

**COMAH LAND USE
PLANNING ASSESSMENT
FOR PROPOSED
SUBSTATION AND
UNDERGROUND CABLE
ROUTES, CO. DUBLIN**

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Huntstown Power Company

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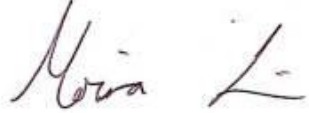
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EXECUTIVE SUMMARY

A Land Use Planning assessment was completed for the proposed construction of a Substation that is in the vicinity of Huntstown Power Station, Co. Dublin. The Huntstown establishment is notified to the Health and Safety Authority (HSA) as a Lower Tier COMAH site and is subject to the provisions of the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, 2015 (COMAH Regulations 2015).

The risk-based approach is completed in accordance with current HSA policy and taking account of the Policy and Approach of the Health and Safety Authority to COMAH Risk-based Land-use Planning (19 March 2010).

This report examines hazards associated with Fuel Oil, LPG, and Natural gas installations on site. The consequences modelling was carried out using TNO Effects Version 11.3.0 modelling software. The following is concluded:

Natural Gas VCE within a Turbine Enclosure:

- Overpressure levels corresponding to safe and light damage extends to the proposed Substation development;
- Overpressure levels corresponding to 1% mortality outdoors do not extend to the proposed Substation development;
- Overpressure levels corresponding to 1% mortality indoors (Cat. 2) do not extend to the proposed Substation development.

Natural Gas Jet Fire at the GNI AGI:

- The jet flame measures up to 258 m in length (depending on wind speed)
- The thermal radiation level corresponding to 1% mortality outdoors extends to the proposed Substation development; therefore, there is a possibility of fatality to persons outdoors in the event of a jet fire; however, the site is designed to be operated remotely and there are no permanent staff on-site.
- The thermal radiation level corresponding to 100% mortality indoors extends to the proposed development but does not extend to any buildings on site.
- The thermal radiation level corresponding to equipment damage extends to the proposed Substation. There is potential for damage to equipment at the substation.
- GNI will be responsible for the installation, operation, and maintenance of all equipment within the AGI gas compound. All operations within the AGI will comply with standard GNI operational procedures and risk assessments and will be carried out by approved GNI contractors.

In relation to impacts from a jet fire following rupture of the natural gas supply pipeline at the GNI AGI, it is noted that the thermal radiation impacts that are predicted are conservative as they are based on a mass flow rate of 661 kg/s, as recommended by TNO and as explained above. It is noted that after approximately 9 s the release rate will reduce to 126 kg/s and after 44 s it will reduce to less than 3 kg/s and will continue to reduce until all of the natural gas has been released from the pipeline (approximately 600 s or 10 minutes). Therefore, the estimated consequences are conservative.

Bunded Pool Fire at Fuel Oil Storage Tanks

- The thermal radiation contour corresponding to the threshold of fatality (4.1 kW/m²) does not extend to the proposed Substation development.

Uncontained Pool Fire following Bund Overtop

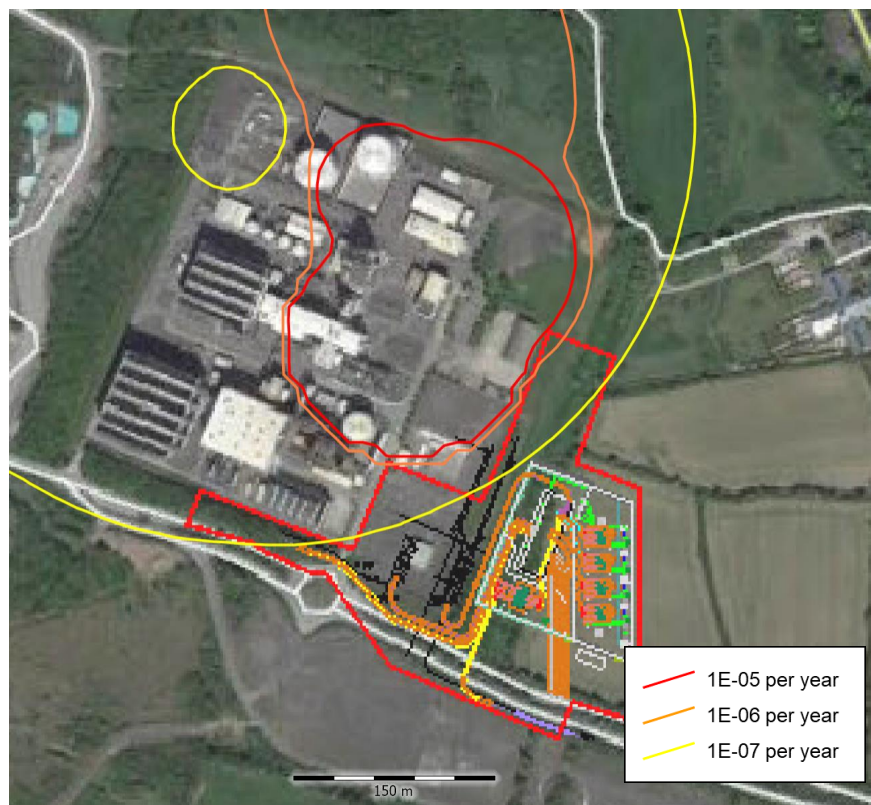
- The thermal radiation contour corresponding to the threshold of fatality does not extend to the proposed development;
- The thermal radiation contour corresponding to persons protected indoors does not extend to the proposed development.

LPG BLEVE and Fireball

- The Fireball radius does not extend to the proposed development.
- The thermal radiation corresponding to 1% fatality (6.8 kW/m^2) extends to the proposed development, there is potential for fatality to persons outdoors at this establishment.
- The thermal radiation level corresponding to 0% mortality indoors (12.7 kW/m^2) extends to the proposed development; however, there will be no buildings in this area; therefore, no fatalities are expected.

It is concluded that there is potential for fatalities to persons outdoors at the proposed development following a Fireball at the LPG tank at the Huntstown Power Station. However, the Substation is designed to be remotely operated and there are no permanent staff on-site.

The cumulative individual risk contours for Huntstown Power Station corresponding to the boundary of the inner, middle and outer land use planning zones are illustrated as follows.



It is concluded that the LUP Outer zone and Middle zone of Huntstown Power Station extends to the proposed development. The individual risk contours corresponding to the Inner LUP zone does not extend to the proposed development; therefore, the level of individual risk at the proposed development is acceptable.

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1.0 INTRODUCTION

AWN Consulting Ltd. was engaged by Huntstown Power Company to complete a COMAH Land Use Planning Assessment to accompany the planning application to An Bord Pleanála (ABP) for the proposed strategic infrastructure development at the site of c.4.33 ha on lands adjacent to Huntstown Power Station, North Road, Finglas, Dublin 11.

The existing huntstown power station, owned by Huntstown Power Company limited, and Operated by Gensys Power Ltd., is located directly to the west of the development lands. This site is a notified to the Health and Safety Authority (HSA) as a Lower Tier COMAH site and is subject to the provisions of the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, 2015 (COMAH Regulations 2015).

This report details the following:

- Description of development;
- Background to risk assessment and land use planning context;
- Land Use Planning assessment methodology and criteria;
- Identification of Major Accident Hazards;
- Land Use Planning Assessment of Major Accident Scenarios;
- Land Use Planning Contours;
- Conclusions.

2.0 DESCRIPTION OF DEVELOPMENT

The proposed development will consist of the construction of a 2 storey 220 kV Gas Insulated Switchgear (GIS) substation known as 'Mooretown' comprising switchgear floor, cable pit/entry room, generator room, relay room, battery room, workshop, toilet, store room, mess room, hoist space, stair cores and circulation areas (c.2,068 sqm total gross floor area) with an overall height of c.17m located within an overall EirGrid and Customer compound (c.11,231 sqm in area). Lightning electrodes are attached to the roof of the substation building resulting in an overall height of c.20m. The compound includes 4 no. 220/20 kV transformers, 4 no. 20 kV switchgear buildings and 1 no. 20 kV control room buildings (c.5 m high and c. 35.5 sqm in area each), 220 kV series coil (equipment), fire walls (ranging from c.10 m-12.5 m high), lightning finials and monopoles (c.20 m high). The overall compound is surrounded by a c.2.6 m high palisade fence.

The underground transmission lines (4 no.) will connect the proposed 220 kV GIS Mooretown Substation serving the data hall development proposed under concurrent application (Reg. Ref. FW21A/0151) located on lands adjacent to Huntstown Power Station, North Road, Finglas, Dublin 11 with the 220 kV Finglas cable route located to the south of the site on the private road connecting the North Road with Huntstown Power Station and Huntstown Quarry, with the 220 kV Corduff cable route located to the west of the site and just north of the private road connecting the North Road with Huntstown Power Station and Huntstown Quarry and to the existing Huntstown 220 kV AIS station to the west via 220 kV cables to the Huntstown A and Huntstown B circuits. The four proposed transmission cables cover a distance of between c.125m and c.300m each between the proposed substation and the adjacent connection points.

The proposed development is designed to be remotely operated and will only be occupied during periodic maintenance.

The proposed development site is c. 4.33 hectares of predominantly greenfield located to the north west of the M50 orbital ring in the townland of Johnstown and Coldwinters, North Road, Finglas, Dublin 11. The surrounding area is characterised by a variety of energy, industrial, commercial, quarrying, agricultural and residential uses. The subject site is generally bounded to the northeast by the Dogs Trust (Dog Rescue and Rehoming Charity), the southern end of the site is traversed by a vehicular entrance leading to the Huntstown Quarry and bound to the south by an Anaerobic Digestion Plant. The site is bound to the west by the existing Huntstown Power Station.

The site location is illustrated on Figure 1 and the proposed substation is illustrated on Figure 2.

2.1 Huntstown Power Station

The existing huntstown power station, owned by Huntstown Power Company limited, and Operated by Gensys Power Ltd., is located directly to the west of the development lands. This site is a notified to the Health and Safety Authority (HSA) as a Lower Tier COMAH site and is subject to the provisions of the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, 2015 (COMAH Regulations 2015).

Huntstown Power Station is a Combined Cycle power station providing electricity to the national grid. The site consists of two separate power plants, referred to as Phase 1 and Phase 2.

Phase 1 consists of a high efficiency 343 MW Combined Cycle Gas Turbine (CCGT) power plant operated on natural gas, with distillate oil as a standby fuel. Phase 2 consists of a high efficiency 401 MW CCGT power plant operated on natural gas, also with distillate oil as a standby fuel. Natural gas is mixed with compressed air and ignited so that the hot gas expands through the turbine which in turn generates energy through the gas turbine generators. Hot exhaust gases are passed through an exhaust duct and are used to raise steam in the waste heat recovery boiler. Steam then expands through the steam turbine to generate additional electricity.

The Huntstown site comprises the following installations with major accident potential:

- 2 no Combined Cycle Gas Turbine (CCGT) (Phase 1 and Phase 2);
- Natural Gas Supply;
- LPG tank;
- Distillate Storage.

The layout of the Huntstown Power Station is illustrated Figure 3.

The dangerous substances and quantities that may be stored at Huntstown Power Station are listed in Table 1.

Substance	Quantity (tonnes)
Hydrogen	0.13
LPG	1.53
Petroleum Products (HFO, Diesel, Petrol)	13420

Table 1 Dangerous Substances Stored at Huntstown Power Station

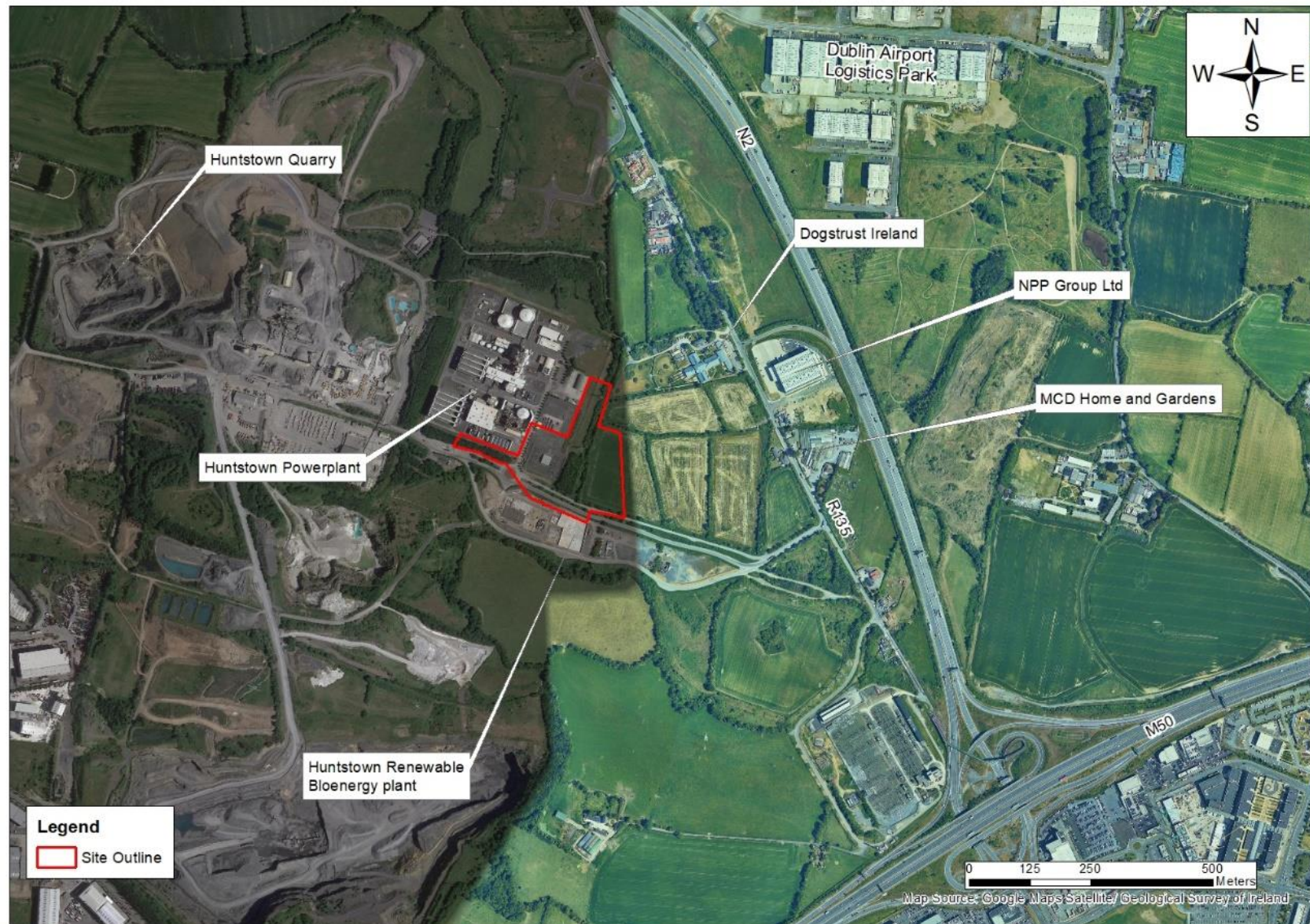


Figure 1 Site Boundary of proposed Substation (red)

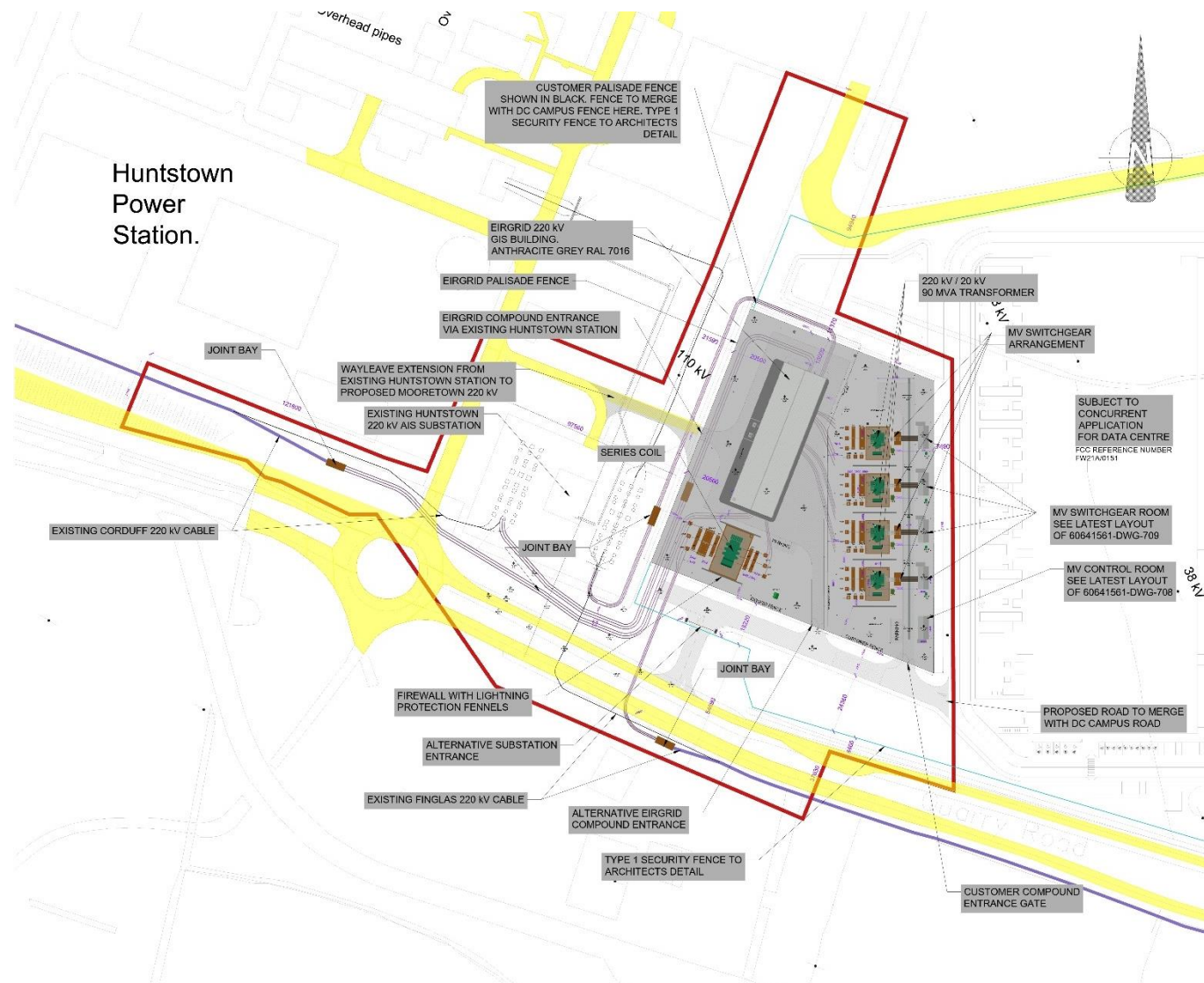


Figure 2 Proposed Substation Site Layout (AECOM 60641561-DWG-701)

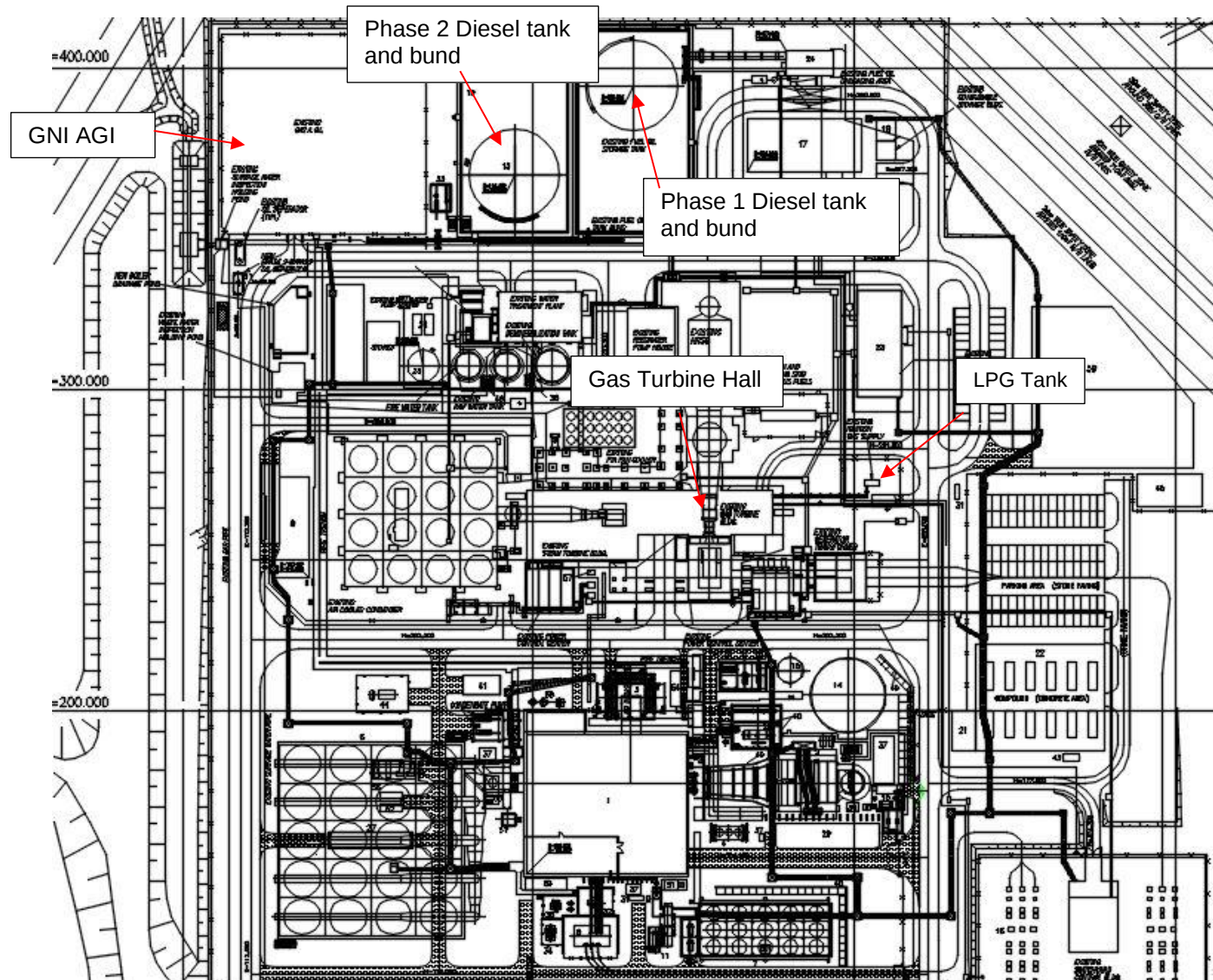


Figure 3 Huntstown Power Station Site Layout

3.0 BACKGROUND TO RISK ASSESSMENT AND LAND USE PLANNING

3.1 Risk Assessment – An Introduction

Trevor Kletz (Kletz, 1999) in his seminal work on the subject stated that the essential elements of quantitative risk assessment (QRA) are (i) how often is a Major Accident Hazard (MAH) likely to occur and (ii) Consequence Analysis – what is the impact of the incident:

Kletz also commented that another way of expressing this method of QRA is:

How often?

How big?

So what?

In QRA, the “how often?” question refers to the frequency of the major accident scenario and is answered with reference to historical industry data for similar incidents, or by using frequency analysis techniques.

Section 2 of the Health and Safety Authority (HSA) Land Use Planning Policy and Approach document (Introduction to Technical Aspects) describes the policy and approach as follows:

“The policy of the HSA is that a simplified application of a risk based approach is the most appropriate for land use planning. The difficulties associated with the complexity of analyzing many scenarios can be avoided by considering a small number of carefully chosen representative events, whose frequency has been estimated conservatively.”

The frequency data for major accident scenarios identified in this assessment is based on these conservative frequency values.

The ‘how big’ element of the QRA was conducted using TNO Effects modelling software.

The “so what” element is perhaps the most contentious issue associated with QRA, as one is essentially asking what is an acceptable level of risk, in this case risk of fatality, posed by a facility.

It is widely accepted that “no risk” scenarios do not exist. The occupier of a house with gas fired central heating is exposed to the risk posed by the presence of a natural gas supply in the house. Statistics from the UK Health and Safety Executive (UK HSE Risks associated with Gas Supply, 1993) show that the annual risk of death from gas supply events in the UK (risks include explosion, asphyxiation by fumes from poorly vented heaters, poisoning by gas leaks) is approximately 1.1 in a million. In other words, for every 10 million persons living in houses with a gas supply, 11 will die annually from events related to the supply.

Table 2 below presents the annual fatality rates, and the risk of fatality, for a number of activities (from CIRIA Report 152, 1995) in the UK.

Risk	Annual Fatality Rate (per 1,000, 000 people at risk)	Annual Risk of Fatality
Motorcycling	20,000	1 in 50
Smoking (all causes)	3000	1 in 333
Smoking (cancer)	1200	1 in 830
Fire fighting	800	1 in 1250
Farming	360	1 in 2778
Police work (non-clerical)	220	1 in 4545
Road accidents	100	1 in 10,000
Fires	28	1 in 35,700
Natural gas supply to house	1.1	1 in 909,090
Lightning strike	0.5	1 in 2,000,000

Table 2 Annual Fatality Rates for a Variety of Activities

Kletz has shown that the average industrial worker is exposed to a risk of accidental death of somewhere around 1×10^{-3} per year, for all situations (work, home, travel).

3.2 Land Use Planning and Risk Assessment

The Seveso III Directive (2012/18/EU) requires Member States to ensure that the objectives of preventing major accidents and limiting the consequences of such accidents for human health and the environment are taken into account in land use planning policies through controls on the siting of new establishments, modifications to establishments and certain types of new developments in the vicinity of establishments. Under the 2015 COMAH Regulations, the Central Competent Authority (the Health and Safety Authority) provides land use planning advice to planning authorities.

This land use planning assessment has been carried out in accordance with the HSA's *Policy and Approach to COMAH Risk-based Land-use Planning* (HSA, 2010). This approach involves delineating three zones for land use planning guidance purposes, based on the potential risk of fatality from major accident scenarios resulting in damaging levels of thermal radiation (e.g. from pool fires), overpressure (e.g. from vapour cloud explosions) and toxic gas concentrations (e.g. from an uncontrolled toxic gas release).

The HSA has defined the boundaries of the Inner, Middle and Outer Land Use Planning (LUP) zones as:

10E-05/year	Risk of fatality for Inner Zone (Zone 1) boundary
10E-06/year	Risk of fatality for Middle Zone (Zone 2) boundary
10E-07/year	Risk of fatality for Outer Zone (Zone 3) boundary

The process for determining the distances to the boundaries of the inner, middle and outer zones is outlined as follows:

- Determine the consequences of major accident scenarios using the modelling methodologies described in the HSA LUP Policy/Approach Document (HSA, 2010);
- Determine the severity (probability of fatality) using the probit functions specified by the HSA;
- Determine the frequency of the accident (probability of event) using data specified by the HSA;

- Determine the individual risk of fatality as follows:

$$\text{Risk} = \text{Frequency} \times \text{Severity}$$

The 2010 HSA Risk-Based LUP Policy/Approach document provides guidance on the type of development appropriate to the inner, middle and outer LUP zones. The advice for each zone is based on the UK Health and Safety Executive (HSE) Land Use Planning Methodology. The methodology sets four levels of sensitivity, with sensitivity increasing from 1 to 4, to describe the development types in the vicinity of a COMAH establishment.

The Sensitivity Levels used in the Land Use Planning Methodology are based on a rationale which allows progressively more severe restrictions to be imposed as the sensitivity of the proposed development increases. The sensitivity levels are:

- Level 1 Based on normal working population;
- Level 2 Based on the general public – at home and involved in normal activities;
- Level 3 Based on vulnerable members of the public (children, those with mobility difficulties or those unable to recognise physical danger); and
- Level 4 Large examples of Level 3 and large outdoor examples of Level 2 and Institutional Accommodation.

Table 3 details the matrix that is used by the HSA to advise on suitable development for technical LUP purposes:

Level of Sensitivity	Inner Zone (Zone 1)	Middle Zone (Zone 2)	Outer Zone (Zone 3)
Level 1	✓	✓	✓
Level 2	✗	✓	✓
Level 3	✗	✗	✓
Level 4	✗	✗	✗

Table 3 LUP Matrix

3.3 Land Use Planning and Societal Risk

Vrijling and van Gelder (2004) have defined Societal Risk as:

“the relation between frequency and the number of people suffering from a specified level of harm in a given population from the realisation of specified hazards”

An important distinction in Societal Risk assessment is the number of persons that may be affected by off-site impacts, such as people with restricted mobility or children that may be affected by the need to rapidly evacuate a significant number of people from an area.

It is therefore prudent, when considering the Societal Risk Impacts of a development, to consider the nature and extent of a population which could be located in the vicinity of establishments with major accident hazard potential, or if adjacent lands are not already developed, to consider the nature and extent of a population which should be permitted to be located in this area.

It is recognised that it is not necessary to restrict all access by people to such lands, but

it is considered prudent to restrict the number and type of persons which could be impacted.

The HSA LUP Policy and Approach document (HSA, 2010) recommends that for some types of development, particularly those involving large numbers of people, it is likely that the deciding factor from the point of view of land use planning is the societal risk, i.e. the risk of large numbers of people being affected in a single accident.

The HSA specifies the following societal risk criteria:

- Upper societal risk criterion value of 1 in 5000 for 50 fatalities (planning authority should advise against permitting the development)
- Broadly acceptable region of 1 in 100,000 for 10 fatalities (planning authority should not advise against permitting the development)
- Significant risk regions between these two values (planning authority should be advised of HSA approach to Risk-based Land Use Planning)

4.0 LAND USE PLANNING ASSESSMENT METHODOLOGY AND CRITERIA

This COMAH land use planning assessment has been completed in accordance with risk based approach set out in the HSA's *Policy and Approach to COMAH Risk-based Land-use Planning* (HSA, 2010). LUP assessments are completed in the following steps:

- Identify major accident scenarios with reference to the HSA Policy document (HSA, 2010);
- Consequence modelling of major accident scenarios;
- Assign frequencies to major accident scenarios with reference to frequency values outlined in the HSA's Policy document (HSA, 2010);
- Assessment of individual risk and generation of individual risk contours;
- Where necessary, assessment of societal risk using societal risk indices.

4.1 Consequence Assessment

The impacts of physical effects were determined by modelling accident scenarios using TNO Effects Version 11.3.0 modelling software.

4.1.1 Flammable and Overpressure Hazards

The flammable hazards, which may be observed during major accidents, include the following:

Flash Fire:

Flash fires are associated with major accidents involving releases of flammable liquids or gases, which form a gas/vapour cloud which ignites at some point remote from the release point.

Combustion takes place relatively slowly and there is no significant overpressure. It is generally assumed that the thermal effects are limited to people within the flame envelope where there is a high probability of fatality. Flash fires would have a negligible effect on plant and buildings due to the short duration of the fire and the negligible overpressures created.

Vapour Cloud Explosion

A Vapour Cloud Explosion (VCE) may be observed during major accidents. Combustion of a flammable gas-air mixture will occur if the composition of the mixture lies in the flammable range and if an ignition source is available. When ignition occurs in a flammable region of the cloud, the flame will start to propagate away from the ignition source. The combustion products expand causing flow ahead of the flame. Initially this flow will be laminar. Under laminar or near laminar conditions the flame speeds for normal hydrocarbons are in the order of 5 to 30 m/s which is too low to produce any significant blast over-pressure. Under these conditions, the vapour cloud will simply burn, causing a flash fire. In order for a vapour cloud explosion to occur, the vapour cloud must be in a turbulent condition.

Turbulence may arise in a vapour cloud in various ways:

- By the release of the flammable material itself, for instance a jet release from a high pressure vessel.
- By the interaction of the expansion flow ahead of the flame with obstacles

present in a congested area.

In the case of a vapour cloud explosion the principal parameter of interest is the overpressure observed at various locations.

Fireball and BLEVE

Fireballs are short-lived flames which generally result from the ignition and combustion of turbulent vapour/two-phase (i.e. aerosol) fuels in air. Releases that fuel fireballs are usually near instantaneous and commonly involve the catastrophic failure of pressurised vessels/pipelines. Fireballs can dissipate large amounts of thermal radiation, which away from their visible boundaries, may transmit heat energy that could be hazardous to life and property.

A BLEVE is an explosion which occurs when a storage vessel containing a liquid at a temperature significantly above its boiling point at normal atmospheric pressure, experiences a catastrophic failure. Unlike a vapour cloud explosion, the liquid in question does not have to be flammable, however most of the BLEVEs recorded have been associated with facilities which stored flammable material. The catastrophic failure of a storage vessel and the subsequent rapid vaporisation of the liquid within the vessel produces an explosion overpressure. A BLEVE involving flammable liquid produces both an explosion overpressure and a buoyant fireball.

4.1.2 Physical Effects Modelling

The impacts of physical and health effects on workers and the general public outside of the proposed development boundary were determined by modelling accident scenarios using TNO Effects modelling software.

Thermal radiation exposure criteria is based on the concept of a 'dangerous dose'.

A 'dangerous dose' is defined by the UK Health and Safety Executive as a dose where there is extreme distress to almost everyone, with a substantial proportion of affected persons requiring medical attention and some highly susceptible people might be killed (about 1% fatalities).

4.1.3 Thermal Radiation Criteria

Fire scenarios have the potential to create hazardous heat fluxes. Therefore, thermal radiation on exposed skin poses a risk of fatality.

Potential consequences of damaging radiant heat flux and direct flame impingement are categorised in Table 4 (HSA, 2010, CCPS, 2000, EI, 2007 and McGrattan et al, 2000).

Thermal Flux (kW/m ²)	Consequences
1 – 1.5	Sunburn
5 – 6	Personnel injured (burns) if they are wearing normal clothing and do not escape quickly
8 – 12	Fire escalation if long exposure and no protection
32 – 37.5	Fire escalation if no protection (consider flame impingement)
31.5	US DHUD, limit value to which buildings can be exposed

Thermal Flux (kW/m ²)	Consequences
37.5	Process equipment can be impacted, AIChE/CCPS
Up to 350	In flame. Steel structures can fail within several minutes if unprotected or not cooled.

Table 4 Heat Flux Consequences

In relation to persons indoors, the HSA have specified the thermal radiation consequence criteria (from an outdoor fire) detailed in Table 5 (HSA, 2010).

Thermal Flux (kW/m ²)	Consequences
> 25.6	Building conservatively assumed to catch fire quickly and so 100% fatality probability
12.7 – 25.6	People are assumed to escape outdoors, and so have a risk of fatality corresponding to that outdoors
< 12.7	People are assumed to be protected, so 0% fatality probability

Table 5 Heat Flux Consequences Indoors

Thermal Dose Unit (TDU) is used to measure exposure to thermal radiation. It is a function of intensity (power per unit area) and exposure time:

$$\text{Thermal Dose} = I^{1.33} t$$

where the Thermal Dose Units (TDUs) are (kW/m²)^{4/3}.s, I is thermal radiation intensity (kW/m²) and t is exposure duration (s).

The HSA recommends that the Eisenberg probit function (HSA, 2010) is used to determine probability of fatality to persons outdoors from thermal radiation as follows:

$$\text{Probit} = -14.9 + 2.56 \ln (I^{1.33} t)$$

I Thermal radiation intensity (kW/m²)
t exposure duration (s)

Probit (Probability Unit) functions are used to convert the probability of an event occurring to percentage certainty that an event will occur. The probit variable is related to probability as follows (CCPS, 2000):

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y-5} \exp\left(-\frac{u^2}{2}\right) du$$

where P is the probability of percentage, Y is the probit variable, and u is an integration variable. The probit variable is normally distributed and has a mean value of 5 and a standard deviation of 1.

The Probit to percentage conversion equation is (CCPS, 2000):

$$P = 50 \left[1 + \frac{Y-5}{|Y-5|} \operatorname{erf} \left(\frac{|Y-5|}{\sqrt{2}} \right) \right]$$

The relationship between Probit and percentage certainty is presented in Table 6 (CCPS,

2000).

%	0	1	2	3	4	5	6	7	8	9
0	—	2.67	2.95	3.12	3.25	3.36	3.45	3.52	3.59	3.66
10	3.72	3.77	3.82	3.87	3.92	3.96	4.01	4.05	4.08	4.12
20	4.16	4.19	4.23	4.26	4.29	4.33	4.36	4.39	4.42	4.45
30	4.48	4.50	4.53	4.56	4.59	4.61	4.64	4.67	4.69	4.72
40	4.75	4.77	4.80	4.82	4.85	4.87	4.90	4.92	4.95	4.97
50	5.00	5.03	5.05	5.08	5.10	5.13	5.15	5.18	5.20	5.23
60	5.25	5.28	5.31	5.33	5.36	5.39	5.41	5.44	5.47	5.50
70	5.52	5.55	5.58	5.61	5.64	5.67	5.71	5.74	5.77	5.81
80	5.84	5.88	5.92	5.95	5.99	6.04	6.08	6.13	6.18	6.23
90	6.28	6.34	6.41	6.48	6.55	6.64	6.75	6.88	7.05	7.33
%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
99	7.33	7.37	7.41	7.46	7.51	7.58	7.65	7.75	7.88	8.09

Table 6 Conversion from Probits to Percentage

For long duration fires, such as jet fires, it is generally reasonable to assume an effective exposure duration of 75 seconds to take account of the time required to escape (HSA, 2010). It is noted that this is a conservative estimation of the time taken to escape and is used in consequence assessment as the maximum exposure duration for heat radiation.

With respect to exposure to thermal radiation outdoors, the Eisenberg probit relationship implies:

- 1% fatality – 966 TDUs (6.8 kW/m² for 75 s exposure duration) (Dangerous Dose)
- 10% fatality – 1452 TDUs (9.23 kW/m² for 75 s exposure duration)
- 50% fatality – 2387 TDUs (13.4 kW/m² for 75 s exposure duration)

4.1.4 Overpressure Criteria

Explosions scenarios can result in damaging overpressures, especially when flammable vapour/air mixtures are ignited in a congested area. Table 7 below describes blast damage for various overpressure levels (Mannan, 2012).

Side-on Overpressure (mbar)	Description of Damage
1.5	Annoying noise
2	Occasional breaking of large window panes already under strain
3	Loud noise; sonic boom glass failure
7	Breakage of small windows under strain
10	Threshold for glass breakage
20	"Safe distance", probability of 0.95 of no serious damage beyond this value; some damage to house ceilings; 10% window glass broken
30	Limited minor structural damage
35 – 70	Large and small windows usually shattered; occasional damage to window frames
>35	Damage level for "Light Damage"
50	Minor damage to house structures
80	Partial demolition of houses, made uninhabitable
70 - 150	Corrugated asbestos shattered. Corrugated steel or aluminium panels fastenings fail, followed by buckling; wood panel (standard housing) fastenings fail; panels blown in
100	Steel frame of clad building slightly distorted
150	Partial collapse of walls and roofs of houses
150-200	Concrete or cinderblock walls, not reinforced, shattered
>170	Damage level for "Moderate Damage"
180	Lower limit of serious structural damage 50% destruction of brickwork of houses
200	Heavy machines in industrial buildings suffered little damage; steel frame building distorted and pulled away from foundations
200 – 280	Frameless, self-framing steel panel building demolished; rupture of oil storage tanks
300	Cladding of light industrial buildings ruptured
350	Wooden utility poles snapped; tall hydraulic press in building slightly damaged
350 – 500	Nearly complete destruction of houses
>350	Damage level for "Severe Damage"
500	Loaded tank car overturned
500 – 550	Unreinforced brick panels, 25 - 35 cm thick, fail by shearing or flexure
600	Loaded train boxcars completely demolished
700	Probable total destruction of buildings; heavy machine tools moved and badly damaged

Table 7 Blast Damage

There are a number of modes of explosion injury including eardrum rupture, lung haemorrhage, whole body displacement injury, missile injury, burns and toxic exposure. Table 8 describes injury criteria from blast overpressure including probability of eardrum rupture and probability of fatality due to lung haemorrhage.

Probability of Eardrum Rupture (%)	Peak overpressure (mbar)
1 (threshold)	165
10	194
50	435
90	840
Probability of Fatality due to Lung Haemorrhage (%)	Peak overpressure (mbar)
1 (threshold)	1000
10	1200
50	1400
90	1750

Table 8 Injury Criteria from Explosion Overpressure

The HSA recommends that the Hurst, Nussey and Pape probit function (HSA, 2010) is used to determine probability of fatality to persons outdoors from overpressure as follows:

$$\text{Probit} = 1.47 + 1.35 \ln P$$

P Blast overpressure (psi)

The Hurst, Nussey and Pape probit relationship implies:

- 1% fatality – 168 mbar (Dangerous Dose)
- 10% fatality – 365 mbar
- 50% fatality – 942 mbar

The HSA uses relationships published by the Chemical Industries Association (CIA) to determine the probability of fatality for building occupants exposed to blast overpressure. The CIA has developed relationships for 4 categories of buildings (CIA, 2010):

- Category 1: hardened structure building (special construction, no windows);
- Category 2: typical office block (four storey, concrete frame and roof, brick block wall panels);
- Category 3: typical domestic dwelling (two storey, brick walls, timber floors); and
- Category 4: 'portacabin' type timber construction, single storey.

The CIA relationships imply the overpressure levels corresponding to probabilities of fatality of 1%, 10% and 50% detailed in Table 9 below.

Probability of fatality	Overpressure Level, mbar			
	Category 1	Category 2	Category 3	Category 4
1% fatality (dangerous dose)	435	100	50	50
10% fatality	519	183	139	115
50% fatality	590	284	300	242

Table 9 Blast Overpressure Consequences Indoors

For the purposes of this assessment, it is assumed that the vulnerability of building occupants in the vicinity of the proposed development to side-on overpressure are represented by Category 2 type structures.

4.1.5 Modelling Parameters

4.1.5.1 *Weather Conditions*

Weather conditions at the time of a major accident have a significant impact on the consequences of the event. Typically, high wind speeds increase the impact of fires, particularly pool fires, while the associated turbulence dilutes vapour clouds, reducing the impact of toxic and flammable gas releases.

Atmospheric Stability Class and Wind Speed

Atmospheric stability describes the amount of turbulence in the atmosphere. The stability depends on the windspeed, time of day, and other conditions. Atmospheric stability classes are described in Table 10 (DNV, PHAST supporting documentation).

Wind speed (m/s)	Day: Solar Radiation			Night: Cloud Cover		
	Strong	Moderate	Slight	Thin, <40%	Moderate	Overcast, >80%
2	A	A-B	B	-	-	D
2 – 3	A-B	B	C	E	F	D
3 – 5	B	B-C	C	D	E	D
5 – 6	C	C-D	D	D	D	D
6	C	D	D	D	D	D

Table 10 Atmospheric Stability Class

Stability classes are described as follows:

- A very unstable (sunny with light winds)
- B unstable (moderately sunny, stronger winds than class A)
- C slightly unstable – very windy/sunny or overcast/light wind
- D neutral – little sun and high wind or overcast night
- E stable – moderately stable – less overcast and windy than class D
- F very stable – night with moderate clouds and light/moderate winds

The following Pasquill stability/wind speed pairs are specified by the HSA in Ireland for consequence modelling:

- Average weather conditions are represented by stability category D and a wind speed of 5 m/s, i.e. Category D5;
- Worst case conditions for toxic dispersion are represented by stability category F and a wind speed of 2 m/s, i.e. Category F2;
- A wind speed of 10 m/s represents the worst case condition for fire scenarios, with stability category D, i.e. Category D10.

Wind Direction and Ambient Temperature

The nearest synoptic metrological station to the Huntstown establishment for which long term meteorological data is available is at Dublin Airport.

Figure 4 illustrates a wind rose for Dublin Airport (1989 – 2018). It can be seen that the prevailing wind direction is from the south west (240°).

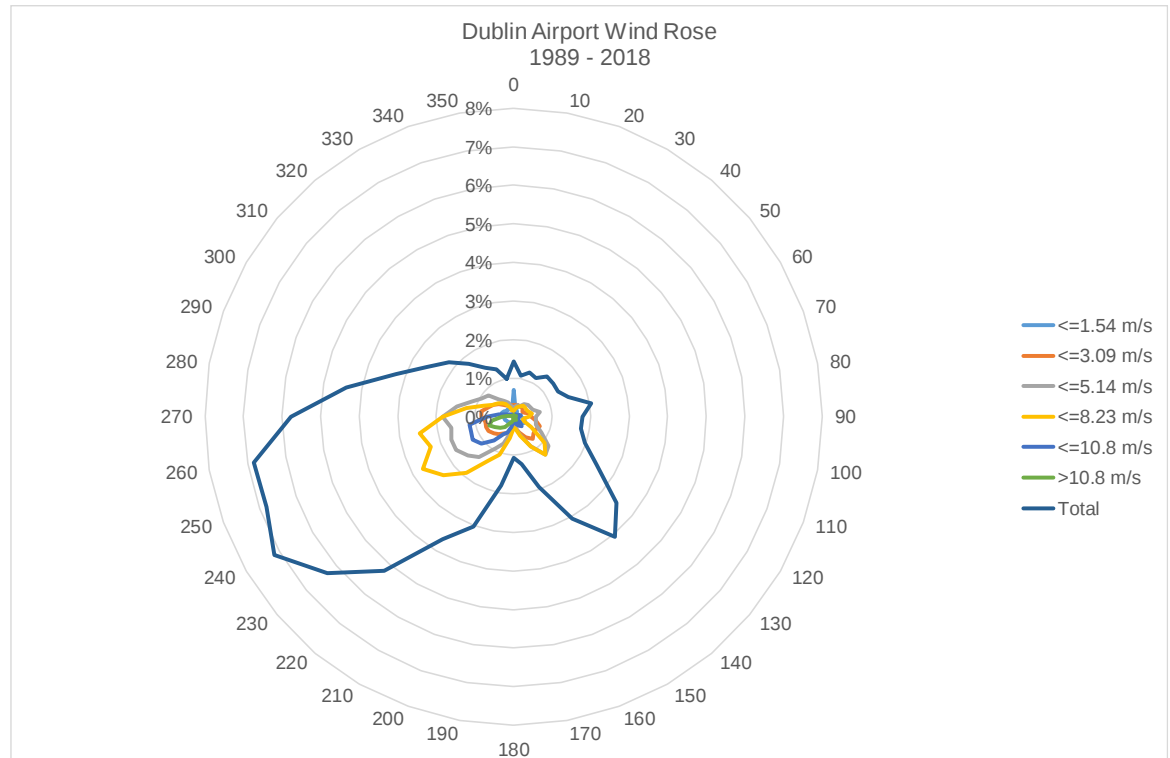


Figure 4 Wind Rose Dublin Airport 1989 – 2018 (Met.ie)

Ambient Temperature

The ambient and surface temperature conditions significantly impact the results of the consequence modelling. Typically, atmospheric temperatures in the Dublin area range from -12.2°C to 28.7°C through the year (Dublin Airport 1989 – 2018 averages, www.met.ie).

According to the weather data recorded between 1980 and 2018 at Dublin Airport, the average atmospheric temperature observed is 9.8°C. Therefore, an ambient temperature of 10°C has been selected to represent typical temperature conditions at the site.

Ambient Humidity

Weather data for Dublin Airport, monthly and annual mean and extreme values datasheet supplied by Met Éireann, indicates a mean morning (09:00 UTC) relative humidity of 83% and a mean afternoon (15:00 UTC) humidity of 73.3%. Therefore, for this assessment, a representative ambient humidity of 80% has been assumed.

4.1.5.2 Surface Roughness

Surface roughness describes the roughness of the surface over which the cloud is dispersing. Typical values for the surface roughness are as follows (DNV, PHAST supporting documentation):

Roughness length	Description
0.0002 m	Open water, at least 5 km
0.005 m	Mud flats, snow, no vegetation
0.03 m	Open flat terrain, grass, few isolated objects
0.1 m	Low crops, occasional large obstacles, $x/h > 20$
0.25 m	High crops, scattered large objects, $15 < x/h < 20$
0.5 m	Parkland, bushes, numerous obstacles, $x/h < 15$
1.0 m	Regular large obstacles coverage (suburb, forest)
3.0 m	City centre with high and low rise buildings

Table 11 Surface Roughness

The terrain within the vicinity of the site is comprised of mainly fields with some industrial plants. A surface roughness length of 1 m has been selected for the study.

4.2 Individual Risk Assessment Methodology

TNO Riskcurves Version 11.3.0 modelling software is used in this assessment to calculate individual risk of fatality contours and risk based land use planning zones associated with major accident scenarios.

5.0 IDENTIFICATION OF MAJOR ACCIDENT HAZARDS

A major accident is defined in the 2015 COMAH Regulations as:

“an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by these Regulations, and leading to serious danger to human health or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances”

5.1 Vapour Cloud Explosion Scenario

There is potential for a semi-confined VCE as a result of a leak of natural gas within a turbine enclosure at Phase 1 turbine hall. The HSA LUP guidance specifies the size of the flammable cloud to be taken as the volume of the region where the release may occur (i.e. building volume). The turbine enclosures has an estimated volume of 944 m³.

Individual risks of fatality can be calculated using a probit of $Y = 1.47 + 1.35 \ln(P)$, with P in psi (Hurst, Nussey and Pape, 1989) for the risk to people outdoors, and the Chemical Industries Association (CIA, 2003) vulnerability curves for the risk to people indoors. See Section 4.1.4 herein.

5.2 Jet Fire Scenario

The HSA LUP guidance document advises that for sites such as Power Stations the most significant major accident risk is associated with potential jet fires from the gas pipelines.

Huntstown Power Station is supplied with high pressure natural gas from a pipeline at the Gas Network Ireland (GNI) AGI.

The AGI is secured by fencing, locked and regularly maintained by GNI (Huntstown

personnel do not have access to it). An emergency shutoff valve on the high-pressure supply pipeline can be activated from the main control room, it is pneumatically operated and fail closed. The area is ATEX rated.

Information on the GNI high pressure natural gas pipeline that supplies natural gas to Huntstown Power Station was obtained from GNI is as follows:

- 300 mm diameter
- 70 bar design pressure

The 'Wilson Model' (TNO Yellow Book, 2005) models discharge from a long pipeline.

The initial release rate mainly depends on the pipe diameter (full bore rupture scenario) or hole size, the friction flow inside the pipeline depending on the wall roughness and the initial pressure inside the pipeline. Because of the release, the pressure inside the pipeline will drop in the region of the leak first. The pressure drop 'travels' along the length of the pipeline with a velocity equal to the sound velocity. This causes the gas release to become non-stationary until the pressure drop reaches the end of the pipeline. The ongoing release can be assumed to be stationary and continuous until the pipeline is empty.

5.3 Pool Fire Scenario

There is potential for a pool fire as a result of a release of fuel oil from the storage tank. In order for a fire to occur at the fuel oil storage tank, it would be necessary for an accidental release of fuel to occur, for an ignition source to be present and for the released fuel oil to ignite (which is extremely unlikely at ambient temperature).

The flash point of DERV fuel oil is 68 °C, and this is the lowest temperature at which it can form an ignitable mixture with air. The fuel oil tanks are at atmospheric temperature and pressure.

The HSA COMAH LUP Guidelines (HSA, 2010) identify the following major accident events associated with large pool fires at fuel storage sites:

1. A major unbunded pool fire extending up to 100 m from the bund wall, with a total frequency of at least 10E-04/year (for a small installation, and increasing for larger installations to ensure that the risks close to large sites are not less than those for small sites, e.g. based on an event frequency of 10E-04/(100π) per metre/year along a locus 50 m from the vessel storage area).
2. A pool fire which covers the entire surface of the bund with a higher frequency of 10E-03/year.

The worst case event is taken to be a circular pool fire located adjacent to the storage bund (i.e. due to bund overtopping or bund failure). The radius (R) of the fire is taken to be given by:

$$R = 6.85 V^{0.44537}$$

with R in metres and V (volume of liquid in pool) in cubic metres, subject to a maximum diameter of 100 m (which occurs when $V = 87 \text{ m}^3$), which should not normally be exceeded (unless there are special circumstances). It is typically assumed that 50% of the maximum vessel contents may overtop the bund, which implies that the maximum 100m pool diameter occurs for vessels of over 175 m^3 .

The distances to thermal doses of 1800, 1000 and 500 tdu can be modelled with the value for the SEP of Xylene (surrogate for all hydrocarbons other than class I) set at 25 kW/m² and at 52 kW/m² in the case of Pentane (surrogate for class I)).

The levels of thermal radiation as a function of distance from the centre of the pool can be calculated using any standard pool fire model. The calculations are undertaken for 5 m/s wind speed, and that the radiation levels taken are those calculated in the downwind direction (this will be conservative). Risks of fatality are then calculated using the standard Eisenberg probit and an assumption that people would be exposed for a period of 75 seconds (at a constant thermal radiation level).

5.4 Fireball and BLEVE

There is a potential for a BLEVE and Fireball following tank rupture the LPG storage tank.

The HSA COMAH LUP guidelines (2010) specifies a frequency of 10⁻⁴ /year. This is deliberately chosen as being relatively high as it is intended to cover sites with more than one LPG vessel (up to about 10). If there are only a few vessels, and the HSA is satisfied that there is a high probability that the measures in place at the site would mitigate against BLEVEs occurring, then a lower frequency of 10⁻⁵ /year per vessel may be adopted.

6.0 LAND USE PLANNING ASSESSMENT OF MAJOR ACCIDENT HAZARDS AT PROPOSED OCGT PLANT

The following major accident scenarios at the Huntstown Power Station that could have consequence effects at the proposed Substation development are assessed herein:

- Vapour Cloud Explosion in a turbine enclosure;
- Jet fire from natural gas AGI area;
- Fireball and BLEVE from LPG tank rupture;
- Uncontained pool fire from Fuel Oil tank rupture and overtop.

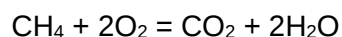
6.1 Natural Gas Vapour Cloud Explosion at Turbine Enclosure

In the event of ignition of a flammable cloud of vapour following a leak of natural gas within the gas turbine enclosure, there is the potential for a vapour cloud explosion to occur with damaging levels of peak overpressure.

6.1.1 VCE Model Inputs

TNO Effects Version 11.3.0 was used to model a VCE in one of the turbine enclosures.

It is assumed that an accidental release of natural gas occurs in the turbine enclosure of the Phase 1 turbine hall. In order for a vapour cloud explosion to occur, the concentration of natural gas must lie between the lower and upper flammable limits. It is assumed that concentration within the turbine enclosure is a stoichiometric mixture of air and flammable gas. The complete combustion equation for methane is:



The volume of the turbine enclosure was estimated as 944 m³. The (mass) fraction of methane within this volume was calculated as 0.056 and the total flammable mass was calculated as 63.73kg.

The VCE model inputs are detailed in Table 12:

Parameter	Units	Value	Source
Chemical name		methane	-
Temperature	°C	5	Huntstown
Volume of turbine hall	m ³	944	Huntstown documents
Flammable mass	kg	63.73	Mass of methane assuming stoichiometric mixture of air and flammable vapour
Fraction of flammable cloud confined	-	1	Confined VCE within turbine enclosure
Curve number	-	7	Strong deflagration – assume high ignition energy, high obstruction and confined conditions
Wind direction	deg	240	Prevailing wind direction at nearest synoptic met station

Table 12 Natural Gas VCE in Phase 1 Turbine Enclosure: Model Inputs

6.1.2 VCE Model Outputs

The model outputs are detailed in Table 13.

Parameter	Units	Value
Confined mass in explosive range	kg	63.73
Total combustion energy	MJ	3188.5
Maximum peak overpressure	bar	1.04

Table 13 Natural Gas VCE Phase 1 Turbine Enclosure: Model Outputs

The following figures illustrate the overpressure effects following a Natural Gas VCE at the Phase 1 Turbine Enclosure

- Figure 5 Natural Gas VCE in Phase 1 Turbine Enclosure: Overpressure vs Distance
- Figure 6 Natural Gas VCE in Phase 1 Turbine Enclosure: Probability of Fatality vs Distance

Mortality results are presented for receptors outdoors and indoors in the following types of structures:

- Category 2 structures, typical office block – representative of occupied buildings on site
- Category 3 structures, residential dwellings

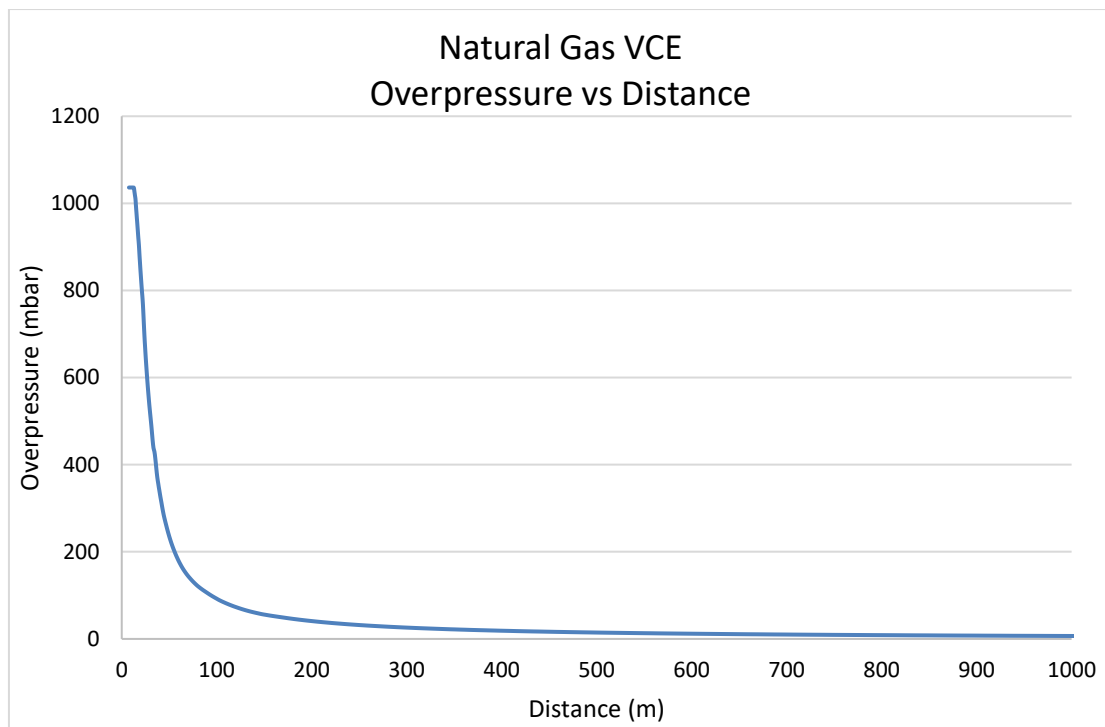


Figure 5 Natural Gas VCE in Phase 1 Turbine Enclosure: Overpressure vs Distance

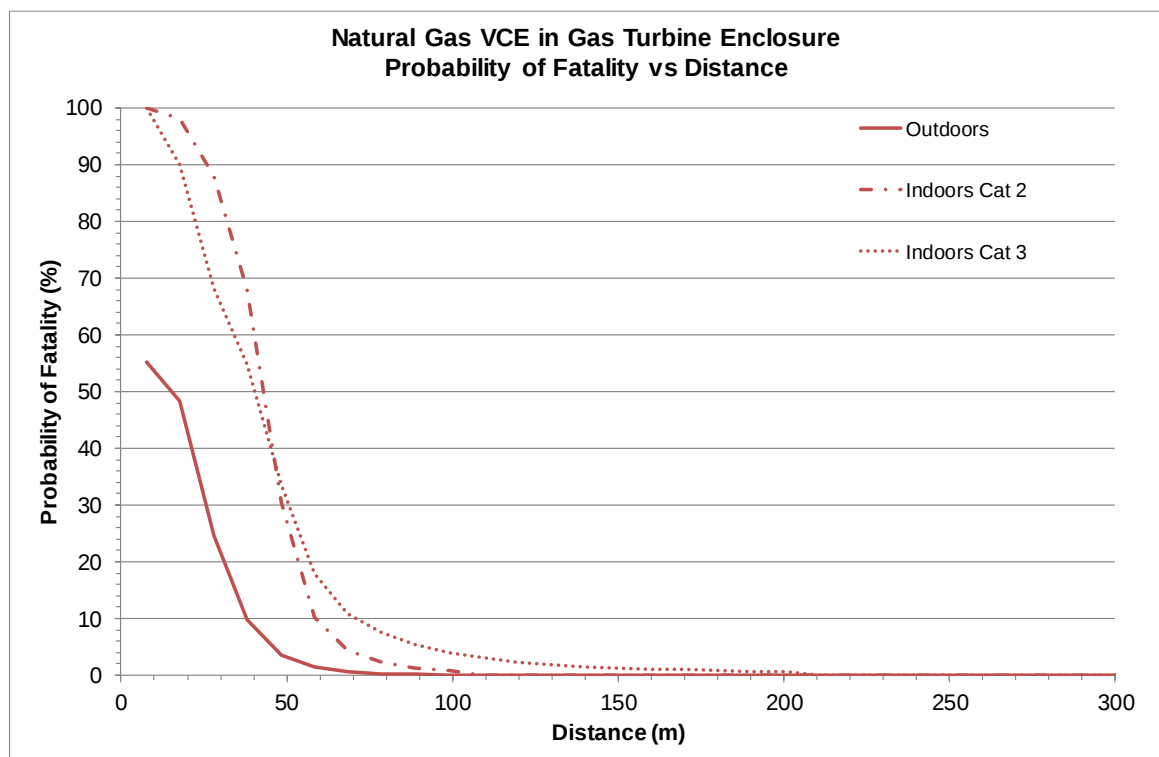


Figure 6 Natural Gas VCE in Phase 1 Turbine Enclosure: Probability of Fatality vs Distance

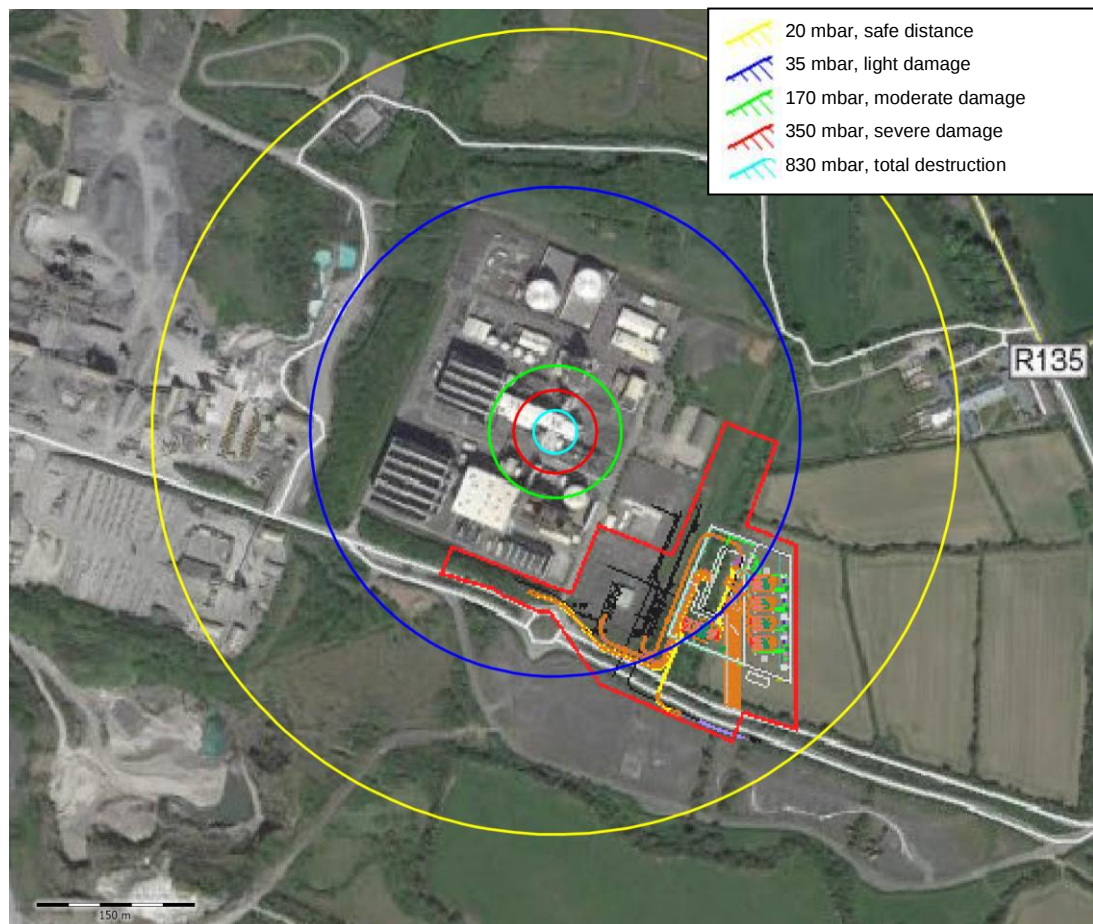
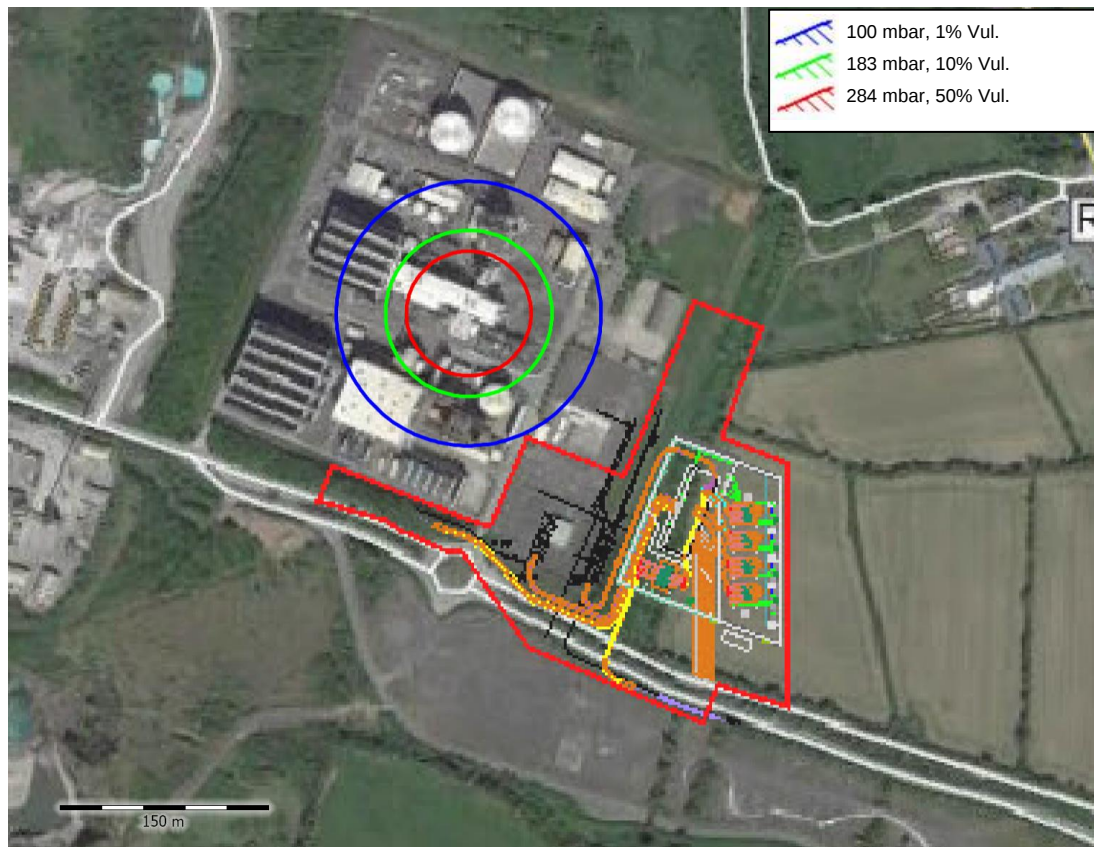


Figure 8 Natural Gas VCE in Turbine Enclosure: Blast Damage Contours



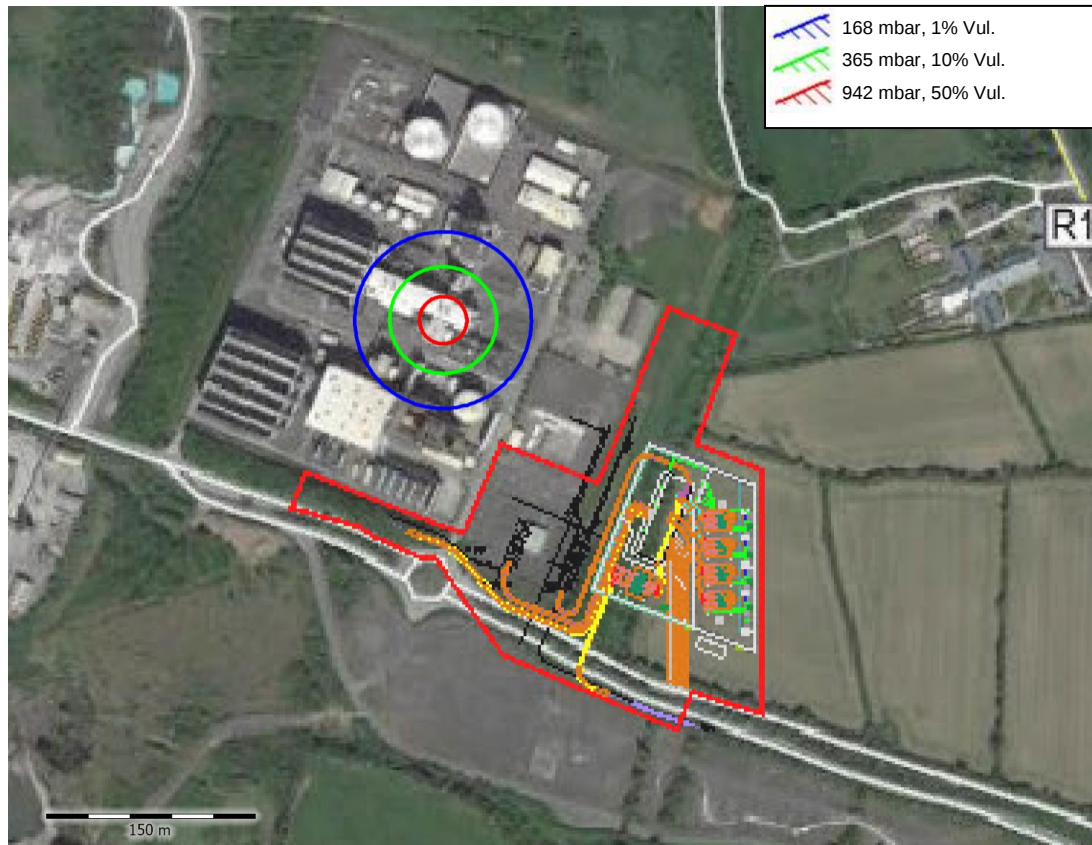


Figure 9 Natural Gas VCE in Turbine Enclosure: Outdoor Mortality Contours

In the event of a VCE in the Phase 1 Turbine Enclosure the following is concluded:

- Overpressure levels corresponding to safe and light damage extends to the proposed Substation development;
- Overpressure levels corresponding to 1% mortality outdoors do not extend to the proposed Substation development;
- Overpressure levels corresponding to 1% mortality indoors (Cat. 2) do not extend to the proposed Substation development.

It is concluded that a VCE in the Phase 1 Turbine Enclosure is not expected to result in equipment damage or fatalities at the proposed Substation development.

6.1.3 VCE Frequency

The HSA specifies a likelihood of 1E-04 per year when assessing Vapour Cloud Explosion scenarios in processing areas, for land use planning purposes.

6.2 Natural Gas Jet Fire

Information on the GNI high pressure natural gas pipeline that supplies natural gas to Huntstown Power Station was obtained from GNI as follows:

- 300 mm diameter;
- 70 bar design pressure;
- Approximately 1.91 km from Kilshane AGI to Huntstown AGI

The “Wilson Model” (TNO Yellow Book, 2005) models discharge from a long pipeline.

The initial release rate mainly depends on the pipe diameter (full bore rupture scenario) or hole size, the friction of the flow inside the pipeline depending on the wall roughness and the initial pressure inside the pipeline. Because of the release, the pressure inside the pipeline will drop in the region of the leak at first. The pressure drop ‘travels’ along the length of the pipeline, with a velocity equal to the sound velocity. This causes the gas release to become non-stationary until the pressure drop reaches the end of the pipeline. The ongoing release can be assumed to be stationary and continuous until the pipeline is empty.

6.2.1 Discharge Model Inputs

The long pipeline model inputs are detailed in Table 14.

Parameter	Units	Value	Source
Chemical name		Methane	-
Initial temperature	°C	10	Assume average ambient temperature
Initial (absolute) pressure in pipeline	bar	70	Huntstown
Pipeline diameter	mm	300	GNI Drawings
Pipeline length	km	1.91	Estimated length from Kilshane AGI to Huntstown AGI (GNI drawings and google earth)
Hole type		Guillotine fracture	Assume pipeline rupture

Table 14 High Pressure Natural Gas Supply Pipeline Rupture: Discharge Model Inputs

6.2.2 Discharge Model Outputs

The long pipeline model calculates the drop off in release rate with time, and also the “Purple Book” representative release rate over time in 5 steps, as illustrated on Figure 10.

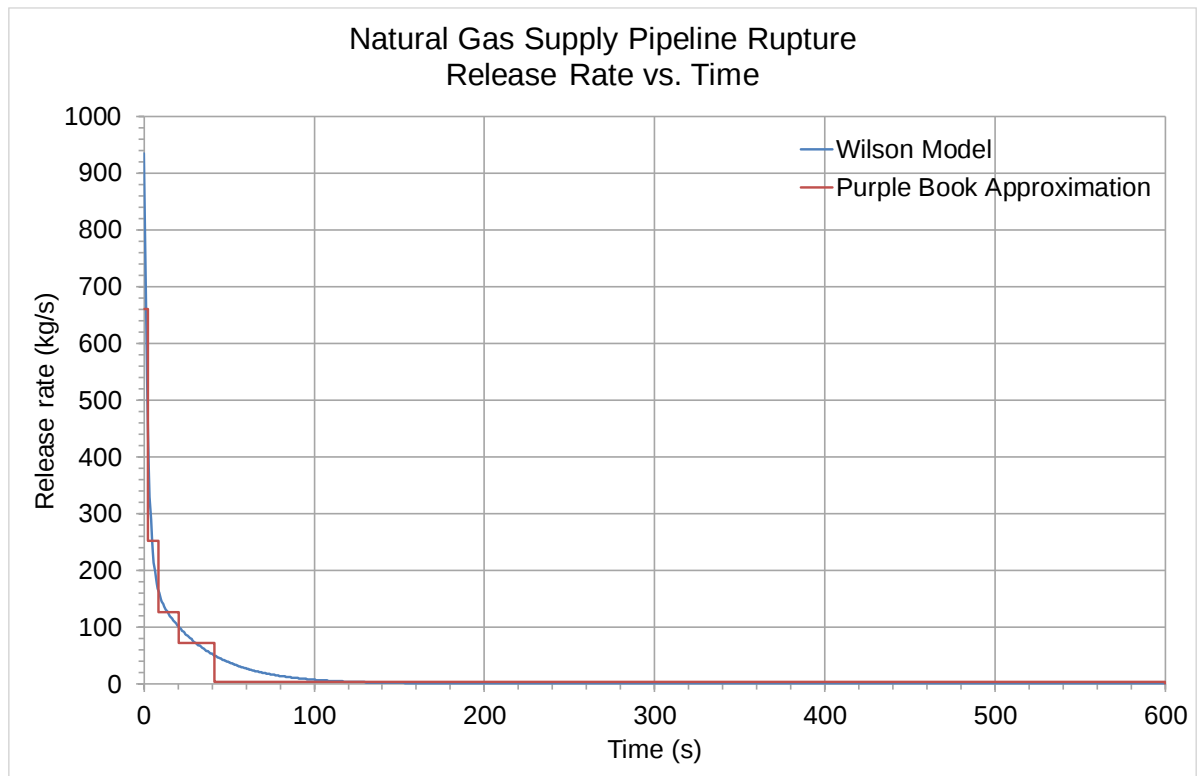


Figure 10 High Pressure Natural Gas Supply Pipeline Rupture: Release Rate vs. Time

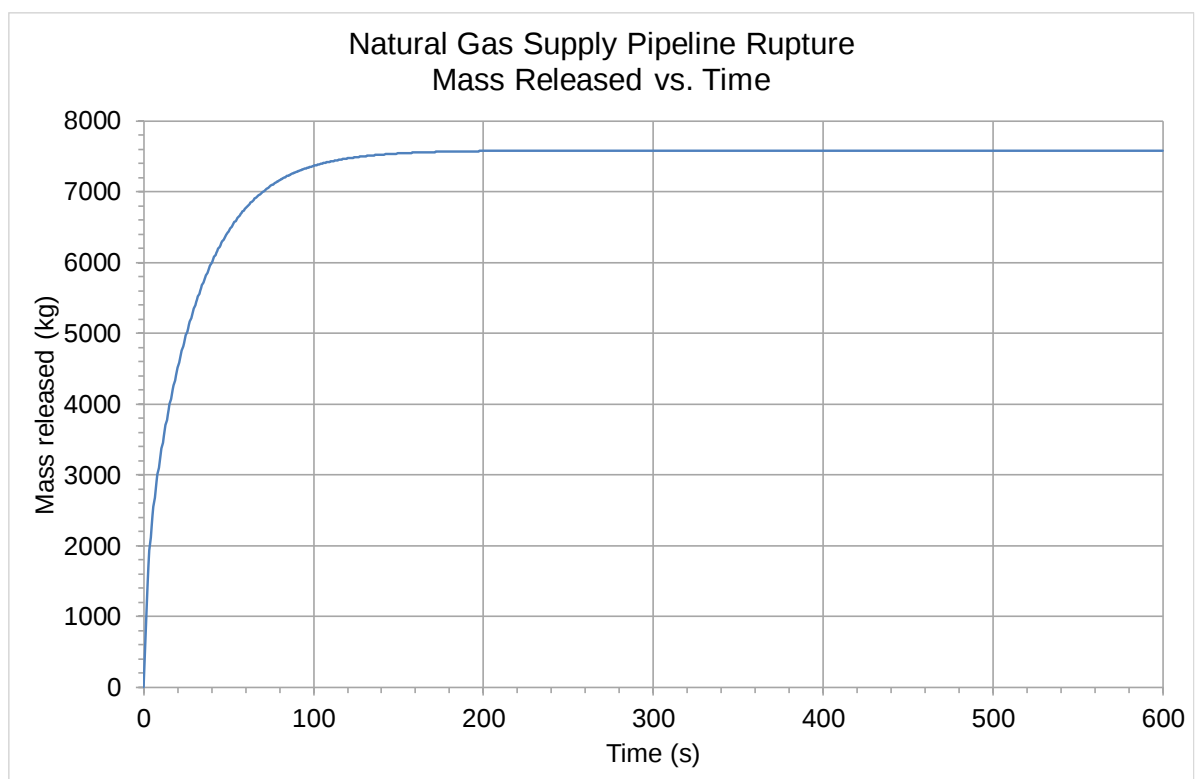


Figure 11 High Pressure Natural Gas Supply Pipeline Rupture: Mass Released vs. Time

The long pipeline model outputs are as follows:

Pipeline volume	135 m ³
Initial mass in the pipe	7,539.3 kg
Average mass flow rate	12.6 kg/s
Maximum mass flow rate	935 kg/s

Effects approximates the time-varying source term into five discrete time segments with constant outflow conditions by dividing the total mass released evenly over these five time segments – the Purple Book Approximation on the Release rate vs. Time chart above.

The following release rates are calculated for the five discrete time segments:

Segment	Time period	Release rate
1	0 – 2.29 s	660.77 kg/s
2	2.29 – 8.32s	251.51 kg/s
3	8.32 – 20.34 s	126.21 kg/s
4	20.34 – 42.26 s	72.5 kg/s
5	42.26 – 600 s	2.77 kg/s

TNO recommends that the following rules can be followed:

- For flammable substances, the outflow conditions are equal to the conditions of the first (highest) segment, having approximated the time-varying release with five time segments.

As natural gas is extremely flammable, the outflow conditions that input to the jet fire and flash fire models are equivalent to the first segment. Therefore, the mass flow rate that is input to the jet fire or flash fire models is taken as 660.77 kg/s.

6.2.3 Jet Fire Model Inputs

The inputs for the Jet Fire model are detailed in Table 15

Parameter	Units	Value	Source
Chemical name		Methane	-
Mass flow rate	kg/s	660.77	Long pipeline model output
Exit temperature	°C	10	Assume average ambient
Exit pressure	bar	70	Pipeline design pressure
Hole diameter	mm	300	Pipe rupture scenario
Outflow angle	deg	0	Assume horizontal release (worst case scenario)
Release height	m	1	Assumption
Ambient temperature	°C	10	Dublin Airport 1989 – 2018 averages, www.met.ie
Wind speed	m/s	2, 5, 10	HSA recommended wind speed for fire models
Receptor height	m	1.5	Assumed

Table 15 Natural Gas Jet Fire at GNI AGI: Model Inputs

6.2.4 Jet Fire Model Outputs

The Jet Fire model outputs are detailed Table 16.

Parameter	Units	2 m/s	5 m/s	10 m/s
Type of flow of met	-	Choked	Choked	Choked
Exit velocity of expanding jet	m/s	886	886	886
Angle between hold and flame axis (alpha)	deg	0	0	0
Frustum lift off height	m	64.505	51.792	42.781
Width of frustum base	m	13.041	1.8758	0.71537
Width of frustum tip	m	84.747	70.25	60.368
Length of frustum (flame)	m	258.02	207.17	171.13
Surface area of frustum	m ²	45788	27667	19529
Surface emissive power	kW/m ²	88.086	145.78	206.52

Table 16 Natural Gas Jet Fire at GNI AGI: Model Outputs

The jet fire frustum shape, and thermal radiation and probability of fatality with distance are illustrated on the following figures.

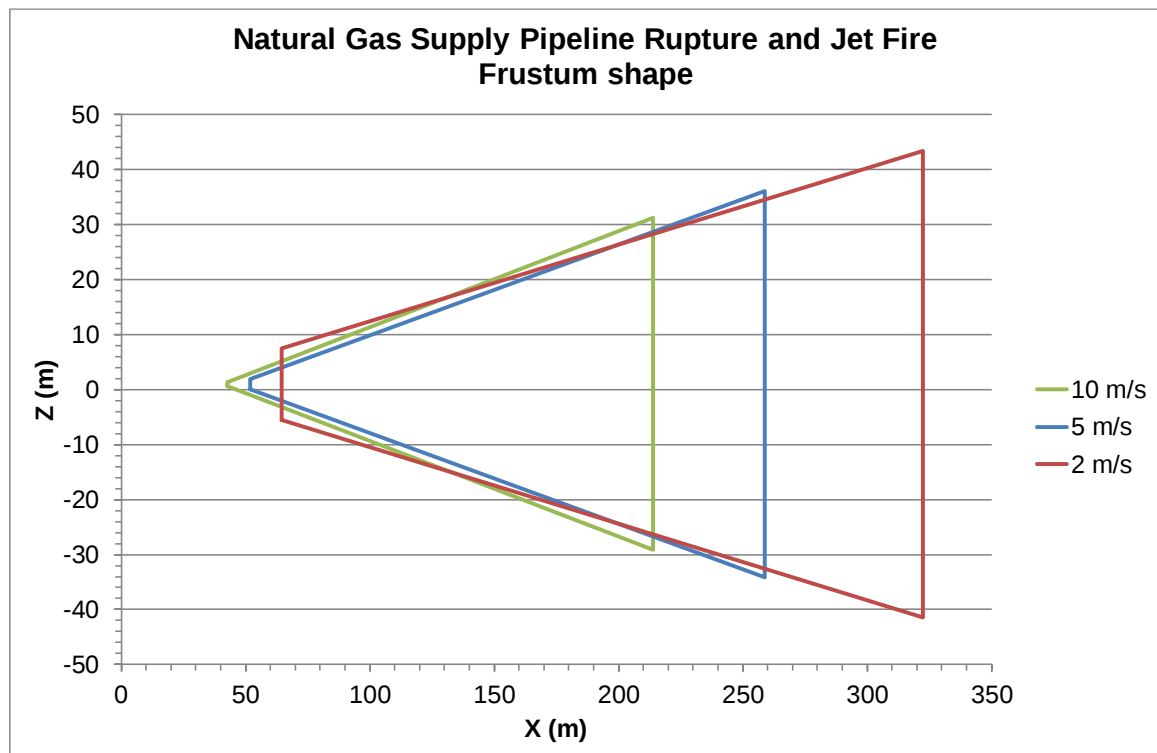


Figure 12 Natural Gas Jet Fire at GNI AGI: Frustum Shape

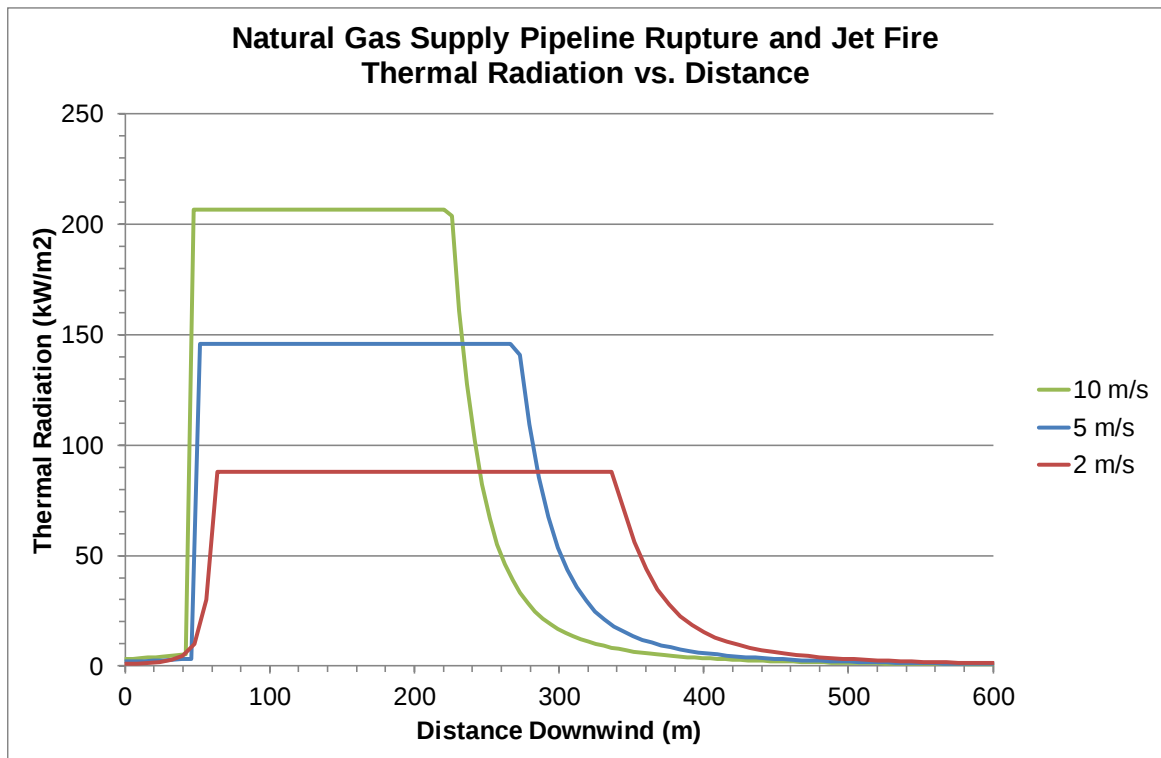


Figure 13 Natural Gas Jet Fire at GNI AGI: Thermal Radiation vs. Distance

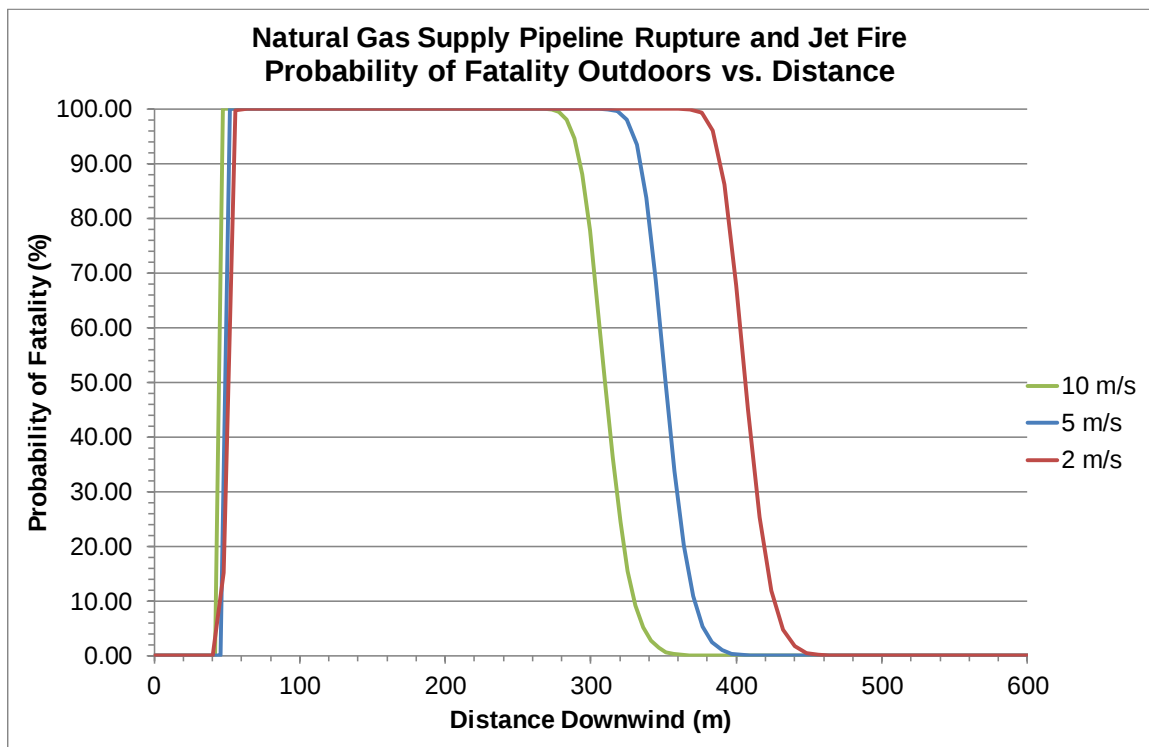


Figure 14 Natural Gas Jet Fire at GNI AGI: Probability of Fatality Outdoors vs. Distance

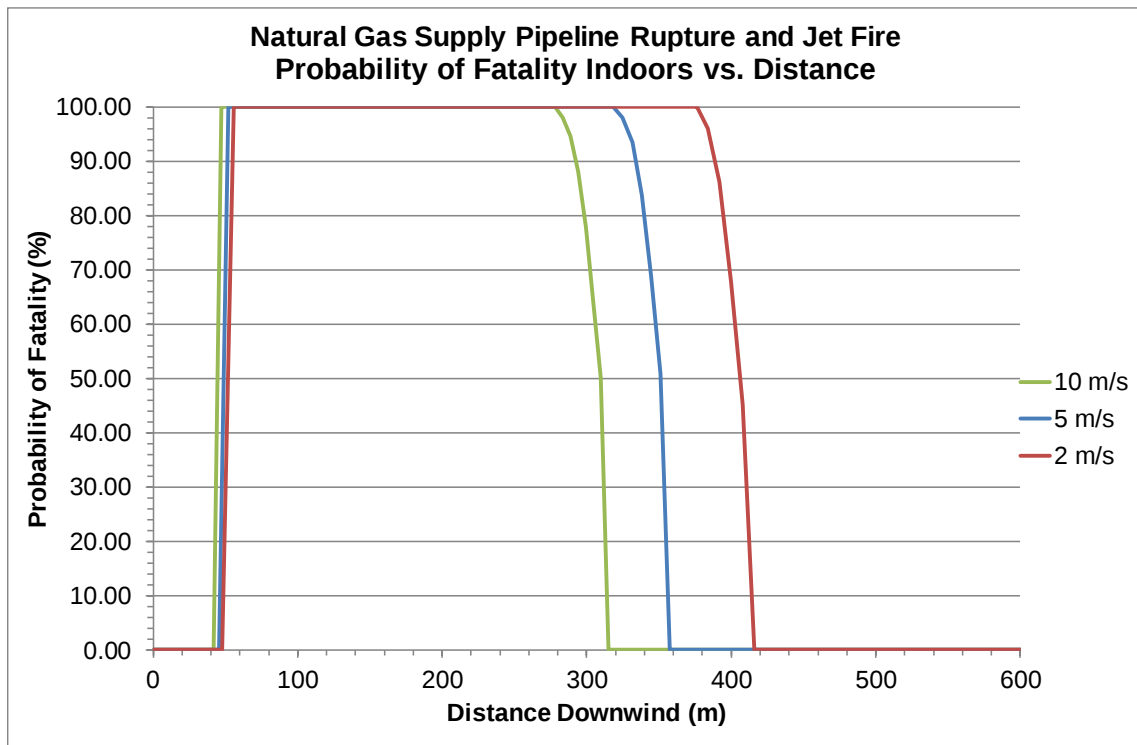


Figure 15 Natural Gas Jet Fire at GNI AGI: Probability of Fatality Indoors vs. Distance

Table 17 details distances to specified thermal radiation levels associated with

- the threshold of mortality
- 1%, 10% and 50% mortality outdoors
- 0% mortality and 100% mortality indoors
- damage to process equipment

Consequence	Thermal radiation level (kW/m ²)	Distance (m)		
		2 m/s	5 m/s	10 m/s
Threshold of fatality	4.1	479	428	387
1% mortality outdoors	6.8	444	390	349
0% mortality indoors	12.7	409	354	313
100% mortality indoors	25.6	379	324	282
Equipment damage	37.5	365	310	269

Table 17 Natural Gas Jet Fire at GNI AGI: Calculated Distances at Specified Thermal Radiation Levels

Thermal radiation contours and effect areas are presented on the following figures (for the worst case wind speed scenario):

- Figure 17 *Natural Gas Jet Fire at GNI AGI: Indoor Mortality and Equipment Damage Contours*
-



Figure 16 Natural Gas Jet Fire at GNI AGI: Outdoor Mortality Contours

- Figure 17 Natural Gas Jet Fire at GNI AGI: Indoor Mortality and Equipment Damage Contours



Figure 16 Natural Gas Jet Fire at GNI AGI: Outdoor Mortality Contours

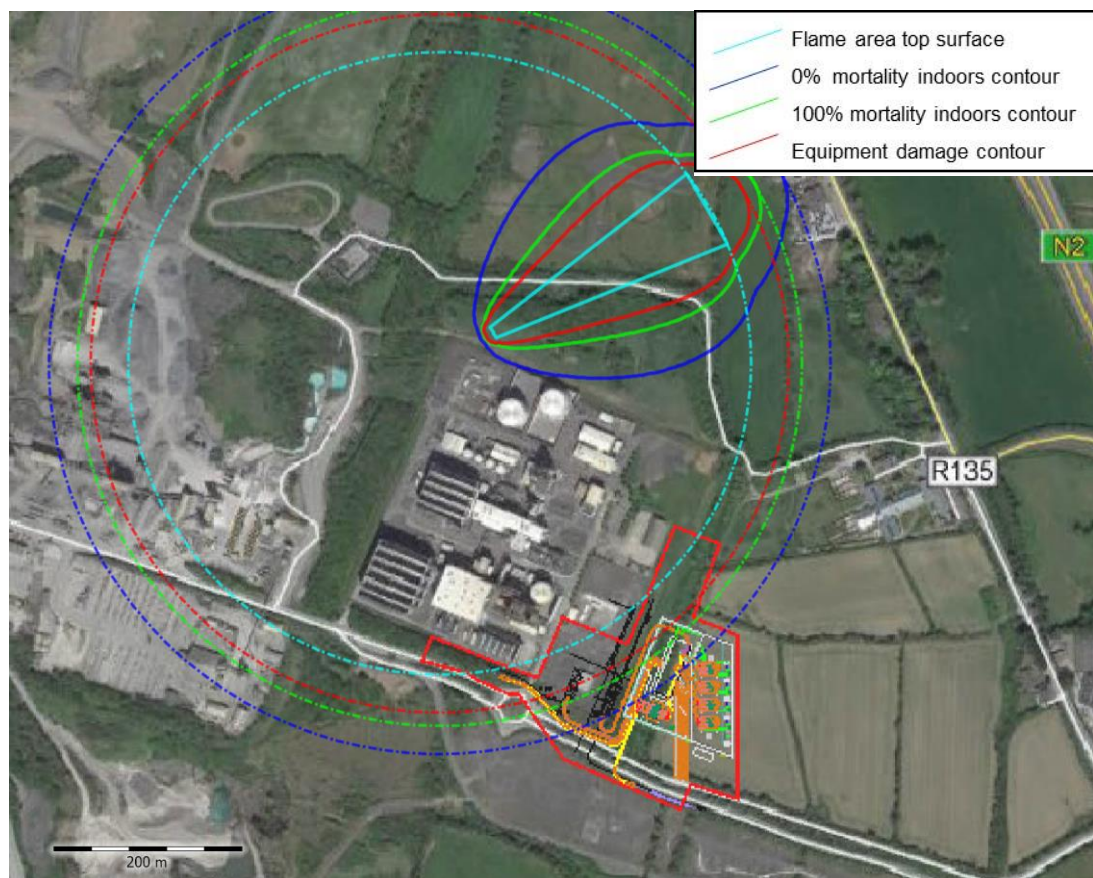


Figure 17 Natural Gas Jet Fire at GNI AGI: Indoor Mortality and Equipment Damage Contours

In the event of a natural gas jet fire following rupture of the natural gas supply line at the GNI AGI, the following is concluded:

- The jet flame measures up to 258 m in length (depending on wind speed)
- The thermal radiation level corresponding to 1% mortality outdoors extends to the proposed Substation development; therefore, there is a possibility of fatality to persons outdoors in the event of a jet fire.
- The thermal radiation level corresponding to 100% mortality indoors extends to the proposed development but does not extend to any buildings on site.
- The thermal radiation level corresponding to equipment damage extends to the proposed Substation. There is potential for damage to equipment at the substation.
- GNI will be responsible for the installation, operation, and maintenance of all equipment within the AGI gas compound. All operations within the AGI will comply with standard GNI operational procedures and risk assessments and will be carried out by approved GNI contractors.

In relation to impacts from a jet fire following rupture of the natural gas supply pipeline at the GNI AGI, it is noted that the thermal radiation impacts that are predicted are conservative as they are based on a mass flow rate of 661 kg/s, as recommended by TNO and as explained above. It is noted that after approximately 9 s the release rate will reduce to 126 kg/s and after 44 s it will reduce to less than 3 kg/s and will continue to reduce until all of the natural gas has been released from the pipeline (approximately 600 s or 10 minutes). Therefore, the estimated consequences are conservative.

6.2.5 Jet Fire Frequency

The HSA Land Use Planning Guidance document does not provide a value for the failure rate of a natural gas pipeline; however, reference is made to the Purple Book (CPD, 2005) which gives a failure rate of 3E-07/yr/m for a full-bore rupture from a pipeline with a diameter between 75 mm and 150 mm. The length of pipeline above ground at the AGI is 150 m. A probability of ignition of 0.09 is assigned based on the Purple Book approximation for a continuous release (>150 kg/s) of a low reactive gas (methane).

Therefore, a likelihood of 4.05E-06/year was used in this study.

6.3 Fuel Oil Tank Rupture and Pool Fire

Ignition of an accidental release resulting in a pool fire has been modelled using TNO Effects version 11.3.0 modelling software. The HSA COMAH LUP Guidelines (HSA, 2010) identify a bunded pool fire and an uncontained pool fire following bund overtop to be the major accident hazards associated with fuel storage.

6.3.1 Bunded Pool Fire

The tank and bund properties for the Phase 1 and Phase 2 tanks are detailed in Table 18.

Parameter	Units	Value	
		Phase 1	Phase 2
Volume of liquid in tank	m ³	7200	7200
Radius of vertical tank	m	14	14
Height of liquid in tank	m	11.69	11.69
Bund width	m	34	32.6
Bund length	m	62.6	62.6

Parameter	Units	Value	
		Phase 1	Phase 2
Bund height	m	5.9	5.9
Bund surface area	m ²	2128.4	2040.8
Bund volume	m ³	12557.6	12040.5
Available Bund Surface Area	m ²	1512.6	1425.1

Table 18 Fuel storage tank and bund properties

It can be seen in Table 18 that the Phase 1 bund has a larger surface area. This will be modelled as a worst-case scenario for a bunded pool fire following fuel tank rupture.

6.3.1.1 Model Inputs

Pool fire model inputs are detailed in Table 19.

Parameter	Units	Value	Source
Chemical name		Fuel Oil Sample	Recommended by TNO for modelling of marked fuel oil
Area of pool	m ²	1512.6	Calculated
Maximum heat exposure duration	s	75	HSA LUP guidance (HSA,2010)
Surface Emissive Power	kW/m ²	52	HSA LUP guidance (HSA,2010)
Temperature of pool	°C	10	Atmospheric Temperature
Wind speed	m/s	5	HSA LUP guidance (HSA,2010)
Ambient temperature	°C	10	30 year average at nearest synoptic meteorological station (Dublin Airport)
Wind direction	deg	240	Prevailing wind direction at nearest synoptic met station

Table 19 Fuel Oil Pool Fire Model Inputs

6.3.1.2 Model Outputs

The thermal radiation vs distance for a bunded pool fire is illustrated on Figure 18.

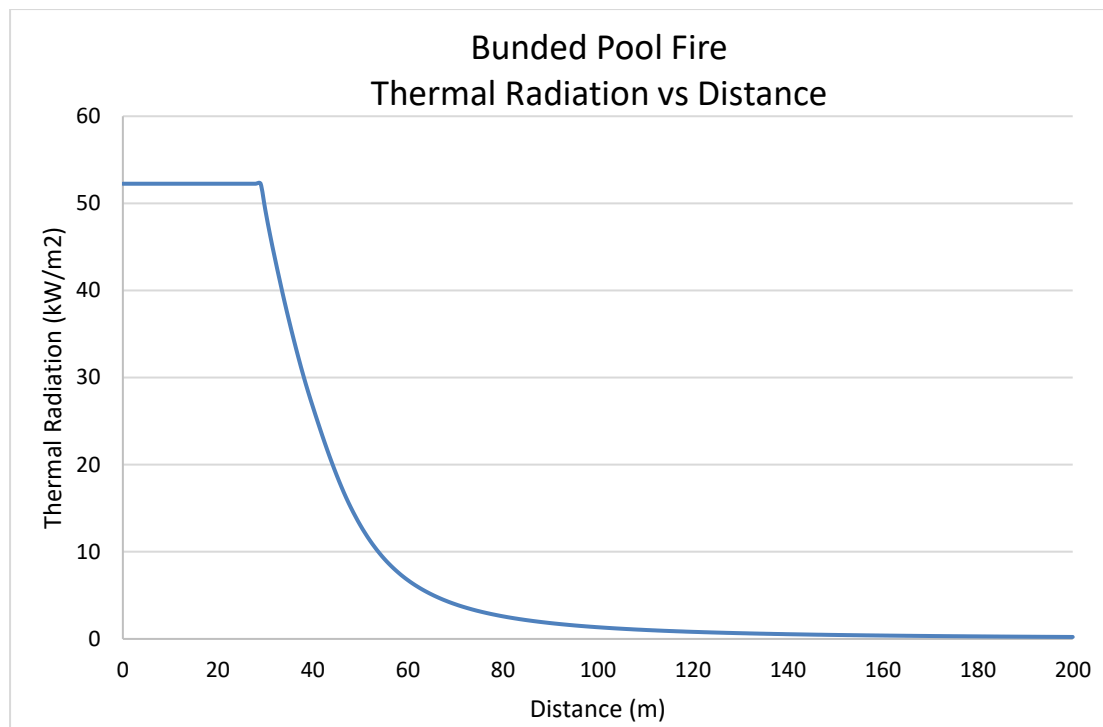


Figure 18 Fuel Storage Bunded Pool Fire: Thermal Radiation vs Distance

The thermal radiation contours corresponding to the threshold of fatality (4.1 kW/m^2) are illustrated in Figure 19.

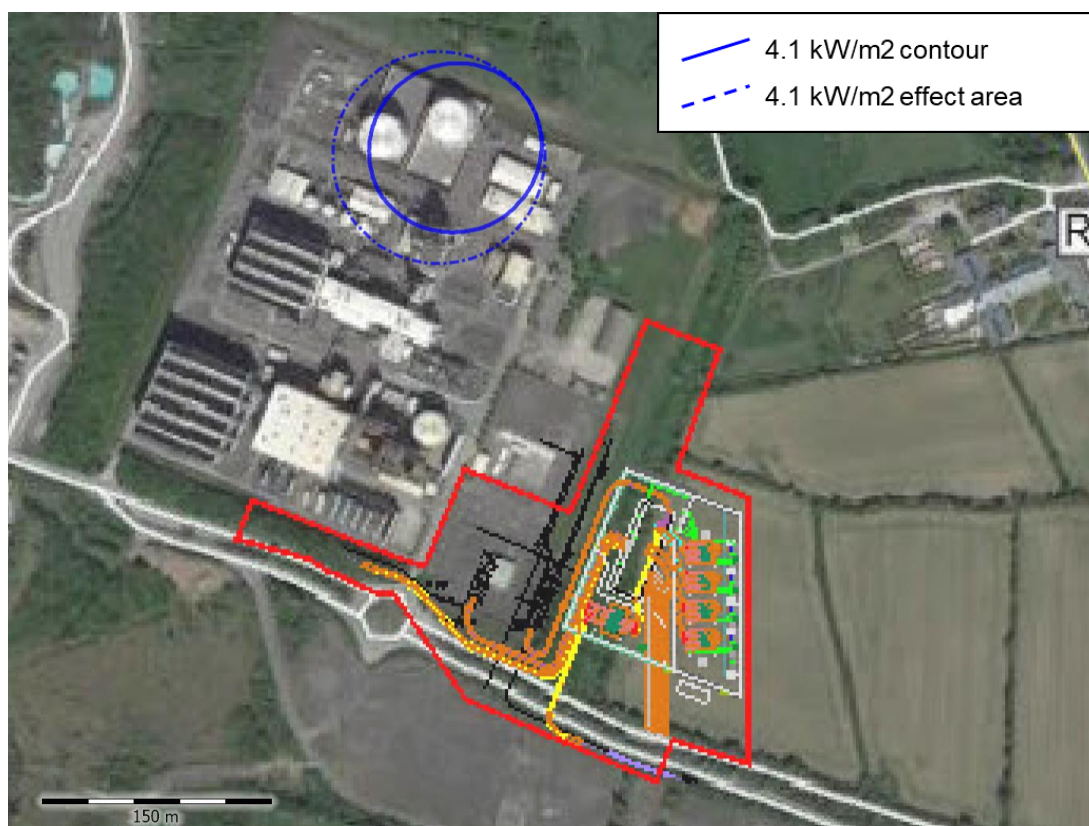


Figure 19 Fuel Storage Bunded Pool Fire: Threshold of Fatality Contour (4.1 kW/m^2)

It is concluded that the thermal radiation contour corresponding to the threshold of fatality

(4.1 kW/m²) does not extend to the proposed Substation development.

It is concluded, that a bundled pool fire at the Phase 1 fuel storage tank is not expected to result in any thermal consequences at the proposed Substation.

6.3.2 Uncontained Pool Fire

6.3.2.1 Model Inputs

The area of the pool is calculated using the equation set out in Risk-based Land Use Planning (HSA, 2010):

$$R = 6.85V^{0.44537}$$

The tank has a volume of 7200m³, therefore, will have the maximum pool diameter as calculated by the equation above (see Section 5.3). The surface area of the pool is 7854 m². The pool fire is centred 50m to the south east of the bund, in the direction of the proposed Substation. This is a representative worst-case scenario.

The pool fire scenario is modelled at a wind speed of 5 m/s as per the HSA's land use planning policy and approach document (HSA, 2010).

The model inputs for the uncontained pool fire are detailed in Table 20.

Parameter	Units	Value	Source
Chemical name		Fuel Oil Sample	Recommended by TNO for modelling of marked fuel oil
Area of pool	m ²	7854	Calculated
Maximum heat exposure duration	s	75	HSA LUP guidance (HSA,2010)
Surface Emissive Power	kW/m ²	52	HSA LUP guidance (HSA,2010)
Temperature of pool	°C	10	Atmospheric Temperature
Wind speed	m/s	5	HSA LUP guidance (HSA,2010)
Ambient temperature	°C	10	30 year average at nearest synoptic meteorological station (Dublin Airport)
Wind direction	deg	240	Prevailing wind direction at nearest synoptic met station

Table 20 Fuel Storage Uncontained Pool Fire: Model Inputs

6.3.2.2 Model Outputs

The uncontained pool fire model outputs are detailed in

Parameter	Windspeed 5m/s
Combustion rate (kg/s)	267
Duration of the pool fire (s)	11055
Flame tilt (deg)	46.1
Flame temperature (°C)	708.2
Length of the flame (m)	43.9

Table 21 Uncontained Pool Fire: Model Outputs

The pool fire thermal radiation and probability of fatality with distance are illustrated on the following figures.

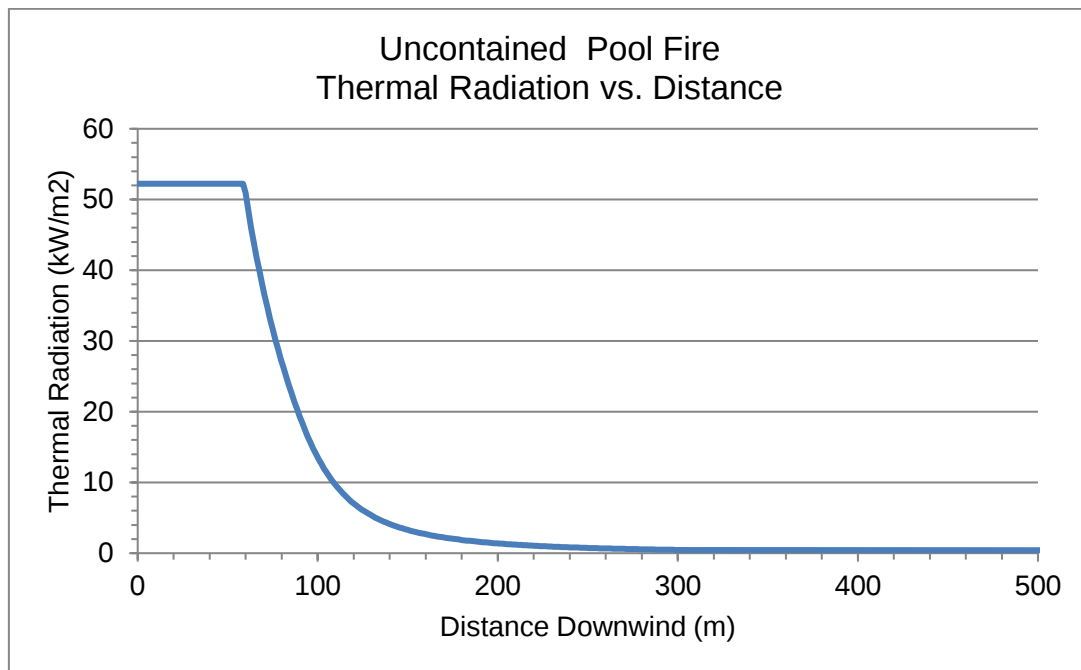


Figure 20 Fuel Oil Uncontained Pool Fire: Thermal Radiation vs Distance

Table 22 details distances to specified thermal radiation levels associated with

- the threshold of morality
- 1 % mortality outdoors
- 0% mortality and 100% mortality indoors
- damage to process equipment

Criterion	Thermal Radiation Level	Distance to specified levels
	kW/m ²	m
Threshold of Fatality	4.1	138
1% Mortality Outdoors	6.8	121
Building protected below this level, 0% fatality probability	12.7	102
Building will catch fire quickly, 100% fatality probability	25.6	82
Damage to process equipment	37.5	69

Table 22 Uncontained Pool Fire: Distances to Specified Thermal Radiation Levels

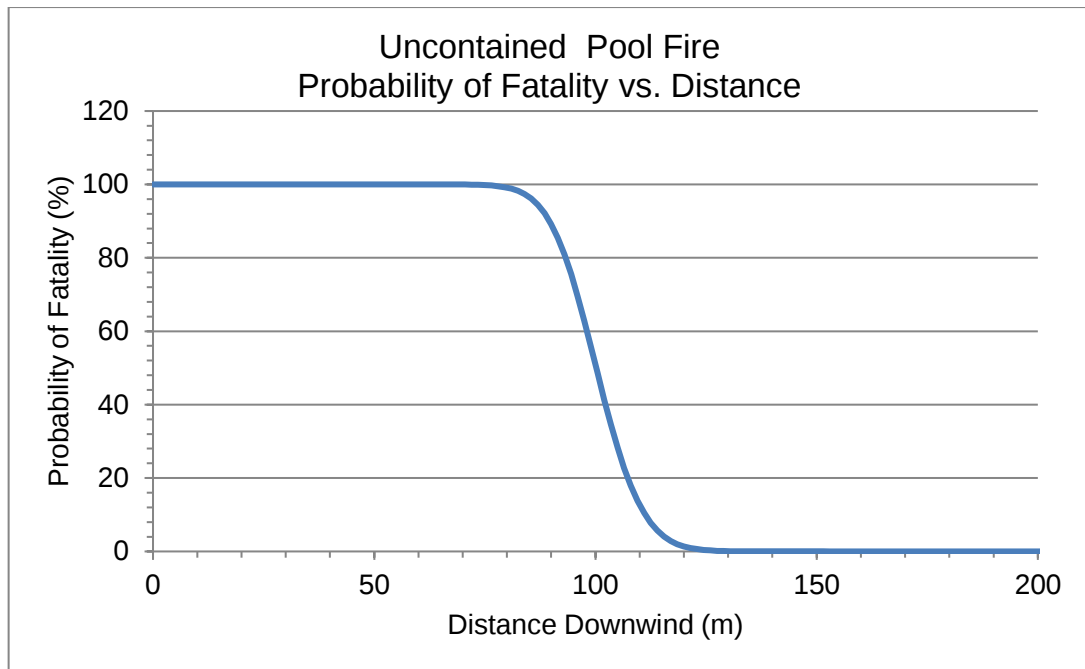


Figure 21 Fuel Oil Uncontained Pool Fire: Probability of Fatality Outdoors vs Distance

Thermal radiation contours and effect areas corresponding to the threshold of fatality (4.1 kW/m^2), 1% fatality (6.8 kW/m^2) and person protected indoors (12.7 kW/m^2) for an uncontained fuel oil pool fire are illustrated on Figure 22.

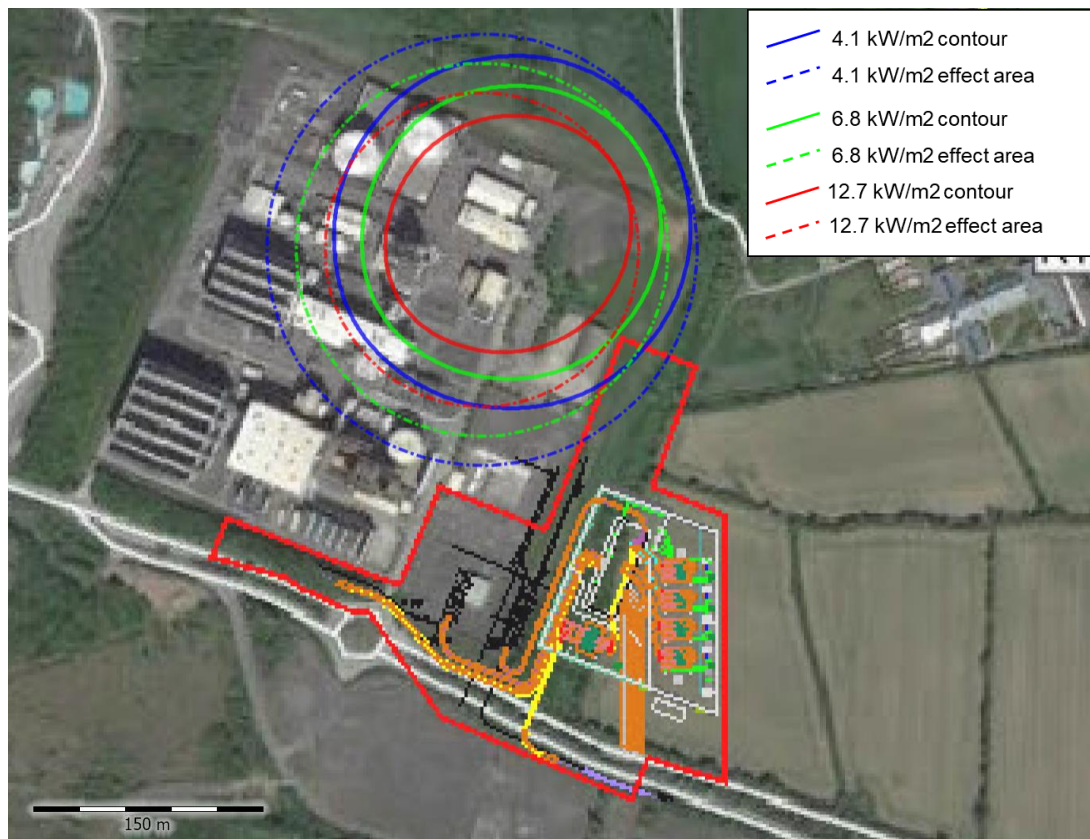


Figure 22 Uncontained Pool Fire: Thermal radiation contours

In the event of a tank rupture resulting in a Fuel Oil uncontained pool fire, the following is concluded:

- The thermal radiation contour corresponding to the threshold of fatality does not extend to the proposed development.
- The thermal radiation contour corresponding to persons protected indoors does not extend to the proposed development.

It is concluded that an uncontained pool fire at the Phase 1 fuel storage tank is not expected to result in any thermal consequences at the proposed Substation.

6.3.3 Pool Fire Frequency

The HSA Land Use Planning Guidance document states that a pool fire which covers the entire surface of the bund has a frequency of 1E-03/year.

The HSA Land Use Planning Guidance document states for larger installations an event frequency of 10E-04/(100π) per metre/year along a locus 50 m from the vessel storage area). The fuel oil tank storage area is 259 m², this gives a frequency of 8.23E-05/year. Therefore, as a conservative approach, a frequency of 1E-04/year is used in this study.

6.4 **LPG Fireball and BLEVE**

The consequences and individual risk of fatality from a BLEVE and Fireball at the LPG tank are assessed in the following sections, as well as details of the protective measures that are in place on the LPG tank.

The LPG tank is used as an ignition gas supply for Unit 1 at Huntstown. The tank has the capacity to hold 5 m³ of LPG however the maximum fill level is set to 60%.

6.4.1 Protective Measures

The following measures are in place to prevent an accidental release of LPG from the propane tank:

- LPG tank is located in outdoor well-ventilated compound that is secured, with fencing and restricted access;
- Housekeeping ensures that there is no combustible debris in the vicinity of tank;
- Tank maintenance and testing is routinely carried out by an external approved contractor. Non-destructive examination inspections are carried out every 8 years and statutory maintenance is carried out as per advice of Competent Person under Pressure Systems Regulations Act, this role for Huntstown is looked after by Inforisk.
- ATEX zones have been identified at the LPG tank and measures are in place to prevent ignition sources within the zones as follows:
 - Control of mobile or portable equipment in classified areas
 - Tanks are earthed
 - Delivery tankers are bonded to LPG tank during unloading
 - Competent driver present during bulk liquefied gas unloading
 - Warning Ex signage is displayed in classified areas
 - Hot work permit to be issued and fully implemented in accordance with local procedures
 - Access to LPG compound is restricted to authorised personnel only
- Pressure relief valves are located on LPG tank;
- Driver training, traffic management measures and speed limits are in place on site roads to minimise the likelihood of a vehicle accidentally impacting tank.

6.4.2 Model Inputs

The LPG BLEVE and fire ball model inputs are detailed in Table 23.

Parameter	Units	Value	Source
Chemical name	-	Propane	-
Tank capacity	m ³	5	Huntstown
Maximum inventory	m ³	3	Huntstown
Operating temperature	°C	55	Huntstown
Ambient temperature	°C	10	30 year average at nearest synoptic meteorological station (Dublin Airport)

Table 23 LPG BLEVE and Fire Ball: Model Inputs

6.4.3 BLEVE Blast Model Outputs

The overpressure vs distance for a BLEVE is illustrated on Figure 23.

The probability of fatality vs distance is illustrated on Figure 24.

Mortality results are presented for receptors outdoors and indoors in the following types of structures:

- Category 2 structures, typical office block – representative of occupied buildings at the proposed development
- Category 3 structures, residential dwellings

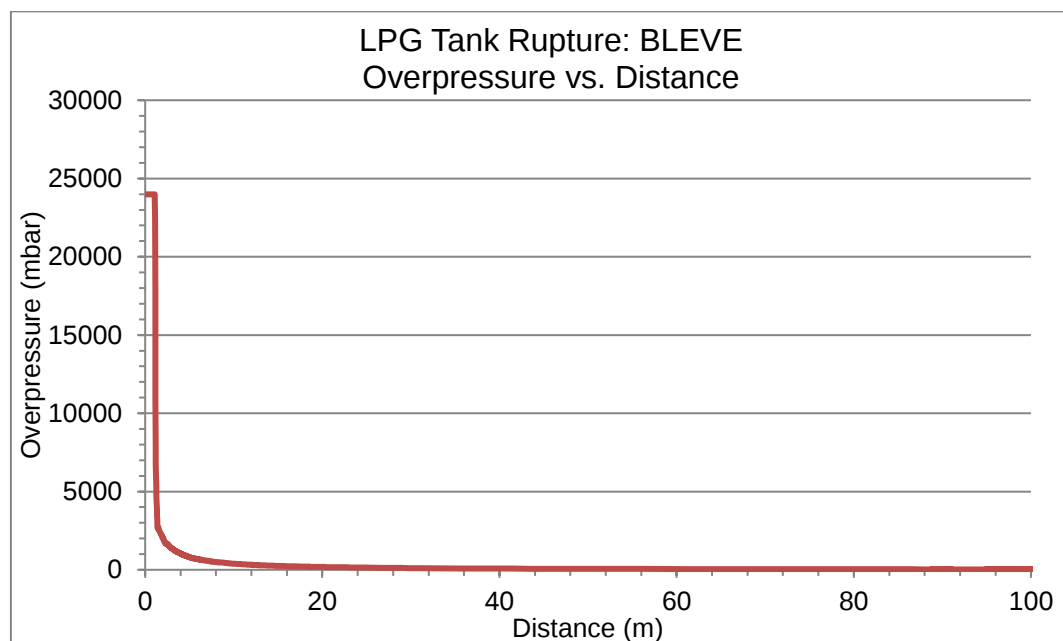


Figure 23 LPG BLEVE: Overpressure vs Distance

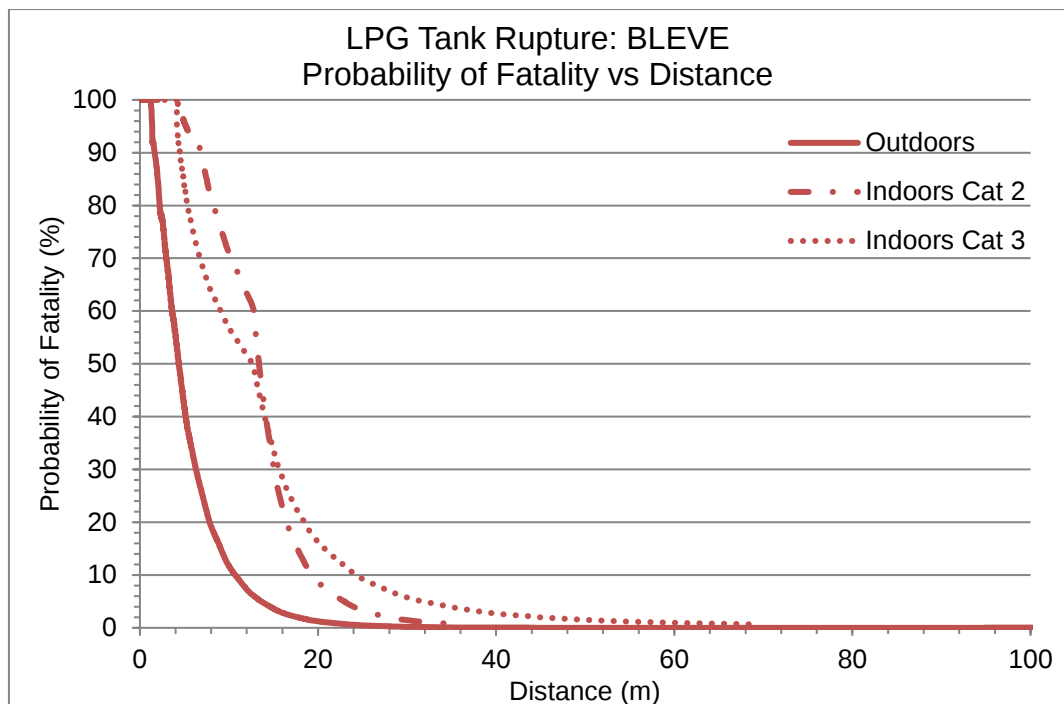


Figure 24 LPG BLEVE: Probability of Fatality vs Distance

The following figures present overpressure contours:

- Figure 25 LPG BLEVE: Blast Damage Contours
- Figure 26 LPG BLEVE: Indoor Mortality Contours (Category 2)
- Figure 27 LPG BLEVE: Outdoor Mortality Contours

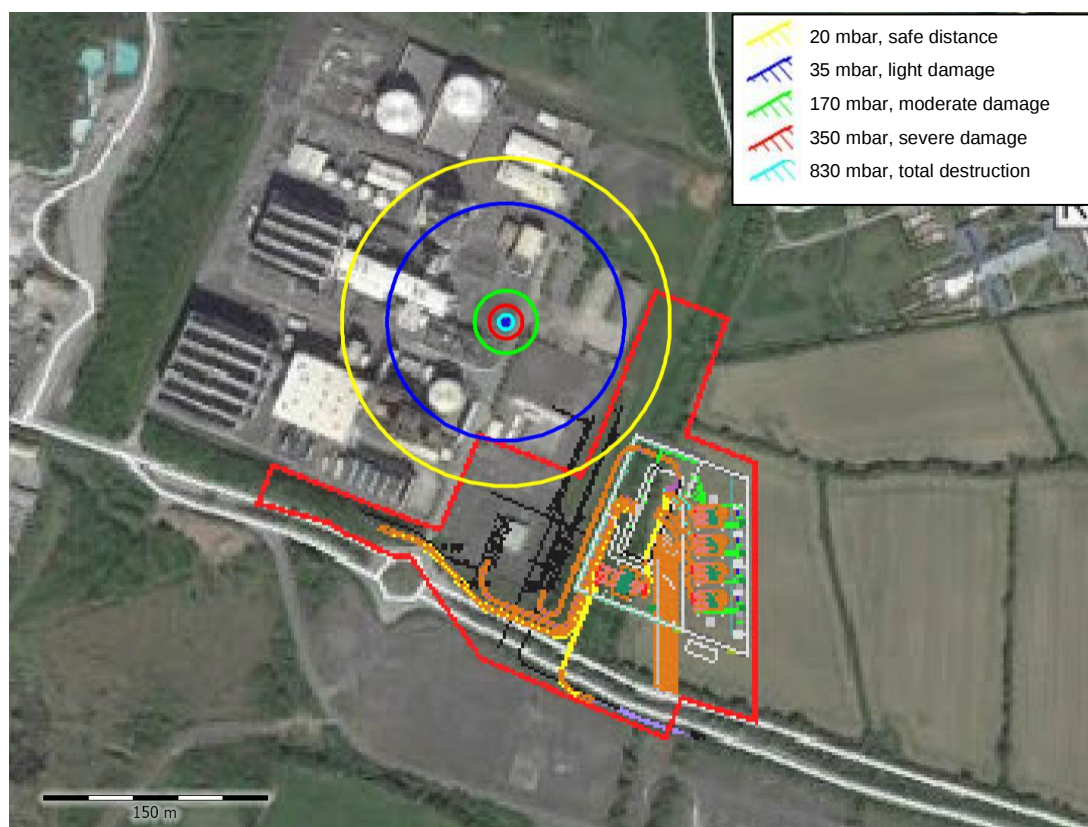


Figure 25 LPG BLEVE: Blast Damage Contours

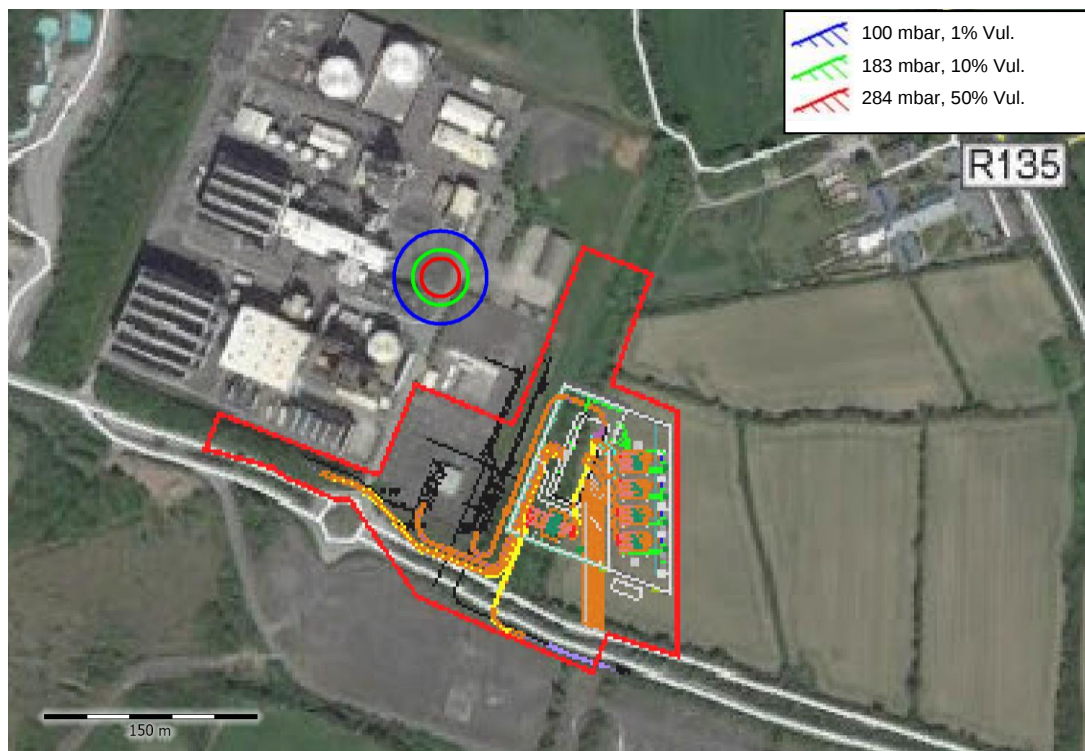


Figure 26 LPG BLEVE: Indoor Mortality Contours (Category 2)

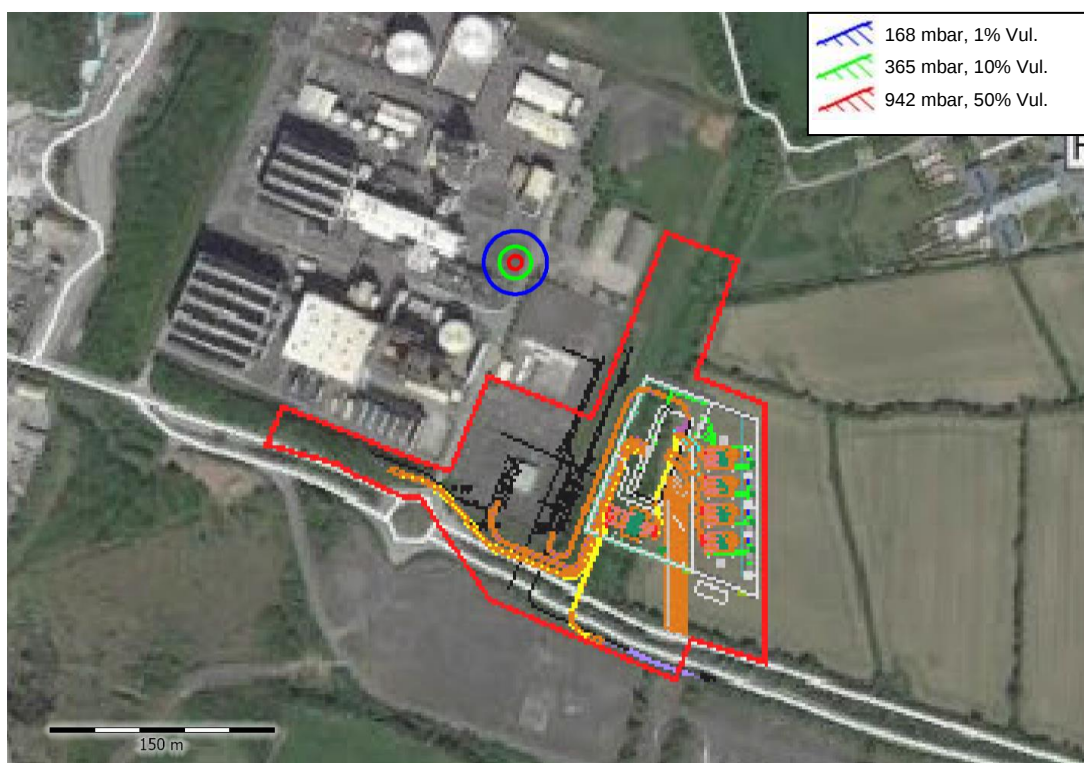


Figure 27 LPG BLEVE: Outdoor Mortality Contours

In the event of a BLEVE following rupture of an LPG tank at Huntstown, the following is concluded:

- The overpressure contour corresponding to safe distance (20 mbar) extends to the the proposed development

It is concluded that there are no expected overpressure consequences at the proposed development following a BLEVE at the LPG tank.

6.4.4 Fireball Model Outputs

Fireball modelling results are summarised in below.

Parameter	Units	Value
Duration of the Fire Ball (s)	s	5.5
Max Diameter of the Fire Ball (m)	m	64.6
Max Height of the Fire Ball (m)	m	96.9
Surface emissive power (max) (kW/m ²)	kW/m ²	400

Table 24 LPG Fireball: Model Outputs

It is concluded that the fireball duration is 5.5 s and the maximum fireball diameter is 64.6 m (radius 32.3 m). The fireball diameter and thermal radiation contours corresponding to the threshold of fatality (4.1 kW/m²) and 1% fatality (6.8 kW/m²) is illustrated as follows:

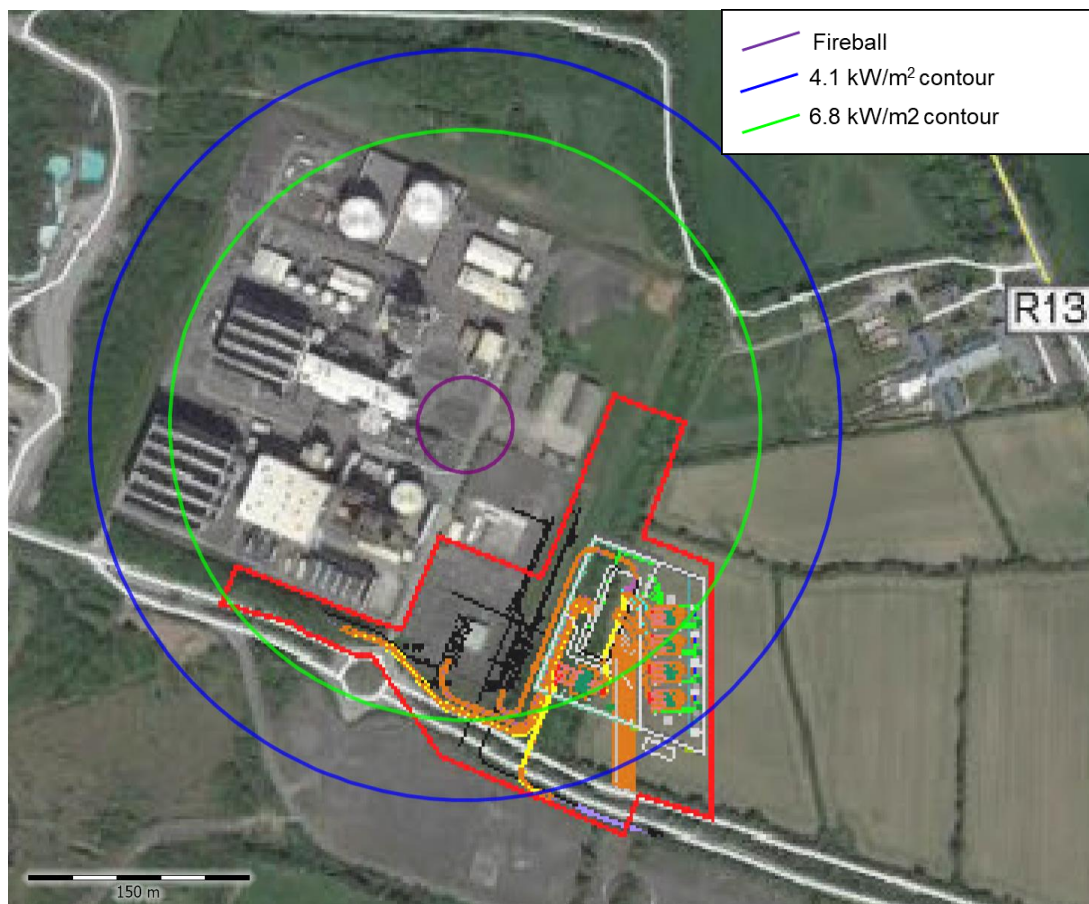


Figure 28 LPG Fireball: Fireball, threshold of fatality (4.1 kW/m²) and 1% fatality contours (6.8 kW/m²)

The thermal radiation levels corresponding to indoor mortality is illustrated on Figure 29.

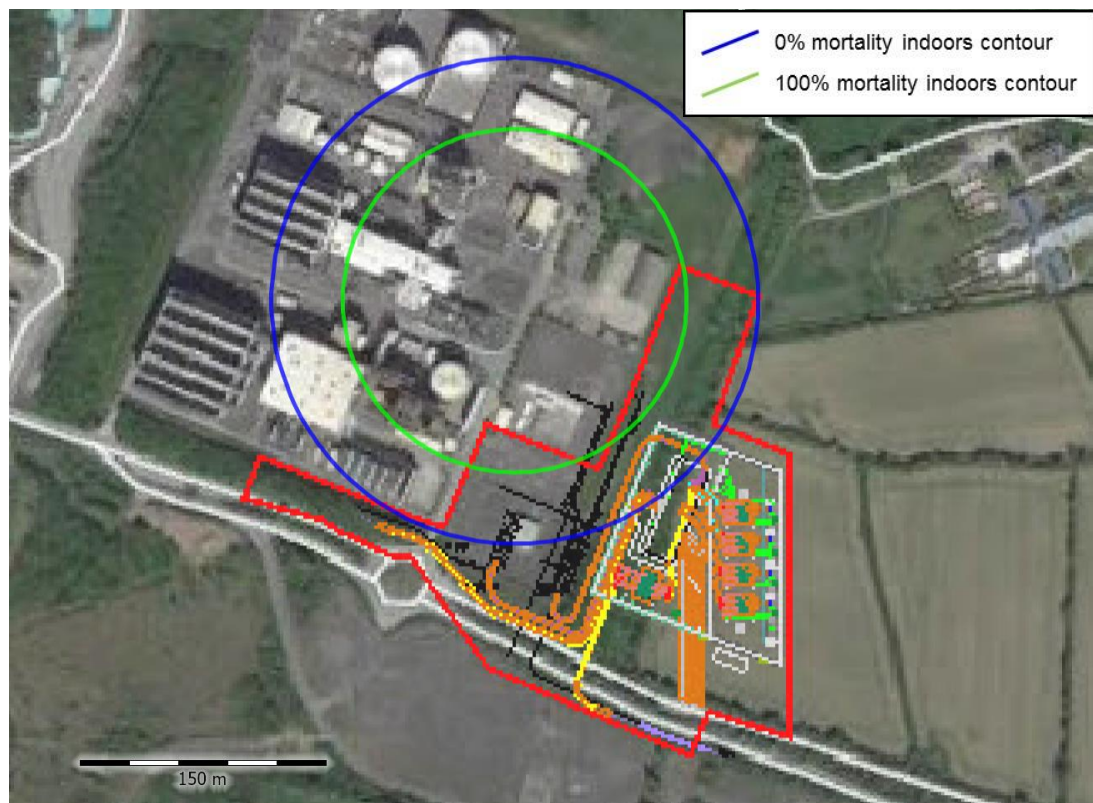


Figure 29 LPG Fireball: Indoor Mortality

In the event of a fireball following rupture of an LPG tank at Huntstown Power Station, it is concluded:

- The Fireball radius does not extend to the proposed development.
- The thermal radiation corresponding to 1% fatality (6.8 kW/m^2) extends to the proposed development, there is potential for fatality to persons outdoors at this establishment.
- The thermal radiation level corresponding to 0% mortality indoors (12.7 kW/m^2) extends to the proposed development; however, there will be no buildings in this area; therefore, no fatalities are expected.

It is concluded that there is potential for fatalities to persons outdoors at the proposed development following a Fireball at the LPG tank at the Huntstown Power Station. However, the Substation is designed to be remotely operated and there are no permanent staff on-site.

6.4.5 BLEVE and Fireball Frequency

There is only 1 No. small LPG tank; therefore, the likelihood of a BLEVE and fireball following rupture of an LPG vessel at Huntstown is taken as $1\text{E-}05$ per year (HSA, 2010).

7.0 LAND USE PLANNING RISK CONTOURS

TNO Riskcurves Version 11.3.0 modelling software was used to model the cumulative risk contours for the establishment.

The consequence results, frequencies of major accident hazards and Dublin Airport wind speed and frequency data (see Section 4.1.5) were input to the software.

The HSA has defined the boundaries of the Inner, Middle and Outer Land Use Planning (LUP) zones as:

10E-05/year	Risk of fatality for Inner Zone (Zone 1) boundary
10E-06/year	Risk of fatality for Middle Zone (Zone 2) boundary
10E-07/year	Risk of fatality for Outer Zone (Zone 3) boundary

Risk contours for the Huntstown Power Station corresponding to the boundaries of the inner, middle and outer risk based land use planning zones are illustrated on Figure 30.

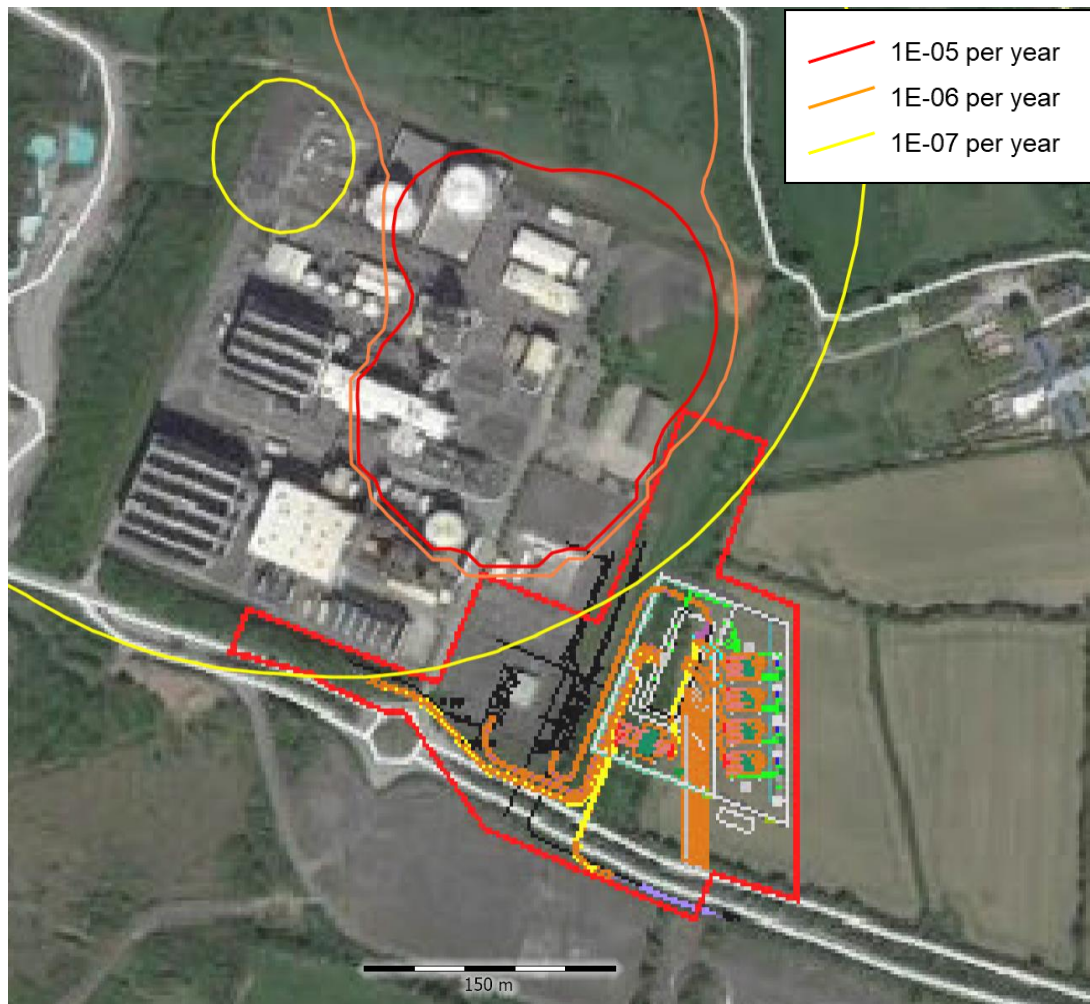


Figure 30 Land Use Planning Individual Risk Contours for Huntstown Power Station

It is concluded that the LUP Outer zone and Middle zone of Huntstown Power Station extends to the proposed development. The individual risk contours corresponding to the Inner LUP zone does not extend to the proposed development; therefore, the level of individual risk at the proposed development is acceptable.

8.0 CONCLUSION

A Land Use Planning assessment was completed for the proposed construction of a Substation that is in the vicinity of Huntstown Power Station, Co. Dublin. The Huntstown establishment is notified to the Health and Safety Authority (HSA) as a Lower Tier COMAH site and is subject to the provisions of the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, 2015 (COMAH Regulations 2015).

The risk-based approach is completed in accordance with current HSA policy and taking account of the Policy and Approach of the Health and Safety Authority to COMAH Risk-based Land-use Planning (19 March 2010).

This report examines hazards associated with Fuel Oil, LPG, and Natural gas installations on site. The consequences modelling was carried out using TNO Effects Version 11.3.0 modelling software. The following is concluded:

Natural Gas VCE within a Turbine Enclosure:

- Overpressure levels corresponding to safe and light damage extends to the proposed Substation development;
- Overpressure levels corresponding to 1% mortality outdoors do not extend to the proposed Substation development;
- Overpressure levels corresponding to 1% mortality indoors (Cat. 2) do not extend to the proposed Substation development.

Natural Gas Jet Fire at the GNI AGI:

- The jet flame measures up to 258 m in length (depending on wind speed)
- The thermal radiation level corresponding to 1% mortality outdoors extends to the proposed Substation development; therefore, there is a possibility of fatality to persons outdoors in the event of a jet fire; however, the site is designed to be operated remotely and there are no permanent staff on-site.
- The thermal radiation level corresponding to 100% mortality indoors extends to the proposed development but does not extend to any buildings on site.
- The thermal radiation level corresponding to equipment damage extends to the proposed Substation. There is potential for damage to equipment at the substation.
- GNI will be responsible for the installation, operation, and maintenance of all equipment within the AGI gas compound. All operations within the AGI will comply with standard GNI operational procedures and risk assessments and will be carried out by approved GNI contractors.

In relation to impacts from a jet fire following rupture of the natural gas supply pipeline at the GNI AGI, it is noted that the thermal radiation impacts that are predicted are conservative as they are based on a mass flow rate of 661 kg/s, as recommended by TNO and as explained above. It is noted that after approximately 9 s the release rate will reduce to 126 kg/s and after 44 s it will reduce to less than 3 kg/s and will continue to reduce until all of the natural gas has been released from the pipeline (approximately 600 s or 10 minutes). Therefore, the estimated consequences are conservative.

Bunded Pool Fire at Fuel Oil Storage Tanks

- The thermal radiation contour corresponding to the threshold of fatality (4.1

kW/m²) does not extend to the proposed Substation development.

Uncontained Pool Fire following Bund Overtop

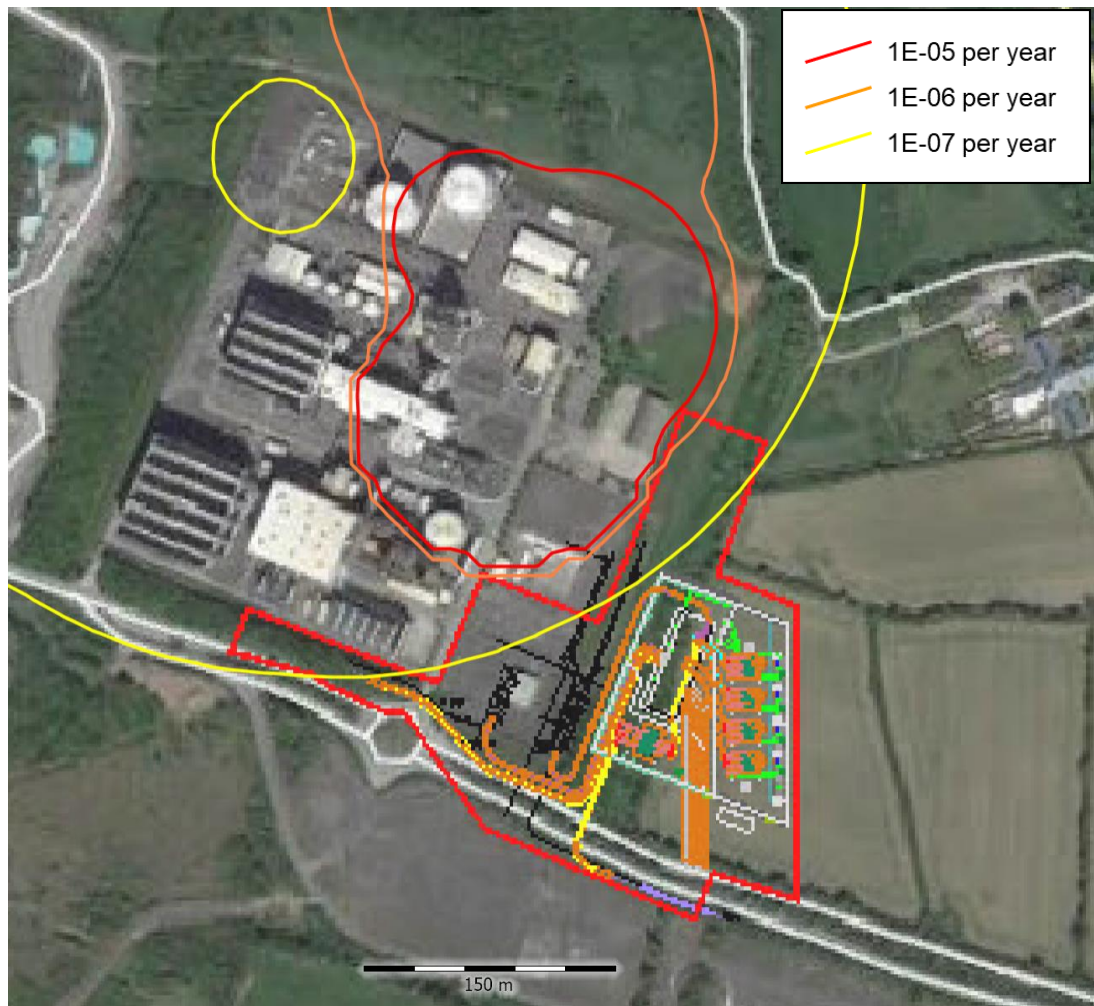
- The thermal radiation contour corresponding to the threshold of fatality does not extend to the proposed development;
- The thermal radiation contour corresponding to persons protected indoors does not extend to the proposed development.

LPG BLEVE and Fireball

- The Fireball radius does not extend to the proposed development.
- The thermal radiation corresponding to 1% fatality (6.8 kW/m²) extends to the proposed development, there is potential for fatality to persons outdoors at this establishment.
- The thermal radiation level corresponding to 0% mortality indoors (12.7 kW/m²) extends to the proposed development; however, there will be no buildings in this area; therefore, no fatalities are expected.

It is concluded that there is potential for fatalities to persons outdoors at the proposed development following a Fireball at the LPG tank at the Huntstown Power Station. However, the Substation is designed to be remotely operated and there are no permanent staff on-site.

The cumulative individual risk contours for Huntstown Power Station corresponding to the boundary of the inner, middle and outer land use planning zones are illustrated as follows.



It is concluded that the LUP Outer zone and Middle zone of Huntstown Power Station extends to the proposed development. The individual risk contours corresponding to the Inner LUP zone does not extend to the proposed development; therefore, the level of individual risk at the proposed development is acceptable.

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End of Report