel Road Tanker where it lies within the 6.3 kW/m^2 contour, but this only impairs escape routes and leads to no fatalities.
- The radiative flux of 37.5 kW/m^2 is the key thermal load in terms of escalation and the risk effects. Any pool fire could escalate to any of the adjacent equipment (i.e. a single pool fire from any storage tank would cause all of the other storage tanks, the diesel road tanker and diesel transfer pump, and vice versa).
- Catastrophic rupture of the road tanker with subsequent pool ignition could result in high thermal loads on the OCGT building, however the effects of drainage in mitigating pool formation have not been modelled.
- The fire water retention tanks lay within the pool fire contours at 12.5 kW/m^2 for all catastrophic ruptures of any fuel storage tanks, road tanker and diesel transfer pumps, however this level of thermal flux is unlikely to cause damage to the fire water tanks.
- Given that all three fuel storage tanks currently share a bund, it is possible that catastrophic failure of one vessel could escalate to a large fire resulting in catastrophic damage to all three tanks. Furthermore, the integrity of the firewater tanks could be compromised in such an event which would result in loss of a key protective safeguard.

Recommendation – Assess the potential to relocate the fire water tanks to an area where they are unlikely to sustain damage in the event of a fire.

Figure 5-1: Contours for Pool Fire Radiation at category 5/D for Diesel Storage Tank (Southern) Catastrophic Rupture in kW/m^2

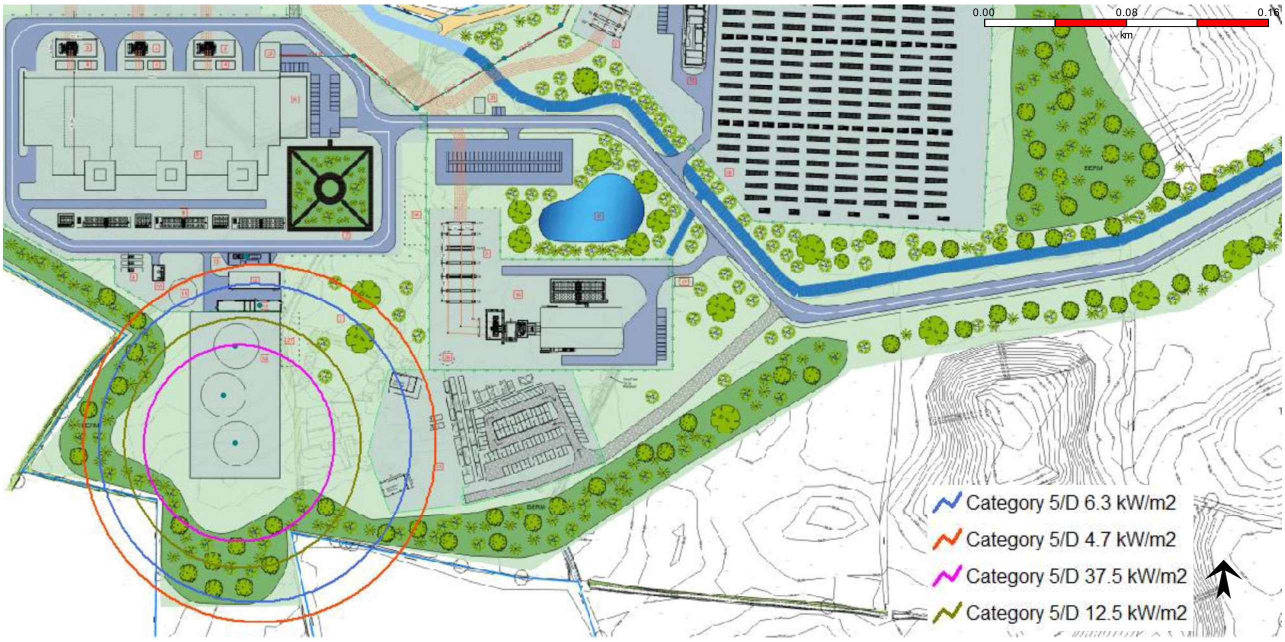


Figure 5-2: Contours for Pool Fire Radiation at category 5/D for Diesel Storage Tank (Central) Catastrophic Rupture in kW/m²

Figure 5-3: Contours for Pool Fire Radiation at category 5/D for Diesel Storage Tank (Northern) Catastrophic Rupture in kW/m²

Figure 5-4: Contours for Pool Fire Radiation at category 5/D for Diesel Storage Tank (Northern) for a small 5mm hole size leak in kW/m2

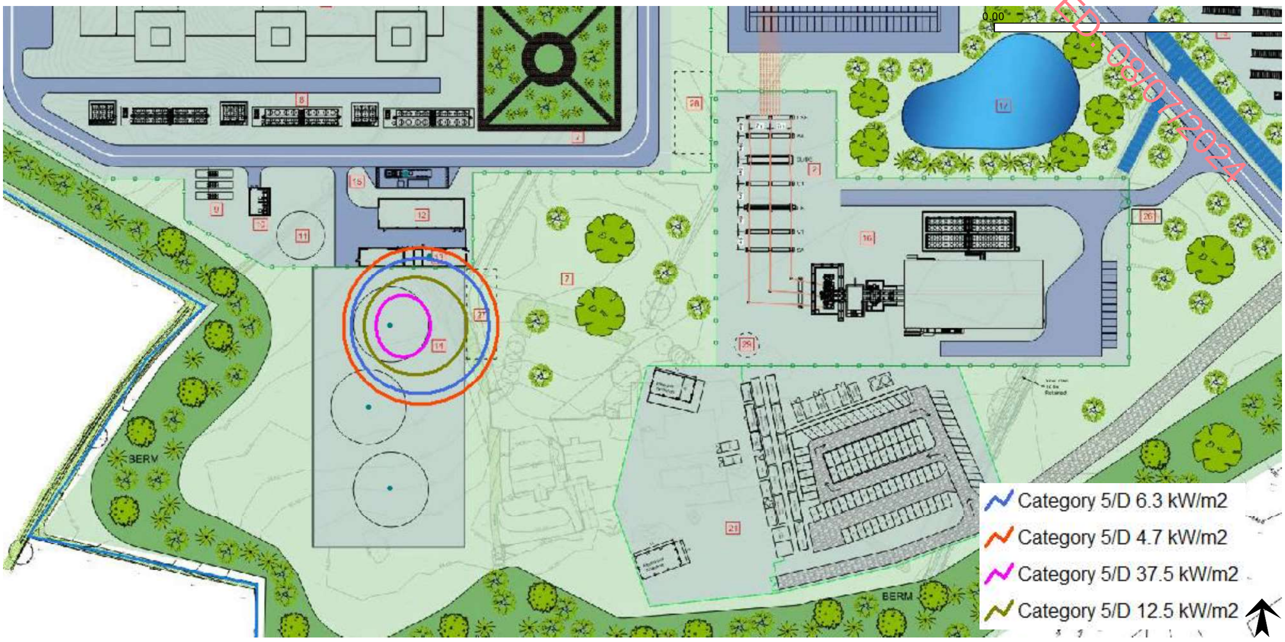


Figure 5-5: Contours for Pool Fire Radiation at category 5/D for Diesel Road Tanker Catastrophic Rupture in kW/m2

Figure 5-6: Contours for Pool Fire Radiation at category 5/D for Diesel Transfer Pump Full Bore Rupture in kW/m²

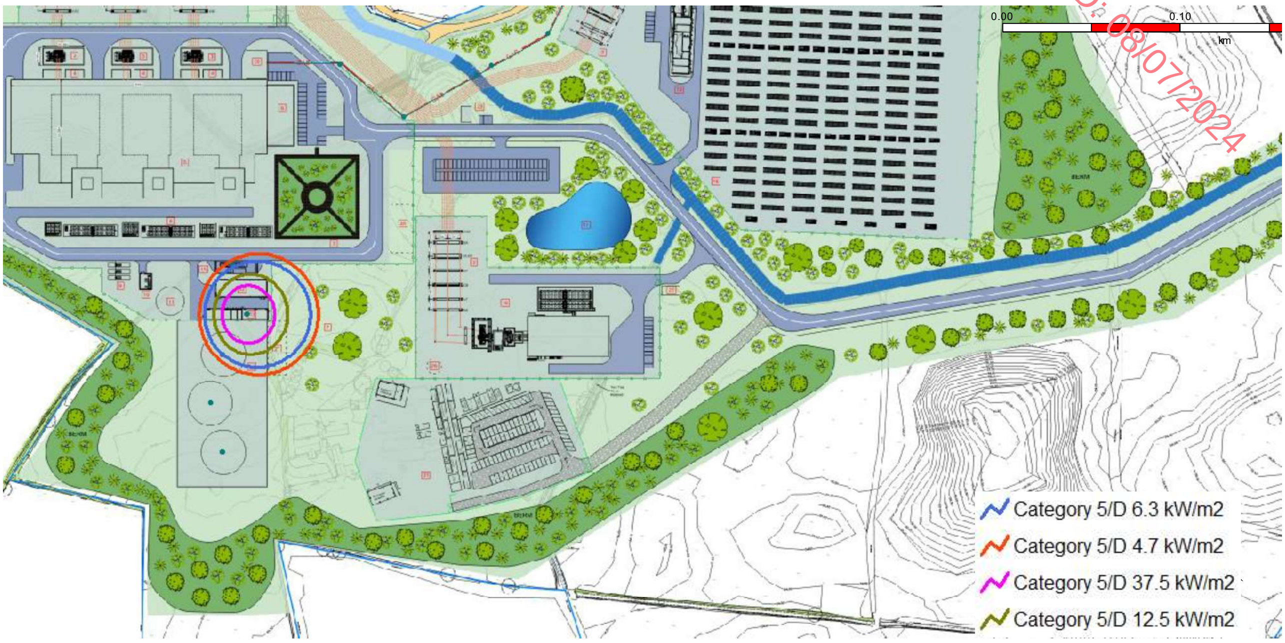
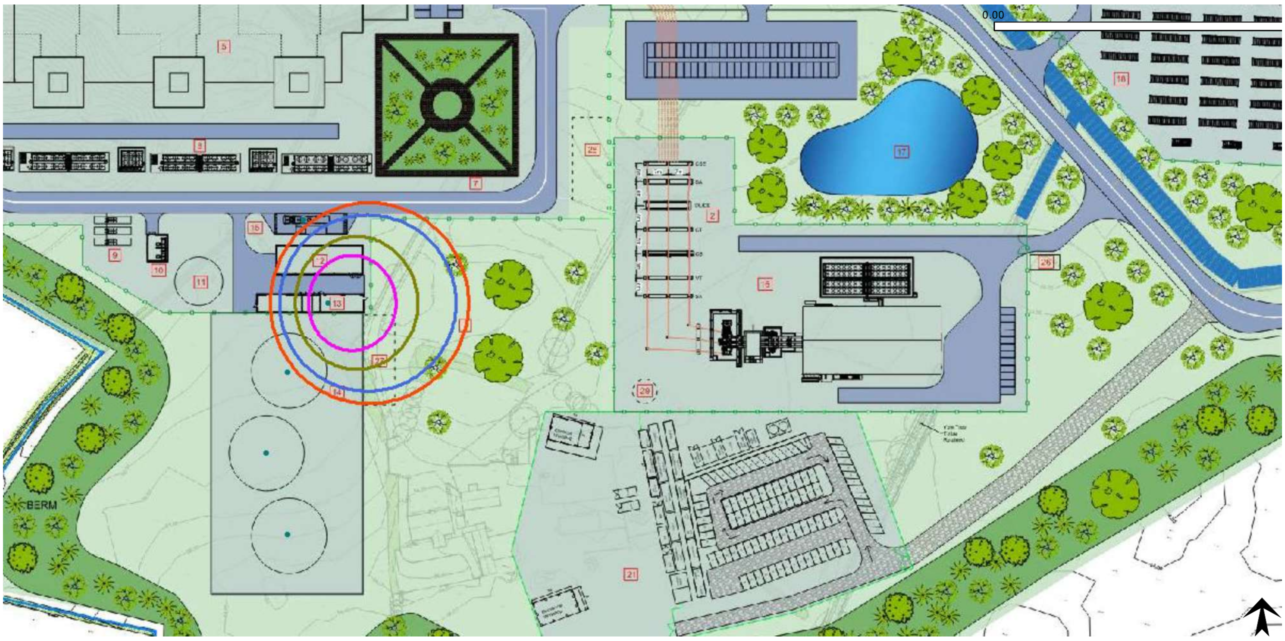


Figure 5-7: Contours for Pool Fire Radiation at category 5/D for Diesel Transfer Pump small 5mm hole leak in kW/m²



5.2 Jet Fire Thermal Radiation

The thermal radiation consequence contours representing all jet fires (irrespective of duration) are shown in Figure 5-8 and Figure 5-9. Jet fires form following ignition of a high momentum natural gas leak, assumed to occur at the facility AGI or on the buried gas pipeline. It can be seen from the shape of the contours that:

- The control room is located outside of all jet fire contours for the AGI.
- The control room is located outside of the long pipeline rupture's 37.5 kW/m^2 hazard frequency contours (corresponding to 100% chance of fatality for occupants for a portakabin style building) and outside the 12.5 kW/m^2 hazard frequency contours (corresponding to 25% chance of fatality for occupants for a portakabin style building). It is within the 6.3 kW/m^2 contour, but this only impairs escape routes and is unlikely to lead to fatalities.
- Security building lies within the 37.5 kW/m^2 contour of the long pipeline rupture and thus if any personnel are present during this event, there could be fatalities.
- There is potential for jet fires to escalate to the adjacent LDES compound, which could result in large fires within the system.

Figure 5-8: Contours for Jet Fire Radiation at category 5/D for Grid Connection AGI in kW/m^2

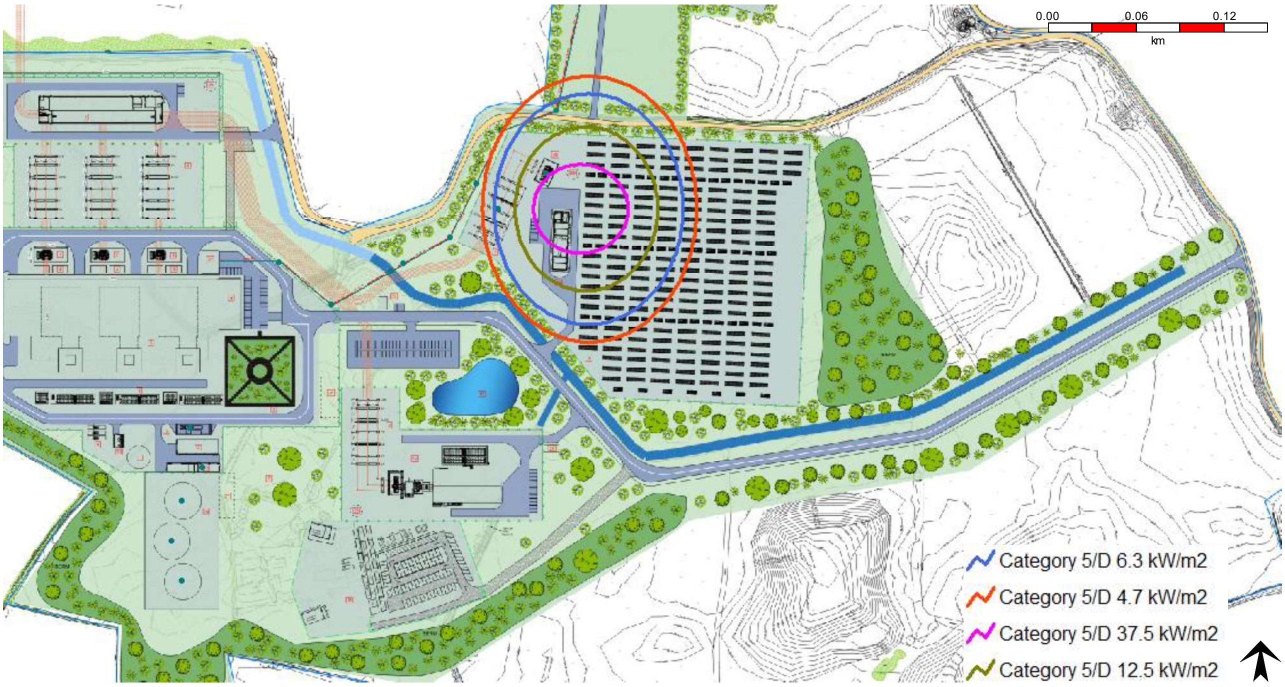
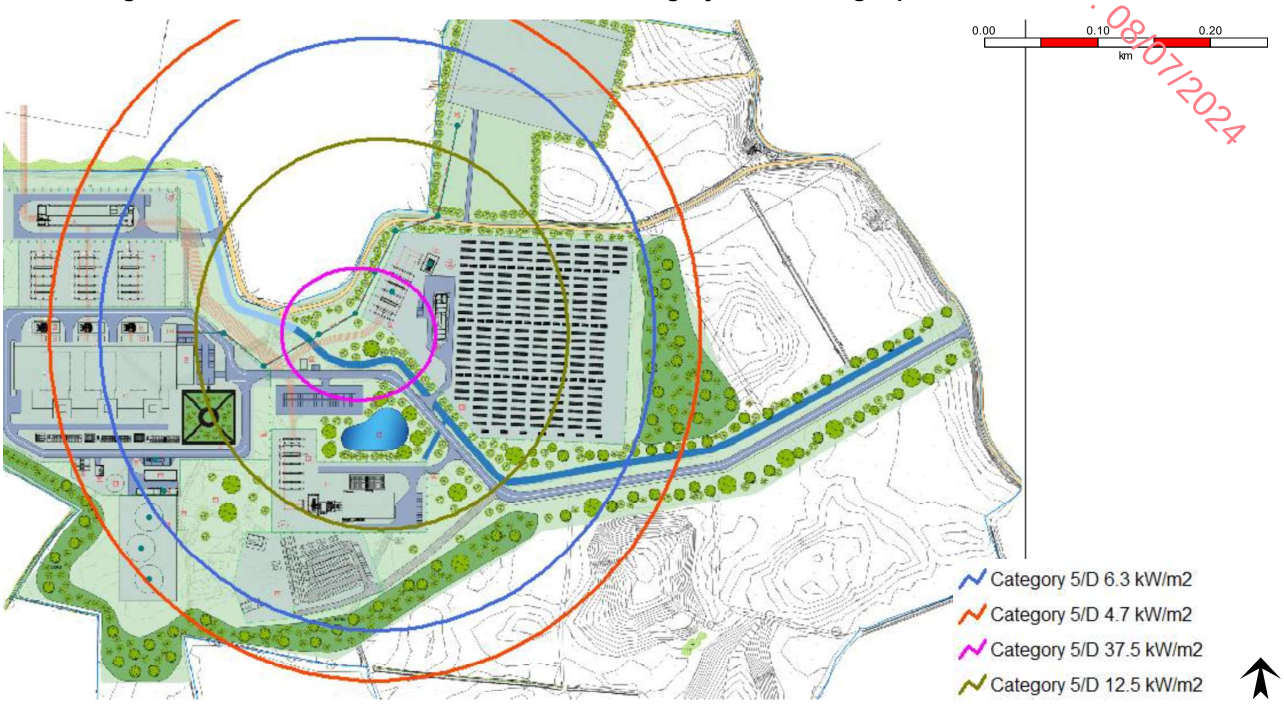


Figure 5-9: Contours for Jet Fire Radiation at category 5/D for Long Pipeline Full Bore in kW/m²

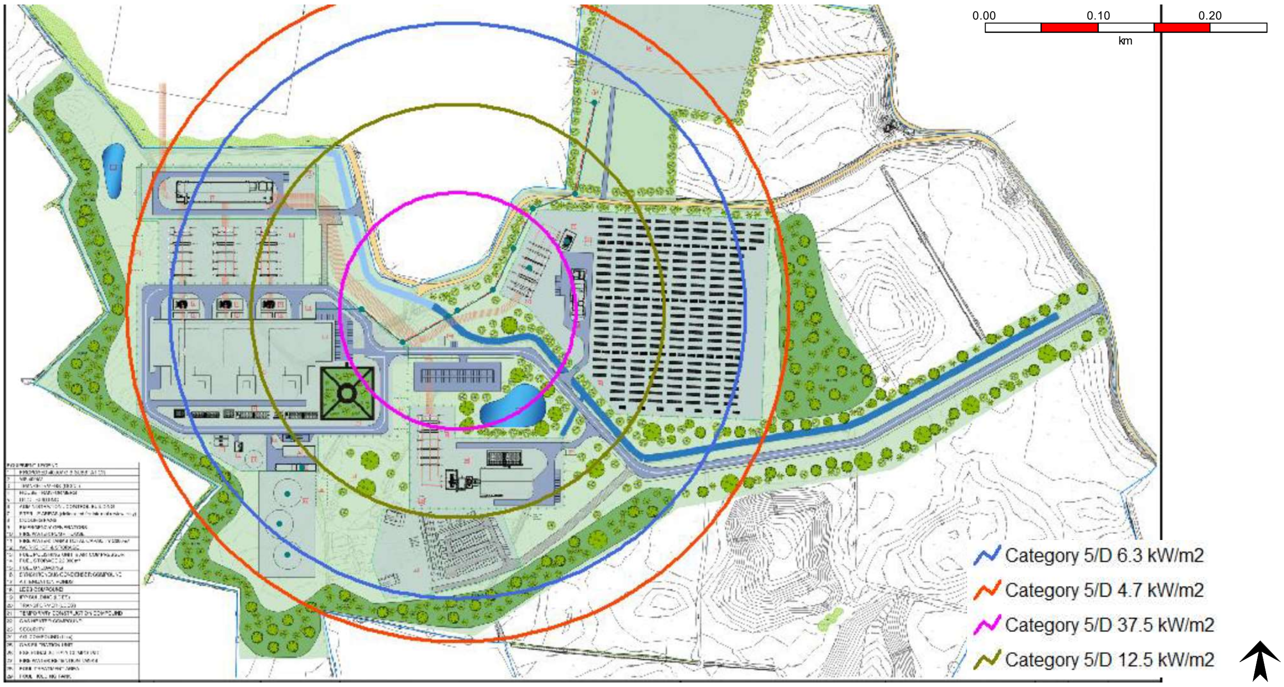


5.3 Fireball Thermal Radiation

The thermal radiation hazard frequency contours representing thermal loading from fireballs is shown in Figure 5-10. Fireballs are typically short duration events associated with catastrophic loss of containment. In the case of the buried pipeline, these are considered highly unlikely.

Security building lies within the 37.5 kW/m^2 and thus if any personnel are present during this event, there could be fatalities. The control room lies within the 12.5 kW/m^2 contour which does not lead to any causalities from fireballs

Figure 5-10: Contours for 5/D Fireball Radiations (kW/m^2) of long pipeline



5.4 Flash Fires

The vapour dispersion / flash fire to LFL hazard contours are shown in Figure 5-11 to Figure 5-16. These provide an indication of the flammable dispersion extents from the plant.

Flash fires associated with the fuel storage systems generally remain very localised, this is due to the fluid being a liquid at ambient temperature with a relatively high flash point. The flash fires associated with releases upstream of the AGI appear to have the potential to engulf the majority of the site within the 1/2LFL envelope, however the shape of the cloud is extremely thin, as shown in Figure 5-15, and the overall risk is consequently reduced.

Figure 5-11: Flash Fire at 5/D for both 3500 and 7000 ppm for catastrophic rupture of Diesel Storage Tank (northern)

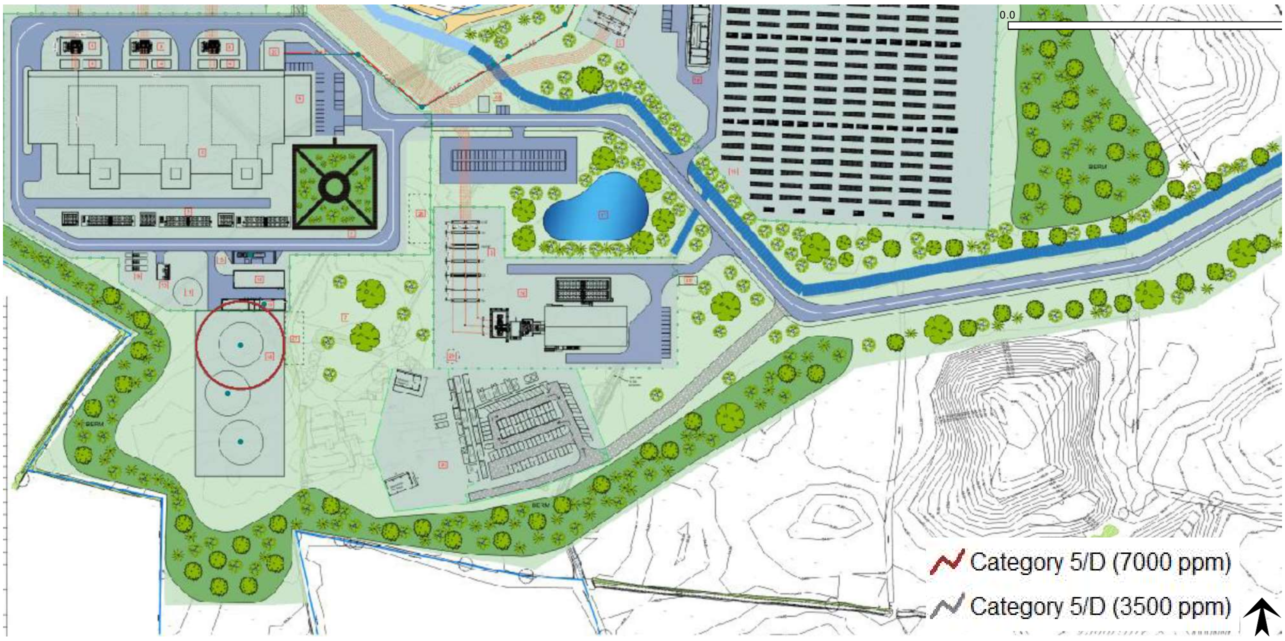


Figure 5-12: Flash Fire at 5/D for both 2500 and 5000 ppm for catastrophic rupture of Diesel Road Tanker

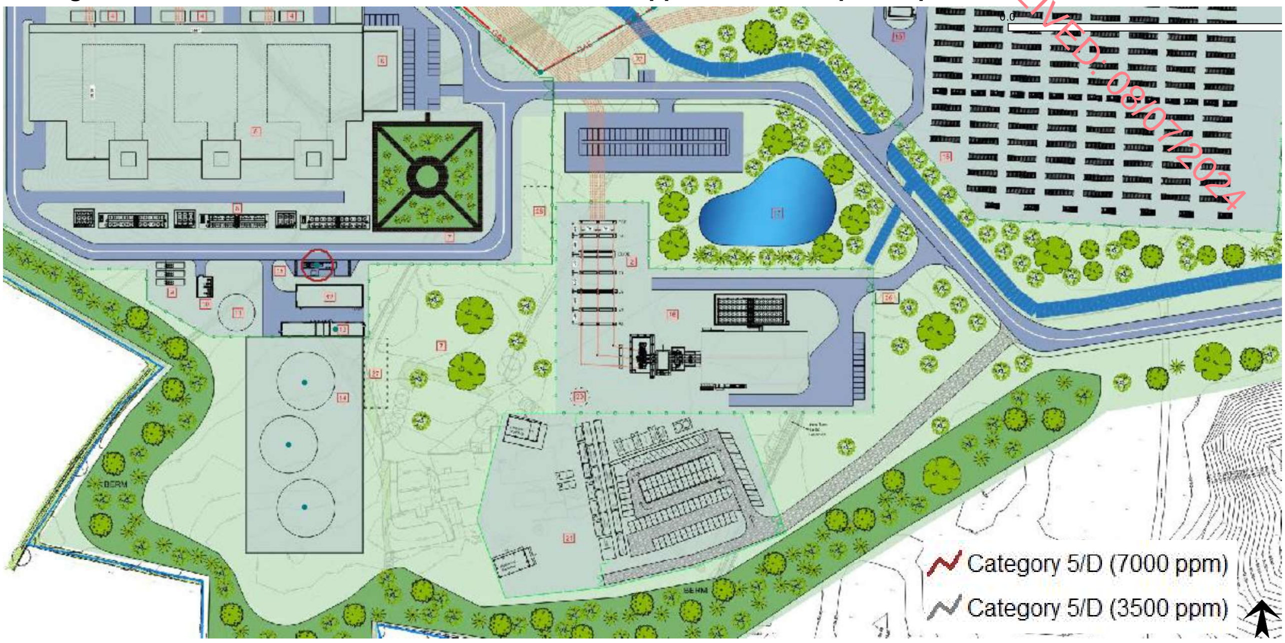


Figure 5-13: Flash Fire at 5/D for both 2500 and 5000 ppm for catastrophic rupture of Diesel Transfer Pump

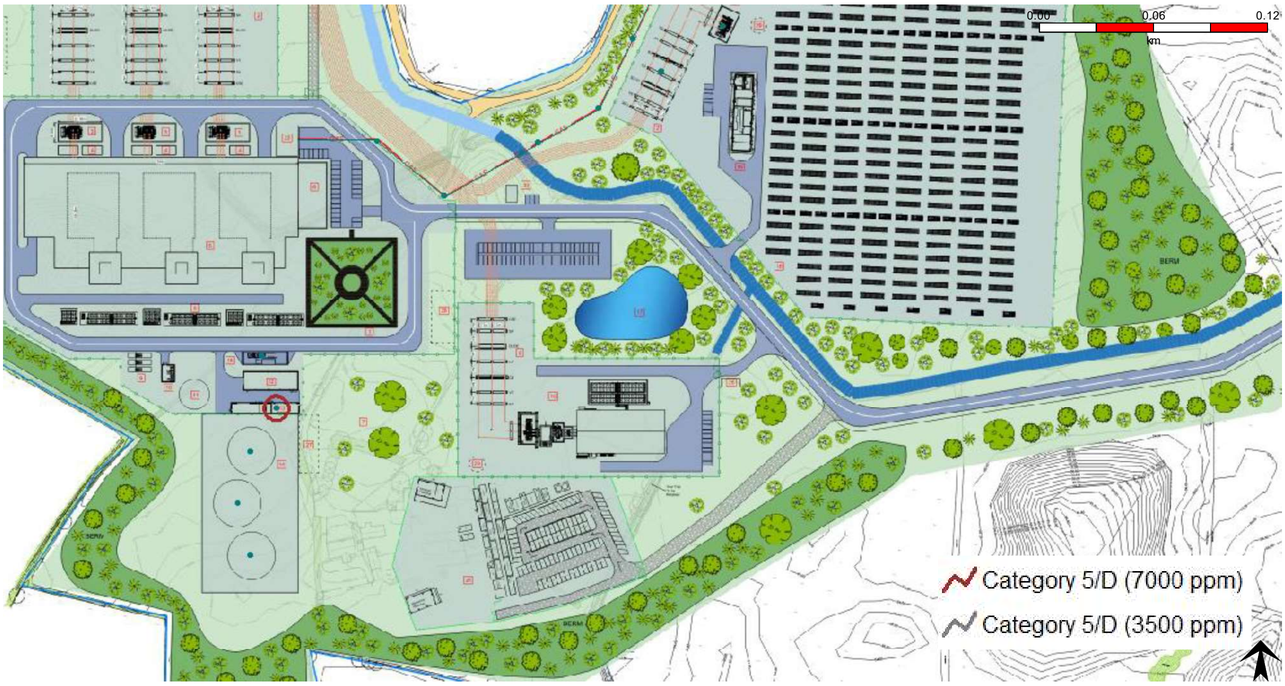


Figure 5-14: Flash Fire at 5/D for both 25000 and 50000 ppm for full bore (6 inch) of AGI grid connection

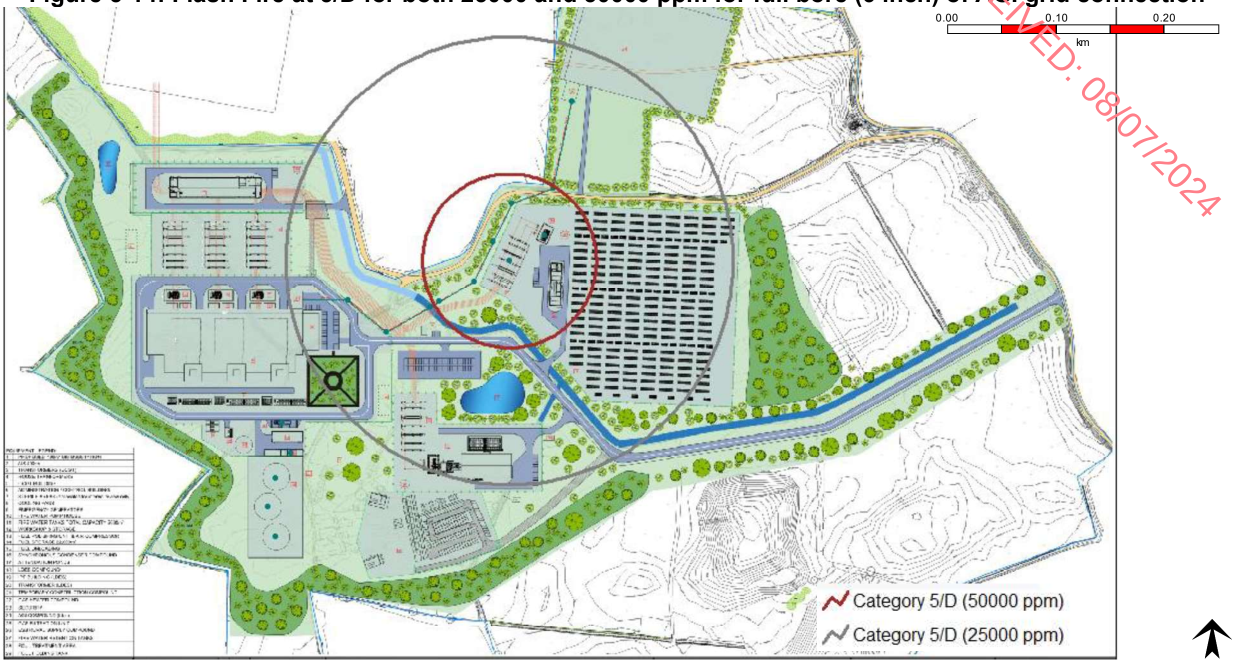
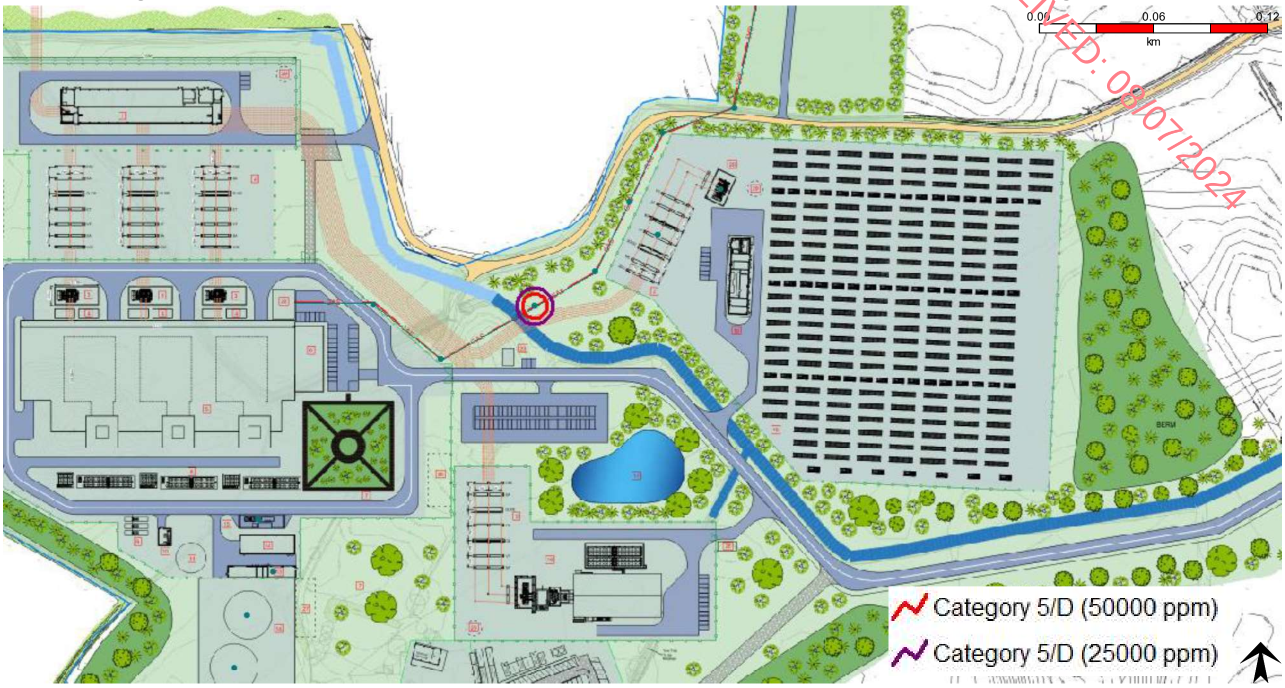


Figure 5-15: Shape of LFL and ½ LFL cloud shown for a release at the AGI.

Figure 5-16 Flash Fire at 5/D for both 25000ppm and 50000 ppm for full bore of long pipeline



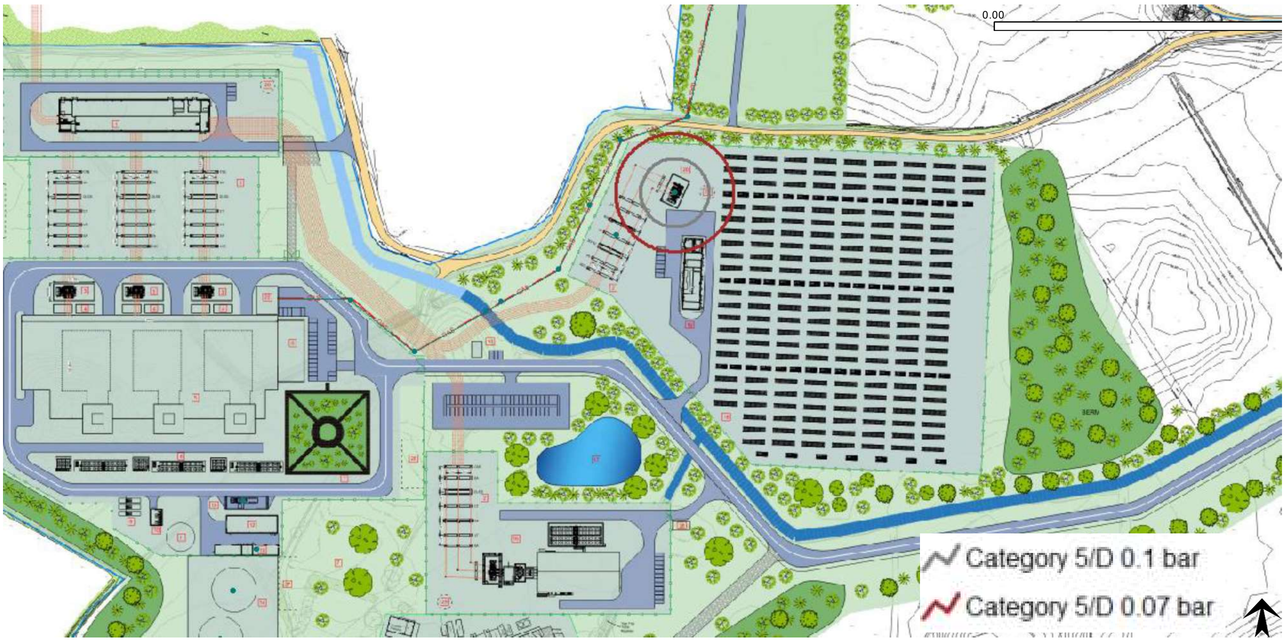
5.5 Explosion Overpressures

The explosion overpressure contours are shown in Figure 5-17 for overpressures of 0.1 bar and 0.07 bar.

The key observations from these contours are:

- The overpressure hazard contours remain localised to the transformer area, however the 0.07 bar contour does reach the IPP building, and there is therefore potential for damage to this building.

Figure 5-17: Contours for Explosion Overpressure of 100 and 70 mbar – Methane VCE Transformer



5.6 Long Duration Energy Storage (LDES) Battery System

Battery Energy Storage Systems (BESS) present significant safety risk through fire and explosion (thermal runaway). In case of the proposed development, the aggregate stored energy will likely exceed 1 GWh (assuming 400 MW with at least 5 hours of capacity); making it one of the largest installations under development globally.

Should a fire occur in one of the LDES battery containers, there is potential that the fire propagates through the entire system, which would have catastrophic consequences in terms of asset loss and potential risk to personnel and first responders. Proper fire management design should be followed during the design of the LDES system such that the potential for a fire to propagate from one container to the next is reduced to ALARP. It is likely that the LDES system will be of particular interest to regulators and insurers, and as such, DNV recommend specific risk assessment for the system when the design is sufficiently mature.

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6 PRELIMINARY RISK ASSESSMENT

Given the early stage of this project, and the resulting lack of engineering design detail, a full quantitative risk assessment (QRA) cannot be undertaken. However, based on engineering judgement and experience of assessing other similar industrial facilities, DNV have conducted a preliminary risk assessment using the consequence results reported above.

The following basis is taken for assessing the severity (S) of the modelled scenarios:

Table 6-1: Severity ranking categories.

Severity Category	Criteria
S5	Multiple Fatalities or one off-site fatality
S4	Multiple serious injuries or one fatality
S3	Serious (life altering) Injury
S2	Serious (non-life altering) injury
S1	Minor injury

The following basis is used for assessing the likelihood (L) of the modelled scenarios:

Table 6-2: Likelihood ranking categories.

Likelihood Category	Criteria
L5	Can occur multiple times per year
L4	Can occur once in a year
L3	Can occur once during the lifetime of the facility
L2	Potential to occur once in 100 years
L1	Unlikely to occur once in 100 years

And the following risk matrix is proposed to rank risks at this stage.

Figure 6-1: Proposed risk matrix

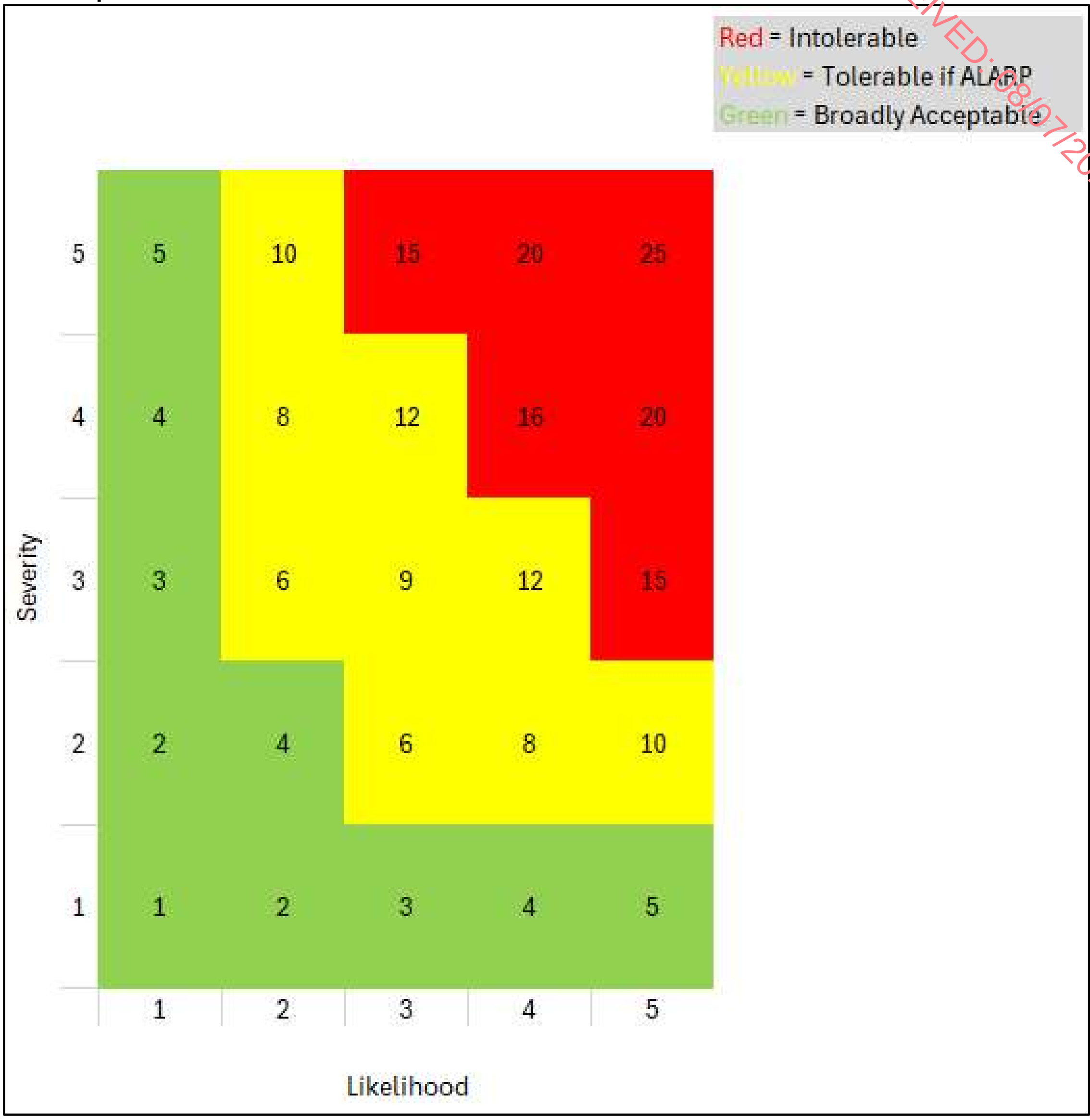

Table 6-3: Semi-quantitative risk assessment of modelled scenarios.

System	Scenario	Severity	Likelihood	Risk
Diesel Storage Tanks	Catastrophic rupture with pool fire	5	1	5
	Small leak with pool fire	3	2	6
Diesel Road Tanker	Catastrophic rupture with pool fire	5	1	5
	Small leak with pool fire	3	2	6
Diesel Transfer Pumps	Small leak with pool fire	3	2	6
	Full bore rupture with pool fire	3	1	3
Grid Connection AGI	Small leak with jet fire/flash fire/VCE	3	3	9
	Full bore rupture with jet fire/flash fire/VCE	5	2	10
Long Pipeline	Small leak with jet fire/flash fire/VCE	3	2	6
	Full bore rupture with jet fire/flash fire/VCE	5	2	10
VCE	Explosion	4	2	8
LDES Battery	Single container fire	4	3	12
	Multi-container fire	5	2	10

At this stage, no intolerable risks have been identified. However, the facility operator will be required to demonstrate that all risks have been managed and that all reasonably practicable measures have been implemented to reduce the risk. The ALARP demonstration principle is a key feature of the Control of Major Accident Hazards (COMAH) regulations, and it is likely that further risk assessments will be required as the design of the facility matures, such that the control of risk can be adequately demonstrated.

7 CONCLUSIONS & RECOMMENDATIONS

7.1 Conclusions

The consequences derived have been both for small 5 mm releases and full bore/catastrophic releases. Despite there being no notable consequences for any small leaks except for the firewater tank locations.

The following conclusions are made from this study:

- **Risk**: All facility risks are, at this point in time, considered tolerable if ALARP. Halston Lumcloom energy will be required to demonstrate that all risks have been controlled as low as reasonably practicable before the facility can be operational.
- **Pool Fire Radiation:** In the event of a catastrophic rupture of a diesel road tanker resulting in a pool fire, the thermal radiation intensity is at levels sufficient to cause multiple fatalities at the administration/control building. Furthermore, there is potential for fuel tank pool fires to escalate to the adjacent tanks, or to cause catastrophic damage to the fire water tanks.
- **Jet Fires:** There is potential for the 37.5 kW/m^2 contours to extend across a large section of the facility, which suggests that there is potential for escalation due to jet fires associated with the natural gas system on-site. There is also potential for personnel situated outside (e.g. walking between areas of the site) to be fatally injured from natural gas jet fires. There is also potential for escalation of jet fires originating in the AGI or on-site pipeline to the LDES compound.
- **Fireballs:** The hazard contours associated with fireballs are relatively large, however these are short lived events and therefore do not contribute greatly to escalation, and the likelihood of a fireball has been deemed improbably over the lifetime of the facility.
- **Flash Fires:** Flash fires can have far reaching effects, as seen in Figure 5-14, however Figure 5-15 provides an indication as to the shape of the flammable cloud which can be seen to be much smaller than the entire cloud envelope. However, the ½ LFL cloud can impact the majority of the site such that any muster points could be considered compromised.
- **LDES System:** The safety risk posed by LDES systems must not be underestimated, and there is potential for very large fires should propagation between containers occur. Should an LDES fire be contained to a single container (as should be the case for properly designed systems), there is potential for localised asset damage and safety risk to first responders.
- **Off-site impacts:** Natural gas and fuel oil consequence modelling has highlighted no particular concerns to third-party buildings or properties outside of the site boundary. In the unlikely event that a large-scale LDES compound fire occurs, with the fire propagating across multiple containers, there is potential for off-site impacts from smoke and evolved gases.

7.2 Recommendations

The following recommendations are made:

1. Consider fire protection strategies for the tanker unloading and fuel oil storage areas, which could include separate bunds for each storage tank, and deluge (sprinkler) systems, and/or foam application on confirmation of a fire. Also consider relocation of the fire water tanks to a location away from all flammable inventories to ensure they are not impacted by fire events.
2. There is currently potential for occupied buildings (security and administration/control building) to be within the 37.5 kW/m^2 hazard ranges associated with jet fires and pool fires. If possible, Halston Lumcloom should

consider relocating these buildings to an area outside all hazard contours – which would be considered an inherently safe solution.

3. Ensure any muster points are located outside of the ½ LFL clouds, as shown in Section 5.4.
4. If possible, the spacing between the natural gas-containing systems and the LDES compound should be increased to reduce the likelihood of a natural gas jet fire escalating to a large-scale battery fire, which could potentially have off-site impacts.
5. Undertake further risk assessments in later design stages and review the input data and assumptions. This should primarily address any uncertainties or assumptions in process information, as these will be more accurately defined as the design progresses. Particular attention should be given to fire and explosion risk within the LDES compound - ensuring that all applicable design standards have been followed to minimise the risk associated with stored electrical energy.

Note, these recommendations aim to further reduce any risk associated with Project Coolpowra, however other risk reduction measures may be deemed more appropriate as the design develops.

8 REFERENCES

/1/ Project Coolpowra, Proposed Reserve Gas-Fired Power Generator, GIS Electrical Substation and Energy Storage System, Project Description SEP-0398, February 2024, Rev 01.

/2/ CPA-HAL-OC-XX-DR-PL-1000, Proposed Site Location, March 2024, Rev P01.

/3/ CPA-HAL-MP-XX-DR-PL-1000,.Master Plan Layout, March 2024, Rev P03

/4/ Summary description of receiving environment, SEP-0398, February 2024, Rev 01

/5/ UK HSE, "Reducing risks, protecting people", ISBN 0 7176 2151 0, 2001.

/6/ UK HSE, "HSE's Land Use Planning Methodology", https://www.hse.gov.uk/landuseplanning/methodology.htm, accessed February 2024.

/7/ IOGP, "Risk Assessment Data Directory – Process Release Frequencies", 434-01, Version 3.0, September 2019.

/8/ TNO, "Guidelines for Quantitative Risk Assessment – 'Purple Book", CPR 18E, 2005.

/9/ UK HSE Failure Rate and Event Data (FRED) report.

/10/ IOGP, "Risk Assessment Data Directory – Ignition Probabilities", 434-06, Version 1.0, September 2019.

/11/ IOGP, "Risk Assessment Data Directory – Vulnerability of Humans", 434-14, Version 1.0, July 2023.

/12/ Guidance to Inspectors on the Assessment of Safety Reports under the COMAH Regulations 2015, HSA, Rev 4, 2017.

APPENDIX A
Flammable Dispersion Results

Scenario	Weather	Hole size (mm)	Distance to LFL fraction (m)	Distance to LFL (m)
Diesel Storage (central) - Catastrophic rupture	Category 1.5/F	Full rupture	22	22
Diesel Storage (central) - Catastrophic rupture	Category 1.5/D	Full rupture	22	22
Diesel Storage (central) - Catastrophic rupture	Category 5/D	Full rupture	25	25
Diesel Storage (central) - leak	Category 1.5/F	5	Not reached at height of interest	Not reached at height of interest
Diesel Storage (central) - leak	Category 1.5/D	5	Not reached at height of interest	Not reached at height of interest
Diesel Storage (central) - leak	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Road tanker - Catastrophic rupture	Category 1.5/F	Full rupture	6	6
Road tanker - Catastrophic rupture	Category 1.5/D	Full rupture	6	6
Road tanker - Catastrophic rupture	Category 5/D	Full rupture	7	7
Road tanker - Leak	Category 1.5/F	5	Not reached at height of interest	Not reached at height of interest
Road tanker - Leak	Category 1.5/D	5	Not reached at height of interest	Not reached at height of interest
Road tanker - Leak	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Leak	Category 1.5/F	5	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Leak	Category 1.5/D	5	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Leak	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Diesel Transfer Pumps - Catastrophic rupture	Category 1.5/F	Full rupture	5	5
Diesel Transfer Pumps - Catastrophic rupture	Category 1.5/D	Full rupture	5	5
Diesel Transfer Pumps - Catastrophic rupture	Category 5/D	Full rupture	6	6
Grid Connection AGI - Leak	Category 1.5/F	5	Not reached at height of interest	Not reached at height of interest

Scenario	Weather	Hole size (mm)	Distance to LFL fraction (m)	Distance to LFL (m)
Grid Connection AGI - Leak	Category 1.5/D	5	Not reached at height of interest	Not reached at height of interest
Grid Connection AGI - Leak	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Grid Connection AGI - Full bore rupture	Category 1.5/F	152	187	83
Grid Connection AGI - Full bore rupture	Category 1.5/D	152	182	77
Grid Connection AGI - Full bore rupture	Category 5/D	152	205	80
Long pipeline (single point) - 5mm	Category 1.5/F	5	1	1
Long pipeline (single point) - 5mm	Category 1.5/D	5	1	1
Long pipeline (single point) - 5mm	Category 5/D	5	Not reached at height of interest	Not reached at height of interest
Long pipeline (single point) - Full bore	Category 1.5/F	914	Not reached at height of interest	Not reached at height of interest
Long pipeline (single point) - Full bore	Category 1.5/D	914	6	5
Long pipeline (single point) - Full bore	Category 5/D	914	9	6

APPENDIX B
Jet fire results

Scenario	Weather	Hole size (mm)	Flame emissive power (kW/m2)	Distance downwind to intensity level 1 (4.7 kW/m2) (m)	Distance downwind to intensity level 2 (6.3 kW/m2) (m)	Distance downwind to intensity level 3 (12.5 kW/m2) (m)	Distance downwind to intensity level 4 (37.5 kW/m2) (m)	Ellipse area at intensity level 1 (4.7 kW/m2) (m2)
Diesel Storage (central) - leak	Category 1.5/F	5	33	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
Diesel Storage (central) - leak	Category 1.5/D	5	33	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
Diesel Storage (central) - leak	Category 5/D	5	64	1	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	1
Road tanker - Leak	Category 1.5/F	5	21	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
Road tanker - Leak	Category 1.5/D	5	22	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
Road tanker - Leak	Category 5/D	5	50	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
Diesel Transfer Pumps - Leak	Category 1.5/F	5	39	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
Diesel Transfer Pumps - Leak	Category 1.5/D	5	40	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
Diesel Transfer Pumps - Leak	Category 5/D	5	78	1	Not reached at height of interest	Not reached at height of interest	Not reached at height of interest	1
Grid Connection AGI - Leak	Category 1.5/F	5	40	4	4	Not reached at height of interest	Not reached at height of interest	3
Grid Connection AGI - Leak	Category 1.5/D	5	40	4	4	Not reached at height of interest	Not reached at height of interest	3
Grid Connection AGI - Leak	Category 5/D	5	37	4	4	Not reached at height of interest	Not reached at height of interest	2
Grid Connection AGI - Full bore rupture	Category 1.5/F	152	350	134	124	106	82	20943
Grid Connection AGI - Full bore rupture	Category 1.5/D	152	350	134	124	106	82	20943
Grid Connection AGI - Full bore rupture	Category 5/D	152	350	135	126	108	88	20639
Long pipeline (single point) - 5mm	Category 1.5/F	5	42	4	4	2	1	29
Long pipeline (single point) - 5mm	Category 1.5/D	5	42	4	4	2	1	29
Long pipeline (single point) - 5mm	Category 5/D	5	70	6	5	4	4	34
Long pipeline (single point) - Full bore	Category 1.5/F	914	184	300	248	132	15	232841
Long pipeline (single point) - Full bore	Category 1.5/D	914	184	300	248	132	15	232841
Long pipeline (single point) - Full bore	Category 5/D	914	286	335	295	219	102	274608

APPENDIX C
Pool fire results

Scenario	Weather	Hole size (mm)	Pool diameter (m)	Distance downwind to intensity level 1 (4.7 kW/m2) (m)	Distance downwind to intensity level 2 (6.3 kW/m2) (m)	Distance downwind to intensity level 3 (12.5 kW/m2) (m)	Distance downwind to intensity level 4 (37.5 kW/m2) (m)
Diesel Storage (central) - Catastrophic rupture	Category 1.5/F	Full rupture	94	104	91	69	54
Diesel Storage (central) - Catastrophic rupture	Category 1.5/D	Full rupture	94	104	91	69	54
Diesel Storage (central) - Catastrophic rupture	Category 5/D	Full rupture	94	112	98	71	55
Diesel Storage (central) - leak	Category 1.5/F	5	14	34	30	22	13
Diesel Storage (central) - leak	Category 1.5/D	5	14	34	30	22	13
Diesel Storage (central) - leak	Category 5/D	5	14	36	33	25	13
Road tanker - Catastrophic rupture	Category 1.5/F	Full rupture	101	107	94	71	57
Road tanker - Catastrophic rupture	Category 1.5/D	Full rupture	101	107	94	72	57
Road tanker - Catastrophic rupture	Category 5/D	Full rupture	101	117	103	74	59
Road tanker - Leak	Category 1.5/F	5	11	28	25	19	10
Road tanker - Leak	Category 1.5/D	5	11	28	25	19	10
Road tanker - Leak	Category 5/D	5	11	30	27	22	10
Diesel Transfer Pumps - Leak	Category 1.5/F	5	17	35	32	23	15
Diesel Transfer Pumps - Leak	Category 1.5/D	5	17	36	32	24	15
Diesel Transfer Pumps - Leak	Category 5/D	5	17	38	35	26	16
Diesel Transfer Pumps - Catastrophic rupture	Category 1.5/F	Full rupture	50	60	53	39	30
Diesel Transfer Pumps - Catastrophic rupture	Category 1.5/D	Full rupture	50	60	53	39	30
Diesel Transfer Pumps - Catastrophic rupture	Category 5/D	Full rupture	50	66	58	40	31

APPENDIX D
Fireball results

Scenario	Weather	Hole size (mm)	Distance downwind to intensity level 1 (4.7 kW/m2) (m)	Distance downwind to intensity level 2 (6.3 kW/m2) (m)	Distance downwind to intensity level 3 (12.5 kW/m2) (m)	Distance downwind to intensity level 4 (37.5 kW/m2) (m)
Long pipeline (single point) - Full bore	Category 1.5/F	914	292	254	182	104
Long pipeline (single point) - Full bore	Category 1.5/D	914	292	254	182	104
Long pipeline (single point) - Full bore	Category 5/D	914	292	254	182	104

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APPENDIX E

Explosion results

Scenario	Weather	Material	Distance downwind to overpressure 1 (0.07 bar) (m)	Distance downwind to overpressure 2 (0.1 bar) (m)	Distance downwind to overpressure 3 (0.35 bar) (m)
Methane VCE - Transformer	Category 1.5/F	METHANE	33	19	Not reachable
Methane VCE - Transformer	Category 1.5/D	METHANE	33	19	Not reachable
Methane VCE - Transformer	Category 5/D	METHANE	33	19	Not reachable

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