Kilkenny OCGT

Major Accident Risk Assessment

March 2011

Greener Ideas Limited
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6. Conclusions

6.1 Compliance with Design Code
6.2 Consequence Modelling
6.3 Probabilistic Risk Assessment

7. References
Executive Summary

The proposed power station does not store large quantities of hazardous materials and therefore is not required to produce a formal safety assessment (Major Accident Hazard report) for review by the Health and Safety Authority under the Seveso Regulations. However, Greener Ideas Limited (GIL) is committed to providing a power station that does not impose an unacceptable risk to the general public or their employees. To better understand the risks GIL have commissioned a risk assessment of the possible major accidents that could potentially occur at the site and which could pose a risk to the public outside the site. The initial risk assessment showed the risks to the general public outside the site to be very low and to be within the limits that the Health and Safety Authority would normally consider tolerable. However, following on from the initial assessment GIL has developed modifications to the design to further reduce the risks.

The risk assessment has used two approaches:
- Examining the design of proposed facility against the gas facility design code of practice; and
- Modelling potential fires and explosions and estimating their frequency.

The design of gas pipelines and Above Ground Installations (AGIs) in Ireland is subject to standard I.S. 328:2003, The Irish Standard Specification for Code of Practice for Gas Transmission Pipelines and Pipeline Installations. This standard sets the allowable proximity distance from habited buildings according to the size and pressure of the gas pipeline. In this case the proximity distance is about 31m for ‘normal’ pipelines and about 12m for ‘thick walled’ pipelines. In this case thick walled (~11mm wall thickness) pipelines will be used. The nearest habited building is more than 40m away. However the Sion Road is within the proximity distance. This is allowed under the Code of Practice providing appropriate measures are taken to reduce the probability of pipeline failure. Given the extent of the Irish gas pipeline network, some 13,150km including offshore pipelines, gas facilities close to roads occur in many places and the location of the pipeline and AGI for the power station near to the Sion Road should not be grounds for concern.

The consequences of potential accidents have also been specifically modelled. The types of accidents modelled have included fires and gas explosions using a well proven standard software package. It should be noted that:
- Full bore gas pipe failures have been assumed, which, given the thickness of the pipe, is considered an almost impossible scenario; and
- As required by law, measures will be taken to eliminate sources of ignition in the vicinity of the gas pipelines; thus a release of gas is unlikely to lead to fire and explosion.

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The Health & Safety Authority have provided guidance on the assessment of risks in their document ‘Policy & Approach of the Health & Safety Authority to COMAH Risk-based Land-Use Planning, 1/9/2009’, available on the H.S.A. website. This document gives guidance on how they would formulate their advice if consulted on the acceptability of the power station location. The risks from this facility have been shown to be well below the levels at which the H.S.A. would consider advising against the proposal.
1. Introduction

Greener Ideas Limited (GIL) is proposing to develop a 100MW Open Circuit Gas Turbine power plant 3km to the east of Kilkenny city centre in the townland of Purcellsinch, County Kilkenny. Though the power plant will have supplementary firing with gas oil, the quantity stored on site, approximately 1,610m$^3$, is below the Seveso Regulations lower tier threshold and therefore a Major Accident Hazard (MAH) Report is not required. However it is appropriate that potential accidents are investigated to ensure that the plant will be 'safe' to operate and address public concerns.

During the consultations on the planning application to Kilkenny County Council (KCC Ref: 10/627) some concern was expressed by the public in respect of health and safety matters associated with the design and construction of the proposed development. For this reason GIL has adopted a proactive approach to managing design health and safety risks. Despite the power plant being below the Seveso Regulations, GIL has commissioned a comprehensive study of the potential MAHs. This assessment demonstrates that the risk to the public from the proposed facility is very small and well within that normally considered acceptable under HSA guidelines for Land Use Planning (Ref. 1).

This report examines the potential consequences of accidents involving the release of natural gas and fires involving the gas oil used for supplementary firing. The consequence modelling has been undertaken using the DNV PHAST modelling code, a well recognised code, which is also used by the Health and Safety Authority. The modelling is mainly deterministic showing the potential extent of the worse case accidents. We have made estimates of the frequencies of accidents and the risks have been compared with H.S.A guidance on the acceptability of risk for planning purposes.

Specific assessments have been carried out of the risks to the following nearby receptors:

(i) the Veolia Building to the north of the site;
(ii) the Kilkenny County Council House to the West;
(iii) the Sion Road to the South;
(iv) the Kilkenny County Council Wastewater Treatment Plant (WwTP); and
(v) the house to the South of Sion Road.

The MAH assessments demonstrate that risks to receptors are very low and are within the limits that the HSA consider tolerable for power plant developments. The risks are considered to be below the levels at which the HSA would consider advising against the proposal.

The location of gas pipelines and Above Ground Installation needs to meet acceptable industry standards and a comparison has been made with requirements of I.S. 328:2003, the relevant code of practice. This assessment found that nearby occupied buildings are outside of the proximity distance for the size and pressure of the pipe to be used.
2. Design Standard for Gas Pipelines

The standard for pipelines in Ireland is I.S. 328:2003, The Irish Standard Specification for Code of Practice for Gas Transmission Pipelines and Pipeline Installations (Edition 3.1). The Code sets out engineering requirements for the safe design, construction and operation of pipelines and associated equipment in accordance with current knowledge. In this context a pipeline is to be regarded as safe if all reasonable steps are taken to protect members of the public and the personnel of the pipeline constructors and operators from possible hazards, and the security of the gas supply is adequately maintained.

This code of practice is intended for buried pipelines and pipeline installations such as Above Ground Installations (AGIs).

I.S. 328:2003 defines three different locality types as follows:

- **Type R** – Rural areas with a population density not exceeding 2.5 persons per hectare.
- **Type S** – Area intermediate in character between Types R and T with a population density exceeding 2.5 persons per hectare, but where the conditions for Type T areas are not all present. Type S areas may be extensively developed, with residential, commercial, educational and/or industrial buildings.
- **Type T** – Central areas of towns and cities

The proposed power station is to be located in a type S area, for which the design factor \( f \) should be a maximum of 0.3. The design factor can be calculated based on equation 1 (Ref. 6).

\[
t = \frac{PD}{20fs}
\]

Where:
- \( t \) = design wall thickness of pipe in mm
- \( P \) = design pressure in bar
- \( D \) = outside diameter in mm
- \( s \) = specified minimum yield strength in N/mm\(^2\)
- \( f \) = design factor

The dimensions of the two main pipelines are listed in Table 2.1, and it can be seen that they are within the minimum design factor as specified by the regulations.

<table>
<thead>
<tr>
<th>Pipeline</th>
<th>Outer Diameter (mm)</th>
<th>Inner Diameter (mm)</th>
<th>Maximum operating pressure (bar)</th>
<th>Minimum yield strength (N/mm(^2))</th>
<th>Wall thickness (mm)</th>
<th>Design factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGI to gas compressors</td>
<td>168.4</td>
<td>146.3</td>
<td>70</td>
<td>241.3</td>
<td>10.92</td>
<td>0.22</td>
</tr>
<tr>
<td>Gas compressors to GT</td>
<td>88.9</td>
<td>78.0</td>
<td>67.6</td>
<td>241.3</td>
<td>5.59</td>
<td>0.22</td>
</tr>
</tbody>
</table>
For a pipeline with a wall thickness exceeding 9.52mm operating at up to 70 bar(g), the Code gives a minimum distance (proximity distance) from normally occupied buildings of 12m. The nearest occupied house is over 40m away from the pipeline and AGI and the occupied buildings on site are further away and therefore the Code requirement is met.

This proximity distance also applies to roads and it has been confirmed that Sion Road lies within the proximity distance along certain sections of the pipeline, with the minimum distance being 9.26m. Notwithstanding this, the Code also contains a Clause related to road traffic routes, which states that [for roads with <12,000 vehicles per day, such as the Sion Road] pipelines within the proximity distance should utilise pipe with a nominal wall thickness of not less than 9.52mm or be provided with impact protection. In addition, the design factor for said pipeline should not exceed 0.3 and it is considered therefore, that the current proposal conforms to all aspects of the Code.
3. Modelling Process

3.1 Introduction

The European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2006 (SI No 74 of 2006) Regulations (commonly referred to as the Seveso Regulations) apply to facilities where dangerous substances are held in quantities above threshold limits as specified in Annex I Parts 1 and 2. Two thresholds apply – Lower Tier and Higher Tier.

Operators of facilities which are subject to these Regulations are required to take all necessary measures to prevent and mitigate the effects of major accidents to human beings and the environment.

Though the power plant will have supplementary firing with distillate gas oil, the quantity stored on site, approximately 1,610m$^3$, is below the Seveso Regulations lower tier threshold and therefore a Major Accident Hazard (MAH) Report is not required. However it is appropriate that potential accidents are investigated to ensure that the plant will be ‘safe’ to operate and address public concerns. For this reason GIL has adopted a proactive approach to managing design health and safety risks. Despite the power plant being below the Seveso Regulations, GIL has commissioned a comprehensive study of potential MAHs which have the potential to occur on site. These include the following:

- Pool fire – Only relevant for liquids, in this case the gas oil for supplementary firing;
- Jet fire – Gas releases with immediate ignition;
- Flash fire – Gas releases with delayed ignition in open areas; and
- Vapour cloud explosion – Gas releases with delayed ignition in confined spaces where an overpressure can be generated.

3.2 Modelling Software

The potential accidents were modelled using the DNV (Det Norsk Veritas) PHAST modelling software. This is a well recognised accident consequence software package and is used by the H.S.A. and the UK HSE.

3.3 Types of Accident Considered

3.3.1 Pool Fire

When a flammable liquid is released from a storage tank or pipeline, a liquid pool may form. As the pool forms, some of the liquid will evaporate and, if flammable vapour finds an ignition source, the flame can travel back to the spill, resulting in a pool fire. A pool fire involves burning of vapour above the liquid pool as it evaporates from the pool and mixes with air.

Note: Gas oil is not defined as flammable (as the flash point is above 55°C). Pool fires are therefore considered unlikely, noting that there are no sources of ignition within the bund.

3.3.2 Jet Fire

If gas is released from or pipelines under pressure, the material discharging through the hole will form a gas jet that entrains and mixes with the ambient air. If the material encounters an ignition source while it is
in the flammable range, a jet fire may occur. Depending on the nature of the failure, the jet fire may be
directed horizontally or vertically. Jet fires continue to burn for as long as the release of gas is not isolated,
and the prolonged thermal radiation (or flame impingement) can lead to significant risks, although the
impact tends to be relatively local.

3.3.3 Flash Fire

When natural gas is released to the atmosphere, a vapour cloud forms and disperses (mixing with air as it
does so). If the resultant vapour cloud is ignited before the cloud is diluted below its LFL, a flash fire may
occur. The combustion normally occurs within only portions of the vapour cloud (where mixed with air in
flammable concentrations), rather than the entire cloud. A flash fire may burn back to the release point,
resulting in a jet fire but is unlikely to generate damaging overpressures (explode) when unconfined.

3.3.4 Vapour Cloud Explosions

A flash fire can occur if natural gas is released into the atmosphere and ignited. If ignited in open
(unconfined) areas, natural gas is not known to generate damaging overpressures (explode). However, if
some confinement of the vapour cloud is present, gas can produce damaging overpressures. Areas
congested with equipment and structures can facilitate damaging overpressures if a vapour cloud is ignited
within such an area. For example, if a vapour cloud infiltrates a process plant area with various vessels,
structures, and piping and the cloud ignites, the portion of the cloud within that congested area may
generate damaging overpressures. A larger volume fraction of heavier hydrocarbons in the natural gas
reduces the minimum ignition energy required for detonation and increases the specific gravity of the
hydrocarbon mixture (and hence reduces the tendency to rapidly disperse). Both of these effects increase
the likelihood of generation of damaging overpressures.

3.4 Gas Conditions

As part of the assessment potential accidents have been modelled using the following key data on the gas
conditions (Ref. 2), upon which the design has been based:

- Maximum Incoming Gas Pressure (up to compressors) – 70 bar(g)
- Incoming Gas Temperature (up to compressors) – 6°C
- Maximum Gas Pressure after the Compressors – 67.6 bar(g)
- Assumed Gas Temperature after the Compressors – 60°C
- Gas modelled as pure Methane

3.5 Gas Pipelines and Leaks

The following key gas pipeline parameters (Ref. 2) were used in the modelling:

- Length of gas pipeline to site – 3km (note: no additional allowance for fittings has been made)
- Diameter of gas pipeline to site and to compressors – 150mm
- Diameter of pipeline after the compressors – 75mm.
- Pipework is assumed to be buried except for the AGI, in the Compressor House and the in the turbine
  enclosure
- Leaks are assumed to be full bore (note: this is pessimistic)
- A wall will be erected to the south of the AGI so that horizontal leaks (and resulting jet fires) in a
  southerly direction cannot occur.
Leaks from buried pipelines are assumed to occur vertically

### 3.5.1 Duration of Failures

As discussed in section 3.8, the potential effects of a failure, in terms of the level of harm from a hazardous agent, are dependent on both the intensity and the duration of [exposure to] the release. As such the modelling of automatic failure detection and associated shutdown systems is important in determining the consequence of a failure, and the following presents a summary of the systems / assumptions modelled as part of this study.

#### 3.5.1.1 Downstream of the Compressor

For failures downstream of the compressor, a pressure transmitter mounted in the discharge line would initiate a signal to shut down immediately on detection of low discharge pressure. This process would involve recycling to allow controlled shutdown with actuator valves. In this scenario, the compressor would be shutdown and valves to and from the compressor would be closed, within a 60 second period.

Based on the information above, all failures between the compressor and the turbines have been assumed to be isolated within 60 seconds.

#### 3.5.1.2 Upstream of the Compressor

Upstream of the compressor, an emergency shutdown valve will be located upstream of the AGI. It is understood that the response time of the valve will be two seconds.

In terms of the modelling, a degree of pessimism has been introduced, in order to account for automatic detection and initiation, and potential delays due to lengths of pipework with residual gas. The valve has been assumed close at 20 seconds following failure, noting that the modelling includes release of residual pressure in the pipeline following closure of the valve.

### 3.6 Fire Wall

In order to provide protection from the effects of jet fires to persons south of the site, a fire wall of approximately 2m height is to be situated immediately adjacent to the above ground pipework at the AGI. As part of the modelling, it has therefore been assumed that unimpeded horizontal releases in a Southerly direction are not credible and that, in such a scenario, the release would be directed in a vertical sense. The ‘worst case’ horizontal releases at the AGI have therefore been assumed to propagate parallel to the wall, as illustrated in Figure 3.1.

---

1 As supplied by the compressor manufacturer, Atlas Copco
3.7 Weather Conditions for Modelling

The PHAST modelling software is capable of modelling accidents under a wide range of weather conditions, which can affect the dispersion of releases and hence the subsequent consequences of accidents. All modelling undertaken as part of this assessment calculated release conditions at the three weather conditions shown in Table 3.1, with the worse case taken forward for further assessment. These are typical of the weather conditions expected to occur for the majority of the time, and are recommended by the PHAST Software supplier (DNV). All wind directions were considered as part of the assessment.

<table>
<thead>
<tr>
<th>Wind speed (m/s)</th>
<th>Pasquill (Atmospheric) Stability Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 m/s</td>
<td>D</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.5 m/s</td>
<td>D</td>
<td>Neutral</td>
</tr>
<tr>
<td>1.5 m/s</td>
<td>F</td>
<td>Stable</td>
</tr>
</tbody>
</table>

3.8 Modelling End Points

3.8.1 Probits for Pool and Jet Fires

In order to estimate the level of harm to an individual from a heat source, it is necessary to provide a means to quantify the exposure in terms of the intensity and duration of the release. This is usually achieved by an estimation of the received dose (based on modelling techniques), and a comparison of this against experimental data.
To this end probits are often used, in which the fatality rate (the ‘lethality’) of personnel exposed to thermal radiation over a given period of time can be determined by the use of probit functions that typically take the form of equation 2.

\[ Y = A + B \ln(V) \]  

(2)

Where:  

\[ Y \] = the probit value (equivalent to a lethality range 1 – 99%)  
\[ A / B \] = constants  
\[ V \] = the received ‘dose’ (the product of thermal intensity, to an exponent ‘N’, and the duration of exposure)

The latest guidance from the H.S.A. is based on the risk from thermal radiation as expressed by the Eisenberg et al (1975) probit, equation 3.

\[ Y = -14.9 + 2.56 \ln(I^{1.33} t) \]  

(3)

Where:  

\[ I \] is measured in kW/m^2 and \[ t \] in seconds

This probit has been integrated into the Phast model (amended to account for specific requirements with regards the input units for thermal radiation) as part of the assessment of the consequence of pool fires, jet fires and fireballs. The end points for the modelling are therefore presented as the risk of fatality (the ‘lethality’), this being a function of the intensity and duration of exposure associated with the failure.

The facility has been redesigned so that the majority of the pipework is buried or within buildings so that there is very limited potential for horizontal jet fires. In the case of the AGI, where the pipework is above ground, there is a wall to the south to prevent jet fires projecting horizontally to the south of the site.

### 3.8.2 Modelling End Points for Pool and Jet Fires

It has been shown that the risk to persons in the vicinity of a pool fire, jet fire or fireball is a function of the intensity of the fire (the thermal radiation), and the duration to which they are exposed to the fire. As part of the modelling of the potential failures on site, these scenarios have been limited to exposure durations of 60 seconds (downstream of the compressor) and 20 seconds (upstream of the compressor), as discussed in section 3.5.1. In order to compare the risk of scenarios of varying duration the lethality end points, for risk of fatality’s of 1%, 10% and 50%, are presented in Table 3.2 for releases of 20 seconds and 60 seconds. The associated end points for a 75 second exposure are also shown for comparison, this being the recommended duration to take account of the time required to escape (Ref. 1). Accordingly, the outputs of the modelling of pool fires and jet fires are presented as lethality contours (see sections 4.2 and 4.3 respectively), these being equivalent to the thermal radiation values appropriate to the duration of exposure of each scenario (Table 3.2).

A point to note when considering short duration exposure, and the associated high thermal radiation, is the fact that the level of risk to persons exposed is less dependent on the exposure time as intensity increases for a given dose. Thus, as the intensity increases, instantaneous exposure can lead to fatality. Ref. 5 notes that, at thermal radiation levels of 25kW/m^2 and 35kW/m^2, there is a ‘significant chance of fatality for instantaneous exposure’. Nonetheless, when considered alongside the pessimism in the 20 seconds
duration, this is consistent with the lethality risk used during the consequence modelling as part of this assessment, in which 10% fatality and 50% fatality constitute a ‘significant’ risk.

Table 3.2: Thermal Radiation associated with Lethality End Points

<table>
<thead>
<tr>
<th>Risk of Fatality</th>
<th>75 second exposure</th>
<th>60 second exposure</th>
<th>20 second exposure</th>
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<tr>
<td>1% Fatality</td>
<td>6.8kW</td>
<td>7.98kW</td>
<td>18.32kW</td>
</tr>
<tr>
<td>10% Fatality</td>
<td>9.23kW</td>
<td>10.85kW</td>
<td>24.87kW</td>
</tr>
<tr>
<td>50% Fatality</td>
<td>13.4kW</td>
<td>15.8kW</td>
<td>36.11kW</td>
</tr>
</tbody>
</table>

Source: Ref 1 and MML calculation

The H.S.A. guidance (Ref. 1) also includes reference to assumptions with regards the risk to persons indoors from exposure to thermal radiation. In this instance, the building is conservatively assumed to catch fire quickly at 25.6kW/m² and hence a 100% fatality probability is assumed. This is approximately equal to the 50% ‘inner’ zone in Table 3.2 for the 20 second exposure scenario, and is discussed further in context in section 4.6.

3.8.3 Flash Fires

Flash fires are intense short duration events which do not generate significant overpressure. It is conservatively assumed that personnel caught in a flash fire would be fatalities. Personnel within buildings would survive. Flash fires are modelled as potentially occurring up to 50% of the lower flammable limit of the gas (Ref 3).

3.8.4 Vapour Cloud Explosion

As discussed above the VCEs are only possible for natural gas when the gas is partially confined by equipment or buildings. We have assumed that a VCE explosion could occur anywhere within the power station site boundary.

The H.S.A. (Ref 1) gives the following guidance on the relationship between the risk of fatality with the associated overpressure for both outdoor and indoor (typical domestic building – Category 3).
In examining the specific risks to persons outdoors, the HSA guidance (Ref 1) shows the relationship between the risk of fatality and overpressure as presented in Table 3.4.

Table 3.4: Relationship between risk of fatality and blast overpressure for persons outdoors

<table>
<thead>
<tr>
<th>Risk of Fatality</th>
<th>Overpressure (mbar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>168</td>
</tr>
<tr>
<td>10%</td>
<td>365</td>
</tr>
<tr>
<td>50%</td>
<td>942</td>
</tr>
</tbody>
</table>

Source: Ref. 1

Vapour Cloud Explosions (VCEs) were modelled using the TNT equivalence method in the PHAST model. This method equates the mass of flammable gas within the vapour cloud to a mass of TNT, and applies a cube root scaling law to calculate the variance of the overpressure with distance from the point of origin. In determining the flammable mass of the vapour cloud sensitivity studies were undertaken and a degree of pessimism was introduced in that the maximum modelled flammable mass was assumed to occur at the site boundary.
4. Modelling Results

4.1 Introduction

Risk can be defined as the likelihood that a hazard will cause adverse affects, together with a measure of the effect of the hazard. A risk-based approach therefore considers the likelihood of events, in this case pipework failures and resulting fires or explosions, occurring as well as the consequences of the events. This is considered to be preferable to a purely hazard-based approach, in which it is implicitly assumed that the particular event under consideration occurs with sufficient frequency to be a cause for concern, though not so high as to make it unacceptable. The risk-based approach is one we intuitively take on a daily basis; were we to adopt a hazard-based approach to where we live for example, we would avoid areas that are close to airports etc., no matter how low the likelihood of a plane crash involving a particular house.

The policy of the HSA is to apply a risk-based approach for Land Use Planning, in which a number of ‘key’ representative events are considered, both in terms of their consequence and frequency. This is termed a ‘probabilistic’ approach and is presented in section 5.

This section presents the assessment of the consequence of the key events as calculated by the modelling, in terms of specific ‘levels’ defined by the HSA (Ref. 2) and discussed in section 3.8. The consequences are presented as contours representing the distance to the defined ‘levels’ of harm from the source of the accident.

4.2 Pool Fire

In the improbable event of a major leak from the tank to the bund it is unlikely that this will lead to a fire as diesel has a flash point of greater than 55°C and is not classified as flammable. There will be no sources of ignition within the bund.

In the remote event of the diesel being ignited a pool fire will result. The worst case pool fire in terms of consequence assumes the loss of the entire contents of the tank into the bunded area, noting that the bunded area exceeds 110% of the volume of the tank. The consequences of such a fire, in terms of the thermal radiation end points for as applicable to an exposure duration of 75 seconds (Table 3.2) are presented in Figure 4.1. The time of 75 seconds is used as the fire would not be quickly extinguished and sufficient time for personnel to escape is allowed. The contours represent distances to thermal radiation levels for which, if encountered by an individual, the associated probability of fatality would be 1% (blue), 10% (green) and 50% (yellow).
4.3 Jet Fires

In the event of a failure, gas will be released from the pipeline. In order for a jet fire to occur the gas would have to encounter an ignition source when in an appropriate concentration. The consequences of jet fires for failures of both the 70 bar(g) incoming gas supply and the 67.6 bar(g) feed to the gas turbines were modelled, noting that the pipelines were assumed to be buried within the site boundary with the exception of overground pipework at the AGI and compressors. Note also that the modelling assumed the worst case failures, i.e. full bore leaks with a resulting horizontal jet fire (for overground pipelines, vertical releases were assumed for buried sections), and discounting the protection offered by buildings and equipment in limiting the propagation of the flame. The effect of the blast wall at the AGI is discussed in section 3.6.

The consequences of the jet fire modelling, in terms of the lethality contours (Table 3.2), are presented in Figure 4.2. These represent distances to thermal radiation levels for which, if encountered by an individual, the associated probability of fatality would be 1% (blue), 10% (green) and 50% (yellow). The most onerous result for the majority of the site is due to a jet fire in the above ground pipework at the AGI, noting that to the West of the site the buried feed pipeline to the turbine dominates, albeit to a lesser extent. The protection offered by the fire wall immediately to the South of the AGI can be seen, with ‘worst case’ horizontal releases propagating parallel to the wall, whilst vertical releases from the buried supply line are such that the radiation seen at ground level does not exceed the outer zone.
Areas to the South of the site that lie in the vicinity of potential releases are therefore protected and it can be seen that the house to the South of Sion road lies outside of all zones. To the West of the site, part of the uninhabited house lies in the middle zone whilst the entire Kilkenny County Council WwTP is outside all zones, as are the Veolia buildings to the North of the site.

The incoming pipeline and AGI are close to the gas oil storage tank. However, given that the gas supply can be quickly isolated it is unlikely that the fire would be of sufficient duration to set the oil storage tank on fire.

Figure 4.2: Lethality end points based on jet fires in both the incoming supply and the feed to the turbine

4.4 Flash Fires

Where a failure results in the dispersion of gas to an open area, the subsequent ignition of the gas cloud can result in a flash fire. The results of the modelling for flash fires, in terms of the contours associated with gas dispersion to LFL (green) and 50% LFL (blue), are presented in Figure 4.3. It can be seen that the most onerous consequence for the majority of the site is based on a failure of the incoming supply at the above ground pipework at the AGI, noting that flash fires due to vertical releases from buried pipework
have little consequence at ground level (and are not considered credible scenarios as vertical releases will not encounter an ignition source).

In terms of buildings in the vicinity of the site, the house to the South of Sion Road is within the LFL zone whilst the uninhabited house to the West and the Veolia Buildings are within the 50% LFL zone, noting that all are affected only by a release at the above ground pipework at the AGI.

**Figure 4.3:** Flash fire distance to LFL and 50% LFL for failures of both the incoming supply and the feed to the turbine

### 4.5 Vapour Cloud Explosions

#### 4.5.1 VCE Outdoors

The analysis has assumed that, following a pipework failure, a VCE could occur anywhere within the site boundary.
The results of the modelling, in terms of the contours associated with the overpressure end points (Table 3.3), are presented in Figure 4.4. These represent distances to overpressure levels for which, if encountered by an individual, the associated probability of fatality would be 1% (blue), 10% (green) and 50% (yellow).

4.5.2 VCE Indoors

In addition to VCEs occurring following a failure and subsequent dispersion within the site boundary, it can be reasonably envisaged that, following a failure within the Turbine enclosure such as to release gas, a cloud could form within the confines of the Turbine House. Should this cloud be subsequently ignited, a VCE could occur. This scenario has been modelled, based on an effective volume within the Turbine House (i.e. factored to include equipment within the enclosure) of 60m³.

The results of the modelling are shown in Figure 4.5, in which the contours represent distances to overpressure levels for which, if encountered by an individual, the associated probability of fatality would be 1% (blue), 10% (green) and 50% (yellow). It can be seen that, outside the site boundary, the effect of the failure in terms of the end points is confined to a small area within the Kilkenny County Council WwTP.
Figure 4.4: Overpressure end points based on VCEs within the site boundary
4.6 Consequences to the Public outside the site boundary

The consequence modelling has demonstrated that the risk to the public from accidents at the proposed site would generally occur in five main areas (Figure 4.6). These are the Veolia Building to the North of the site (1), the Kilkenny County Council house to the West (2), Sion Road to the South (3), the Kilkenny County Council WwTP (4) and a house to the South of Sion Road (5). Note that the house to the west of the site (2) has not been inhabited for a number of years and due to extensive water damage, is not considered habitable without considerable refurbishment.
A summary of the perceived risk to the public is presented in Table 4.1, noting that the modelling undertaken to date is assessed to be pessimistic in some areas. In particular it is expected that the following may affect the consequences of accidents:

- Though the resistance of 3km of pipeline is considered in the modelling no further restrictions are accounted for;
- Currently pipeline failures are considered to be full bore guillotine failures;
- No account is taken of the shielding effects of buildings and equipment on site; and
- The potential for an unconfined natural gas could explosion (VCE) with natural gas of the scale modelled is debatable (see Ref 4). As far as the author is aware no such large unconfined vapour cloud explosion has ever occurred with natural gas.
Note that the distillate pool fire has been omitted from this assessment as it is not considered to present a risk to the public outside the site.

**Table 4.1: Summary of risk to the public**

<table>
<thead>
<tr>
<th>Location</th>
<th>Jet Fire</th>
<th>Flash Fire</th>
<th>VCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veolia Building (1)</td>
<td>The entire building is outside the outer (1% lethality) zone, and therefore there is little or no risk.</td>
<td>Persons within the building are protected from the effects of the fire. Persons outside of the building are likely to be within the 50% LFL zone.</td>
<td>South side of building is within 50% fatality zone. Persons outside the building are likely to be to the North and within the 1% - 10% zones.</td>
</tr>
<tr>
<td>House (2) (note: not currently habited)</td>
<td>Part of the building is within the middle (10% lethality) zone, noting that persons indoors would be likely to escape.</td>
<td>Persons within the building are protected from the effects of the fire. Persons outside of the building are likely to be within the 50% LFL zone.</td>
<td>Persons indoors are within the 50% fatality zone. Persons outdoors are likely to be within the 50% fatality zone.</td>
</tr>
<tr>
<td>Sion Road (3)</td>
<td>The majority of the road alongside site boundary is within the inner (50% lethality) zone. Thus there is a possibility of pedestrian fatality. Persons within vehicles likely to survive.</td>
<td>Pedestrians alongside the South site boundary are within the LFL zone. Motorists are likely to be protected.</td>
<td>Pedestrians alongside the south site boundary are within the 50% fatality zone. Motorists also at risk.</td>
</tr>
<tr>
<td>Kilkenny County Council WwTP (4)</td>
<td>The entire site is outside the outer (1% lethality) zone, and therefore there is little or no risk.</td>
<td>The entire site is outside the 50% LFL zone, and therefore there is little or no risk.</td>
<td>Persons to the East of the site are within the 1% - 50% fatality zones.</td>
</tr>
<tr>
<td>House (5)</td>
<td>The entire building is outside the outer (1% lethality) zone, and therefore there is little or no risk.</td>
<td>Persons within the building are protected from the effects of the fire. Persons outside of the building are likely to be within the LFL zone.</td>
<td>The North side of the building is within the 1% fatality zones. Persons indoors likely to be in the 1% zone.</td>
</tr>
</tbody>
</table>

As discussed in section 4.1, the results of the modelling presented herein describe the **consequences** of particular accidents, which is only part of the **risk-based** approach that forms the HSA policy for Land Use Planning (Ref. 2). Where this assessment shows that the consequence of a particular accident is sufficiently low, further assessment of the overall risk of the accident (i.e. considering the likelihood as well as the consequence) may not be deemed necessary.

Table 4.1 therefore presents a summary of the consequences to the public at each location, in terms of the probability of fatality, **should the accident occur**. Where the probability of fatality is shown to be less than 1% (i.e. the area is outside the outer zone), the overall risk can be assumed to be sufficiently low and no further assessment may be necessary. On this principle, as part of this assessment, locations at which the risk exceeds this limit, for the applicable accident scenario(s) have been considered as part of probabilistic risk assessment presented in section 5.
5. Probabilistic Approach

5.1 H.S.A. Guidelines on Acceptability of Risk

Should Regulatory Authorities be asked to adjudicate on the safety of projects they are likely to base their advice on the risk, rather than the consequences. An assessment of the measures taken to reduce the frequency of occurrence, or consequence of a particular hazard will be undertaken, and the outcome of this will depend on the boundaries between the unacceptable, tolerable or broadly acceptable regions of risk.

With regards to planning consents, the boundaries used by the HSA are based on an assessment of the risk of fatality to a person in a fixed relation to the hazard. The HSA will also consider the existing land use within three concentric zones around the proposed establishment. The zone boundaries are established as follows:

![Figure 5.1 - Definition of Planning Zones](image)

The HSA also define levels for facilities that might be present within the accident zones.

The levels can be summarised as:

- Level 1 – Work places
- Level 2 – Housing and Transport Links
- Level 3 – Institutional accommodation
- Level 4 – Large sensitive developments

The H.S.A. consider the acceptability of facilities being within the planning zones as shown in figure 5.2.

![Figure 5.2 - Applicable Planning Zones](image)
The original intention of the HSA method is to give advice for potential new developments near Seveso sites. However, the method is used ‘in reverse’ to advise on the development of new Seveso facilities.

Based on this approach, persons actually exposed to the risks can compare their own circumstances with those of the modelled persons, and therefore reach a decision as to whether adequate protection measures have been provisioned as part of the design. In gauging the magnitude of risk to which the individual is exposed, a comparative approach, that is assessing the risk against risks to which we live with on a daily basis, is useful. Table 5.1 presents the risk of fatality associated with various causes, averaged over the entire population.

Table 5.1: Risk of fatality to the entire population (UK) due to various causes

<table>
<thead>
<tr>
<th>Cause of Fatality</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury and poisoning</td>
<td>$3 \times 10^{-4}$/year</td>
</tr>
<tr>
<td>All forms of road accident</td>
<td>$6 \times 10^{-5}$/year</td>
</tr>
<tr>
<td>Lung cancer caused by naturally occurring Radon in dwellings</td>
<td>$3.5 \times 10^{-5}$/year</td>
</tr>
<tr>
<td>Domestic gas fire incident (fire, explosion, CO poisoning)</td>
<td>$7 \times 10^{-7}$/year</td>
</tr>
<tr>
<td>Caused by electric current</td>
<td>$4.6 \times 10^{-7}$/year²</td>
</tr>
<tr>
<td>Lightning</td>
<td>$5 \times 10^{-8}$/year</td>
</tr>
</tbody>
</table>

5.2 Risk Assessment

This section presents a probabilistic risk assessment of the locations at which the consequence of the modelled accidents was determined to be significant (see section 4.6).

5.2.1 Kilkenny County Council House

Although this house is currently uninhabited, should persons be present they have been shown to be within the consequence contours, and therefore potentially at risk, from jet fires, flash fires and VCEs. The following presents an assessment of each accident in turn, followed by a summary of the overall risk to persons located at the house.

5.2.1.1 Jet Fire

It can be seen in Figure 4.2 that part of the house lies within the middle (10% fatality) zone for jet fires, this being for a vertical release in a section of the buried pipeline from the compressor to the turbine. It has been conservatively assumed that a failure along a section of pipework close to the house of 50m in length may result in an accident that could harm persons at the house.

Pipeline failure rates are given in the UK HSE Health and Safety Executive Failure Rate and Event Data (FRED) as shown in Table 5.2.

---

2 Royal Society for the Prevention of Accidents, 2002
Table 5.2: Pipeline Failure Rates

<table>
<thead>
<tr>
<th>Release Hole Size (mm)</th>
<th>Failure Frequency (per metre year) for Pipe Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;50  50.149  150.299  300.499  500.1000</td>
</tr>
<tr>
<td>3</td>
<td>1 x 10^-5  2 x 10^-5  1 x 10^-4  8 x 10^-5  7 x 10^-7</td>
</tr>
<tr>
<td>4</td>
<td>5 x 10^-6  1 x 10^-6  4 x 10^-6  2 x 10^-6  4 x 10^-6</td>
</tr>
<tr>
<td>25</td>
<td>1 x 10^-6  5 x 10^-7  2 x 10^-7  7 x 10^-7  4 x 10^-7</td>
</tr>
<tr>
<td>1/3 pipe diameter</td>
<td>1 x 10^-6  5 x 10^-7  2 x 10^-7  7 x 10^-7  4 x 10^-7</td>
</tr>
<tr>
<td>Full bore</td>
<td>1 x 10^-6  5 x 10^-7  2 x 10^-7  7 x 10^-7  4 x 10^-7</td>
</tr>
</tbody>
</table>

Source: UK HSE

To potentially provide a fatal dose to persons at the house a full bore pipe failure of the buried pipework is required. Thus the estimated pipe failure rate is $5.0 \times 10^{-7}$ m$^{-1}$ y$^{-1}$. Assuming the equivalent of 50m of such pipeline, the probability of full bore failure of the pipeline is approximately $2.5 \times 10^{-5}$ y$^{-1}$.

In order to have a jet fire affecting the house the wind would have to be such as to orient the release towards the house. This set of circumstances has conservatively been assumed to occur in 25% of pipe failures. Therefore the risk is reduced to $6.25 \times 10^{-5}$ y$^{-1}$. In order for a jet fire to occur the gas released would need to find an ignition source within the 60 seconds before the pipeline is isolated. The immediate ignition probability where there is no apparent ignition source is about 0.1 (UK HSE). In this case the pipeline would be in a zoned area on site and ignition sources would not be present.

Further, the risk of fatality for this accident is 10% and therefore the risk is $6.25 \times 10^{-6}$ y$^{-1}$, equivalent to 1 fatality in 16 million years.

5.2.1.2 Flash Fires

The house lies within the 50% LFL zone for flash fires, noting that persons in the house would expect to be protected from a flash fire and therefore this scenario is not included as part of the assessment.

5.2.1.3 VCE

It can be seen in Figure 4.4 that the house lies within the inner (50% fatality) zone for VCEs following release at the overground pipework at the AGI.

Conservatively assuming a failure rate of $2.0 \times 10^{-7}$ m$^{-1}$ y$^{-1}$ (Table 5.2) and the equivalent of 5m of pipeline (noting that there is limited effect at ground level from vertical releases from buried pipework and, in any case, there are no ignition sources), the frequency of a large leak is $1.0 \times 10^{-6}$ y$^{-1}$. In order to for the leak to result in a Vapour Cloud Explosion creating a dangerous overpressure at the house the atmospheric conditions would have to be appropriate and the an ignition source located. Assuming the appropriate wind direction (southerly) and strength occurred 25% of the time and probability of an ignition source being encountered before the gas disperses of 0.1, the overall probability of a VCE affecting the house is $2.5 \times 10^{-8}$ y$^{-1}$, equivalent to 1 fatality in 40 million years.

5.2.1.4 Overall Risk

The overall risk to persons located at the Kilkenny County Council house is therefore calculated to be $8.75 \times 10^{-8}$ y$^{-1}$, equivalent to 1 fatality in 11 million years and approximately equal to one fifth the risk of fatality...
due to electric current. This would put the house outside the outer planning zone and therefore the risk should be considered acceptable by the HSA.

5.2.2 House south of Sion Road

In terms of the proposed plant at Kilkenny, the closest occupied dwelling is the house to the south of Sion Road, for which the only risk to persons at the house is due to a flash fire following release from the overground pipework at the AGI.

In such a scenario, it would be expected that persons indoors would be protected from a flash fire. However, in order to ensure that all credible scenarios are considered the risk is assessed below.

5.2.2.1 Flash Fire

It can be seen in Figure 4.3 that the house lies within the LFL zone for a flash fire for a full bore failure of the overground pipework at the AGI. Thus the estimated pipe failure rate is $2.0 \times 10^{-7}$ m$^{-1}$ y$^{-1}$ (Table 5.2). Assuming the equivalent of 5m of such pipeline at the AGI, the probability of full bore failure of the pipeline is approximately $1 \times 10^{-6}$ y$^{-1}$. In order to have a flash fire affecting the house to the south the pipe break would have to occur in the right orientation and with a northerly wind blowing. This set of circumstances has conservatively been assumed to occur in 10% of pipe failures. Therefore the risk is reduced to $1 \times 10^{-7}$ y$^{-1}$.

In order for a fire to occur the gas released would need to find an ignition source before the pipeline is isolated and the gas disperses. The immediate ignition probability where there is no apparent ignition source is about 0.1 (UK HSE). In this case the pipeline would be in a zoned area on site and ignition sources would not be present, however the gas cloud could extend off-site where there is more likelihood of an ignition source being encountered and an ignition probability of 0.3 has been assumed. Thus the overall probability of a flash fire at the house to the south of Sion road is estimated at $3.0 \times 10^{-8}$ m$^{-1}$ y$^{-1}$, equivalent to one fatality every 33 million years.

5.2.2.2 Overall Risk

The overall risk to persons located at the house to the south of Sion Road is therefore calculated to be $3.0 \times 10^{-8}$ m$^{-1}$ y$^{-1}$, equivalent to one fatality every 33 million years and less than the risk of fatality due to lightning strike. This is considered to be outside the outer planning zone and therefore the risk should be considered acceptable by the H.S.A., noting that, in any case, persons inside the house would be expected to be protected from a flash fire.

5.2.3 Veolia Building

Persons at the Veolia building have been shown to be within the consequence contours, and therefore potentially at risk, from flash fires and VCEs. The following presents an assessment of each accident in turn, followed by the overall risk to persons located at the house.

5.2.3.1 Flash Fire

The building lies within the 50% LFL zone for flash fires following a full bore release from the overground pipework at the AGI. In such a scenario, it would be expected that persons indoors would be protected
from a flash fire. However, in order to ensure that all credible scenarios are considered the risk is assessed below.

It can be seen in Figure 4.3 that the building lies within the LFL zone for a flash fire for a full bore failure of the overground pipework at the AGI. Thus the estimated pipe failure rate is $2.0 \times 10^{-7} \text{ m}^{-1} \text{ y}^{-1}$ (Table 5.2). Assuming the equivalent of 5m of such pipeline at the AGI, the probability of full bore failure of the pipeline is approximately $1 \times 10^{-6} \text{ y}^{-1}$. In order to have a flash fire affecting the building to the north the pipe break would have to occur in the right orientation and with a southerly wind blowing. This set of circumstances has conservatively been assumed to occur in 10% of pipe failures. Therefore the risk is reduced to $1 \times 10^{-7} \text{ y}^{-1}$.

In order for a fire to occur the gas released would need to find an ignition source before the pipeline is isolated and the gas disperses. The immediate ignition probability where there is no apparent ignition source is about 0.1 (UK HSE). In this case the pipeline would be in a zoned area on site and ignition sources would not be present, however the gas cloud could extend off-site where there is more likelihood of an ignition source being encountered and an ignition probability of 0.3 has been assumed. Thus the overall probability of a flash fire at the Veolia Building is estimated at $3.0 \times 10^{-8} \text{ y}^{-1}$, equivalent to one fatality every 33 million years, noting that persons within the building would expect to be protected from a flash fire.

5.2.3.2 VCEs

It can be seen in Figure 4.4 that the Veolia building lies within the inner (50% fatality) zone for a VCE, this occurring following release at the overground pipework at the AGI. Conservatively assuming a failure rate of $2.0 \times 10^{-7} \text{ m}^{-1} \text{ y}^{-1}$ (Table 5.2) and the equivalent of 5m of pipeline (noting that there is limited effect at ground level from vertical releases from buried pipework and, in any case, there are no ignition sources), the frequency of a large leak is $1.0 \times 10^{-6} \text{ y}^{-1}$. In order for the leak to result in a Vapour Cloud Explosion creating a dangerous overpressure at the Veolia building the atmospheric conditions would have to be appropriate and an ignition source located. Assuming the appropriate wind direction (southerly) and strength occurred 25% of the time and probability of an ignition source being encountered before the gas disperses of 0.1, the overall probability of a VCE affecting the Veolia building is $2.5 \times 10^{-8} \text{ y}^{-1}$.

Assuming a 100% risk of fatality for persons indoors, the risk of fatality due to a VCE is $2.5 \times 10^{-8} \text{ y}^{-1}$, equivalent to one fatality in 40 million years.

5.2.3.3 Overall Risk

The overall risk to persons located at the Veolia Building is therefore calculated to be $5.5 \times 10^{-8} \text{ y}^{-1}$, equivalent to 1 fatality in 18 million years and approximately equal to the risk of fatality due to lightning strike. This would put the building outside the outer planning zone and therefore the risk should be considered acceptable by the HSA. It should also be noted that this figure assumes that a flash fire at the building would result in a fatality; in reality persons inside the building would be expected to be protected from flash fires.

5.2.4 Kilkenny County Council WwTP

The only occupied building at the Kilkenny County Council WwTP is the administration building, which lies within the consequence contours for VCEs. The following presents an assessment of the risk to persons at the Works.
5.2.4.1 VCEs

It can be seen in Figure 4.4 that the administration building lies within the middle (10% fatality) zone for a VCE, this occurring following release at the overground pipework at the AGI. Conservatively assuming a failure rate of $2.0 \times 10^{-7} \text{ m}^{-1} \text{ y}^{-1}$ (Table 5.2) and the equivalent of 5m of pipeline (noting that there is limited effect at ground level from vertical releases from buried pipework and, in any case, there are no ignition sources), the frequency of a large leak is $1.0 \times 10^{-6} \text{ y}^{-1}$. In order to for the leak to result in a Vapour Cloud Explosion creating a dangerous overpressure at the administration building the atmospheric conditions would have to be appropriate and the an ignition source located. Assuming the appropriate wind direction (southerly) and strength occurred 25% of the time and probability of an ignition source being encountered before the gas disperses of 0.1, the overall probability of a VCE affecting the administration building is $2.5 \times 10^{-8} \text{ y}^{-1}$.

Assuming a 100% risk of fatality for persons indoors, the risk of fatality due to a VCE is $2.5 \times 10^{-8} \text{ y}^{-1}$, equivalent to one fatality in 40 million years.

5.2.4.2 Overall Risk

The overall risk to persons located at the administration building is therefore calculated to be $2.5 \times 10^{-8} \text{ y}^{-1}$, equivalent to 1 fatality in 40 million years and approximately equal to half the risk of fatality due to lightning strike. This would put the building outside the outer planning zone and therefore the risk should be considered acceptable by the HSA.

5.2.5 Sion Road

It can be seen in section 4 that the section of Sion Road immediately to the south of the proposed facility lies within the inner zones for jet fire, flash fire and VCE accidents. Single carriageways are considered level 1 receptors by the HSA, due to the minimal number of persons present at a given time, and the small period of time said persons are exposed to a risk. Under the HSA Land Use Planning guidance (Ref. 1), level 1 receptors are permitted within the inner zone (section 5.1) and therefore the level of risk should be considered acceptable. However, in order to ensure that all credible scenarios are considered the following sections present an assessment of each accident in turn.

5.2.5.1 Jet Fire

It can be seen in Figure 4.2 that part of the road lies within the inner (50% fatality) zone for jet fires, this being for a full bore release from the overground pipework at the AGI. Thus the estimated pipe failure rate is $2.0 \times 10^{-7} \text{ m}^{-1} \text{ y}^{-1}$ (Table 5.2). Assuming the equivalent of 5m of such pipeline at the AGI, the probability of full bore failure of the pipeline is approximately $1 \times 10^{-8} \text{ y}^{-1}$. In order to have a jet fire affecting the road the south the pipe break would have to occur in the right orientation and with a northerly wind blowing. This set of circumstances has conservatively been assumed to occur in 25% of pipe failures. Therefore the risk is reduced to $2.5 \times 10^{-7} \text{ y}^{-1}$.

In order for a jet fire to occur the gas released would need to find an ignition source within the 20 seconds before the pipeline is isolated. The immediate ignition probability where there is no apparent ignition source is about 0.1 (UK HSE). In this case the pipeline would be in a zoned area on site and ignition sources would not be present. In addition, persons on the road would be within the 50% lethality zone and hence the overall risk of a jet fire at Sion Road is estimated at $1.25 \times 10^{-8} \text{ m}^{-1} \text{ y}^{-1}$, equivalent to one fatality every 80 million years.
5.2.5.2 Flash Fire

The section of road lies within the LFL zone for flash fires following a full bore release from the overground pipework at the AGI. In such a scenario, it would be expected that persons in cars etc. may be protected from a flash fire. However, in order to ensure that all credible scenarios are considered the risk is assessed below.

It can be seen in Figure 4.3 that the section of road lies within the LFL zone for a flash fire for a full bore failure of the overground pipework at the AGI. Thus the estimated pipe failure rate is $2.0 \times 10^{-7} \text{ m}^{-1} \text{ y}^{-1}$ (Table 5.2). Assuming the equivalent of 5m of such pipeline at the AGI, the probability of full bore failure of the pipeline is approximately $1 \times 10^6 \text{ y}^{-1}$. In order to have a flash fire affecting the road to the south the pipe break would have to occur in the right orientation and with a southerly wind blowing. This set of circumstances has conservatively been assumed to occur in 25% of pipe failures. Therefore the risk is reduced to $2.5 \times 10^{-7} \text{ y}^{-1}$.

In order for a fire to occur the gas released would need to find an ignition source within the 20 seconds before the pipeline is isolated. The immediate ignition probability where there is no apparent ignition source is about 0.1 (UK HSE). In this case the pipeline would be in a zoned area on site and ignition sources would not be present, however the gas cloud could extend off-site where there is more likelihood of an ignition source being encountered and an ignition probability of 0.3 has been assumed. Thus the overall risk of a flash fire at Sion Road is estimated at $2.5 \times 10^{-8} \text{ m}^{-1} \text{ y}^{-1}$, equivalent to one fatality every 13 million years, noting that persons within vehicles may be expected to be protected from a flash fire.

5.2.5.3 VCEs

It can be seen in Figure 4.4 that the section of road lies within the inner (50% fatality) zone for a VCE, this occurring following release at the overground pipework at the AGI. Conservatively assuming a failure rate of $2.0 \times 10^{-7} \text{ m}^{-1} \text{ y}^{-1}$ (Table 5.2) and the equivalent of 5m of pipeline (noting that there is limited effect at ground level from vertical releases from buried pipework and, in any case, there are no ignition sources), the frequency of a large leak is $1.0 \times 10^6 \text{ y}^{-1}$. In order to for the leak to result in a Vapour Cloud Explosion creating a dangerous overpressure at the section of road to the south the atmospheric conditions would have to be appropriate and the an ignition source located. Assuming the appropriate wind direction (northerly) and strength occurred 25% of the time and probability of an ignition source being encountered before the gas disperses of 0.1, the overall probability of a VCE affecting Sion Road is $2.5 \times 10^{-8} \text{ y}^{-1}$.

Assuming a 100% risk of fatality for persons indoors (e.g. those in vehicles), the risk of fatality due to a VCE is $2.5 \times 10^{-8} \text{ y}^{-1}$, equivalent to one fatality in 40 million years.

5.2.5.4 Overall Risk

The overall risk to persons on Sion Road is therefore calculated to be $1.125 \times 10^{-7} \text{ y}^{-1}$, approximately equivalent to one fatality every 9 million years. This is within the outer planning zone as defined by the HSA (section 5.1), in which sensitive receptors only (e.g. large hospitals) are advised against and hence the risk should be considered acceptable by the HSA.

It should also be noted that this assessment assumes that a person is always present on the section of road to the south of the proposed facility when an accident occurs, and this would appear to be pessimistic since Sion Road is not a major road. In addition, this assessment discounts any protection provided by vehicles.
For example, if it were assumed that 1,000 vehicles passed along the section every 24 hours, travelling at 30mph, persons would be present along the section (assumed to be 100m in length) for a maximum of 9% of the time and therefore the risk of a fatal accident would be reduced to $1.01 \times 10^{-8} \text{y}^{-1}$, noting that some of the vehicles could have multiple occupants and multiple fatalities are possible.
6. Conclusions

The risks to the public from the proposed power station have been examined using three approaches:

- Compliance with the applicable design code
- Examination of the consequences of potential accidents
- An outline probabilistic risk assessment

The results of these assessments are discussed below.

6.1 Compliance with Design Code

The location of the pipelines and AGI has been assessed against the applicable design code (I.S. 328:2003). This shows that the dwellings and occupied buildings are outside the proximity distance for the size and pressure of the pipe to be used. The Sion Road is just within the proximity distance but that is acceptable for a minor road.

6.2 Consequence Modelling

The risks to the public off-site are summarised below (numbering refers to figure 4.6).

- Veolia Building (1) – Personnel within the building should be protected from all accidents
- Sion Road (3) – There are some risks to the public from jet fires, flash fires and VCEs
- Kilkenny County Council WwTP (4) – There is a small risk to personnel working outdoors. Persons within the admin building would be at low risk
- House on Sion Road (5) – The risk to persons located at the house has been shown to be very low

Note: the house to the south west of the site (2) is considered to be unoccupied, although the risk has been shown to be very low.

As part of the consequence modelling assessment, locations at which members of the public could be within the accident contours (for the applicable accident scenarios) were considered further as part of probabilistic risk assessment.

6.3 Probabilistic Risk Assessment

The policy of the HSA is to apply a risk-based approach for Land Use Planning, in which a number of ‘key’ representative events are considered, both in terms of their consequence and frequency. The risks to persons at all the identified receptors have been shown to well within the H.S.A. guidance on risk for land use planning. Risks to site staff would be higher than the general public but are considered to be well within tolerable limits.
7. References

2. E-mail from Emmet Cregan BGE, 21 July 2010
3. UK HSE Safety report assessment guide: Methane gas holders
5. UK HSE Methods of approximation and determination of human vulnerability for offshore major accident hazard assessment