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13.6 RISK ASSESSMENT

13.6.1 Introduction

The Galway Harbour Enterprise Park was developed by Galway Harbour Company [GHC]. In 2010 Entec provided advice to GHC to assess the influence of the existing COMAH (Control of Major Accident Hazards) establishment and a possible new COMAH facility on the development.

The scheme to be taken forward in a planning application to An Bord Pleanala has now been fixed, having been modified considerably since the previous review. It comprises a new jetty area built from reclaimed land with provision for mainly industrial use and a marina.

The main hazard to the new development is from the existing Topaz (Formerly EnWest) petroleum storage site. There will also be some risk from the jetty and pipelines but this will be low in comparison, as explained in Sections 13.6.5 and 13.6.6.

13.6.1.1 Existing Petroleum Import Facilities

Petroleum is currently discharged to the Topaz site from ships at either Folan Quay or Dun Aengus Docks through 250 mm diameter hoses. Separate oil mains run to each terminal. There are three oil mains to the Topaz terminal to allow for simultaneous discharge of more than one product.

The Leeside Site is served by a separate facility with discharge points at Folan Quay only. The routing of the existing facilities is shown on Tobin drawing 2139-2234 “Existing Inner Harbour Services”.

The existing Harbour is close to the city centre. There are a number of Hotels within close proximity of the existing Jetties, these being mainly to the north and east. Within this area there are also a large number of bars, restaurants and residential properties. The Eyre Square shopping centre is located approximately 300 m to the North.

Other facilities used by public in significant numbers include Taibhdhearc na Gaillimhe the Irish Language Theatre located on Middle Street which holds public events and concerts and Galway City Museum approximately 300 m to the west of the existing jetties. Ceannt Railway Station and Transport Hub is approximately 350 m to the North.

13.6.1.2 Existing Oil Terminals

As the proposed development is in the vicinity of the Topaz and Leeside Sites, the Planning Authority should seek technical advice from the Health and Safety Authority (HSA) about the risks to the development. GHC will need to demonstrate in their planning application that the risk from the Leeside and Topaz Oil Terminals to the occupants using any new facilities is tolerable. An indication of the risk to individual parts of the development can be made by comparison with the HSA Land Use Planning criteria however it is also necessary to assess the overall societal risk. This has been performed by preparing a quantified risk assessment based on the scheme described above by considering the following:

- Identify the incidents at Topaz and Leeside Sites with off-site impact and review the consequence distances of these events;
- Superimpose the consequence distances onto the plan of the development to identify which parts of the development could be affected;

- Use site-specific data to establish the probability of the incidents occurring;
- Use information about the development to determine the vulnerability of the population in the event that the selected events occur;
- Calculate site-specific risk integrals for the different sections of the development based on a representative set of scenarios;
- Assess the overall risk to the development with reference to the criteria that are included in the HSA planning approach document and make a comparison to the current situation.

The Topaz facility is described at 13.6.3.1, Leeside at 13.6.4.1.

The existing Cold Chon bitumen storage has been excluded from this analysis. It is not considered a major hazard site under the COMAHDS Regulations (section 13.6.1.4) and therefore is unlikely to contribute significantly to the risk to occupants of the new port development.

13.6.1.3 New Jetties and Pipeline

The jetties and transfer pipelines do not come under the scope of the EU Seveso 2 Directive and therefore the COMAHDS[2] Regulations which implement the Directive in Ireland. There is no specific regulatory requirement to submit a quantified risk assessment of petroleum pipelines in Ireland[1].

Whilst a quantified risk assessment for the jetties and pipeline is not strictly required for planning approvals nevertheless they potentially present a high hazard and as such the HSA would expect that a suitable and sufficient risk assessment is carried out. A detailed risk assessment of the jetties and pipeline would:

- Demonstrate adequate separation between hazards and people (or identify any problems at an early stage);
- Reassure the authorities as to the compatibility of elements within the development;
- Aid the development of emergency plans for the harbour;
- Provide input into the scale and likelihood of accidental releases to be considered in the Environmental Impact Study (EIS).

The development also designates a plot for a future fuel storage site and a plot for a future bitumen yard extension. The risk from the future fuel storage yard has not been analysed in detail as the current planning application does not include for fuel storage at this time. The future oil storage yard will not store class I fuel or ethanol and so the risk to the development is assumed to be dominated by the existing neighbouring Topaz site. Before being constructed and brought into operation further planning permission will be required. Should the inventory exceed 2,500 tonnes of petroleum products the COMAHDS Regulations[2] will apply and a further risk assessment will be required.

Bitumen is not considered a major hazard under the COMAHDS Regulations and is unlikely to contribute significantly to the risk to occupants of the new harbour extension.

[1] One of the recommendations from the Buncefield incident in the UK was for the UK to consider including gasoline pipes in the scope of the UK Hazardous Pipeline Regulations which would require a QRA. Within Irish Health and Safety legislation there are no equivalent Regulations covering Hazardous Pipelines and so what is deemed to be good practice in other international jurisdictions has been considered in this report.

[2] S.I. No. 74 of 2006 European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2006 (COMAHDS 2006)

13.6.1.4 Major Hazard Regulations

The Seveso 2 Directive is the main piece of EU legislation that applies to the control of major accident hazards involving dangerous substances. It applies to installations where there are inventories of dangerous substances above listed thresholds:

- Directive 96/82/EC (December 1996) *on the control of major-accident hazards involving dangerous substances*;
- Directive 2003/105/EC (16 December 2003) amending Council Directive 96/82/EC *on the control of major-accident hazards involving dangerous substances* expanded the scope of the directive.

In Ireland the requirements of the above Directives are promulgated in the COMAHDS[2] Regulations. The objective of the regulations is to reduce the risk to the general public and there are two tiers of application and the requirements are greater where the installation exceeds the higher inventory threshold (upper tier). Operators of upper tier installations must notify the competent authority if they are holding dangerous substances in excess of the lower tier threshold. Member States must make arrangements in the Land Use Planning process to prevent incompatible developments encroaching too close to COMAHDS sites and for the suitable location of such sites when first built. Operators of upper tier sites produce a safety report in order to demonstrate that adequate safety and reliability have been incorporated into the design, construction, operation and maintenance of the installation. Lower tier sites must produce a Major Accident Prevention Policy (MAPP).

Some of the bulk liquids storage tanks contain petroleum products and come within the scope of the COMAHDS Regulations [S.I. No. 74 of 2006] and Planning and Development Regulations 2001-2006. Those containing petroleum spirit (gasoline) in particular are required to have significant separation from some other types of land use to ensure adequate safety in the event of a rare but possible major accident. The separation distances required can impose restrictions on the location of such storage and developments in the vicinity of them.

13.6.1.5 HSA Land Use Planning Advice

The Health and Safety Authority (HSA) has issued a document[3] describing how they provide advice on Land Use Planning issues around Major Hazard sites.

13.6.1.5.1 <u>Policy</u>

The HSA's approach to land use planning policy is based upon the requirement of Article 12 of the European “Seveso 2” Directive [2003/105/EC] which requires that for Member States ‘the objectives of preventing major accidents and limiting the consequences of such accidents are taken into account in their land use policies and/or other relevant policies’.

The HSA adopts a three level approach to assessing the tolerability of risk, where risk is intolerable (very high), development will be advised against; where it is insignificant (“broadly acceptable) development will not be advised against, and in the middle region of significant risk the risk will be “tolerable if ALARP” but the Planning Authority should be advised of the risk and take it into account when considering the benefits and costs of the scheme[3],

[3] Policy and Approach of the Health and Safety Authority to COMAH Risk-based Land-use Planning March 2010

13.6.1.5.2 Approach

The HSA follow a similar approach to the UK HSE, but, with particular reference to flammable liquid bulk storage allow for a more risk based approach. Therefore planning zones around petroleum products storage are defined based upon levels of individual risk of fatality arising from potential major accidents at the storage including fires and explosions. It should be emphasised that the primary objective of the HSA and operators is to prevent such accidents and the low levels of risk of such accidents are the residual levels of risk after "all measures necessary" have been taken to prevent them. This would be in compliance with the main requirement of the Seveso 2 Directive which is the prevention of major accidents.

In order to maintain suitable separation distances between hazardous materials and people not related to the hazardous material operations, three zones are defined to represent the areas of elevated, but decreasing levels of risk with increasing distance from the hazard. The HSA defines a Consultation Distance (CD) from the Major Hazard, set out in the Planning and Development Regulations 2001-6 and notified to the planning authority by the HSA at the time of notification of the establishment[3].

The outer boundary of each zone is defined in terms of the risk of fatality to an individual permanently at one location (i.e. Individual Risk):

- Inner Zone 1 x 10-5 per year (10 in a million years or 1 in a hundred thousand years);
- Middle Zone 1 x 10-6 per year (1 in a million years);
- Outer Zone 1 x 10-7 per year (0.1 in a million years or 1 in ten million years).

The acceptability of development in each zone depends on the nature of the development and the vulnerability of the people likely to be present. The vulnerability will depend on several characteristics such as the ability to organise people in an emergency, the mobility of the people, the number of people and the proportion of their time spent in the vicinity.

The HSA has followed the UK HSE's characterisation of the sensitivity level of each type of development exactly (see pages 39 to 44 of Reference[3] and compare with section 4 of the HSE PADHI[4]).

The online version of the HSA document has a print error: the Exclusions under DT2.4 (indoor use by the public) have been copied from the Exclusions under DT2.5 (outdoor use by the public) in error[5]. The HSA policy is in harmony with PADHI and will be corrected at the next update. The DT2.4 category is split into three 'levels', namely:

- Level 1 – development is less than 250 square meters (sq. m);
- Level 2 – development is > 250 sq.m up to 5,000 sq.m;
- Level 3 – development is > 5,000 sq.m.

In the following assessments the HSA Policy and Approach document has been used, but where no detailed guidance has been given the approach used by the UK HSE has been described.

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[4] PADHI – HSE'S Land Use Planning Methodology September 2009 www.hse.gov.uk/landuseplanning/padhi.pdf

[5] E-mail from Brendan Rudden to Morag Armstrong 27/7/2010 forwarding on comments from the HSA to Tobin.

13.6.1.5.3 Societal Risk

Societal risk refers to the risk of large numbers of people being affected in a single accident. In addition to the considerations in section 13.6.1.5.2 above for developments involving large numbers of people societal risk criteria must also be satisfied.

13.6.1.6 Description of Development

The following information is pertinent to the quantified risk analysis.

The development will consist of reclaimed land using salvaged dredged silts and sands capped with a rock fill. A degree of permeability will exist. This has the potential to have a bearing on the persistence of any leak and has been considered in the type of modelling performed.

There will be 5 normally occupied buildings on the development these being of block construction:

1. Harbour Company Warehouse Max 10 people, 24 hrs operation (5 day and 5 nights);
2. Marina Office (assume up to 10) Max 3 x employees, plus members of public (users of marina);
3. New Harbour Office Max 7 employees (5 day; 2 night time) plus occasional meetings (20-40);
4. Passenger Terminal Occupancy up to 100 at a time for a short time while disembarking;
5. Security Gatehouse Max 2 employees day and night.

Provision is made to receive cruise ships and it is estimated that there could be up to 30 cruise ships visiting per year. Typically each ship could bring 850 passengers of which 70% go on bus tours, 15% walk to the city and 15% stay on board during the day. Those going on bus tours would not all disembark at the same time and the passenger terminal is designed for 100 passengers at a time. The ships could be in harbour for up to 2 days.

A new jetty will be provided for importing petroleum products. These will be piped directly to the Topaz terminal. The Leeside Site will not be served from the new jetties.

The development includes provision for a possible future marina village. Public access will be permitted along the Marina Village but will be restricted in the Quays and Jetty.

13.6.2 Properties of Petroleum Products

The following substances are considered within this report:

- Gasoline (which is also sometimes referred to as ULP (unleaded petrol), ULG (unleaded gasoline), motor spirit, and petrol);
- Kerosene (which is sometimes referred to as kero);
- Diesel (which is sometimes referred to as ULSD (Ultra Low Sulphur Diesel) and Derv;
- Gasoil (marked gasoil, MGO);
- Ethanol (Also referred to as ETDN, Denatured Ethanol); and
- Diesel and gasoline additives.

Gasoline, Kerosene, Diesel and Gas Oil qualify as dangerous substances under the COMAHDS Regulations as they are considered ‘Petroleum Products’ a named substance under schedule 1 part 2.
Ethanol qualifies under the generic categories as ‘highly flammable’.

Some Diesel additives and gasoline additives are classed as dangerous substances under the Regulations via schedule 1 part 3 (generic categories) as they are ‘Dangerous to the Environment’.

The petroleum products identified below do not mix with water whilst the chemical Ethanol is fully miscible in water.

The substances handled and their hazards (taken from material safety data sheets) are summarised below:

13.6.2.1 Class I Petroleum Products

ULG 95 (Gasoline / Unleaded Petrol) - Risk (R) Phrases:

- R12- Extremely flammable;
- R45- May cause cancer;
- R46- May cause heritable genetic damage;
- R63- Possible risk of harm to the unborn child;
- R65- Harmful: may cause lung damage if swallowed;
- R38- Irritating to skin;
- R67- Vapours may cause drowsiness and dizziness;
- R51/53- Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

13.6.2.2 Class II (1) Petroleum Products

KERO (Kerosene) - Risk (R) Phrases:

- R10 Flammable;
- R38 Irritating to skin;
- R65 Harmful: may cause lung damage if swallowed;
- R51/53 Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

13.6.2.3 Class III (1) Petroleum Products

Diesel (Ultra Low Sulphur Diesel) - Risk (R) Phrases:

- R40 Limited evidence of a carcinogenic effect;
- R65 Harmful: may cause lung damage if swallowed;
- R51/53 Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Gas Oil - Risk (R) Phrases:

- R40 Limited evidence of a carcinogenic effect;
- R65 Harmful: may cause lung damage if swallowed;
- R66 Repeated exposure may cause skin dryness or cracking;
- R51/53 Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

13.6.2.4 Other Products

Ethanol - Risk (R) Phrases:

- R11 - Highly flammable.

13.6.2.5 Major Accident Hazards

The potential major accident scenarios can be categorised as follows:

- Loss of containment (with or without ignition);
- Internal explosion (due to air ingress);
- Fire (Pool Fire from ignited liquid on the ground or Flash Fire from ignited drifting vapour);
- Vapour Cloud Explosion (Ignition of a Vapour Cloud which covers a congested area).

Loss of Containment without Ignition

Unignited releases are not considered to present a major hazard to people as the products are not classed as toxic. A release into a confined space could present a hazard to personnel by displacing the oxygen however this is not considered a potential major accident to people under the COMAHDS Regulations.

Gasoline, kerosene, diesel, and gasoil are all classed as toxic to the aqueous environment; therefore loss of containment without ignition presents a risk of major accident to the environment.

Loss of Containment with Ignition

Gasoline (flash point below minus 40^{o}C) is classed as extremely flammable, ethanol (flashpoint 13^{o}C) is classed as highly flammable and kerosene (flashpoint 38^{o}C) is classed as flammable. In the event that loss of containment of one of these products was to ignite several outcomes are possible and these are considered in Table 13.6.2.1.

Diesel and Gas oil (flash point > 55^{o}C) are not classed as flammable for storage. In certain release scenarios it is possible that an aerosol could form vaporising lower boiling components and forming a flammable cloud, however the risk of ignition is very much lower than for gasoline, ethanol and kerosene. Also the consequences for people and equipment are generally less severe.

Consequences of Loss of Containment with Ignition		
Outcome	**Conditions**	**Comments**
Pool Fire	Either immediate or delayed ignition of a liquid release which has formed a pool on the ground	
Flash fire	Delayed ignition	
Vapour Cloud Explosion (VCE)	Delayed ignition, cloud accumulates in congested area	Not considered credible for kerosene
Jet Fire	Ignition of high momentum release e.g. from discharge pipe work of export pumps.	

Table 13.6.2.1 - Consequences of Loss of Containment with Ignition

All types of fire can cause harm to people, structures and other equipment by heat transfer. The main mechanism for this outside the area of the flame is thermal radiation. The degree of harm caused is dependent upon the rate of transfer (heat flux) and duration which together determine the total heat received, or thermal dose.

Fires will also generate smoke which could contain hazardous combustion products. The buoyant nature of a smoke plume means that it is unlikely to result in exposure to dangerous concentrations of smoke products off-site. The exception is if there are people in high rise buildings close to the site. This is not the case in the proposed developments around the Topaz and Leeside terminals and therefore the consequences of the exposure to such smoke events have not been considered quantitatively within this report.

Pool Fire

Pool fires may be contained or uncontained. Oil storage tanks are located within 'bunds' which are designed to contain any spillage. In some circumstances a release could occur outside the bund (e.g. over-topping in the event of a sudden failure of a storage tank or releases from pipework outside the bund). These over-topped fractions would be 'uncontained' e.g. if onto road way or nearby ground, or semi-contained e.g. if the release was to a yard area.

Jet Fire

Releases from pressurised equipment may give rise to vapour or liquid jets which, if ignited burn rapidly giving rise to higher local heat flux than pool fires. Generally these fires have a shorter duration and do not spread so widely as a pool fire. If the pressurised release is not ignited and the liquid falls to the ground then a pool will form and later a pool fire will occur if ignition occurs. A vapour cloud could also be formed if the liquid is sufficiently volatile.

Flash Fire and Vapour Cloud Explosion (VCE)

All the incidents identified above could also give rise to a flammable vapour cloud. This could drift off the pool, driven by the wind, before being ignited and give rise to a burning vapour cloud or flash fire. This could then be followed by a pool fire burning on the residual liquid.

The area impacted by a flash fire depends on a number of variables including the rate and duration of release, the dispersion conditions, and the topography (the cloud formed by gasoline would be heavier than air).

Vapour cloud explosions occur when there is sufficient turbulence within the burning flammable cloud to accelerate combustion leading to higher over-pressures. This can occur if a flammable mixture is ignited within a congested area e.g. of process pipework and equipment.

In the extreme a worst case scenario would be a 'Buncefield' type event where an ignited vapour cloud burned so rapidly that detonation occurred and caused widespread damage from blast overpressure as well as severe fire damage within the vapour cloud.

The incident which occurred at Buncefield[6] in 2005 was as a result of a major loss of containment of gasoline when up to 300 tonnes of gasoline overflowed from a storage tank. The vapour migrated and eventually ignited causing a flash fire and large explosion leading to a pool fire. The subsequent major accident investigation determined that such a large VCE was a credible risk for gasoline where:
Tank filling rates exceeded 100 te/hr;
Tank height was greater than 5m.
The investigation concluded that a large VCE was not credible for Ethanol, Kerosene or Diesel.

[6] The Buncefield Incident 11 December 2005: The final report of the Major Incident Investigation Board, 2008

Risk to Environment

Gasoline, kerosene, diesel, and gasoil are all classed as toxic to the aqueous environment; therefore loss of containment without ignition presents a risk of major accident to the environment.

In the event of an ignited release firewater contaminated with unburned petroleum products and fire-fighting foam also presents a risk to the environment if it runs off the site and it cannot be contained.

The consequences of an accidental release to the environment have been considered in Appendix 3.3.4.3 and Chapters 7 and 8.

13.6.3 Topaz Site

13.6.3.1 Overview of Activities

The Topaz (formerly Enwest) site is located in the Galway Harbour Enterprise Park and is operated by Topaz Energy Ltd.

The Topaz site compromises nine bulk tanks used for the storage of Kerosene (KERO), Unleaded Gasoline, Gas Oil (MGO), Diesel (ULSD) and Ethanol. The product area is split into 4 No. main storage tanks and 5 No. day tanks. There are also several smaller tanks used for the storage of additives and marker dyes.

The Tank farm is contained within a single bund, with intermediate bund walls in place to sub-divide the bund into three compartments.

Diesel, Kerosene, gasoil and gasoline are transferred to the main tanks T1 to T4 from ships in the local harbour (approximately 300 m from the tank farm). Day tanks are provided so that tanker filling can be maintained whilst a ship is being unloaded. Road tankers can be loaded either from bulk tanks or day tanks at one of six purpose built loading gantries. There is also provision to receive ethanol from road tankers into a day tank T9, Ethanol is blended with gasoline at 5.75% - 10% directly at the road tanker gantry.

The main process blocks of the facility are:

- Gasoline – transfer from ship to bulk tank; transfer from bulk tank to day tank, tanker loading from either bulk tank or day tank;
- ULSD (Diesel) – transfer from ship to bulk tank; transfer from bulk tank to day tank, tanker loading from either bulk tank or day tank;
- MGO (Gas oil) – transfer from ship to bulk tank; transfer from bulk tank to day tank, tanker loading from either bulk tank or day tank;
- KERO (kerosene) – transfer from ship to bulk tank; transfer from bulk tank to day tank, tanker loading from either bulk tank or day tank;
- Ethanol – transfer from ship to day tank, tanker loading from day tank (added to gasoline as a biofuel). Also receipt of ethanol from road tankers;
- Road tanker loading – to load gasoline, diesel, MGO and kerosene into road tankers;
- Vapour Recovery Unit – to recover vapour from the road tanker vents;
- Additives – additives may be added to bulk tank during unloading from ship or may be fed directly into the road tanker during loading.

The Topaz site qualifies as a top tier Seveso site under the “Control of Major Accident Hazards Involving Dangerous Substances Regulations” which implement the European Communities Seveso 2 E.U. Directive.

13.6.3.2 Basis of Analysis

The following table identifies the basis of the analysis used for the Topaz site. The number of tanks, their contents, the capacity, the diameter and height above ground are all identified in the table below.

Storage

Details of Topaz Storage Tanks (Bulk and Day Tanks)				
Storage Tank	Contents	Capacity (m^3)	Dia*(m)	Height*(m)
1	Kerosene	8,000	30	13.2
2	Gasoline	15,000	40	13.2
3	Gasoil	12,000	36	13.2
4	Diesel	8,000	30	13.2
5	Diesel	763	9	13.2
6	Kerosene	763	9	13.2
7	Gasoil	763	9	13.2
8	Gasoline	763	9	13.2
9	Ethanol	1,039	10.2	13.2

Table 13.6.3.1 - Details of Topaz Storage Tanks (Bulk and Day Tanks)

13.6.3.3 Accidents with Possible Off-Site Impact

The HSA land use policy document[7] identifies the possible major accidents to be considered when determining the consultation distances from a site which meets the Seveso qualifying criteria. For a Large Scale Flammable Storage Site such as Topaz these are:

- Large Vapour Cloud Explosion [VCE] such as occurred at Buncefield;
- VCE from congested areas such as tanker loading bays;
- Large Pool Fires, contained and uncontained.

13.6.3.4 Consequence Review

The consequences of these scenarios have been modelled using the methods described within the HSA land use policy document which is as described in Appendix 13.6. The detailed results of the consequence modelling are also provided for reference in this Appendix.

In order to determine the parts of the development that could be affected by an incident at the Topaz site, consequence contours were produced showing the distance within which there could be significant impact. These are shown on Drawing No. 28135/R/CVD/001/A. Note that on the drawing the hazard ranges have been adjusted to read the distance from the centre of the site (bulk storage event), centre of the gantry and the centre of day tank bund. The result of this screening is given in Table13.6.3. An incident is assumed not to have potential for significant impact if:

- The thermal radiation intensity does not exceed 4 kW/m^2;
- The explosion over-pressure does not exceed 5 kPa;
- Flammable concentration is below the Lower Flammable Limit (LFL).

[7] Policy and Approach of the Health & Safety Authority to COMAH Risk-based Land-use planning (19 March 2010)

Areas of the Development affected by an Incident originating at the Topaz Site			
Accident Scenario	Hazard	Distance	Areas
Bulk tank Event 1 (over-topped)	Thermal	330 m	3.0, 3.1,.3.2, 3.4, 3.8, 4.2, 4.3
Bulk tank Event 2 (in bund)	Thermal	230 m	3.1, 3.2,
'Large' VCE (from storage)	Over Pressure	650 m	3.0, 3.1,.3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.10, 3.11, 3.12, 3.16, 3.17, 4.2, 4.3, 4.4, 4.5,
VCE at tanker loading gantry	Over pressure	240m	3.1,.3.2, 3.3 (just) 3.4, 3.8, 4.1, 4.2
Day Tank Event 1 (over-topped)	Thermal	290 m	3.1,3.2, 3.3
Day Tank Event 2 (in bund)	Thermal	190 m	3.1, 3.2 (just)
Ethanol Event 1	Thermal	270 m	3.1,3.2, 3.3 (just)

Table 13.6.3.2 - Areas of the Development affected by an incident originating at the Topaz Site

13.6.3.5 Frequency Assessment

The frequency of these events is based on the information provided in the HSA land use policy document.

13.6.3.5.1 Frequency of a VCE

The frequencies adopted for this study are those used in the HSA land use planning policy document and in their associated decisions.

VCE from Storage

The HSA methodology for land use planning uses a frequency of large scale VCE of 10^{-4} per year per terminal. This is based on there being ten tanks that could give rise to a Buncefield type explosion. Furthermore the HSA allows a ten fold reduction in frequency where recommendations from Buncefield regarding over-fill prevention have been implemented.

The investigation into the Buncefield explosion mechanism[8] concluded that:

- There was the potential for large VCE from gasoline storage tanks that were more than 5 m tall and filled at rates greater than 100 m^3/hr;
- Ethanol, kerosene and diesel were not likely to form a large vapour cloud leading to a Buncefield type VCE.

Both the gasoline bulk storage tank and the gasoline day tank meet the first of these criteria meaning that a large VCE of the type that occurred at Buncefield could in theory occur if the tanks were to be over-filled, the over-fill go undetected and the resulting flammable cloud ignite after a delay.

It is understood that the recommendations from the Buncefield investigation have been implemented at the Topaz terminal (a layer of protection analysis has been carried out and there is an independent high level automatic shut off trip).

On this basis the frequency of a large VCE from storage is taken as **2 x 10^{-5} per year**.

[8] Process Safety Leadership Group (PSLG) Final Report – 'Safety and Environmental Standards for Fuel Storage Sites, Appendix 1.

VCE at Out Loading Gantry

The frequency of a VCE at the Out-loading bay is taken as **1 x 10^{-3}per year**.

13.6.3.5.2 Pool Fire

Event 1: Over-topped Fire

The guidance in the land use policy document proposes a frequency of 10^{-4} per year for a small site, and that the frequency should be distributed along a locus 50m from the edge of the bund at a frequency of $10^{-4}/(100\pi)$ per year.

This event could occur in any direction. Should the pool form on any side apart from the opposite side to the harbour development, thermal radiation at the development will exceed 4 kW/m^2.

Therefore applying the HSA generic method the frequency that a fire occurs outside the bund would be **7.5 x 10^{-5} per year**.

A site specific frequency can be calculated based on the likelihood of catastrophic failure of a bulk storage tank capable of over-topping a volume greater than 175 m^3 which will give the maximum pool size. At the Topaz site five of the storage tanks contain products that could ignite:

- Gasoline bulk tank and day tank;
- Ethanol day tank;
- Kerosene bulk tank and day tank.

Lees (1996) gives a frequency of catastrophic failure for atmospheric storage tanks of 6 x 10^{-6} per yr. If the probability of ignition is conservatively taken as 1 for all of these products a site specific frequency of **3 x 10^{-5} per yr** is arrived at, which is similar to the HSA value.

Event 2: Pool Fire Contained in Bund

The guidance in the HSA land use policy document proposes a generic frequency of 10^{-3} per year for a pool fire that covers the surface of the bund.

A site specific estimate can be determined based on the number of storage tanks. Tarns IChemE, Vol.74, part B, May 1997 quotes the following frequencies for a fire in a bund:

- highly flammable liquids 1.2 x 10^{-4} per vessel per year;
- flammable liquids 1.2 x 10^{-5} per vessel per year.

Gasoline and Ethanol are considered highly flammable, and kerosene flammable which gives a frequency of **3.84 x 10^{-4} per year** split 40% from bulk tank and 60% from day tanks. This is lower than the HSA frequency as there are fewer tanks on the site compared to that of a generic terminal. Hence, this is the frequency adopted for the study.

13.6.4 Leeside Site

13.6.4.1 Overview of Activities

The Leeside site is located to the west of the Topaz site, and comprises eleven bulk tanks used for the storage of Kerosene (KERO), Unleaded Gasoline, Gas Oil (MGO) and Ultra Low Sulphur Diesel. There are also several smaller tanks used for the storage of additives, marker dyes, Gas, Kerosene and Non-conformity Diesel, these are situated within the tank farm.

The Tank farm is contained within a single bund, with intermediate bund walls in place to sub-divide the bund into two compartments.

The main process blocks of the facility are:

- Gasoline – transfer from ship to bulk tank and tanker loading from bulk tank;
- Diesel (ULSD) – transfer from ship to bulk tank and tanker loading from bulk tank;
- MGO (Gas oil) – transfer from ship to bulk tank and tanker loading from bulk tank;
- KERO (kerosene) – transfer from ship to bulk tank and tanker loading from bulk tank;
- Road tanker loading – to load gasoline, diesel, MGO and KERO into road tankers;
- Vapour Recovery Unit – to recover vapour from the road tanker vents;
- Additives – additives may be added to a bulk tank during unloading from ship or may be fed directly into the road tanker during loading.

The Leeside site qualifies as a lower tier site under COMAHDS due to the quantity of petroleum products stored on site. The site has prepared a 'Safety Statement' which includes a description of the major accident scenarios for the site and describes the prevention, control and mitigation measures in place to manage the risk.

13.6.4.2 Basis of Analysis

The Leeside site will presently continue to import petroleum using the existing jetty and transfer pipeline. It is envisaged in the medium term that this facility will close down and that business will transfer to the Topaz site. The new oil pipelines are therefore not proposed to extend from the new jetty to Leeside. The details of the storage tanks and their contents are tabulated below.

Details of Leeside Storage Tanks				
Storage Tank	Contents	Capacity (m^3)	Dia*	Height*
1	Kerosene	1,840	12.2	16.78
2	Gasoline	1,772	12.2	16.78
3	Gasoline	3,434	17.0	16.78
4	Diesel	2,634	14.8	16.78
5	Kerosene	2,615	14.8	16.78
6	Gas oil	2,652	14.8	16.78
7	Gas oil	646	8.0	14.0
8	Gasoline	593	8.0	14.0
9	Gasoline	593	9.0	14.0
10	Diesel	787	9.0	14.0
11	Diesel	1,004	10.0	14.0

Table 13.6.4.1 - Details of Leeside Storage Tanks

13.6.4.3 Accidents with Possible Off-Site Impact

Activities at the Leeside Site are similar to the Topaz Site and the same potential accidents are considered, namely:

- Large Vapour Cloud Explosion such as occurred at Buncefield;
- VCE from congested areas such as tanker loading bays;
- Large Pool Fires, contained and uncontained.

13.6.4.4 Consequence Review

The consequences of these scenarios have been modelled using the methods described within the HSA land use policy document as described in Appendix 13.6. Detailed results are also reported in this Appendix.

In order to determine the parts of the development that could be affected by an incident at the Leeside Site the consequence contours were produced showing the distance within which there could be significant impact. These are shown in Drawing No. 28135/R/CVD/002/A. The results of this screening are given in Table 4.2.

An incident is assumed not to have potential for significant impact if:

- The thermal radiation intensity does not exceed 4 kW/m^2;
- The explosion over-pressure does not exceed 50 mbar (5 kPa);
- Flammable concentration is below the Lower Flammable Limit (LFL).

Areas of the Development affected by an Incident originating at the Leeside Site			
Accident Scenario	Hazard	Hazard Range	Areas
Pool Fire (Over Topped)	Thermal	330m	None
'Large' VCE	Over Pressure	650m	3.0, 3.1, 3.2, 3.3, 3.4, 3.6, 3.7, 4.2, 4.3
VCE at Tanker Loading Gantry	Over Pressure	240m	None

Table 13.6.4.2 - Areas of the Development affected by an Incident originating at the Leeside Site

13.6.4.5 Frequency Assessment

13.6.4.5.1 <u>VCE from Storage</u>

The frequency of a VCE from the storage of flammable liquids was determined as described in Section 13.6.3.5.1 in the preceding section.

At the Leeside Site there are four gasoline tanks considered capable of creating a large VCE and these are tanks 2, 3, 8 and 9. These are fitted with independent high level alarms which are tested every 6 months. However these are not SIL (Safety Integrity Level) rated[9] therefore the more conservative probability of explosion is used.

The likelihood of a large VCE occurring at Leeside is therefore assumed to be **4 x 10^{-5} per year**.

[9] SIL equipment is certified to IEC 61508 as meeting a given target reliability (e.g. SIL 1, SIL 2 etc). The high level trips will reduce the likelihood of a major vapour cloud explosion but the level of risk reduction has not been formally demonstrated.

13.6.5 Jetties

13.6.5.1 Overview of Activities

Petroleum will be unloaded from tankers at the jetty. Petroleum products are unloaded either through loading hard arms or hoses.

The analysis is based on the design of the unloading and transfer being similar to the existing unloading facilities in Galway Harbour i.e. three lines so that different products can be offloaded simultaneously. Lines will be blown clear after unloading of the ship. Amec has been advised[10] that the new facility will use hard arms. Safety features will include ranging alarms and emergency release couplings.

The petroleum products will only be pumped to the Topaz site from the new jetty. The Leeside Site will not be connected into the new jetty.

Detailed design of the jetties and pipelines is on going there is sufficient information from design work so far to enable an assessment of major hazards for planning purposes. The jetties and pipelines will be designed in accordance with recognised international standards and codes of practice such as The Bulk Transfer of dangerous liquids and gases between ship and shore (HSG 186), 1999, Health and Safety Executive and PD8010 -1:2004: Code of Practice for Pipelines. In accordance with these codes and recognised best practice the detailed design process includes formal safety reviews such as HAZOP.

13.6.5.2 Basis of Analysis

It is assumed that the diameter of the unloading hose is the same as the transfer pipeline i.e. 10” nominal bore (254.4 mm internal diameter). The operating pressure is expected to be in the range 4 – 8 bar and conservatively the consequence modelling is based on 8 barg. The transfer rate is 550 m^3/hr (pumped from the ship). Ships will transfer in lots of approx 4,000 m^3.

13.6.5.3 Representative Accident Scenarios

Three release cases were considered:

- Full bore rupture;
- 80-mm leak (representing 10% of the cross sectional area);
- 10-mm leak.

Possible outcomes considered were flash fire, pool fire (which would occur if liquid ‘rained out’) and a jet fire. These were determined for both vertical and horizontal releases and at two representative dispersion conditions.

13.6.5.4 Consequence Review

The consequence modelling undertaken follows the methods explained in Appendix 13.6 and the details of the findings are also contained in this Appendix.

The consequence results have been screened and the thermal radiation scenarios which effect the development are outlined in the table below.

[10] Telecon with B. Rudden of Tobin 4/8/2011

Areas of the Development affected by an Incident originating at the Jetty			
Accident Scenario	**Hazard**	**Hazard Range**	**Areas**
Pool Fire FB Rupture (worst case)	Thermal	146 m	None
Jet Fire 80-mm (worst case)	Thermal	220 m	3.15 (including building)
Jet Fire 10-mm (worst case)	Thermal	37 m	None
FB Release Flash Fire, F2	Burn	204 - 240 m	3.15 (including building), cruise ship
FB Release Flash Fire D5 & D15	Burn	87 - 140 m	None
80-mm Horizontal Release Flash Fire; F2,	Burn	340 m	3.15 (including building) 3.14 (including building), cruise ship
80-mm Horizontal Release Flash Fire; D5	Burn	220 m	3.15 (including building), cruise ship
80-mm Horizontal Release Flash Fire; D15	Burn	156 m	None
80-mm Vertical Release Flash Fire (all)	Burn	41 m	None
10-mm Releases Flash Fire (worst case)	Burn	42 m	None

Table 13.6.5.1 - Areas of the Development affected by an Incident originating at the Jetty

13.6.5.5 Frequency Assessment

FPC Advantica (1990) cites a frequency of spills more than 1-te of 2.2×10^{-4} per cargo for a transfer hose for petroleum products, based on 12 hour operation.

This is approximately three times greater than the generic frequency quoted by the UK HSE[11] for transfer of liquid cargoes using loading / unloading arms. It quotes the frequency of full bore rupture as 3.8×10^{-5} per cargo; and the frequency of an 80mm hole leak of 3.3×10^{-5} per year, when one arm is used. These frequencies assume a transfer time of 12 hours, that there will be 10 passing ships during unloading and that the following safety features are present:

- The unloading system is fitted with ranging alarms; and
- Emergency release couplings.

Currently the Topaz Terminal receives approximately 50 gasoline cargoes per year. The medium scenario for the Harbour extension envisages a threefold increase in throughput of petroleum products[12] by 2035. There will be fewer passing ships in the location proposed for the petroleum jetty.

Based on using one hard arm for gasoline the total failure frequency would be 1.0×10^{-2} per year of gasoline. Assuming that the probability of ignition is 0.3, this gives a frequency of a gasoline fire of 3.2×10^{-3} per year. Note that even if the release did not ignite this presents a potential major accident to the environment (MATTE) as it is likely that any spillage would run to the harbour. Oil booms will be deployed during unloading to minimise the risk of spillage (See Appendix 3.34).

A release of kerosene could also give rise to a fire. Assuming a similar number of cargos (ships usually deliver more than one petroleum product) and conservatively taking a probability of

[11] Failure Rate and Event Data for use within Land Use Planning Risk Assessments, UK HSE

[12] Email from B. Rudden of Tobin Consulting to M. Armstrong of Entec dated 02 June 2011

ignition of 0.3, the overall risk of release of a major ignited release is 6.4 x 10^{-3} per year. This is broken down as:

- The frequency of fire caused by full bore rupture of an unloading arm = **3.4 x 10^{-3} per year;**
- The frequency of fire caused by an 80mm hole release from an unloading arm = **2.9 x 10^{-3} per year.**

It is assumed that of the ignited releases one third are delayed ignition events.

Consequence modelling has been based on gasoline which is much more volatile and higher flammability compared to kerosene. Kerosene has a flash point of 49^{o}C which is above ambient temperature. Kerosene does not give rise to a significant flash fire hazard.

13.6.6 Pipeline

13.6.6.1 Overview of Activities

It is proposed that the pipeline will run from the jetty underground to the Topaz terminal following the route taken by the road as shown on Drawing No. 28135/R/CVD/003/A (The Leeside site will not be supplied from the new jetty). Three lines will be routed within an impervious lined chamber. The trench will be approximately 3 m wide. This is shown on Drawing No. 2139-2187.

13.6.6.2 Basis of Analysis

The pipeline will have the same specification as the pipeline that is currently used to transfer petroleum products from the Harbour to the Topaz site. These are summarised in the table below.

Pipeline Specifications	
Feature	**Parameter Value**
Design Code:	The pipeline will be constructed to an appropriate recognised code of practice e.g. PB8010 -1:2004: Code of Practice for Pipelines Part 1: Steel Pipelines on Land
Pipeline Length	1.13km
Pipeline Diameter (nominal)	254.4mm (10 inch)
Pipe Wall Thickness	9.5 mm
Design Pressure	19.6barg
Maximum Allowable Operating Pressure (MAOP)	18barg
Normal operating Pressure	4 – 8 barg
Depth of Cover	1.5m to 2.0m (nominal)
Physical protection	200-mm pre-cast slabs
Grade of Steel	ASTM A106 or API 5L Grade B
Corrosion Coating	To be advised
Product – Substance Carried	Gasoline, Kerosene, Marked Gas Oil (MGO) and Diesel
Isolation Valves	There are no intermediate isolation valves.

Table 13.6.6.1 - Pipeline Specifications

13.6.6.3 Representative Accident Scenarios

Three release cases were considered:

- Full bore rupture;
- 80mm leak (representing 10% of the cross sectional area);
- 10mm leak.

Possible outcomes considered were flash fire, trench fire, pool fire and jet fire. The circumstances in which these outcomes will occur and the detailed results are presented in Appendix 13.6 and summarised in the event tree in Figure 13.6.1 below.

13.6.6.4 Consequence Review

The consequences were modelled for two separate wind and dispersion meteorological conditions as summarised in Appendix 13.6. In order to be consistent with the assumptions in the HSA land-use policy document pentane has been used as a surrogate compound for gasoline.

Trench Fire

The distance to a thermal dose of 1,000 tdu (which corresponds to 1% fatality) is approximately 40 m for a 75 second exposure. This has the potential to affect all sections of the development along the route, depending upon the direction of the wind. Buildings that would be vulnerable are the passenger terminal and the security gate house.

Pool Fire (unconfined)

Only vertical releases that occur when the pipe is uncovered are considered to have the potential to spray outside of the trench forming an unconfined pool fire. Full bore releases do not have sufficient pressure to spray outside of the trench. Modelling results for an 80 mm and 10 mm vertical release indicates that this will not result in a pool fire as there is no rain out. This result is based on using pentane as a surrogate compound for gasoline. In practice gasoline will contain higher boiling components and there would be some rain out.

Jet Fire

Only vertical releases that occur when the pipe is exposed are considered to have the potential to spray outside of the trench forming a jet fire. For an 80mm release the distance to a thermal dose of 1,000 tdu (which corresponds to 1% fatality) is approximately 100 - 125 m for a 75 second exposure. This has the potential to affect most of the development, depending upon the direction of the wind although sections further from the route may be protected by buildings and other obstacles closer to the fire. Buildings that could be affected are the passenger terminal, security gate houses, the marina office and the Harbour Company warehouse. For a 10mm release the corresponding distance is 20 – 22 m.

Explosion inside the Chamber

Although unlikely due to the lack of ignition sources it is possible that a release of gasoline into the chamber could ignite. If sufficient quantities were involved this could damage the duct and cause damage at the surface, with the attendant hazard of missiles.

13.6.6.5 Frequency Assessment

The failure frequency analysis is based on updated failure data published by CONCAWE (2002, 2003, 2004, 2005, 2006 and now 2010[13]). The two highest causes of pipeline incidents are third party interference and mechanical failure, with corrosion in third place and minor contributions from operational and natural hazards.

The pipeline failure frequency data presented by CONCAWE covers the carriage of Crude Oil, Clean Products and hot oils. Gasoline and kerosene are considered to be a clean oil product. Data has been collected from 1971 to 2009 (39 years). At approximately 35,000 km the inventory covers transporting 870 million m^3 per year of crude oil and oil products. A subset of the CONCAWE data was selected to consider only pipelines carrying clean oil products and with a diameter class of 8 to 12". The summary of this analysis is detailed in Table 13.6.6.2. It is assumed that the transfer pipeline will be continuously welded and so all flange failures have been excluded. For the length of pipe involved (inventory $57.4m^3$) isolation valves would not normally be required. Note that smaller diameter pipelines have thinner pipe walls and less structural resistance to interference and other damage. Therefore using the whole of this category for a 250mm pipeline is conservative.

[13] Performance of European cross-country oil pipelines Statistical summary of reported spillages in 2009 and since 1971

Pipeline Failure Frequency based on CONCAWE Data (2009) (700,872 km-yr)			
Failure Cause Description	Recorded Failures	Failure Frequency	Failure Frequency
	(# Failures)	($km^{-1}.yr^{-1}$)	(1.13km Pipeline) (yr^{-1})
Mechanical Failure	123	1.755E-04	1.98E-04
Operational	31	4.42E-05	5.00E-05
Corrosion	130	1.85E-04	2.10E-04
Natural Hazard	15	2.14E-05	2.42E-05
Third Party Activity	175	2.50E-04	2.82E-04
Total	**474**	**6.76E-04**	**7.64E-04**

Table 13.6.6.2 - Pipeline Failure Frequency based on CONCAWE data (2009) (700,872 km-yr)

This base data is conservative in that it does not take into account other specific mitigation measures such as depth of cover, pipeline wall thickness and additional protection measures. These are examined separately in the following sections and adjustment factors determined.

13.6.6.5.1 “Depth of Cover”

The CONCAWE failure data does not include information regarding depth of cover. Other data sources such as UKOPA[14] and EGIG[17] show that pipes which are buried deeper have a lower frequency of incidents.
In the design proposed above the pipes will run below ground but rather than being buried will be fixed within a concrete channel protected by a 200-mm slab. Therefore no adjustment has been made to base failure frequencies to allow for depth of cover. (An allowance has been made for protection in section13.6.6.5.3).

13.6.6.5.2 Pipeline Wall Thickness

Thicker walled pipes have lower frequency of incidents. Jones and Gye[15] (1991) discuss the effect of pipeline wall thickness as a method of protection. However, this is not presented in terms of failure frequencies. EGIG[17] (2008) presents a breakdown of failures arising from external interference and corrosion with pipeline wall thickness. The failure data is based on European natural gas transmission pipelines. PD8010 part 3 and IGEM/TD/2[16] also include methods for adjusting frequency to account for wall thickness, depth of cover additional protection (e.g. slabs) and inspection frequency.

The pipe specification has a wall thickness of 9 mm. For this thickness there is no adjustment as the reference number for the scale is one.

13.6.6.5.3 Additional Protection Measures – Slabs

Over the period from 2000 to 2009 external interference was found to contribute to almost 50% of incidents in the CONCAWE data set. The majority of these were caused by digging or earth moving machinery. The data set also included a number of events (approx 13%) where the damage was intentional, mostly due to attempted theft.

[14] 6th Report of the UKOPA Fault Database Management Group: Pipeline Product Loss Incidents (1962 - 2008), G.Arunakumar, Dec 2009.

[15] Jones, D.A. and T. Gye (1991); “Pipelines Protection - How protective measures can influence a risk assessment of pipelines”, Pipe Protection Conference, Cannes, 23 - 25 September

[16] Application of pipeline risk assessment to proposed developments in the vicinity of high pressure Natural Gas pipelines, Institution of Gas Engineers and Managers

The Transfer line from the jetty to the oil terminal will be protected against external interference by 200-mm concrete slabs. The pipeline runs through port land and any maintenance work will be under the control of the Harbour Management Company. The transfer pipes will be segregated from other services. It has been assumed that this additional protection will eliminate 90% of failures due to external activities.

13.6.6.5.4 Additional Protection Measures – Inspection Frequency

Another means of preventing failures of the pipeline is inspections and initial testing. The entire pipeline will be inspected and pressure tested when installed in accordance with recognised standards for pipelines. Transfer of product from ship to terminal will be monitored to ensure that fuel leaving ships is reaching the terminal. This will detect large leaks.

Continuous leak detection would reduce the likelihood of a failure going unrevealed and hence reduce the frequency of spillage as a result of line failure. This measure is most valuable for long distance pipelines that run through property belonging to third parties. For the purpose of analysing the risk for planning purposes it is assumed to be not required for the Harbour transfer line which is 1.13 km long and runs through Harbour land.

13.6.6.5.5 Adjusted Total Pipeline Failure Frequencies

The frequency data above have been used and adjusted to calculate the frequencies for the complete pipeline (Table 13.6.6.3 below). This includes all major and minor leaks from valves, flanges and thermal relief.

Failure Frequencies for Complete Pipeline			
Failure Cause Description	Base Failure Frequency	Adjustment Factor	Adjusted Failure Frequency
	(1.13km Pipeline) (yr^{-1})	(1.13km Pipeline) (yr^{-1})	(1.13km Pipeline) (yr^{-1})
Mechanical Failure	1.98E-04	1	1.98E-04
Operational	5.00E-05	1	5.00E-05
Corrosion	2.10E-04	1	2.10E-04
Natural Hazard	2.42E-05	1	2.42E-05
Third Party Activity	2.82E-04	0.1	2.82E-05
Total	**7.64E-04**		**5.10E-04**

Table 13.6.6.3 - Failure Frequencies for Complete Pipeline

Date from EGIG[17] has been used to distribute the pipeline failure frequency by hole size giving the following results:

Failure Frequency with Hole Size			
	Pinhole (10-mm)	Hole (80-mm)	Rupture (FB)
Fraction	0.506	0.129	0.055
Failure rate / km year	3.14E-04	8.02E-05	3.42E-05

Table 13.6.6.4 - Failure Frequency with Hole Size

The event tree illustrates that several outcomes are possible depending on whether the release comes to the surface, is ignited, whether the line is covered or uncovered and the orientation of the release.

The probability of a leak giving rise to a specific effect (jet fire, flash fire and pool fire) was determined by event tree for the purposes of the risk calculation. The event tree is detailed in Figure 13.6.6.1 below.

[17] EGIG (2008); “7th EGIG Report 1970-2007 Gas Pipeline Incidents”, report EGIG 08.R.0002

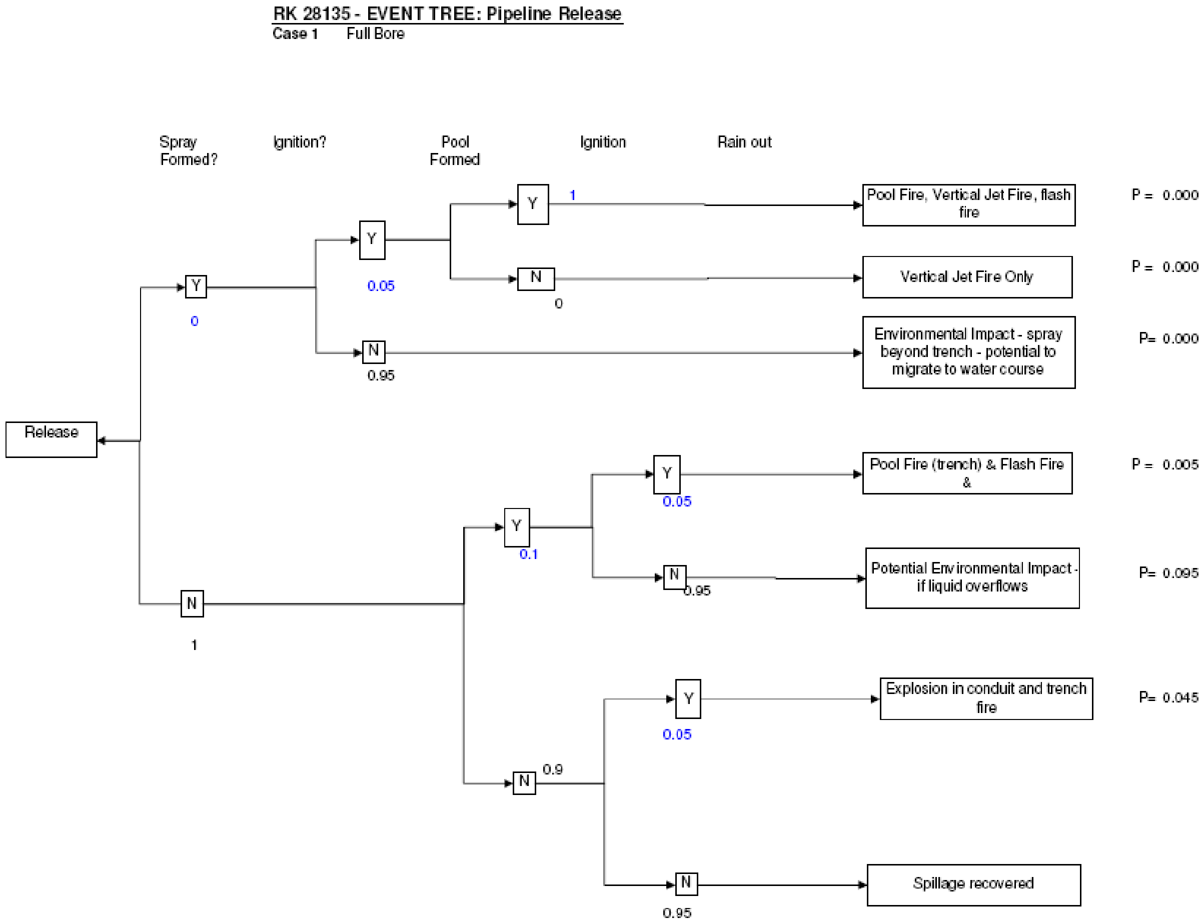

Figure 13.6.6.1 - Event Tree for Pipeline Accident Scenario

The probability of ignition from pipework was based on the findings contained in HSE Contract Research Report (CRR) 210/1999[18] and was taken as 0.05. It was assumed that 25% of ignitions were immediate and 75% delayed.
The CRR found that the fraction of releases giving rise to a spray was 0.16 across all incidents analysed. It is assumed that there is insufficient pressure from a full bore release to give rise to a spray. Therefore the probability of an10-mm and 80-mm release resulting in a spray was adjusted to 0.19 so that the overall probability remained at 0.16.

This is conservative as the CRR included lines operating typically at much higher pressures than the transfer line which would be more likely to result in spray releases.

A release while the chamber is covered would collect within the duct. As noted in Appendix 13.6.3 it cannot be ruled out that it could escape and rise to the surface forming a pool. The CRR found that approximately half of pipeline incidents resulted in a surface pool forming. That is considered to be conservative for the transfer line which is designed to contain a release. Therefore it is assumed that if the leak is detected before the section fills no pool fire will occur. At full rates it would take approximately 20 minutes for a 100-m sub-section to fill. During transfers from ship to shore the level at the receiving tank will be monitored and compared to the quantity being transferred from the ship. Therefore the probability that the leak is not detected before a surface pool forms is taken as 0.1, (equivalent to failure to follow a procedure). Release

[18] CRR 210/1999 Assessing the risk from gasoline pipelines in the United Kingdom based on a review of historical experience. Health and Safety Executive

that reached the surface would be visible and may also be detected during surveys of the pipe route. Smaller releases will be harder to detect and so the probability that a pool forms is taken as 0.5 after the CRR report.

The pipe failure frequency and the conditional probabilities are used to develop a ‘risk transect’ for the pipe line as described in section 13.6.7.1.

13.6.7 Risk Analysis

13.6.7.1 Risk from Pipeline

A risk transect is a means of illustrating the frequency or probability of a specific hazardous outcome at a range of distances from the pipe. The risk transect is of interest in this case as it enables the risk to people in the vicinity of the pipeline to be determined.

A risk transect is developed as follows:

- Identify possible accidents that present a hazard to personnel in the vicinity of the pipeline and define representative accident scenarios;
- For each hazard define a specified level of harm ('harm criteria') for example, the HSA fatality criteria, or UK HSE "dangerous dose";
- Determine the hazard range to the specified level of harm for each representative accident scenario;
- For a range of distances determine the likelihood that the specified level of harm will be exceeded for each accident scenario; and
- Determine the overall likelihood of exceeding the specified level of harm by adding the frequencies of all the scenarios that could exceed the specified level of harm.

The accident hazards were identified and modelled as described in sections 13.6.6.3 and 13.6.6.4. For the risk transect for jet fires and pool fires the hazard range was set as the distance to thermal radiation of 13.4 kW/m^2. This is equivalent to a 50% probability of fatality for persons who are located outside. For persons who are located inside within buildings and other structures that provide some shelter from thermal radiation the HSA assumes that at this range they will escape outside and so have a risk of fatality corresponding to that of people outdoors.

The probability of fatality in event of flash fire was taken as 1 within the lower flammable limit and 0 outside. This is conservative compared to the findings of the Contract Research Report and as people inside would be protected.

Failure frequencies for the range of leak scenarios were determined in the way described in Section 13.6.6.5.

There are three unloading lines for use with gasoline, kerosene, diesel, and gasoil. Based on the discharge rates and parcel size given in section 13.6.5.2 gasoline and kerosene transfer will be equivalent to 1 line in use 60% of the time. Therefore to be conservative failure frequency is based on one pipeline.

The resulting risk transect is shown in Figure 13.6.7.1 below.

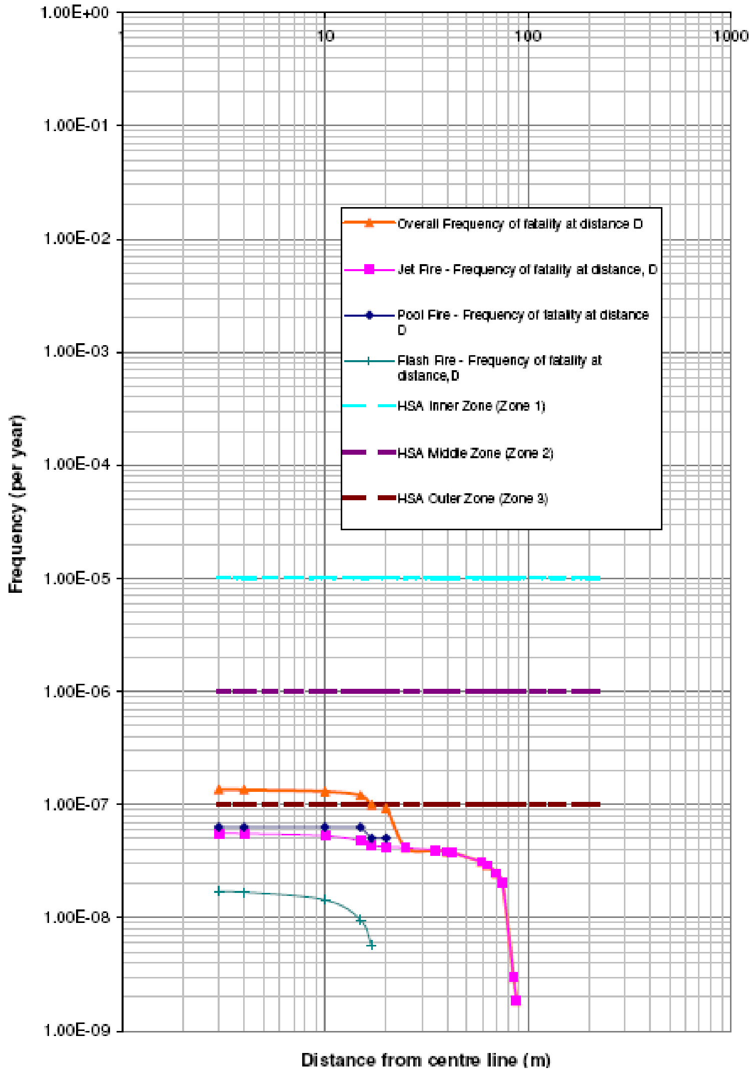

Figure 13.6.7.1 - Pipeline Risk Transect

For comparison the risk of fatality equivalent to HSA planning zone boundaries is shown. Note that the pipeline is outside the scope of the Seveso Directive and there are no regulatory planning restrictions around pipelines carrying hazardous substances in Ireland.

Overall within about 25 m of the line the individual risk of fatality is approximately 1.5 x 10^{-7} per year (or less than 1 in 5 million years).

A generic study of gasoline pipeline risks for the UK HSE[19] found that for cross country pipelines (more exposed to third party damage than the Galway Harbour route) the level of risk at 100m would be below the “broadly acceptable” threshold of concern.

Within 20 m of the pipeline the risk is approximately equal between jet fire and trench fire with flash fire making a significant contribution. Above 20 m vertical jet fire dominates.

[19] Risks from Gasoline Pipelines in the United Kingdom, Research Report 206/1999 by AD Little for HSE.

13.6.7.2 Risk to Development

13.6.7.2.1 General Industrial Areas

The main use of the development is for Port related services. The area most at risk are those adjacent lands at the north end of the development, area 3.1 future oil yard and area 3.2 Harbour Company yard / maintenance compound. The table below summarises the risk to individuals at these developments on the basis that they are outdoors. The consequence levels are based on the part of the development closest to the source of hazard.

Individual Risk Calculations for Affected Industrial Areas 3.1 & 3.2						
Location	Event	Frequency per year	Consequence Level		Vulnerability	Individual Risk of Fatality per year
Topaz	VCE from storage	2.00E-05	43	kPa	0.165	3.30E-06
Topaz	VCE from loading gantry	1.00E-03	50	kPa	0.2	2.00E-04
Topaz	Bulk / Day tank event 1	2.40E-05	38	kW/m2	1	2.40E-05
Topaz	Bulk tank event 2	1.52E-04	14	kW/m2	0.52	7.90E-05
Topaz	Day tank event 2	2.28E-04	9.5	kW/m2	0.05	1.14E-05
Topaz	ETDN event 1	6.00E-06	13	kW/m2	0.5	3.00E-06
Leeside	VCE from storage	4.00E-05	9.5	kPa	0.05	6.00E-06
						3.23E-04

Table 13.6.7.1 - Individual Risk Calculations for Affected Industrial Areas

It can be seen that the individual risk of fatality is less than 3.4 x 10^{-4} per year and is dominated by the calculated risk of VCE from the out loading gantry. The risk from the pipe is small in comparison.

Some of the events above have potential to cause damage to process equipment at the future oil storage yard. This will be considered in detail during the design of the yard to ensure that design is optimised (e.g. separation distances and protective measures guided by relevant codes of practice) and that communication and emergency response plans are revised / developed to manage this risk.

13.6.7.2.2 Nautical Slipway and Yard

The nautical slipway and yard (area 3.10) is provided for use by youth and other groups. It is within the 5 kPa contour of a large VCE originating at Topaz storage. It is outside the contours from Leeside and beyond the consequence distances of scenarios at the jetty and pipeline.

The actual over-pressure would be 7 – 9 kPa. As the users would be outside this is unlikely to result in serious injuries.

13.6.7.2.3 Risk to Occupied Buildings

The following occupied buildings have been identified on the site:

- Harbour Company Warehouse Max 10 people, 24 hrs operation (5 day and 5 nights);
- Marina Office Max 3 x employees, plus members of public (users of marina), assume up to 10 total;
- New Harbour Office Max 7 employees (5 day; 2 night time) plus occasional meetings (20-40);
- Passenger Terminal Occupancy up to 100 at a time for a short time while disembarking;

- Security Office Max 2 employees day and night.

The risk to occupants of these buildings is calculated in the same way as above.

Harbour Company Warehouse

The Harbour company warehouse is building 4.2 in area 3.4.

Harbour Company Office Warehouse 4.2 in Area 3.4 195 m from Centre of Topaz						
Location	Event	Frequency per year	Consequence Level		Vulnerability Indoors	Individual Risk of Fatality per year
Topaz	VCE from storage	2.00E-05	30	kPA	0.06	1.20E-06
Topaz	VCE from loading gantry	1.00E-03	9.5	kPa	0.05	5.00E-05
Topaz	Bulk / Day tank event 1	2.40E-05	8.5	kW/m2	0	0.00E+00
Topaz	Bulk tank event 2	0.00E+00	2.5	kW/m2	0	0.00E+00
Topaz	Day tank event 2	0.00E+00	2.5	kW/m2	0	0.00E+00
Topaz	Ethanol event 1	6.00E-06	9	kW/m2	0	0.00E+00
Leeside	VCE from storage	4.00E-05	6.5	kPa	0.02	8.00E-07
						5.2E-05

Table 13.6.7.2 - Harbour Company Office Warehouse 4.2 in Area 3.4

The individual risk of fatality is 5 x 10^{-5} per year and is dominated by the calculated risk of VCE from the Topaz out loading gantry. The risk from the pipe is small in comparison (the warehouse is about 75 m from the pipeline).

There could be up to ten people in this office.

Marina Office

The Marina Office is building 4.5 in area 3.5. The Marina Office can only be affected by VCE from storage on Topaz site. The over-pressure experienced would be 9.5 kPa, with vulnerability for people indoors of 0.05. Individual risk of fatality is **1 x 10^{-6} per year.**

New Harbour Office

The New Harbour Office is building 4.6 at the edge of area 3.5. It is outside the area that could be adversely affected by an incident at the Leeside Site and at 350 m from the unloading jetty it is not predicted to be affected by an incident originating there. The predicted over-pressure from a large VCE at Topaz is 4 kPa which could cause minor damage such as broken windows which could cause injuries but these are not likely to be fatal.

It is approximately 10 m from the pipeline and so could be affected in event of an incident. In event of a trench fire or a vertical spray fire thermal radiation levels could exceed 25 kW/m^2. At these levels the building could catch fire. Several of the flash fire scenarios could encompass the Harbour office. As the occupants are inside they are protected from the effects of the fire. The frequency of fatality to the occupants has been determined using the same method described for the transect in section 13.6.7.1 by increasing the consequence and vulnerability levels for spray fire to take into account that at 10 m thermal radiation levels will be greater than 13.4 kW/m^2, and to reduce vulnerability from flash fires to 0.1 and is found to be **1.5 x 10^{-7} per year**.

There are typically 5 occupants during the day and 2 in the evening. Occasionally there could be 30 – 40 people attending a meeting.

Passenger Terminal and Cruise Ship

The Passenger Terminal is building 4.7 and is approximately 290 m from the jetty. The passenger terminal can be affected by a horizontal release with delayed ignition from the jetty or by an incident involving the pipeline.

A horizontal flash fire from an 80-mm release will only affect the terminal in F2 conditions (assumed to occur 20% of the time) and if the wind is blowing towards the terminal (conservatively assumed to be 50% of the time). Thus the frequency of a flash fire affecting the terminal is 2.4×10^{-5} per year.

On occasions there could be up to 100 passengers disembarking in the area. Projections are that there could be up to 30 cruise ships visiting per year. The ships could be in harbour for up to 2 days, but there would only be this number of people exposed disembarking at any one time. It is assumed that they take 30 minutes to disembark and 30 minutes to re-embark, and that up to 600 per ship could go on trips. Therefore 100 people are present 2% of the time and the risk of 100 fatalities is **5.0×10^{-7} per year** (if they were all outside). In fact this is an over estimate as passengers are more likely to be in the terminal during the day when dispersion conditions tend to be more favourable.

The cruise ship can also be affected by flash fire from a horizontal release in F2 conditions. Cruise ships will be in Harbour for approximately 2 days per visit. Typically there could be 850 passengers of whom it is assumed 70% go on bus tours, 15% walk to the city and 15% stay on board during the day. F2 conditions are more likely to occur at night when it is assumed that a higher fraction would be on board. People inside would be less vulnerable than those outside.

Adjusting for the fraction of time a ship is in harbour (16%) the frequency of a flash fire affecting the ship is **4.0×10^{-6} per year**. If 10% of the occupants were outside this could result in 80 - 100 casualties.

This is a conservative estimate of probability as it does not take into account that unloading of class I products will be restricted when the cruise ship is in harbour. This management measure will reduce the risk by approximately one order of magnitude.

Security Office

The security office is building 4.3 in area 3.7. It could be affected by a large VCE originating at the Topaz site or by an incident in the transfer pipeline.

At 335 m from the centre of a VCE the predicted over-pressure is 11.5 kPa at which the vulnerability of occupants is 0.05. The risk of fatality from the pipeline is determined by adjusting the transect as described for the new harbour office above and is 1.5×10^{-7} per year. The overall risk of fatality is **1.15×10^{-6} per year**, dominated by VCE from Topaz. This could result in two casualties.

Future Marina Village

The risk to an individual indoors at the future Marina Village (area 3.5) ranges from **9×10^{-7} per year** down to **2×10^{-7} per year** and is dominated by a large VCE originating at the Topaz site.

Vulnerability indoors ranges from 4.5% to 1% (average 3%) so if the development was used by 500 people, all indoors there is risk of 15 fatalities at a frequency of **2×10^{-5} per year**.

With a maximum vulnerability of 0.1% the risk to people outdoors is low.

13.6.8 Risk Acceptance Criteria

The HSA has a two stage approach to assessing the acceptability of developments in the vicinity of hazardous sites as described in section 13.6.1.5.

The first is based on the size and type of development using the PADHI system. If the recommendation is to advise against then the HSA will not examine the risk further. If the outcome of the PADHI review is not to advise against then the HSA will assess the development based on societal risk.

13.6.8.1 Planning Criteria

The HSA have specified the following Zones around the Topaz Site.

Topaz Site Planning Zones (HSA May 2010)	
Zone	**Distance from Bund (m) Class 1**
Outer Limit of Inner Zone	188
Outer Limit of Middle Zone	230
Outer Limit of Outer Zone	471

Table 13.6.8.1 - Topaz site Planning Zones (HSA May 2010)

The majority of the development would be considered as workplaces, predominantly non-retail. Provided they are for fewer than 100 occupants and with less than three occupied stores these are considered level 1 development and would not be advised against.

The nautical centre, marina and cruise liner berth and terminal are for use by the general public so more stringent restrictions apply. The cruise liner berth and terminal are outside the consultation distance for Topaz.

Marina Village
The site of the proposed marina village is 225 to 425 m from the bund and so this straddles the middle and outer zones. The UK HSE has a 10% straddling rule which applies to developments straddling two zones. The rule can be applied if more than 10% of a development area is within the innermost zone then the whole development is counted as being within that zone. The HSA document does not refer to this rule, but in the absence of such guidance it is assumed that it is appropriate to apply this approach.

The village would therefore be considered as in the outer zone and the HSA would not advise against level three developments based on the PAHDI criteria:

- Shops, restaurants and cafes of total floor space below 5,000 m2 would be considered level 2 and would not be advised against;
- Shops, restaurants and cafes of total floor space more than 5,000 m2 would be considered level 3 and would not be advised against;
- If it was considered a predominantly outdoor facility for use by between 100 and 1000 people it would be considered level 3 sensitivity and would not be advised against;
- If the facility were for use by more than 1,000 people outdoors, it would be considered level 4 and would be advised against.

Table 13.6.8.2 below summarises the sensitivity of the development in relation to the planning zones around the TOPAZ terminal.

Developments in New Harbour Extension Area			
Development	**Assumed Category**	**Sensitivity Level**	**Zone from Topaz**
General Industrial Areas e.g. 3.1, 3.2	DT 1.1 Workplaces (predominantly non-retail), providing for less than 100 occupants in each building and less than 3 occupied storeys	Level 1	Inner Middle Outer
Nautical Centre	DT 2.5 if for general population <1000	Level 3	Outer
	DT4.1 if specific facilities for school age or those with disabilities	Level 4	Outer
Harbour Company Warehouse	DT 1.1 Workplaces (predominantly non-retail), providing for less than 100 occupants in each building and less than 3 occupied storeys	Level 1	Inner
New Harbour Office	DT 1.1 As above	Level 1	Outside Planning Zones
Marina Marina Office	DT 2.2 cf Caravan Site > 33 boats (see below)	Level 3	Outer
Cruise Liner Berth	DT2.2 Holiday Accommodation > 100 beds or DT 2.5 Ferry Terminal 100 – 1,000 people	Level 3 Level 3	Outer
Inshore Fishermen	DT1.1 or 1.2 No more than 100 in any building	Level 1	Outside Planning Zones

Table 13.6.8.2 - Developments in New Harbour Extension Area

13.6.8.2 Societal Risk

Societal risk considers the risk to a population exposed to a particular hazard. It considers the risk of a large numbers of fatalities as a result of an incident.

The HSA, in its Land-use Planning policy describes its approach to societal risk (section 2.2). In effect it uses the risk integral concept. Risk Integrals were introduced by the UK HSE in the late 1990's as a measure of the scale of potential major accidents, in terms of the numbers of people that could be affected as well as the frequency of the accident. It is an indicator of what is described as "Societal Risk".

The Scaled Risk Integral which is used for new developments in the vicinity of a COMAH Site is described as a 'useful' screening tool, prior to the use of an FN curve to resolve inconclusive results from the approximate methods. The proposed development is not straightforward to analyse for approximate integrals as it is spread over a large area, with diverse uses and local concentrations of population exposed to different risks, from several sources. Therefore the approach taken in this report is to develop an FN curve. An FN curve was determined for the development taking into account the risk presented by the pipeline, the jetties and the Topaz Site.

The risk to the development from the Leeside Site is low and therefore was not included in the FN curve. The nearest part of the development is approximately 375 m from the centre of Leeside Site. In the event of a large VCE originating at the Leeside site the over-pressure at the development would be 9.5 kPa, which corresponds to 5% chance of fatality to people indoors and is unlikely to cause fatalities to those outdoors. The over-pressure at the nearest building (the Harbour Warehouse) results in a risk of fatality to occupants of 8 x 10^{-7} per year. A large VCE is an omni-directional event and societal risk from a large VCE at Leeside is dominated by the population to the east. It can be concluded that the Harbour development results in negligible increase in societal risk from the Leeside Site.

As described in section 13.6.7.2.2 the risk of fatality to people using the nautical yard is small and so has been neglected in determination of the FN curve.

None of the events are predicted to impact on the fisherman's pier.

The FN curve was determined as follows:

- For each of the representative scenarios that could result in multiple fatalities the total number of fatalities that would occur under different representative conditions was determined;
- Where the day time and night time population differed it is assumed that the day population is present 50% of the time and the night time population 50% of the time;
- The exposed population is based on the number of occupants where known (e.g. buildings);
- For the future oil storage yard (3.1) and bitumen yard (3.0), a shift presence of four per yard is assumed (two operators and two drivers) with an additional four personnel on site during the day (maintenance, management). This is considered conservative as in fact it is possible that they will be operated by the same personnel who operate the existing yards;
- It is assumed that the other outside industrial yards (3.6, 3.11, 3.12, 3.13, 3.14, 3.15, 3.17) will only be manned when a ship is being unloaded to that area or when goods are being collected for onward distribution. The population of the Galway Harbour Warehouse includes Harbour personnel who will be involved in the loading / unloading. There will also be visitors such as lorry drivers present. It is assumed that in total there could be up to five people present during loading/unloading operations, that at any one time there will be loading / unloading in one area, and that the proportion of time is equal per yard. (For simplicity no reduction was made to the occupancy of the Galway Harbour warehouse). There are seven of these yards so it is assumed that 5 personnel are present 14% of the time in each;
- Area 3.2 and 3.4 are used to store the equipment that harbour personnel use. There could be 1-2 people present for short periods of time to collect / deliver equipment;
- The marina buildings and yards (area 3.5 and 3.3) a population 20 people is assumed.
- The number of fatalities is determined by the population of the area multiplied by the average vulnerability;
- Where an event affects only part of an area it is assumed that the population are evenly distributed;
- The frequency of fatalities is calculated as the frequency of the initiating event multiplied by any conditions necessary to affect the area such as dispersion, wind direction, probability that the numbered population was present, and directionality (e.g. of over-topped bund, of horizontal release);
- The FN curve excludes the impact on existing units which are not part of the new development.

Results are shown on figure 13.6.3. It is the cumulative risk curve, which plots the risk of 'N or more' fatalities, against which acceptability is judged. For information the individual event points are also plotted from which the main contributors to overall risk can be identified (NB these are not cumulative).

In the land use policy document the HSA does not state what they consider to be an unacceptable level of societal risk when measured by FN curve. The criterion that they use for the risk integral is the same as the criterion used by the UK HSE. These have been developed based on the so called 'Canvey Island' point described in R2P2[20] which states "*the risk of an accident causing the death of 50 people or more in a single event should be regarded as intolerable if the frequency is estimated to be more than one in five thousand per annum*".

This is extrapolated to other numbers of casualties by drawing a line of slope -1 on the FN curve. The 'broadly acceptable' level of risk is considered to be two orders of magnitude lower.

Overall the cumulative risk to members of the public at the development is tolerable if ALARP. The risk of large numbers of casualties (N>10) is dominated by horizontal flash fire at the jetty in F2 conditions. If the rule that unloading of gasoline will not take place when a cruise ship is at berth is strictly enforced then the casualties from this event are reduced and the FN curve for N.10 is all in the "broadly acceptable" region. Even allowing for 90% reduction in the chance of a release whilst the cruise liner is in port, by restricting unloading operations would make it broadly acceptable. The only other event identified that could give rise to more than 10 casualties is an incident associated with the pipeline that affected the Galway Harbour Office when a meeting was taking place. At a frequency of $< 10^{-8}$ per year this is not considered a significant societal risk.

At N between 5 and 10 the risk is dominated by an event that could occur at Topaz. The major group affected are personnel running the new fuel yard (area 3.2). As described above it is possible that the future yard will be run by the same personnel who run the current yard. In which case this represents negligible increase in societal risk (the future fuel yards will not store class I products). If it is not the case that the same team runs the extended yard then this risk could be reduced by locating occupied buildings such as control rooms and workshops at the opposite side of the area to Topaz. Consideration could also be given to designing any buildings so as to protect the occupants. The emergency plans that Topaz is required to prepare under COMAH include procedures for communicating with neighbours in event of an incident. These plans should dovetail with the Ports own emergency response plans to ensure that there is good communication between the Port and Topaz in event of an incident which will also help to reduce the overall risk.

For comparison Figure 13.6.8.2 shows the FN curve taking into account that gasoline will not be offloaded whilst there is a cruise ship in harbour and assuming that the future fuel yards will be run by the same personnel who run the existing yards.

[20] R2P2 Reducing Risks Protecting People, UK HSE

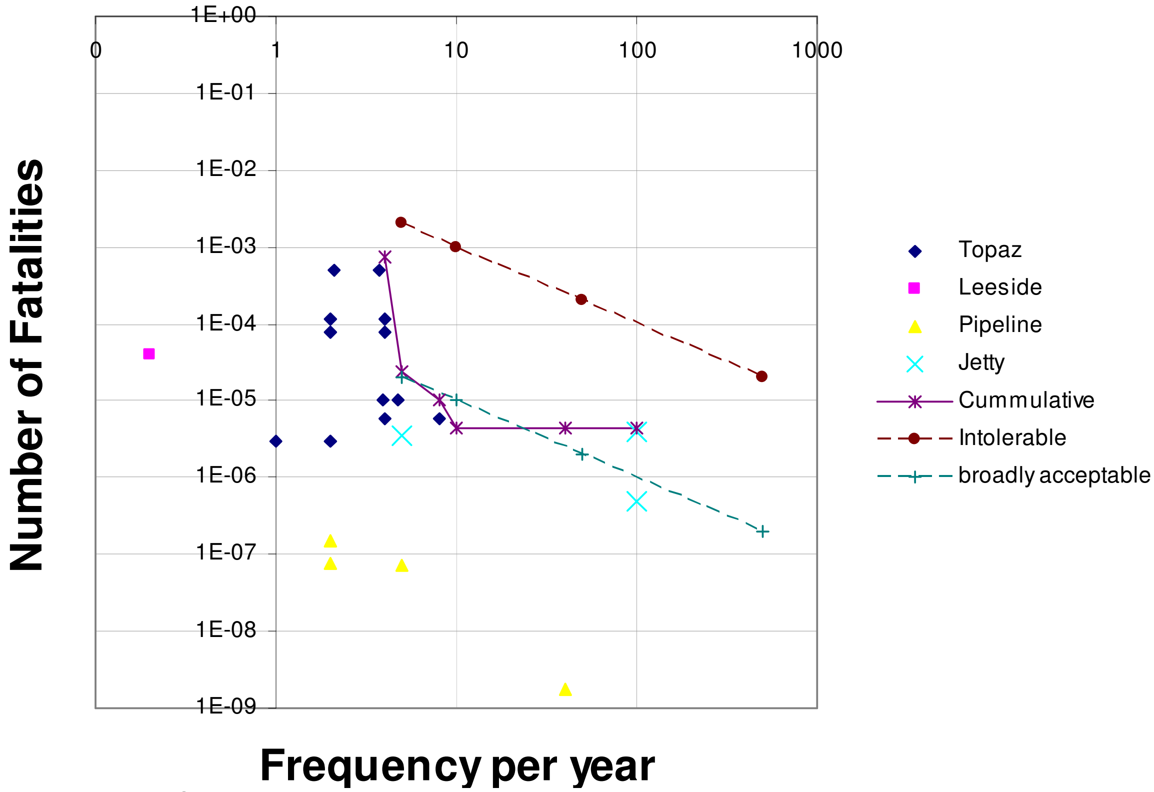

Figure 13.6.8.1 - FN Curve for Development (Unrestricted unloading, non combined fuel yards)

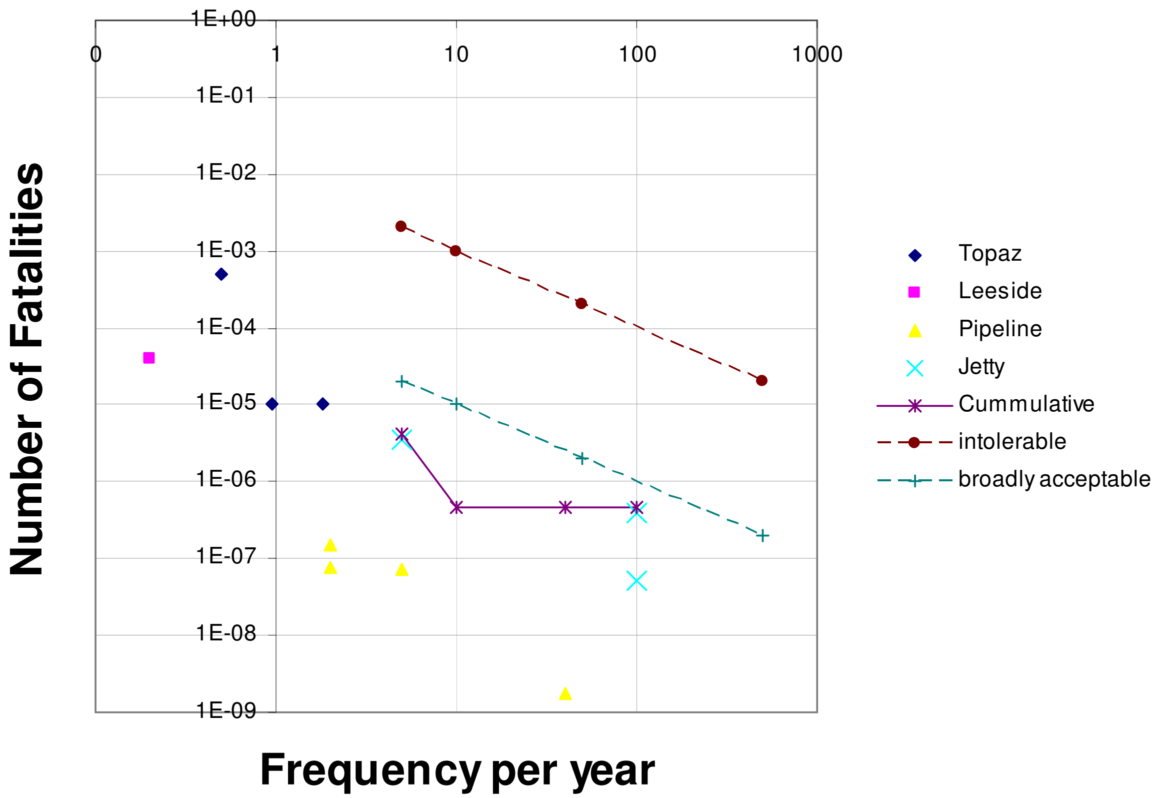

Figure 13.6.8.2 - FN Curve for Development – Sensitivity Study (restricted unloading, combined fuel yards)

Discussion

13.6.8.3 General Background to Assessment

This report investigates the likely impacts of the Topaz and Leeside terminals, the new jetty and pipeline on the proposed new development at Galway harbour. Specifically it investigates the risks associated with potential major accident scenarios which have possible offsite impacts on the new development. As a basis of performing this work it is necessary to make various assumptions regarding the likely size of a given upset scenario as well as the frequency with which it is likely to occur. Knowledge is also required of the developments and land use around the site which could be impacted by these events. Of particular concern are the people who might be present at the time of an accident, how many there are likely to be and what is the probability of them being present at the time. All these factors are taken into account when determining both the individual and the societal risks.

In order to guide the assumptions this report relies heavily on the HSA policy and approach document[3] for land-use planning near COMAH sites.

For example this document provides guidance on how consequence distances should be determined and what accident scenarios should be considered in the assessment. It also provides criteria on what vulnerability and consequence criteria should be used for the effects of various scenarios studied. This includes overpressure effects for vapour cloud explosions and thermal radiation effects from flash fires, jet fires and pool fires. Guidance is also provided on what substance should be used as a surrogate to particular petroleum substances (e.g. pentane is used to reflect the composition of gasoline).

The HSA document also provides guidance on failure frequencies which are based on a typical or generic terminal which assumes a terminal containing 10 tanks. In some cases these assumptions can be conservative and where relevant this report has modified the failure frequency to reflect the smaller size of the facility (e.g. Topaz terminal). The assumptions adopted are nevertheless still deemed to be conservative (pessimistic). In this report it has been assumed that kerosene has similar properties as gasoline which is a conservative assumption as in practice it is a less volatile and less flammable (heavier) petroleum product. There is an allowance in the HSA guidance to reduce the failure frequencies where facilities recommended following the Buncefield accident, have been incorporated into the design. For the Topaz site this has been done. However, at the Leeside site no credit or reduction in failure frequency has been taken because the level control instrumentation is not SIL rated.

The COMAHDS Regulations in practice only cover installations such as the Topaz and Leeside terminals and do not cover the jetty and the pipeline. Consequently the assumptions and guidance provided in the HSA land-use policy document do not cover these aspects. Therefore reference has been made to international practice and codes and standards to determine the risks from these facilities. For the pipeline a risk transect has been derived using the UK HSE methodologies. Ship to shore transfers at the jetty will be by loading / unloading arms rather than hoses. The failure rates for both devices are included in Section 13.6.5.5 and the international references for these are provided. For the pipeline the failure rate is based on CONCAWE data wherever possible as this takes extensive data on the failures associated with the use of pipelines containing liquid petroleum (crude oil and products). The release cases use typical UK HSE hole sizes for pipelines. The report also makes some adjustments for the protection of the pipeline in determining the likely failure frequencies from external damage. To be consistent with the requirements of the HSA land-use policy document pentane has been used as a surrogate compound for gasoline releases.

13.6.8.4 Discussion of Results

13.6.8.4.1 Risks from Pipeline

The risks from the pipeline are shown in the pipeline transect in Figure 13.6.2. The overall risk within 20 m of the line is around 1.5×10^{-7} per year which is very low and is less than the HSA criteria for the middle zone and approximately equivalent to the outer zone threshold criteria. In fact this is conservative as it does not take into account that the pipeline is emptied after each unloading operation and therefore only contains product some of the time i.e. not all pipe failures will result in loss of containment.

Hence, the risks to people are low and broadly acceptable and would not result in an 'Advise Against' recommendation from the HSA.

The routing of the pipe within an impervious chamber is designed for containment however there is a residual risk that unignited releases (including of diesel and gasoil) may not be contained with a frequency of approximately 6.0×10^{-4} per year. Some such leaks may gather in road drains and run to interceptors but there is the potential to run to water. The pipelines are emptied after each unloading operation. Procedures to monitor for leaks will be in place. This might be by flow comparison at the ship end of the line and at the terminal end of the line or other proprietary leak detection measures. It is also considered that for unloading operations personnel will be present at the jetty and the terminal monitoring the progress of the ship to shore transfer. Thus major leaks should be detected rapidly and transfer stopped. The line will be protected from external interference by 200-mm slabs and the route will be marked. Road surface drains in the development will run to interceptors and oil spillage response plans will be in place with pre-determined action to prevent spillages reaching the environment.

It should be noted that the pipeline represents a transfer of risk from the existing pipe which runs to the Topaz facility from Dun Aengus Docks and Folan Quay.

13.6.8.4.2 Risks to the Development (Industrial Areas)

The highest risk impacting on the industrial area is from a VCE at the Topaz road loading bays with the total individual risk estimated to be 3.4×10^{-4} per year which in an industrial area is considered to be tolerable. This risk level is equivalent to the levels expected in the inner land use planning zone. Whilst buildings used by large numbers of the public or high density housing would be advised against by the HSA in such a zone, industrial developments would not be advised against. Industrial premises such as a fuel yard or warehouse providing for less than 100 occupants and having fewer than 3 occupied storeys are considered a level 1 development.

The level of risk drops off with distance from the terminal. For example at the nearest point of area 3.7 and within 20 m of the pipeline the individual risk to a person outdoors is 2×10^{-7} per year.

13.6.8.4.3 Risks to the Development (Occupied Buildings)

The risks at various occupied buildings are also estimated in Section 13.6.7.2.3. The individual risk at the harbour company warehouse is determined to be 5×10^{-5} per year and tolerable for industrial premises. This is because although the location lies within the inner zone it is a Level 1[21] development which would not trigger an advise against criteria. The risks at the marina office are 1×10^{-6} per year and are tolerable as they are in the 'Broadly Acceptable' region. This location would lie in the outer land use planning zones and is tolerable as the Marina Office would be deemed a Level 1 Development.

[21] Industrial premises such as a fuel yards, warehouses, offices and non-retail markets providing for less than 100 occupants and having fewer than 3 occupied storeys are considered a level 1 development

For the passenger terminal the risk of 100 people being affected during their embarkation or disembarkation is 5 x 10^{-7} per year. This level of risk is equivalent to the levels expected in the middle land-use planning zone, where Level 2 (e.g. ferry terminals or railway stations 250m^2 to 5000m^2) would not be advised against but where Level 3 developments (e.g. ferry terminals, railway stations greater than 5000m^2) would be advised against. The societal risk, as indicated below, is identified as being in the 'Tolerable' region and therefore should support the decision to not advise against.

The distance between the unloading gantry and the passenger terminal is over 200 m, which is more than the recommended minimum separation distance of 75 m for passenger ferries and their associated assembly areas given by HSG 186[22].

The New Harbour Office (fewer than 100 occupants) is a level 1 development. It could be affected by an incident at the pipeline. The estimated individual risk is 1.5 x 10^{-7} per year. This level of risk is equivalent to the levels expected in the outer land-use planning zone and so would not be advised against.

13.6.8.4.4 <u>Risks to the Development (Cruise Ships)</u>

The cruise ships themselves are not subject to land-use planning regulations, but clearly decisions about the risks posed by the land developments need to take account of the cruise ship which may be in dock and occupied by a large number (assumed to be possibly around 1000 to 1200) of passengers and crew.

The distance between the unloading gantry and the cruise ship berth is over 200 m, which is in excess of the recommended minimum separation distance of 75 m for passenger ferries and their associated assembly areas given by HSG 186[23].

The individual risk to a person on the ship of fatality from a flash fire resulting from a leak at the gasoline offloading jetty has been conservatively estimated as 3 x 10^{-6} per year. This figure takes into account the likelihood that a person is present on the cruise ship and the cruise ship is in dock. This level of risk is equivalent to the levels expected in a middle land-use planning zone. A ship occupied by passengers might be considered to be similar to a hotel of more than 100 beds, so would be a level 3 development. This would be advised against in the middle zone. However the ship is not always present and not always occupied by passengers so the PADHI method is difficult to apply. The societal risk analysis below gives a better approach.

Furthermore if the management measure to restrict unloading of flammable products to when there is no cruise ship in is factored in, the individual risk becomes 4 x 10^{-7} per year, equivalent to the outer zone where a level 3 development would not be advised against.

13.6.8.4.5 <u>Societal Risk</u>

In Section 13.6.8 an FN curve has been prepared to determine societal risk to the development. The areas covered included the passenger terminal, the cruise ship and the Marina Office. The FN curve shows that even without restrictions to unloading the residual risk for all locations is low and that they would be in the 'Tolerable if ALARP' region and therefore tolerable.

The risk will be reduced by managing jetty operations so that gasoline transfer does not take place whilst passengers are on the cruise liner in port. This will reduce the risk to broadly acceptable.

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[22] The bulk transfer of dangerous liquids and gases between ship and shore (HSG 186) , 1999, Health and Safety Executive

[23] The Bulk Transfer of dangerous liquids and gases between ship and shore (HSG 186) , 1999, Health and Safety Executive

It should be borne in mind that the new jetty will replace activities at existing facilities at Folan Quay and Dun Aengus Docks, which have a larger surrounding population. The area within a 340 m radius of the current unloading facilities (the consequence distance of a horizontal flash fire) includes a number of hotels, a major shopping centre and the Ceannt Transport hub.

Future Marina Harbour Village

The societal risk at the proposed Marina Harbour Village has also been determined. This is not shown on the FN curve as it is not part of the current planning application. The only event that could cause fatalities at the future harbour village is a large VCE originating at the Topaz site. The potential number of casualties depends upon the location of users and number. For example if there were 500 users indoors, equally distributed then there could be approximately 15 casualties. If incorporated into the FN curve the risk would be tolerable. The actual risk of any scheme brought forward would need to be determined as part of any future application for the marina village. Methods to reduce risk include siting buildings for use by more people further from the site and enhancing the resistance of any buildings to blast damage (e.g. by selection of construction materials and avoiding placing heavy equipment such as air conditioning on the roof).

13.6.8.4.6 Summary of Risk Reduction Measures for Jetty and Pipeline

In this section the main measures for managing the risk from jetty and pipeline are outlined. (This list does not include the many risk reduction measures at the existing Topaz). One key requirement is that the jetties and pipeline comply with or exceed appropriate recommended codes of good practice and standards. A number of trade organisations and professional bodies have prepared codes of good practice for the design, operation and maintenance of ship to shore transfers and some pertinent ones are listed below.

The approach taken is one that includes a combination of engineering / design measures to minimise the hazard and prevent incidents occurring; mitigation measures to limit damage in event that an incident occurs; coupled with management measures to ensure that these controls remain effective and to manage human factors.

Technical Measures - Design

- Jetty and Pipeline will be designed to appropriate codes of practice and standards;
- Hard arms which are higher integrity compared to hoses will be used.

Protective / Preventative Technical Measures

- Jetty arms will be fitted with ranging alarms and emergency release couplings;
- The tank inlets are fitted with non-return valves;
- Pipes will be run in an impervious chamber and protected by concrete slabs. This chamber will be segregated from other services;
- Pipe route will be labelled;
- Pipe will be externally coated (coating to be selected based on ground conditions);
- Lines will be emptied after transfer;
- Ignition sources will be controlled in locations where flammable atmospheres may form. These to be identified by hazardous area classification according to a recognised code of practice. Electrical and instrumentation equipment to be to an appropriate ATEX rating and measures to control naked flames, hot work and static electricity will be in place;
- As detailed design progresses the pipeline will be subject to a Hazard and Operability study to systematically review provision of safety devices e.g. pressure relief and flame arrestors.

Mitigatory Technical Measures

- Surface area of petroleum quay will be designed so that as far as possible spillages will run to an interceptor;
- Booms will be deployed during unloading of petroleum products;
- Oil Spillage Response plan will be developed taking into account foreseeable accidents, implemented and tested regularly;
- Provision has been made for the retention of firewater that may be contaminated (area 3.7).

Management and Procedural Measures

- Petroleum unloading operations will be carried out in accordance with good practice as outlined in the International Oil Tanker and Terminal Safety Guide and HSG 186;
- Operatives will be trained in the unloading procedures, the hazards of the products and the actions to take in event of an incident;
- Class 1 petroleum products will not be unloaded whilst there is a cruise ship in dock;
- Off loading will be continuously monitored at the terminal and at ship so that discrepancies in flow will be quickly identified and transfer can be isolated;
- The pipe route is entirely under the control of the harbour management company who will control any excavation work required;
- Emergency response plans will be prepared and practiced to ensure that in the event of an incident rapid action is taken to minimise consequences. Emergency plans to include rapid isolation in event of a release, deployment of resources such as fire-fighting equipment, booms and spillage recovery equipment, evacuation of non-essential personnel, and provision of information to the off-site authorities;
- Public access will be restricted in the Quays and Jetty. Security is provided.

Relevant Codes of Practice (Non-exhaustive)
International Oil Tanker and Terminal Safety Guide 5th Edition, 2006 (OCIMF[24]/ SIGTTO[25])
Design and Construction Specification for Marine Loading Arms 3rd Ed. May 1999 (OCIMF)
Jetty Maintenance and Inspection Guide (OCIMF/ SIGTTO) 2008
Mooring Equipment Guidelines, 2008 (OCIMF)
Marine Terminal Training and Competence Assessment Guidelines for Oil and Petroleum Product Terminals 2001(OCIMF)
Model Code of Safe Practice Part 2: Design, Construction and Operation of Petroleum Distribution Installations 2005 (Energy Institute)
Model Code of Safe Practice Part 15: Area Classification Code for Installations Handling Flammable Fluids 2005 (Energy Institute)
Model Code of Safe Practice for the Petroleum Industry Part 21: Guidelines for the Control of Hazards Arising from Static Electricity, 2002 (Energy Institute)
Model Code of Safe Practice Part 1: The selection, installation, inspection, and maintenance of electrical and non electrical apparatus in hazardous areas 2010 (Energy Institute)
Revised recommendations on the safe transport of dangerous cargoes and related activities in port areas, 2007 (International Maritime Organisation)
The Bulk Transfer of dangerous liquids and gases between ship and shore (HSG 186), 1999, Health and Safety Executive
PD8010 -1:2004: Code of Practice for Pipelines.

Table 13.6.8.3 - Relevant Codes of Practice (Non-exhaustive)

13.6.9 Conclusions

This report has investigated the likely risks associated with various accident scenarios from the terminals at Topaz and Leeside as well as those presented by the pipeline and the jetty to the proposed development in Galway harbour. The main conclusions from this assessment are:

1) The overall conclusion is that the risks to the land-based developments such as occupied buildings are tolerable when compared to the criteria used by the HSA to assess the level of risk to people.

2) The societal risks at the jetty are considered to be tolerable. The separation distances between the jetties and occupied building and passenger terminal comply with recognised good practice.

3) Relocating petroleum unloading to the new jetty will reduce societal risk even allowing for increased throughput as there is a much larger surrounding population at the existing facilities at Folan Quay and Dun Aengus docks.

4) The risk of a spill to the environment cannot be ruled out. The risks of such a spill will be managed by use of higher integrity unloading arms fitted with emergency release couplings for petroleum liquid transfers. Unloading arms reduce the likelihood of a release that threatens the environment compared to hoses. The design of the jetty and the pipeline route will be such that spills can be contained and recovered as far as is practicable.

   Compared to the new jetty the existing harbour is protected by dock gates so it is easier to contain and recover any spillage before it reaches an environmentally sensitive area. The open nature of the Port means that this is not the case and so booms will deployed during petroleum unloading. An oil spillage response plan will be in place.

[24] The Oil Companies International Marine Forum (OCIMF)

[25] The Society of International Gas Tanker and Terminal Operators Ltd (SIGTTO)

5) From a safety perspective the risks from the pipeline are low and the main concern would be a spill to the environment. These risks can be reduced by the implementation of appropriate leak monitoring systems as well as unloading procedures which ensure vigilance in monitoring offloading progress. Procedures that empty the pipeline following the unloading also help to reduce the risk of a spill as it reduces the potential exposure time of the pipeline when it contains an inventory. Emergency spill protection procedures and appropriate spill protection equipment will be provided.

6) The risks from the Topaz and Leeside terminals to the development have been estimated as being tolerable.