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Land-use Planning Advice for Mayo County Council

In relation to the application

By

Shell E&P Ireland Limited

To

Construct a facility

At

Bellanaboy Bridge, Co. Mayo.

[P03/3343]

8th April 2004

Report compiled by the following H.S.A. inspectors

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1. Introduction

This document contains the basis for the findings of the H.S.A. (hereafter referred to as the Authority) with regard to the request for land use planning advice from Mayo County Council for the proposed gas terminal at Bellanaboy Bridge.
This document is divided into six sections with a further six appendices. The executive summary in section two lists the main points from the assessment carried out by the Authority. Section three provides information on the detailed analysis of the likelihood and consequences of the major accident scenarios identified, and also an analysis of the major accidents to the environment. Section four provides commentary by the Authority on the separate risk assessment provided by the Shell E&P Ireland Limited (the applicant). Section five provides information on the Authority's review of the applicants proposed technical and operational measures. Finally section six details the conclusions of the Authority. Appendix one contains a copy of the letter from Mayo County Council requesting advice on the said development. Appendix two gives information on the role of the Authority and the legal context under which it operates. Appendix three describes the policy criteria that the Authority uses when considering requests for land use planning advice. Appendix four contains a copy of the applicant's risk assessment report. Appendix five contains a list of all references that appear in this document. Finally appendix six contains additional information requested from the applicant.
Based on the information supplied by Shell E&P Ireland Limited (the applicant) in their Notification, the proposed gas-oil terminal would be a lower-tier Seveso site under the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, 2000. Consequently the planning application falls within the remit of the Authority to offer technical advice in relation to land-use planning.
Should the development proceed and notwithstanding any conditions of a planning permission, Shell E&P Ireland Limited will be required under the above regulations to demonstrate to the Authority at any time, that it has taken all necessary measures to prevent major accidents occurring and to limit the consequences of any such major accidents for man and the environment, and that it has a safety management system in place. It will also be subject to regular inspection by the Authority, and in the event of 'development' that could have significant repercussions for major accident hazards, planning permission will also be required.

2. Executive Summary

This document has been prepared for Mayo County Council in respect of a request for land-use planning advice (appendix 1) in relation to a proposed development at Bellanaboy Bridge by Shell E&P Ireland Limited, as described in planning application No.P03/3343. Part of the development would constitute an establishment within the context of the E.C. (Control of Major Accident Hazards Involving Dangerous Substances) Regulations S.I. 476 of 2000.
In formulating its advice, the Authority considered potential major accidents involving flammable gas, flammable and toxic liquids, projectiles and the potential for impact of these on the surrounding people and the environment.
The Authority determined that the risk of dangerous dose posed by the establishment was found to be less than 5 $x10^{-6}$/year to their to their current non residential neighbours and less than 1 $x10^{-6}$/year to the nearest residential type property.
The Authority determined these risks were at such a level that, according to the land use planning criteria of the Authority for this purpose, it **does not advise against** the granting of planning permission in relation to this development.
The Authority also makes the following recommendations:

a) Paved areas to be extended to bund walls and arranged so that any accidental releases over bund wall are diverted to the open drains sump
b) Extension of impermeable areas around the slugcatcher such that any potential release is contained.
c) Online Total Organic Carbon monitoring to be installed at silt ponds with provision for automatic re-routing of flow to contaminated firewater pond in event of accidental discharge to system.

For the purposes of emergency planning:

In addition arrangements should be made between the applicant and Mayo Co. Co. to provide for traffic control on roads close the terminal in the event of a major incident.

For the purpose of control on future development:

Should there be any proposed amendment to the permitted scheme which relates to the control of impact of major accident hazards (as defined by Seveso II Directive) then that amendment shall not proceed until the agreement of the H.S.A. has been obtained.

Consultation Zone

Noting that the risk contours predominantly fall within the applicant's landholding; the Authority;

- does not suggest any restriction on land use outside the applicant's landholding or outside the parcel of land defined by the 3 x 10-7 contour (establishment northwest corner, Figure 1)
- advises that any development within the aforementioned landholding or parcel of land should be referred to the Authority. This area is greater than would normally be specified as a consultation zone but for administrative convenience this approach is suggested

3. Quantified Risk Assessment (H.S.A.)

3.1 Introduction

The functions of the Authority are set out in appendix 2. One of its many functions relates to the provision of land use planning advice to planning authorities, which is a legal obligation under SI 476 of 2000.
However there are a number of general exclusions contained in the regulations, the most relevant to this proposed development being as follows:

the occurrence outside an establishment of -

- the transport of dangerous substances by road, rail, internal waterways, sea or air,
- associated intermediate temporary storage,
- the transport of dangerous substances in pipelines and pumping stations.

Then there are some activities, not listed as exclusions, which do not come within the scope of the regulations:

- Comparison of potential sites for a proposed establishment
- Activities related to site development / construction

There are aspects specific to this application which are excluded:

- Excavation of Peat at Bellanaboy Bridge site
- Deposition of Peat at the Srahmore Site

The Authority has defined the scope of the analysis as follows

The Establishment:
The establishment is considered to be the terminal (the area within the security fence footprint where the hazardous substances are processed and stored). This decision was taken in respect of the previous planning applications and has been retained following discussions between the Authority and E.U. Commission officials and representatives of the other E.U. member states.

Assessment of Global Stability of Terminal:
The Authority retains no expertise in-house for consideration of this issue in its provision of land-use advice. The stability issues have been addressed in the Environmental Impact Statement (EIS) provided by the applicant for normal conditions. The Authority has requested and received specific information relating to major accident hazards affecting global stability from the applicant. This has been forwarded to Mayo County Council. It is the understanding of the Authority that Mayo County Council have already retained a consultant to advise it in this regard.

The way in which the Authority develops its technical advice and criteria it uses are set out in Appendix 3. It will be noted that for new establishments the authority takes an approach based on the estimation of risk.
Although the risk of fatality is commonly used for major hazards assessment (see table 10 of Appendix 3) the Authority, for land-use planning purposes, uses the 'dangerous dose or greater' endpoint employed by the UK HSE. While the risk of receiving dangerous dose could equate to risk of fatality close in to the source of hazard, further out the risk of dangerous dose could be up to 100 times greater than the risk of fatality. It is therefore a very conservative approach for looking at off-site effects. In addition, the Authority takes a conservative approach to the selection of scenarios to model, for example assessing catastrophic failure or modelling VCEs using TNT method.
The hazards that are considered by the Authority for the determination of risk of dangerous dose posed by a new establishment of this type are

- Explosion overpressure of 140 mbar
- Thermal radiation dose of 1000 Thermal Dose Units
- Flash fire to half lower flammable limit (½ LFL)

Explanations

This report makes reference to specific terminology related to consequence and risk assessment modelling. Explanations of terminology used in this report are listed below

Thermal Dose Unit is a measure of intensity of heat flux and its duration.

A **dangerous dose** is defined as one where

- There is severe distress to almost everyone.
- A substantial fraction requires medical attention.
- Highly susceptible people might be killed.

Flash Fire is defined as the combustion of a flammable gas or vapour and air mixture in which the flame propagates through the mixture at a rate less than sonic velocity so that negligible damaging overpressure is generated.

Vapour Cloud Explosion (VCE) is the explosion resulting from a pre-mixed cloud of flammable vapour, gas or spray with air, in which flames accelerate to sufficiently high velocities to produce significant overpressure. The resulting pressure wave has the potential to cause damage to people and property.

3.2 Methodology

The consequence modelling packages used for analysis of this proposed development were PHAST v6.3 (DNV Technica) and ALOHA (USEPA). Reference was made to documents from CCPS books (2,3) and the Yellow Book (4)

For calculation of risk, and its visualisation, the Authority used – Riskplot Graphic version 5, produced and supported by Environmental Resources Management (ERM) Risk, Manchester, U.K.

Failure frequency figures were sourced from the Purple Book (5)

3.3 Key Assumptions for Analysis

Upon examination of loss history databases and also through consultation, engineering judgements and experience, the Authority chose a selection of different hazards, from across the span of the site to determine the overall off-site risk posed by the proposed terminal.

The types of scenarios selected were guided by the methodology set out in the Purple Book. Scenarios chosen included full-bore & partial failures of pipe-work, catastrophic failures of pressurised equipment in the processing area and major fires at the storage tanks and tanker loading areas.

A full-bore or partial rupture of a pipe or storage vessel involving natural gas, if not immediately ignited, will lead to the formation of a flammable gas cloud which will drift downwind, being diluted as it goes. If this cloud meets a source of ignition in an uncongested area a flash fire may result. It is conservatively assumed that anyone inside the cloud will suffer fatality. The extent of this flash fire corresponds to the region where the gas concentration is at or above the lower flammable limit (LFL) for the gas and below the upper flammable limit. Because of fluctuations in the gas concentrations within the cloud, the distance to half the lower flammable limit is modelled by the Authority as the extent of the flash fire envelope. If the gas cloud encounters an ignition source in an area of congestion, a Vapour Cloud Explosion (VCE) may occur.

In this analysis it was conservatively assumed that each release results in a flammable cloud, which is always ignited, with subsequent thermal radiation and / or overpressure effects. No allowance was made for the possibility that the gas cloud could safely disperse without ignition. This assumption therefore overestimates the level of risk. The key assumptions are outlined below for each stage of the risk assessment process.

3.3.1 Modelling Assumptions

1. The rate of release of gas from long pipelines will decay over time as the pressure in the pipeline drops. The rates of release used in this analysis for long pipeline releases were those predicted for the initial stage (initial 60 seconds) of the release and thus the extent of the resultant consequence zones are maximised.

2. The following endpoints were chosen as relevant for the quantified risk assessment;

- For Flash Fire, the distance to the Half Lower Flammable Limit (1/2 LFL) envelope. The Purple Book methodology advocates the use of the LFL envelope, however the Authority's conservative approach takes account of potential rich pockets of gas outside the LFL region.

- 1000 Thermal Dose Units zone for jet-fires and late pool fires.

- Overpressure effects of 140mbar for late explosion with ignition source located 200m from release.

3. Calculation of overpressure effects was conducted using the TNT Equivalency method. This method is based on relating the available combustion energy in a vapour cloud to an equivalent weight of TNT and thus determining the blast characteristics of the cloud. In practice, methane gas releases are very unlikely to lead to vapour cloud explosions – in fact the FM Global Solutions Loss Prevention Data sheets actually consider natural gas explosions as 'beyond the scope of worst credible scenario'. Notwithstanding this, the Authority's analysis included Vapour Cloud Explosions and also applied an extra level of conservatism by placing an ignition source some 200m from the source of release, to maximize the flammable cloud available for explosion.

3.3.2 Scenarios Selected for Modelling

1. Full bore rupture of pipe and a leak equivalent to 10% of the diameter of the high pressure gas piping in the pipe rack, taken at multiple points along the run of the pipe work.

2. Full bore rupture of pipe and a leak equivalent to 10% of the diameter of the Slugcatcher pipe work leading to release of methane / condensate mixture at multiple points along the pipe work.

3. Full bore rupture of pipe and a leak equivalent to 10% of the diameter of the 'Sales Gas Export Pipeline' at the Pig Launcher.

4. Full bore rupture of the pipe work to the Compressors in the Processing Area.

5. Catastrophic failure of the Methanol Flash drum in the Processing Area.

6. Catastrophic failure of the Methanol Coalescer in the Processing Area.

7. Catastrophic failure of the Methanol Reflux in the Processing Area.

8. Major bund fire at the Product Methanol Storage Area.

9. Major bund fire at the Condensate Storage Area.

10. Road tanker release of 20,000 litres of methanol with subsequent pool fire at the tanker loading / unloading area.

11. Full bore rupture of pipe and a leak equivalent to 10% of the diameter of the high pressure gas inlet pipe.

12. Major bund fire at the Raw Methanol storage area.

3.3.3 Input Data for Risk Assessment

1. Atmospheric conditions are normally classified according to six Pasquill stability classes (A-F). These classes related to air turbulence are correlated to wind speed and quantity of sunlight, with A representing least stable conditions and F most stable. For the purposes of quantified risk assessment and in the absence of detailed meteorological weather data for a particular area, two common weather combinations are typically used D5 (D stability class, wind speed 5m/s) and F2 (F stability class, wind speed 2m/s). Weather data was taken as 88.7% D5 and 11.3% F2 as per meteorological data supplied by Met Eireann for the Belmullet station. There was no synoptic weather data available from the Glenamoy weather station.

2. The weather data used does not differentiate between day and night.

3. Failure Frequencies are assigned from Purple Book.

4. The probabilities of release incidents leading to Flash Fires, Jet Fires or Vapour Cloud Explosions were determined using event trees (e.g. Figure 1 in Appendix 3) applying the Purple Book methodology.

3.3.4 Rationale for Exclusion of Certain Scenarios from further analysis

1. **Hydrogen Chloride** gas releases were evaluated from a spill of 30% Hydrochloric Acid into a bund area of 10m^2. The effect distance found to the Dangerous Dose (10 minutes) was 11 metres under F2 weather conditions and less under D5 and would therefore be entirely contained on the terminal site.

2. **Methanol** vapour releases were evaluated for toxic effects to the Dangerous Dose (10 minutes) for differing release scenarios. The analysis indicated the greatest effect could extend to 30 metres. This effect would be completely contained within the site boundary.

3. **Flare Stack** – point of release taken as 40 metres from ground. Analysis shows that the dangerous dose level was not reached beyond the establishment boundary.

4. **Missiles** could conceivably be produced from catastrophic equipment failures at the proposed terminal site. The Authority's analysis predicted that the likelihood of a missile striking the nearest residential type development, having been generated at the nearest part of the plant to the residence to be less than one in 10 million years. Other credible sources of missile generation are further set back and as such the risk is further reduced. This risk is so remote that it was excluded from the risk analysis.

5. The **odorant gas** is composed of 80% Butyl mercaptan and 20% Dimethyl sulphide. This material is classified as highly flammable, however a release leading to a flash fire or pool fire was not deemed credible on account of the double-walled tank containment specified for the material. The failure frequency stated in the Purple Book for

instantaneous failure of a double containment atmospheric storage tank is 1.25 x10^{-8} / year. A spill of these materials into the containment bund was modelled for a toxic effect to the Dangerous Dose (10 minutes) level for each and found to occur within 5 metres of the bund area and thus the effects are totally contained on the terminal site. For this reason this event was excluded from the risk analysis.

6. A small number of **Propane cylinders** are expected to be present on site. The cylinder sizes will be 50 kilogram in weight and will be stored in cylinder arrays as per IS 820 (Standard Specification Non Domestic Gas Installation). The major accident hazard predicted from failure of the cylinders is significantly less than other scenarios already modelled. These other scenarios modelled have adequately addressed the effects of this type of incident and for this reason this event was excluded from the risk analysis.

3.4 Results

3.4.1 Individual Risk of Dangerous Dose around Proposed Terminal

The individual risk contours generated due to the combined effects of overpressure and thermal radiation for the scenarios listed in Section 3.3.2 are graphically represented below in Figure 1. Figure 2 represents the risk profile calculated for the nearest road to the proposed terminal, the R314.

Figure 1. Individual Risk of Dangerous Dose based on Purple Book

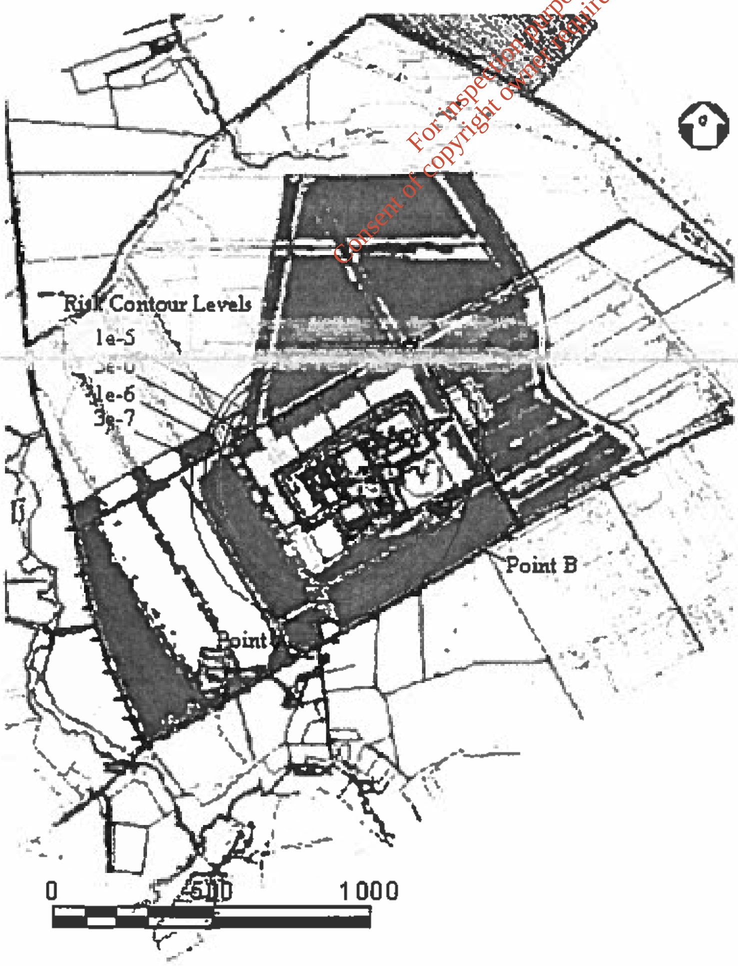


Figure 1 shows that the contour which represents the Individual Risk of Dangerous Dose per year at 5×10^{-6} extends beyond the establishment but is completely contained within Shell E & P's landholding. The risk contour for the $1x10^{-6}$ and $3x10^{-7}$ levels are predominantly contained within the applicant's land holding, however both contours extend off the landholding at the North-West corner of the terminal site. The Authority's normal practice on Land-Use Planning advice for new establishments is that they should not present a risk of dangerous dose greater than 5×10^{-6} per year to their current non residential neighbours or a risk of $1x10^{-6}$ per year to the nearest residential type property. The analysis indicates that the risk posed by the proposed terminal to the nearest residential neighbour is less than $1x\ 10^{-6}$ per year.

Figure 2. Risk profile for Road R314 between Points A & B

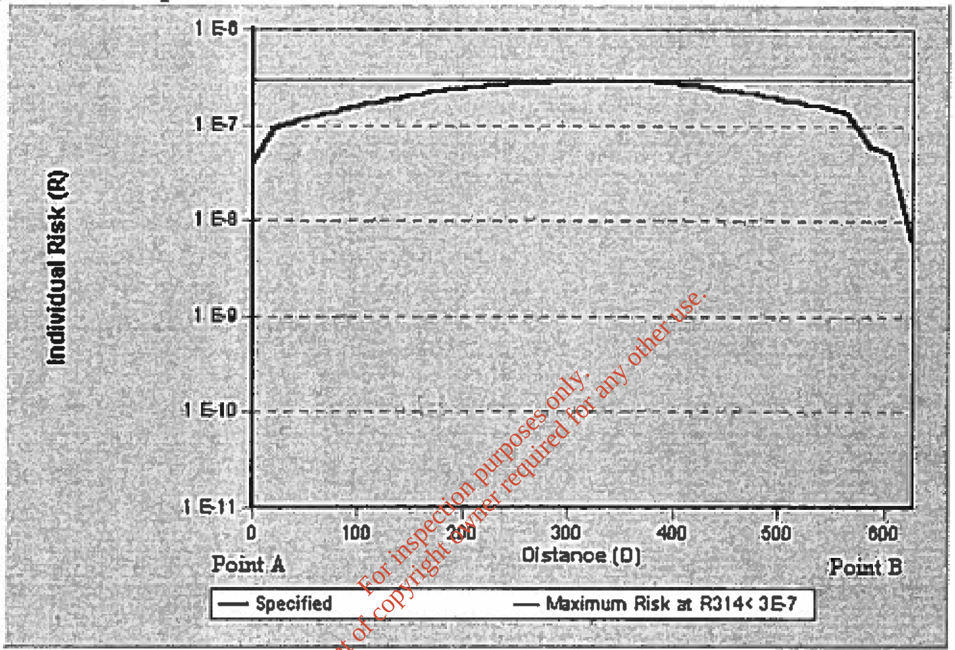


Figure 2 presents the risk profile for the closest 600 meter stretch of the R314 running directly parallel to the Terminal (between Points A & B) and the analysis shows that the maximum risk of dangerous dose posed at the R314 road way is less than 3×10^{-7} / year. This risk level is less than the $1x\ 10^{-6}$ / year criteria used by the Authority for the nearest residential type property.

3.4.2 Sensitivity Study

As a sensitivity study, to allow for uncertainties in using the Belmullet weather data and the inland location of the proposed terminal site, the Authority took a more conservative approach and used the 75% D5 / 25% F2 weather set. This represents a higher proportion of calm weather at the location. This percentage of calm, F2 weather conditions is greater than any F2 figure recorded by Met Eireann for inland weather stations across the country. When this weather set is applied for the proposed terminal, Figure 3 depicts the risk contours and Figure 4 the risk at the road R314.

Figure 3. Individual Risk of Dangerous Dose –based on Purple Book with 25%F weather

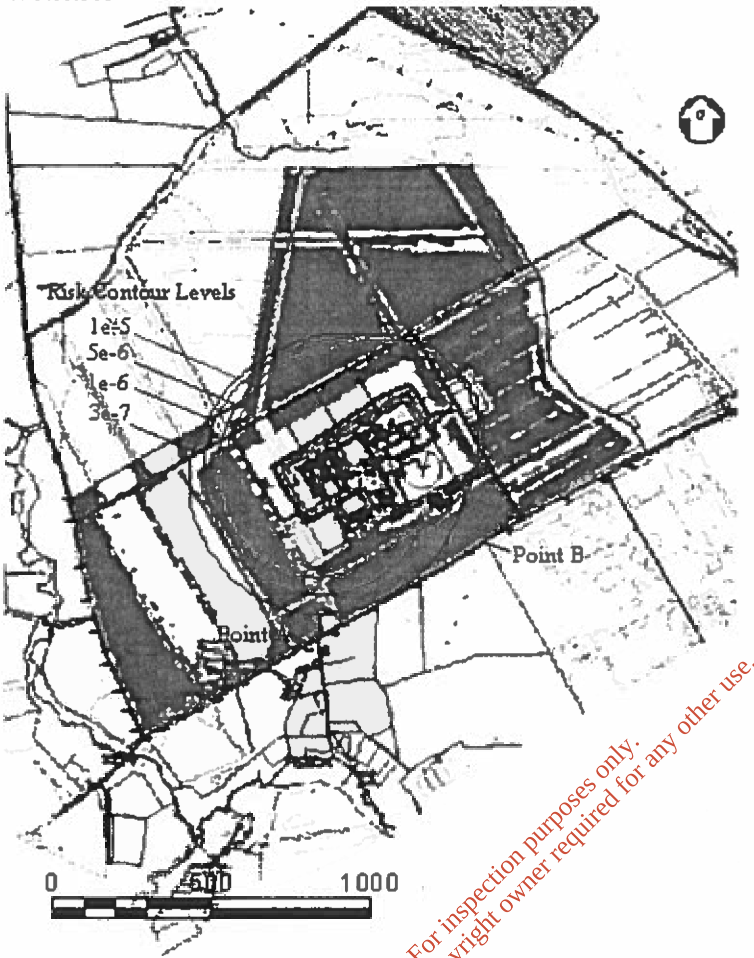


Figure 3 shows that the contour that represents the Individual Risk of Dangerous Dose per year at 5×10^{-6} extends beyond the establishment but is completely contained within the applicant's landholding. The risk contour for the 1×10^{-6} and 3×10^{-7} levels are predominantly contained within the applicant's land holding, however both contours [illegible] therefore no significant difference to the risk profile around the site when the 75% D / 25% F weather data set is used.

Figure 4. Individual Risk of Dangerous Dose at R314 between Points A & B based on Purple Book 25%F

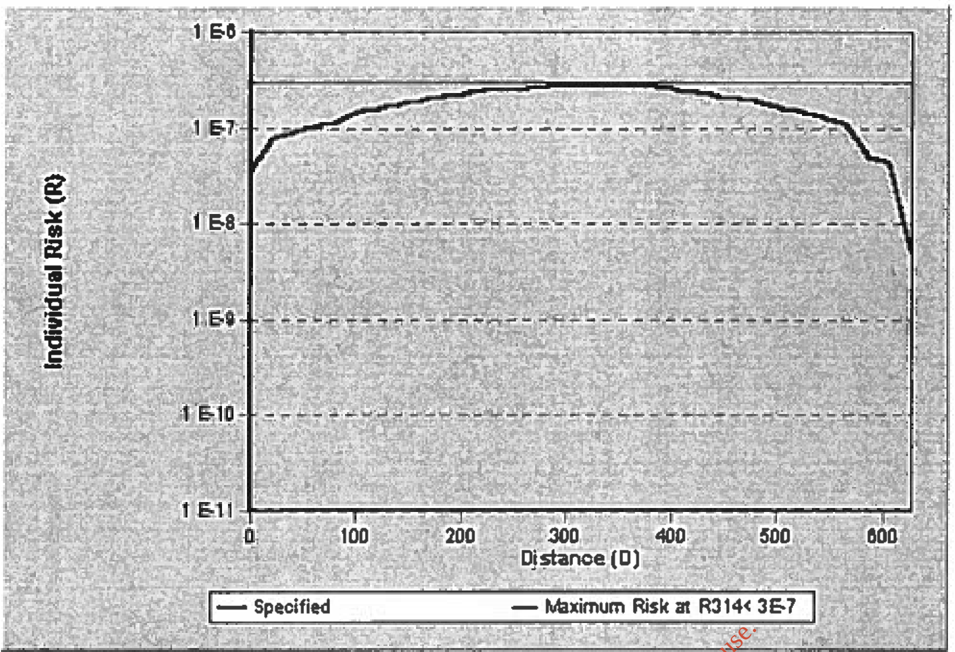


Figure 4 presents the risk profile for the closest 600 meter stretch of the R314 running directly parallel to the Terminal (between Points A & B) and the analysis shows that the maximum risk of dangerous dose posed at the R314 road way is less than 3×10^{-7} / year, which is less than the 1×10^{-6} / year criteria used by the Authority for the nearest residential type property.

It is normal practice for the Authority to reference the 'Guidelines for Quantitative Risk Assessment – CPR 18E' (Purple Book) when assigning failure frequencies to plant and equipment. As a further sensitivity check, the Authority also considered the failure frequencies listed in the HSE Offshore Hydrocarbon Release Statistics, 2001 (for the period October 1992 to March 2001)(HCR 2001) (11) for comparison. The source data was that compiled by the Health and Safety Executive for equipment failures used for offshore applications. This data set differs from the Purple Book data as it is based on failure events of equipment used in offshore environments. The offshore conditions are more challenging to the equipment's containment integrity than those presented by land based conditions. The individual risk contours generated due to the combined effects of overpressure and thermal radiation for each scenario due to the use of this data (HCR 2001) set is represented graphically below. The Individual Risk contours are represented in Figure 5, while Figure 6 represents the Risk Profile at the R314 roadway.

From Figure 5 it can be seen that the risk contours for the 1×10^{-5} down to 3×10^{-7} levels do extend beyond the edge of the landholding at the Northwest corner of the terminal site and also at the southern boundary adjacent to the R314. The contour representing the risk of dangerous dose of 1×10^{-6} / year extends close to the nearest residential type property. The risk of dangerous dose predicted at the nearest property is less than 9×10^{-7} / year, which is less than the 1×10^{-6} / year criteria used by the Authority for the nearest residential type property.

Figure 6 presents the risk profile for the closest 600 meter stretch of the R314 running directly parallel to the Terminal (between Points A & B) and the analysis shows that the maximum risk of dangerous dose posed at the R314 road way is less than 7×10^{-6} / year.

Figure 5. Individual Risk of Dangerous Dose –based on HCR 2001

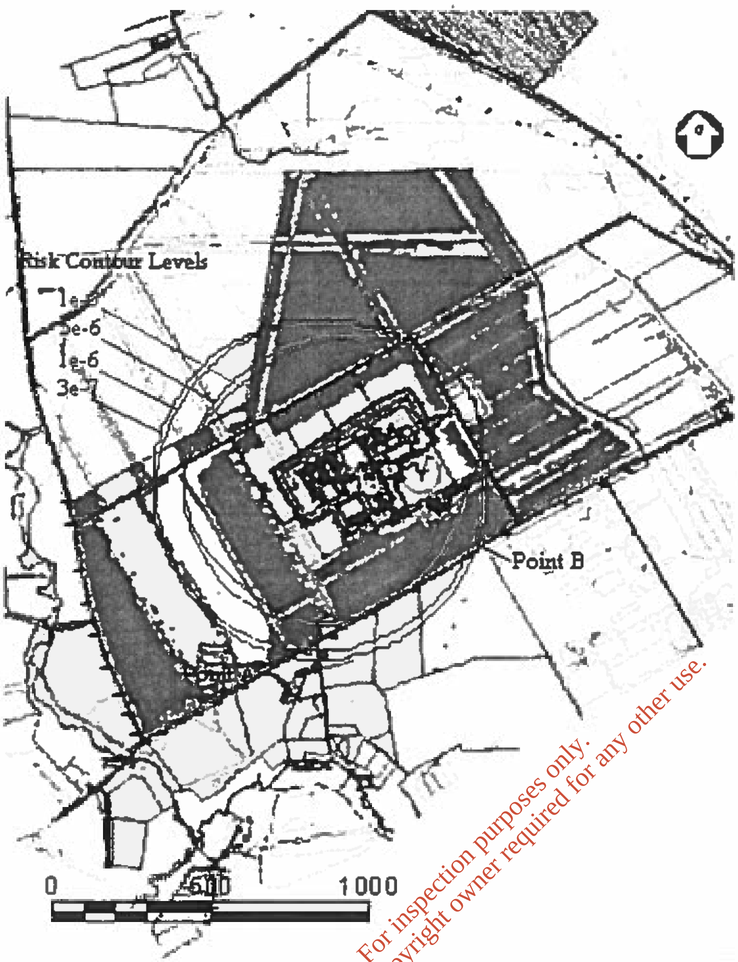
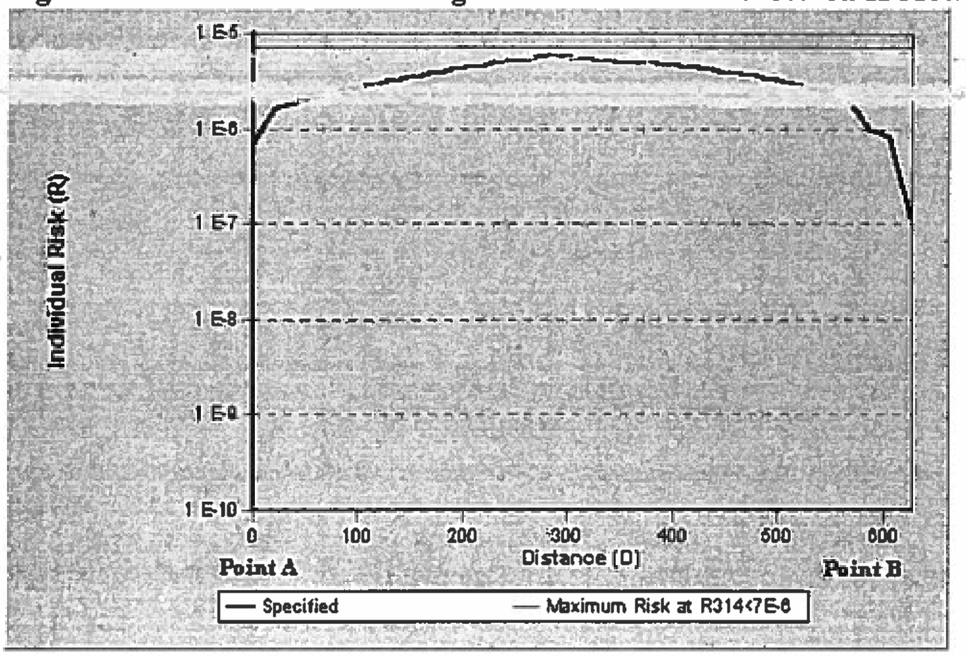


Figure 6. Individual Risk of Dangerous Dose at R314 based on HCR 2001



Based on the findings of these sensitivity studies, the Authority has not found reason to revise its initial conclusion.

3.4.3 Other Issues Addressed by the Authority

3.4.3.1 Occupied On Site Buildings

Based on the analysis conducted by DNV and information supplied by the applicant (Appendix 6), the level of risk posed at any of the occupied buildings complies with the criteria laid down in the Chemical Industry Associations 'Guidance for the location and design of occupied buildings on chemical manufacturing sites' (13).

3.4.3.2 Effects of Trees

3.4.3.2.1 Effects of Forest Fire on the Terminal Offices

The block of trees closest to an occupied building on the proposed terminal is located to the south of the terminal, some 30 meters from the Administration & Maintenance buildings. Using Cohen & Butler as a reference (14) based on the fiercest type of tree fire – crown fires, at a setback distance of 30 meters the expected incident thermal flux at these locations is 25 kW/m^2 for a maximum duration of two minutes. This thermal flux level exceeds the 6.3 kW/m^2 recommended in the Chemical Industry Associations 'Guidance for the location and design of occupied buildings on chemical manufacturing sites'. However this part of the forest is so far set back from the pressurised / processing part of the terminal that the risk of direct ignition is extremely low. Therefore considering these tree fire events will not occur instantaneously and could only develop in severity over time and combined with the shielding effect afforded by the buildings themselves, the ability for personnel to safely escape these buildings will not be compromised.

Similarly the control room, at a setback distance of 40 meters, the expected incident thermal flux is 18 kW/m^2 for a maximum duration of two minutes. As the Control Room is designed to be fire resistant for two hours, any tree fire incident would be incapable of jeopardizing the integrity and function of the Control Room. The processing equipment and transport piping around the site are set back from the nearest tree line by at least 90 meters ranging to 170 meters. No tree fire set back this distance would be capable of directing the required 25 kW/m^2 thermal flux to jeopardize the containment integrity of the plant. No account was taken of the mitigation measures proposed to be available at the terminal.

The applicant has committed that the layout of the surrounding trees will be in compliance with the Forest Protection Guidelines 2002 (Department of Communications, Marine and Natural Resources), and also the requirements of the Mayo County Council Fire Officer and as such will lessen the risk of fire spread.

3.4.3.2.2 Effects of the Terminal on surrounding Trees

Based on the analysis of the worst credible scenarios for the proposed terminal, the risk of these highly unlikely release incidents leading to conditions capable of ignition of the surrounding forested areas has been postulated as being due to a jet fire from rupture of the high pressure system. The risk of an event like this occurring has been calculated to be less than or equal to 2.2×10^{-6} / year.

The fiercest type of tree fire is known as a crown fire, which is a fire event that has developed from a surface / ground fire and spread into the tree canopy. Crown fires are capable of spreading quickly and burning extremely intensely. However the UK Forestry Commission's Technical Note 'Forest and Moorland Fire Suppression' (24) states that 'sustained crown fires are rare in UK conditions'. Coillte rate this particular area of forestland as low risk. There is no quantified value available for the background risk level for tree fires in Ireland, however DNV in the QRA quote the background level for any wooded environment in the U.K. to be 2×10^{-4}/year. Based on this background level, the increase in risk of forest fire initiated from events at the terminal is extremely low.

The nearest residence to the forest area subject to risk from the terminal is set back more than 40 meters from the nearest tree and is therefore not at risk of ignition from forest fire radiation.

3.4.4 Worst Possible Consequences of Major Accident

The question is sometimes posed regardless of the risk as to what the worst possible consequences of a major accident at a proposed development might be. Based on the Authority's analysis, the worst possible consequences would be caused by a full-bore rupture at the high-pressure import gas pipeline. In the event of such an unlikely event occurring, the following consequences may occur;

Table 1: Consequences of Worst Possible Scenario

Event	Distance (Meters) D5	Distance (Meters) F2
Extent of 1000 TDU from Jet Fire	456	527
Extent of Piloted Ignition of wood* region (14.7 kW/m²)	398	470
Extent of 140 mbar overpressure	334	344

* Piloted Ignition is defined as the thermal flux level required to sufficiently heat a material to decompose to form a volatile –air mixture capable of sustaining a flame, in the presence of a pilot flame. The ignition heat flux/temperature in a standard test is normally lower than the ignition temperature in an actual fire scenario.

However the Authority regards this scenario as less than credible based on

- The degree of operator control of pipeline
- The thickness of the import pipeline at the terminal
- The short length of above ground pipe and it's location
- The Purple Book gives a full bore loss of containment frequency of 1 x 10^{-7} per metre per year for this diameter pipeline above ground

and as such the risk of such an event is considered highly unlikely.

3.5 Assessment of Major Accidents to the Environment

3.5.1 Introduction

This section of the submission is concerned with the environmental effects of major accidents applicable to the proposed development. It should be noted that routine emissions are not considered. Regulations of such emissions are the responsibility of, and will be licensed by, the local authority or the Environmental Protection Agency as applicable. Operation of the proposed terminal will be subject to an IPPC Licence as regulated by the Environmental Protection Agency on the basis of a projected energy consumption of greater than 50MW.

The assessment is based on information drawn from –

- A Quantified Analysis of the Process Hazards at the Proposed Bellanaboy Bridge Terminal – prepared by Det Norske Veritas (Appendix 4)

- Environmental Impact Statement prepared in respect of the proposed Bellanaboy Bridge Gas Terminal and associated Srahmore Peat Deposition Site prepared by RSKENSR Environment Limited

- Corrib Gas Field Development Planning Application

- Additional Information supplied by the Applicant(Appendix 6)

3.5.2 Environmental Impacts

Scenarios were considered on the basis of their potential to cause a Major Accident to the Environment. Of these, scenarios 2, 8, 9 and 12 as listed in Section 3.3.2 were deemed to represent the worst-case major accident from an environmental effects viewpoint. These are namely –

Scenario 2 – Full bore rupture of pipe and a leak equivalent to 10% of the diamter of the Slugcatcher pipe work leading to release of methane/condensate mixture at multiple points along the pipe work

Scenario 8 - a major bund fire at the Product Methanol storage area
Scenario 9 – a major bund fire at the Condensate storage area
Scenario 12 – a major bund fire at the Raw Methanol storage area.

3.5.3 Qualitative Assessment of Consequences

In assessing potential Major Accidents to the Environment, primary regard is given to sensitive Receptors that may be impacted in the event of a major accident occurring. Consideration of the environment of the proposed terminal highlighted the following sensitive Receptors.

- Carrowmore Lake cSAC and associated surface water systems
- Glenamoy River and Sruwaddacon Bay SPA
- Underlying groundwater resources
- Terrestrial habitat surrounding establishment

Assessment of the consequences of each of the scenarios selected recognises that a major accident to the environment could occur in the absence of engineered control and containment, were these scenarios to occur. As such, the Authority must be satisfied that the measures as outlined by the operators are such that the general statutory duties assigned by Regulation 9 of S.I. No. 476 of 2000 will be complied with. In making this assessment, the Authority is particularly mindful of Regulation 9(2)(e) requiring operators to use best practicable means to prevent a major emission into the environment from any part of the establishment of dangerous substances resulting from uncontrolled developments in that establishment, and to use best practicable means for rendering harmless and inoffensive such substances as may be so emitted.

3.5.4 Spill Prevention

3.5.4.1 Primary Containment

The Terminal tank farm facility will comprise of 8 major storage tanks, in addition to individual storage tanks for each of acid wash, heating medium and diesel. The major storage tanks will be comprised of three Raw Methanol tanks, two Condensate tanks, one Off spec Condensate Tank and two Product Methanol tanks. The Condensate on site is treated as two substances – the unstabilised liquid contained in process vessels at high pressure is categorised as a highly flammable liquid, while the stabilised liquid contained in the storage tanks is categorised as 'automotive petrol and other petroleum spirits'. Methanol is classified as flammable and toxic. Uncontrolled release of each of these materials into the environment, at sufficiently high volumes, is likely to result in a major accident to the environment under the terms of Directive 96/82/EC.

The storage tanks are to be designed to British Standard 2654 – specification for manufacture of vertical steel non-refrigerated storage tanks with butt-welded shell for the petroleum industry. Tanks are to be subject to hydrostatic testing before being put into service.

The operator has indicated that the tanks would be equipped with high-level indicators and high-level alarms. In the event of an inadequate response to a rising liquid level a "High-High" alarm and trip system would automatically isolate the supply to the tank.

3.5.4.2 Local Containment

All bulk inventories are located in bunded areas. Three Condensate tanks will be located in common bunds, separated by dwarf walls. Similarly, three Raw Methanol tanks will be located in a common bund, also with dwarf walls. Two Product Methanol tanks will be located in a separate common bund, again with dwarf separating walls. The base of the tanks will be arranged so that leaks will be directed to the base rim of each tank allowing for a leak detection system to operate. The volume of the bunds in each case will be designed to contain a minimum of 110% of the largest tank in the bund, or greater than 25% of the total tank contents.
The bulk storage tanks are to be arranged inside common bunded areas in accordance with National Fire Protection Association Standards, while spatial arrangements as proposed are to be in accordance with the Institute of Petroleum Model Code of Safe Practice Part 3 specifying tank spacing. Materials of construction are to be such that they are impervious to the contained liquids.

The operator has indicated that drainage of bunds to remove rainwater, which is to be performed by a manually operated valve, will be subject to a permit to work system to prevent the inadvertent discharge of any contaminated water. A concern with such manual valve systems is that there is a temptation to leave the valve continuously open to remove rainwater thus defeating the purpose of the bund. Current guidance on the issue suggests that such a gravity drain system, even with lockable valves provided should not be employed in new installations unless the bund is part of a properly designed combined system. The Authority is satisfied that the bunds as outlined are part of a designed combined system.
The operator has indicated that bund overflow pipes in methanol and condensate areas are sized to take the largest combination of product, firewater and rainfall. The open drains sump, which receives bund contents via gravity flow, is fitted with a pump to allow transfer of any contaminants to the contaminated firewater retention pond.

3.5.4.3 Remote Containment

In the event of a major fire at the condensate, raw or product methanol tank bund, the operators design as proposed allows for up to 6 hours deluge of firewater at an application rate of 1200m^3 per hour, thus totalling, 7200m^3. Provision is made for containment of this material on-site via the tank bund, the Open Drains Sump and the Contaminated Firewater Pond, in addition to tank contents and associated rainfall run-off concurrent with the fire scenario. Contaminated firewater is then tested to determine whether on or off-site disposal is appropriate. Therefore, the operators proposed design provides for on-site containment of generated contaminated firewater, in the event of a bund fire in either of the main storage areas.

Containment issues may also be subject to conditions under an EPA administered licence.

3.5.4.4 Issues at Slugcatcher

Areas beneath flanged connections of the slugcatcher pipe work are to be paved. In addition, the orientation of instrument connections will be such that any associated leaks are to be contained via paved areas and the open drains system feeding to the surface water treatment system. The operator asserts that a leakage from any other part of the slugcatcher that would result in condensate/methanol being discharged outside of the terminal fence is not credible. Furthermore, the operator asserts that any liquid spilled onto unpaved areas will be recovered in accordance with proposed terminal emergency procedures. The operator in considering this scenario, calculates that a maximum of 10 tonnes of condensate could be released, and concludes that a release 'to unpaved ground may contaminate the surface and/or groundwater. Any condensate released to the receiving watercourse may raise the Chemical Oxygen Demand in excess of a few days and may therefore constitute a MATTE (Major Accident to the Environment), although the small quantities of condensate involved mean that this is unlikely.'

3.5.4.5 Comments regarding Spill Prevention

The Authority recognises the potential for a major accident to the environment resulting from a release of a dangerous substances from the proposed terminal site. This is particularly the case when the nature of the vulnerable receptors as identified is considered. Containment measures as proposed must satisfy the 'best practicable means' criteria with regard to prevention of release of dangerous substances to the external environment. In considering the primary containment measures, bunding arrangements for either of the product methanol, condensate or raw methanol areas, allied to the remote containment system, the Authority acknowledges that the design proposal as outlined can be considered as satisfying this criteria.

However, the Authority recommends that:

- Paved areas should extend up to the bund walls to further protect against the possibility of spigot flow leaks overshooting the bund wall/catastrophic failure of primary containment, allowing such releases to be collected in the open drains sump and associated treatment system/contaminated firewater pond.

- In consideration of a leak at the slugcatcher pipe work, additional measures would be required to further satisfy the 'best practicable means' criteria. These measures should include at a minimum, an impermeable area around the slugcatcher to capture any potential release.

3.5.5 Other Scenarios

3.5.5.1 Toxic Gas

Toxic gas emissions were not considered as initiators of a major accident to the environment in light of the material inventories on site and estimated concentrations at the terminal boundary in the event of a gaseous release.

3.5.5.2 Flooding

The site drainage system has been designed to cater for a one in 100 year rainfall event (of 31mm in one hour), and assessed for a maximum 45mm in one-hour event. As such, flooding at the proposed terminal site was not considered as an initiator of a credible accident scenario.

3.5.5.3 Lightning

The operator states that lightning protection has been provided in the design of the terminal facilities in accordance with the requirements of BS 6651, Code of Practice for Protection of Structures against Lightning. The earthing system is designed to British Standard Code of Practice 1013: Earthing, and all storage tanks will be electrically grounded.

3.5.5.4 Silt Ponds

Surface water from unpaved areas and ground water from the terminal site is to be routed through the silt ponds prior to discharge to the local watercourses, and ultimately, to Carrowmore Lake.

While a proposed interceptor system is designed into this system prior to the silt ponds, as an additional control, **the Authority recommends that:**

- On-line organic content monitoring be installed at the silt ponds inflow point with an associated provision for re-routing flow to the on-site wastewater treatment system/contaminated firewater pond. Should the organic content increase above background in the unlikely event of accidental discharge to this system, this would allow diversion of the silt pond outfall from local watercourses to the on-site treatment system.

4. H.S.A. Commentary on DNV/Shell Risk Assessment

DNV were commissioned by Shell to conduct a quantified risk assessment (QRA) for the proposed terminal with a view to estimating the offsite risk of dangerous dose at the request of H.S.A. to neighbouring populations. Appendix 4 contains a copy of the QRA as supplied to the Authority from Shell E &P Ireland Limited. The QRA report addresses the Terminal Facilities in Section 2, the consequence and frequency methodologies in Section 3 and Appendix II and presents the main predictions from the analysis in Section 4.

DNV regard their report as being a best estimate in most respects but conservative i.e. an overestimation, in its determination of maximum overpressure for explosions in the slugcatcher area and in its selection of frequencies for full or large failures in the high pressure gas system. The failure frequency data used is based on a modified version of the 'Offshore Industry Hydrocarbon Release (OIR 12)' database and the methodology used to modify the database is described in Appendix II of the report. DNV regard this database as the most representative failure frequency dataset for the types of failures that could be expected at the proposed terminal. The figures used are more conservative than those used in the Purple Book. The report is based on consideration of a wide range of scenarios and includes reasoned arguments for the exclusion of certain scenarios.
The DNV analysis indicates that, on the basis of the above criteria, the location of the nearest housing is not at any significant risk from:

- Overpressures greater than 70 mbar [Figure XIII.2]
- Flash fires [Figure XIII.12]
- Thermal radiation greater than 4 kW/m^2 from jet or pool fires [Figures XIII.10and XIII.11]
- Thermal radiation greater than 500 thermal dose units from short duration thermal radiation events [Figure XIII.13]

These figures show that the overall risk contours for dangerous dose are predominantly contained within the boundary of the applicant's landholding. Appendix XV indicates that the overall risk of dangerous dose to 1 x 10^{-6} and 3 x10^{-7} / year are completely contained with in the landholding.

The report does indicate that the nearest residence to the proposed terminal could experience overpressures equivalent to less than one fifth of the dangerous dose overpressure. Overpressures of this size have been documented as causing window breakage.

The report examined trees in Section 3.6 in the context of:

- Ignition of trees from a fire at the terminal
- Increase in explosion potential if the trees act as a region of congestion
- Level of thermal radiation at the plant boundary due to a forest fire.

The predictions from the analysis are presented in Section 4.3. and updated in Appendix XVI of the DNV report

Section 4.3.1 gives the predicted thermal radiation from a serious forest fire at the tree bank closest to the terminal –some 40 meters away - as being 18 kW/m^2. This thermal radiation level is insufficient to affect the function of the Control Room. The thermal radiations levels predicted at processing equipment from forest fires do not exceed 8 kW/m^2, which is insufficient to jeopardize the containment integrity of the process equipment.

The risk of a short duration thermal radiation event igniting the surrounding trees is presented in appendix XVI. The risk differs around the site and certain tree banks are at higher risk than others depending on their proximity to the processing area of the terminal. The predicted risk levels are less than 1 $x10^{-5}$/year with the tree banks to the north and east at the highest risk. It is pointed out that this is significantly lower than the published UK background rate.

Section 3.6.3 makes a convincing case that the trees cannot act as regions of congestion for explosion events due to major release incidents at the terminal.

The Authority, using its approach to Land-Use Planning under S.I. No. 476 of 2000 concludes that the DNV Limited analysis constitutes a reasonable rationale for the assessment of the off-site risks posed by the proposed terminal.
The analysis has been conducted by experienced experts in the field of quantified risk assessment and is premised on reputable methodologies for estimation of consequence zones and risk assessment. The approach taken by DNV differs from that chosen by the Authority, however the overall risk contours generated by the differing approaches yield broadly similar results concerning the level of overall risk posed by the terminal.

5. Applicants Proposed Technical and Operational Measures

5.1 Introduction

This section reviews a range of issues related to the ability of the proposed development to meet the requirements of the Seveso II Directive. It provides qualitative information as a support to the quantified assessment process.

This review examines the codes of practice and standards that the operator proposes to adopt in the design, construction, commissioning and operation of the gas terminal. This review also includes an examination of how the operator intends to verify that all standards and codes are complied with throughout the terminal lifecycle.

Clearly some of the organisational and technical issues cannot be fully developed at this time since the development is at the design stage but clear commitments have been given to the Authority in documentation provided by the operator.

5.2 Hazard and Risk Assessment

The Directive requires operators to identify the hazards and assess their likelihood and severity. The terminal design has been subjected to a range of techniques widely used in the process industries such as:

HAZARD IDENTIFICATION METHODS

The operator uses both HAZID (Hazard Identification) and HAZOP (Hazard and Operability Studies) techniques at the FEED stage (Front End Engineering Design). These systematic techniques identify hazards, consequences and preventative controls at an early stage. They also identify protective and mitigating measures for dealing with residual risk.

FIRE AND EXPLOSION RISK ASSESSMENT

This analysis involves the consideration of the impact of various types of fire/explosions, and identifies the requirements for passive fire protection or deluge.

QUANTIFIED RISK ASSESSMENT

The operator submitted a quantified risk assessment report to the H.S.A. to assist in giving land use planning advice. This document contains a detailed hazard analysis consisting of

Generation of Representative Set of Major Accident Scenarios

An assessment of the likelihood and consequence (on site and off site) of these scenarios

DEPRESSURISATION STUDIES

The operator has commissioned blowdown studies that provide data on the actual conditions the terminal would experience in the event of an emergency blowdown. The data generated during these studies was used to design the emergency blowdown system.

The company indicated that assurance systems are in place that track the outputs from all safety management programmes throughout the terminal lifecycle, and that the documentation will be available for future use should any plant changes need to be considered (See Verification Section Below).

5.3 Plant Layout

The operator has indicated that the plant design is laid out in accordance the Industrial Risk Insurers guidelines publication IM 2.5.2 for layout and spacing of oil and chemical plants. The operator has indicated that the general layout in some instances provides separation distances that exceed those laid down in the guidelines. Industrial Risk Insurers, based at Hartford, CT, USA, were formed in 1975 from the merger of the Factory Insurance Association and the Oil Insurance Association.

5.4 Control of Ignition Sources

The operator has confirmed that hazardous area classification has been carried out in accordance with the procedures laid down in the Institute of Petroleum Model Code of Safe Practice, Part 15 Area Classification Code for Petroleum Installations. This code provides a methodology for the appropriate selection of electrical /electronic equipment. It has also been indicated that all equipment will be certified in accordance with the ATEX (EU) Directive.

The operator has indicated that the terminal will be earthed and provided with a site wide equi-potential bonding system to ensure that all equipment remains at the same potential thus minimising the risk of a spark between structures. The operator has indicated that all earthing systems will be designed in accordance with recognised standards.

The operator has indicated that all radios for use in hazardous areas will be certified as intrinsically safe i.e. unable to produce sufficient energy to present an ignition source, and that all equipment will be in compliance with the EMC Electro-magnetic compliance Directive.

The operator has indicated that a permit to work system will be operated for any hot work in hazardous areas.

5.5 Plant Control Systems

The plant will be equipped with a distributed control system (DCS) that will monitor and control plant conditions and permit emergency action to be taken in the event of a process upset or non-scheduled release.

The operator has indicated that the control system (DCS) and the emergency shut down (ESD) system will be separate systems (completely separate instrumentation and controls). The operator has indicated the ESD system will be designed in accordance with the recognised standard IEC61508 (Functional Safety of Electrical/Electronic/

Programmable Electronic Safety Related Systems). This methodology determines how many sensors are required for a particular process variable and the need for other systems in addition to the instrumentation system. The ESD system has the capability of shutting down and isolating all terminal systems automatically. It can also be initiated manually from a number of locations on the terminal site.
The operator has indicated that power supplies to the DCS, ESD and FG (Fire and Gas Detection) systems will be supplied by a dual redundant UPS (un-interruptible power supply) with battery for two hours.

Control Room:

The operator has indicated that the Central Control Room (CCR) has been designed to withstand any predicted overpressure for that location (viz. up to 200mbar). It will be permanently manned with two operatives and access to the room will be controlled so as to limit potential distraction. The layout of the control room has been determined with the aid of ergonomic studies in order to minimise the risk of operator fatigue. The alarm warning system has been designed from an audio and visual perspective to enable an operator to identify those alarms, which are critical.
The control room will be provided with a comprehensive communication system including telephone, intercom, video, VHF radio and Internet services.
The operator has indicated that, in order to ensure operator competence a special simulator will be constructed so that control room operators can be trained in a more realistic environment.

5.6 Pressure Vessel Integrity

5.6.1 Design Codes

The operator has indicated that design codes such as British Standard PD5500 and American Society of Mechanical Engineers ASME VIII for pressure vessels, ASME B31.3 for process piping, have been used and will offer a high degree of protection.

Compliance with these codes will be ensured by the appointment of a competent third party to confirm compliance with the PED (EU, Pressure Equipment Directive) throughout the design, fabrication and construction phases of the project.

5.6.2 Protection against Overpressure

The operator has indicated that the terminal protection system (TPS) is provided by means of a detection, relief and flare (blowdown) system. The TPS system is separate from both the plant control system (DCS) and the emergency shutdown system (ESD). The TPS depressurises vessels by venting the contained gas to a flare system. This venting can be initiated automatically (by detection by sensor or by the lifting of a pressure relief device) or manually by an operator if required. The operator has indicated the TPS system and associated instrumentation will be designed in accordance with the recognised standard IEC61508 (Functional Safety of Electrical/Electronic/Programmable Electronic Safety Related Systems).
The pressure relief devices, which connect to a flare system, will be sized according to

- API RP 520[Design and Installation of Pressure Relieving Systems in Refineries] and
- API RP 521[Guide to Pressure Relief and Depressurisation Systems]

The flare system is comprised of:

- System for high-pressure (HP) sources
- System for low-pressure (LP) sources
- System for maintenance related activities.

The operator has indicated that the HP flare system is designed to provide full flow relief of the gas export system as per the required design code. The operator has indicated that suitably designed knock out vessels will be installed in the flare lines to remove any liquid from the lines so that burning liquid is not discharged from the flare stack. Flare headers will be continuously purged with nitrogen to prevent air ingress and thus limit the risk of explosion.

5.6.3 Protection against Corrosion

The integrity of a plant depends on corrosion issues being identified and addressed so a safe plant does not degenerate to an unsafe one over time. Natural Gas and condensate from this reservoir are regarded as non-corrosive. Methanol is also non-corrosive.
In some terminals corrosion problems are aggravated by the presence of H_2S (hydrogen sulphide)(sour gas). Reservoir analysis has not recorded the presence of H_2S.
The operator has indicated that a programme of corrosion monitoring will be put in place using corrosion probes and wall thickness measurements.

External corrosion protection will be provided by surface coatings and /or cathodic protection.

5.7 Tank Farm Issues

5.7.1 Design

See section 3.5.4 above.

5.7.2 Protection against overfilling

See section 3.5.4 above.

5.7.3 Protection against vapour ignition

The operator has indicated that the tanks for methanol and condensate will have internal floating roofs and will be nitrogen blanketed so that there will not be a flammable air mixture above the liquid level, thus minimising any risk of an internal explosion. This

also means that there will not be a flammable zone at the tank vents thus minimising any risk from external ignition. According to the American Petroleum Institute's (API) Recommended Practice 2003 Protection Against Ignitions Arising out of Static, Lightning and Stray Currents "Internal floating roof tanks are inherently protected against internal ignitions from lightning induced sparking by Faraday cage effect".
The operator has confirmed that hazardous area classification has been carried out in accordance with the procedures laid down in the Institute of Petroleum Model Code of Safe Practice, Part 15 Area Classification Code for Petroleum Installations and that all equipment will comply with the EU Directive (ATEX)

5.7.4 Protection against loss of containment

See section 3.5.4. Above.

5.8 Incident Intervention Issues

This is addressed in the order of incident detection, process isolation, process venting, and fire fighting.

5.8.1 Incident Detection

The first line of defence is the normal range of process instrumentation that will monitor high/low pressures, liquid fill levels, temperatures etc and provide warnings/alarms to the control room. The operator has indicated it will incorporate the full range of instrumentation, which will:

1. Display numbers/figures that will give a plant operative some warning of an impending alarm condition allowing action to be taken before that condition occurs and
2. Devices that will only trigger once the alarm condition has been met.

5.8.2 Gas Detection

The operator has indicated that two types of flammable gas detectors will be used to detect presence of gas before the LEL (lower explosion limit) is reached.

IR (infra-red) open path suitable for the outdoor environment will be provided at the slugcatcher and other process areas. These devices are most suitable for detection of gas clouds in outside area regardless of fog or sunlight interference.

IR (infra-red) point gas detectors (infra red point detectors) will be provided at the following:

- Buildings liable to gas accumulation
- Heating, ventilation and air conditioning air intakes
- Combustion air intakes for gas turbine and diesel engines

Gas alarm points will in general be set to operate at 25% and 50% of the lower explosive limit and at lower levels where the alarm automatically initiates an equipment shutdown/closure.

The operator has indicated that a minimum of three gas detectors will be located in an area to provide suitable back up in the event of a sensor failure. Initiation of an alarm condition on two out of the three will trigger an automatic response (e.g. alarm at HVAC will shut inlet flaps)

5.8.4 Fire Detection

The operator has indicated that the plant will be protected by a comprehensive high sensitivity smoke detection system that can initiate a terminal shutdown.
The site will also have closed circuit television monitoring (CCTV). The methanol and condensate areas will be fitted with suitable IR flame detection that is required to detect invisible methanol fires.

5.8.5 Process Isolation

In the event of a gas release the main object would be to isolate the relevant section of plant so that the fuel to the release can be shut off. To this end the operator has indicated that the plant will be equipped with a comprehensive emergency shut down (ESD) system where the critical items of plant can be remotely (manually or automatically) isolated by ESD valves. Failure on a signal line to such valves will cause them to move to a safe condition so the operability of these valves will be maintained in the event of loss of power.
The ESD system will be provided with duplicated control systems and continuous self - checking diagnostics.
The location of the ESD isolation valves will be such that the major items of plant can be readily isolated in the event of an incident.

5.8.6 Process Venting

Depending on the incident scenario vessel isolation may be sufficient. Vessel contents may be blown down, under operator control to the flare line.
As described earlier each pressure vessel is also equipped with a pressure relief valve connection to a flare line to limit vessel overpressures.
The storage tanks will be equipped with local vents, in accordance with BS2654.

5.8.7 Emergency Arrangements/Fire Fighting

The operator has indicated that the site will be self sufficient with regard to fire water supplies with a 7200 m3 firewater pond that is designed to fight the worst credible fire scenarios. In addition to the sites own water a 10-inch emergency fill line; stated to have a capacity of 300m3/hour will be supplied from the local authority water system. The worst case firewater demand has been estimated to be 1200m3/hr thus giving a 6 hour capability which exceeds the minimum 2 hour recommendation in the Institute of Petroleum's Model Code of Practice, Part 19.
The operator has proposed to install 4 firewater pumps any one of which can supply half the design firewater requirement.

Firewater monitors are to be positioned around the terminal that can be locally or remotely activated from the central control room. This degree of remote acting capability lessens the risk of staff being injured should they have to deal with an incident. Where required, e.g. at the tank farm, monitors will be equipped with foam facilities.
The operator has indicated that the methanol and condensate tanks are fitted with surface pourers that dispense alcohol resistant foam. The bund area will also be fitted with a foam monitor that can be used to extinguish any fire that starts in the bund.

Finally the operator has indicated that fire hydrants and associated fully equipped fire hose cabinets will also be provided at appropriate locations points throughout the terminal.

The company has indicated that the fire fighting system has been designed with reference to:
Institute of Petroleum's code for Fire Precautions at Petroleum and Bulk Storage Installations (IP 19)
National Fire Protection Association's standard for Low Expansion Foam (NFPA 11)
National Fire Protection Association's standard for Water Spray Fixed Systems for Fire Protection (NFPA 15)

The operator has indicated that emergency response arrangements will be put in place that will address the following

- Emergency command and control
- Emergency response teams (Roles and Responsibilities)
- Emergency response facilities
- Emergency response plans and programmes
- Training
- Requirements for reporting and notification
- Liaison with Local Emergency Services

5.9 Operability Issues

In respect of the prevention of major accidents it is clear that technology alone does not provide sufficient protection. The Directive requires companies to implement a safety management system which address such issues as organisation, training, operational control and management of change. Whilst such detail may not be fully developed at the planning stage the company has been able to demonstrate an appropriate philosophy to such issues.

5.9.1 Staffing Levels

The company proposes to conduct a Business Risk Assessment to establish suitable staffing levels to cope with normal and major accident conditions. Later after production has begun a further assessment will be conducted to ensure that the company can demonstrate adequate staffing levels for the purposes of Seveso II. The operator has also indicated that it will compare manpower arrangements with other sites (manpower index assessment). Finally the operator has indicated that once production commences a full detailed analysis based on a HSE (UK) Contract Research Report 348/2001 will carried out.

5.9.2 Competency

The operator have signalled the intention to put in place a competence assurance system which will be to the National Vocational Qualification Standard D32 and D33 with independent third party verification of the assessment. This system is intended to verify the attainment of a threshold of performance for personnel before they are allowed to work unsupervised. The operator has also committed to include safety management performance indicators for all staff in their appraisal system.

5.9.3 Training

The operator has indicated that training will be competence based and include both employees and contractors as appropriate. Reference has been made to the development of a simulator for training of control room staff and shift supervisors.
The training will cover routine operations and non-routine operations such as emergency shutdown, permit to work, alarm management and fire/gas systems. The operator has committed all personnel to emergency response training that will include the participation of Mayo County Fire Brigade. Finally, the operator has committed to one major exercise test per calendar year (Seveso II Directive has requirement for once every three years).

5.9.4 Management of Change

The management of change is a crucial issue in the control of major hazards. The operator has committed to developing a change control process as part of the safety management system to ensure that any changes to hardware or software are properly assessed and documented before implementation. This system will operate throughout the terminal lifecycle (design to decommissioning). All change requests will go through a formal assessment programme that will require a signature of a designated person before proceeding with a change. In particular any deviations from standards/specifications will be reviewed in a major accident prevention context (as is required by Seveso II Directive).

5.9.5 Permit to Work

The operator has indicated that it will develop a permit to work system that will incorporate isolation principles, practices and task based risk assessments. The system will formally control the hazards and risks associated with particular tasks (e.g. hot work) and make those responsible aware of these activities. The system will require an approval signature from a designated individual before a task can proceed and it will provide a formal hand over system for plant and equipment.

5.10 Verification/Safety Assurance

The operator has indicated that a Quality Assurance programme covering all aspects of the terminal throughout its lifecycle will be put in place. The objective will be to ensure adherence with all standards and codes of practice. In addition to their own internal assurance the operator has committed to the appointment of recognised independent third party verification that will include an assessment of all aspects of work deemed critical to the safe and reliable functioning of the terminal. The operator has also committed to have a Safety Audit and Review programme as is required by the Seveso II Directive. Finally, if built the terminal would be subject to full safety management system audit in year one and routine annual inspections by the Authority thereafter.

6. Conclusions

Based on the foregoing assessment, the following conclusions have been drawn by the Authority: Concerning the environmental assessment of major hazards, the Authority is satisfied that best practicable means will be employed in relation to spill containment, provided the following conditions are complied with –

a) Paved areas to be extended to bund walls and arranged so that any accidental releases over bund wall are diverted to the open drains sump

b) Extension of impermeable areas around the slugcatcher such that any potential release is contained.

c) Online Total Organic Carbon monitoring to be installed at silt ponds with provision for automatic re-routing of flow to contaminated firewater pond in event of accidental discharge to system.

For the purposes of emergency planning:

In addition arrangements should be made between the applicant and Mayo Co. Co. to provide for traffic control on roads close the terminal in the event of a major incident.

For the purpose of control on future development:

Should there be any proposed amendment to the permitted scheme which relates to the control or impact of major accident hazards (as defined by Seveso II Directive) then that amendment shall not proceed until the agreement of the H.S.A. has been obtained.

The QRA supplied by Shell and carried out by DNV, reflected a detailed and reasonable assessment of the risks likely to be posed by this development.

The off-site risks of dangerous dose are estimated to be less than 1 x 10^{-6} per year to the nearest residential dwelling and less than 5 x 10^{-6} to the current nearest non residential neighbour

The Authority **'does not advise against'** this proposed development.

Noting that the risk contours predominantly fall within the applicant's landholding; the Authority;

- does not suggest any restriction on land use outside the applicant's landholding or outside the parcel of land defined by the 3 x 10-7 contour (establishment northwest corner, Figure 1)
- advises that any development within the aforementioned landholding or parcel of land should be referred to the Authority. This area is greater than would normally be specified as a consultation zone but for administrative convenience this approach is suggested

Appendix 1 Request for Advice

PLANNING AND DEVELOPMENT SECTION
MAYO COUNTY COUNCIL

ARAS AN CHONTAE

CASTLEBAR

P03/3343

18/12/2003

MR JOHN COLREAVY
HEALTH AND SAFETY AUTHORITY
10 HOGAN PLACE
DUBLIN 2

RE.: PERMISSION: CONSTRUCT GAS TERMINAL FOR THE RECEPTION AND SERAPATION OF GAS FROM THE CORRIB GAS FIELD, AND FOR A PEAT DEPOSITION SITE, RESPECTIVELY. THE DEVELOPMENT WILL CONSIST OF THE CONCURRENT DEVELOPMENT OF TWO SITES LOCATED 11 KILOMETRES APART, APPROXIMATELY, AND IDENTIFIED AS THE SITE OF THE GAS TERMINAL FOR THE RECEPTION AND SEPARATION OF GAS FROM THE CORRIB GAS FIELD IN THE TOWNLAND OF BELLAGELLY SOUTH AND THE SITE OF THE PEAT DEPOSITION SITE IN THE TOWNLANDS OF SRAHMORE AND ATTAVALLY, BANGOR ERRIS. THE DEVELOPMENT AT THE BELLAGELLY SOUTH SITE WILL CONSIST OF: A GAS TERMINAL FOR THE RECEPTION AND SEPARATION OF GAS INCLUDING PLANT AND EQUIPMENT; PROVISION OF 4,935 SQ M (GROSS FLOOR AREA), APPROXIMATELY, OF BUILDINGS; ACCESS ROADS; 40 NO. CAR PARKING SPACES; AND ANCILLARY DEVELOPMENTS, OF WHICH 13 HA, APPROX, WILL BE DEVELOPED INRESPECT OF THE GAS TERMINAL'S FOOTPRINT. THE PROPOSED DEV. WILL OF THE BELLAGELLY SOUTH SITE WILL ALSO CONSIST OF; THE EXCAVATION AND REMOVAL OF 450,000 CUBIC M at BELLAGELLY SOUTH SRAHMORE ATTAVALLY - **Applicant Name:** SHELL E & P IRELAND LIMITED

Dear Mr Colreavy

I refer to the above application and I enclose herewith one set of documents received with same.

Please let us have any comments **before the 22nd January 2004** and return documents.

Mise le meas,

M. Moore

FOR COUNTY SECRETARY

JM/MM

Appendix 2 Role of HSA (Legal Framework)

1. *NAOSH Background*

The National Authority for Occupational Safety and Health (for convenience this is often shortened to the Health and Safety Authority - HSA) was set up under the Safety Health & Welfare at Work Act, 1989.

As the name implies, it is primarily concerned with the health and safety of people at work.

The principal functions, as set out in Section 16 of the Act are:

- To make arrangements for enforcement of relevant legislation
- To promote, encourage and foster the prevention of accidents
- To encourage & foster measures directed towards the promotion of health and safety of persons at work

The Authority is divided up into operational units.

The Process Industries Unit (PIU), which deals with the process industry including pharmaceutical sector, Bulk Petroleum Storage, LPG etc. is responsible for the implementation of the Seveso II Regulations and provision of Land-use Planning advice thereunder.

2. *Seveso II Legal Context*

The Authority, acting as the Central Competent Authority under the EC (Control of Major Accident Hazards involving Dangerous Substances) Regulations, 2000 (SI 476 of 2000), gives technical advice to a planning authority when requested, under regulation 29(1) in relation to

- The siting of new establishments,
- Modifications to an existing establishment to which Article 10 of the Directive applies
- Proposed development in the vicinity of an existing establishment

In general, the Authority will always look for the best estimate, where there are uncertainties, it will tend to takes a conservative approach and favour that which will overestimate the consequence or risk.

SI 476 of 2000 implements EU Directive 96/82/EC [Control of Major-accident Hazards involving Dangerous Substances]. Article 12 of that Directive states:

'Member States shall ensure that their land-use and/or other relevant policies and the procedures for implementing those policies take account of the need, in the long term, to maintain appropriate distances between establishments covered by this Directive and residential areas, areas of public use and areas of particular natural sensitivity or interest, and, in the case of existing establishments, of the need for additional technical measures in accordance with Article 5 so as not to increase the risks to people.'

The Major Accident Hazard Bureau/ Joint Research Centre of the European Commission has produced guidance in this area for the National Competent Authorities, concerning the status of technical advice furnished to planning authorities:

'It is recognised that consideration of major-accidents is only one input to the process of land-use planning controls and policies.... many other considerations can be relevant, and that these may already be elaborated in various national policies and implemented in national, regional or local structure and development plans.'

Exclusions
It should be noted that the Regulations exclude certain activities:
"These Regulations shall not apply to -

(a) any property occupied by the Defence Forces and any land or premises referred to in section 268(1) of the Defence Act, 1954 (No. 7 of 1954);

(b) hazards created by ionising radiation;

(c) the occurrence outside an establishment of -

(i) the transport of dangerous substances by road, rail, internal waterways, sea or air,

(ii) intermediate temporary storage associated with a subparagraph (i) activity,

(iii) the loading or unloading of dangerous substances at docks, wharves or marshalling yards,

(iv) the transport to and from another means of transport at docks, wharves or marshalling yards, and

(v) the transport of dangerous substances in pipelines and pumping stations.

(d) the activities of extractive industries concerned with exploration for, and the exploitation of, minerals in mines and quarries or by means of boreholes;

(e) waste land-fill sites.

It should also be noted that biological agents are not within the definition of 'dangerous substance' and are therefore not covered by the Regulations.

In giving its advice, the Authority considers only the effects of credible major accident scenarios at the establishment and does not deal with routine emissions. It is the understanding of the Authority that such emissions will be subject to EPA or Local Authority scrutiny and control.
The Authority's advice does not deal with site selection or the suitability of one site over another.
Activities related to site development /construction are not within the remit of the Authority in the context of the provision of Land-use planning advice.

Appendix 3 Criteria for Land Use Planning

1. *Policy in Relation to Siting of New Establishments*

The question considered by the HSA when it provides technical advice to a planning authority is:
'If operational, would the risks posed by this establishment be tolerable?'
The Board-approved policy of the HSA in relation to LUP for new establishments states that:
'It is ... necessary to demonstrate for new "Greenfield/Brownfield" establishments that they do not present a risk of a dangerous dose greater than 5 x 10^{-6}/yr. to their current neighbours or a risk of a dangerous dose greater than 1 x 10^{-6} /yr. to the nearest residential type property. This may be relaxed in respect of neighbours where the new development is the same/similar to the existing neighbours; for example new oil storage depot being set up in a location already occupied by tank farms.
The Authority will seek from the operators of proposed establishments a detailed consequence and risk assessment in order to help it formulate a response to a request for advice on a planning application.
The Authority will also consider any potential impact on local access/egress arrangements in the context of public behaviour in the event of an emergency and access for emergency services.
The Authority will give consideration to any other issues it deems relevant to a particular application notwithstanding what has been indicated above.'

2. *Technical Basis for Advice*

There are, as yet, no European or international standards for the provision of Land-use Planning advice. An EU working group (European Working Group on Land-use Planning), which has been in existence since 2002, was set up to consider the implementation of Article 12. The HSA represents Ireland on this group.
At present in the EU, a variety of approaches are taken in developing LUP advice, including

- The use of generic distance tables, where the distance relates to activity or storage quantity
- Consequence only. i.e. the distance is related to the consequence
- Risk & Consequence i.e. the likelihood of the consequence is estimated

At present, the Authority takes either a 'consequence' or a 'risk and consequence approach' in relation to developments, depending on the nature of the activity. For new establishments, a 'risk & consequence' approach is taken.
Advice is provided concerning the potential effects of major accidents at establishments.

2.1 Establishment

Establishment is defined in the Regulations-
"Establishment" means the whole area under the control of an operator where dangerous substances are present in one or more installations, including common or related infrastructures or activities and includes new, existing and other establishments. In practice, the establishment is considered to be the area within the security fence footprint where the hazardous substances are processed and stored. This area comes under the remit of the regulations. This approach has historically being taken and has been retained following discussions between the Authority and E.U. Commission officials and representatives of the other E.U. member states.

2.2 Major Accident

The Regulations define a major accident as follows:
"Major accident" means an occurrence such as a major emission, fire or explosion resulting from uncontrolled developments in the course of the operation of any establishment, leading to a serious danger -

(a) to human health, or

(b) to the environment,

whether immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances.'

Major accidents inevitably involve a loss of containment of a dangerous substance. The general approach adopted by the Authority is, therefore, to identify credible 'loss of containment' hazards, identify the consequences if such hazards were realised and, in certain cases, estimate the likelihood of those consequences.
Because Land-use planning concentrates on matters related to off-site risks, these form the focus of the approach. Lesser, but more likely, events are therefore not usually included as they do not have off-site impacts.
The Authority examines the process and material inventories of the proposed establishment to determine the location of inventories of dangerous substances that have the potential for an off-site impact in the event of a major accident. Bulk storage tanks, gas cylinders, pipelines, process and storage areas, road tankers etc. are all likely sources.

2.3 Credible Scenario

Credible accident scenarios that are considered (depending on the particular establishment) include major spills, releases of flammable or toxic vapours, fires, vapour cloud explosions and boiling liquid evaporating vapour explosions [BLEVE's].
The selection of credible scenarios is a critical part of any analysis. In selecting such scenarios, the HSA has particular regard to the Purple Book, the CCPS, reports published by the UK Health and Safety Executive (HSE) and other reliable sources.
Some events are not considered credible:

- Earthquake is ruled out, based on a paper by the Dublin Institute for Advanced Studies.

- Using a methodology set out in a UK HSE commissioned research report CRR 150/1997 aircraft crash can be ruled out other than for sites near an airport or significant flight path.

Other off-site initiators of major accidents are considered on a case-by-case basis. They will not be included if -

- The event is of equal or lesser damage potential than the events for which the plant has been designed.
- The event has a significantly lower frequency of occurrence than other events
- With similar uncertainties and could not result in worse consequences than those events.
- The event cannot occur close enough to the plant to affect it.
- The event is included in the definition of another event.
- The event is slow in developing and there is sufficient time to eliminate the source of the threat or to provide adequate response.

On the other hand, instantaneous failure of storage tanks and pressure vessels may be considered credible, as are fullbore pipeline failures and fires in storage areas.
The precise events chosen are based around 'Event Trees', which describe the different scenarios that could result from the loss of containment. An example, for a leak of flammable pressurised gas, is given below.

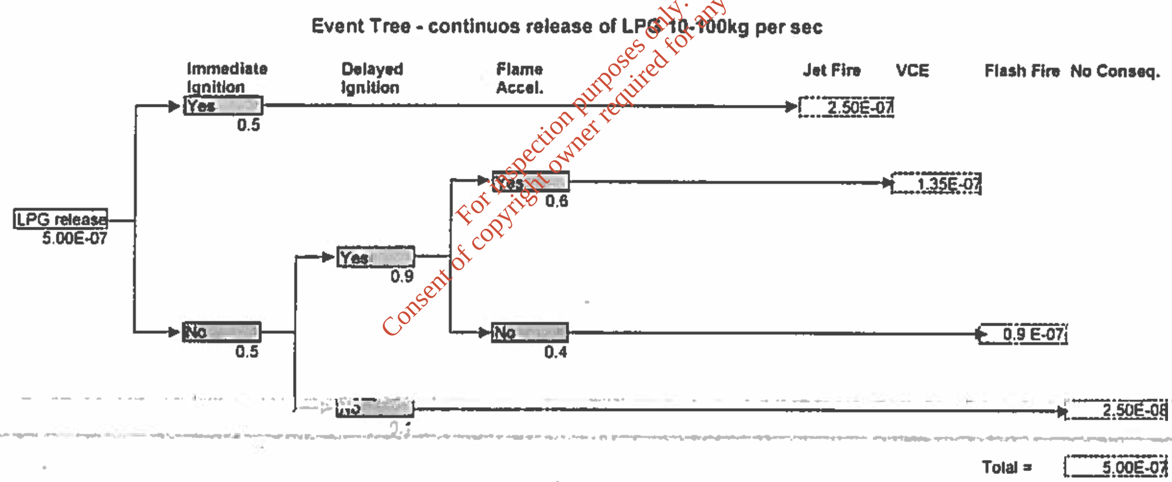


Fig.1 Event tree medium level flammable gas release

The HSA use a high probability of on-site ignition even though more detailed models might predict lower probabilities.
For many events the weather will be an important variable. The HSA will use weather data from the nearest weather station in F_2 and D_5 conditions, as supplied by Met Eireann and re-formatted by the Authority. If the site is a very great distance from any of the named weather stations then the Authority will use the F_2/D_5 weather-stability pairs for dispersion modelling, assuming a split of 25% F_2 and 75% D_5; this will give a more conservative result than using data from any of the known stations.
For new establishments the Authority performs an 'Intermediate Quantitative Risk Assessment (QRA)', in that a representative set of incidents is chosen and historical

frequency values are applied. Given the conservative approach adopted by the Authority, insofar as off-site risk is concerned this will yield results equivalent to a detailed QRA.

2.4 The Consequences of Major Accidents

Different types of physical effects could result, depending on the hazard:

Hazard	Effect
Release of Toxic material	Contamination of air/water
Vapour Cloud explosion, Physical Explosion	Overpressure wave, Heat flux Physical effects of projectiles
Pool Fire, Jet Fire, BLEVE Flash fire	Heat Flux

Table 1: Major Accident Consequences

2.4.1 Effects of overpressure

A 'level of concern' at which these effects could be experienced must be chosen in order to draw conclusions about impact
The effects of overpressure are set out below:

Side-on overpressure (kPa)	Description of Damage
0.15	Annoying noise
0.2	Occasional breaking of large windowpanes already under strain
0.3	Loud noise; sonic boom glass failure
0.7	Breakage of small windows under strain
1	Threshold for glass breakage
2	"Safe distance," probability of 0.95 of no serious damage beyond this value; some damage to house ceilings; 10% window glass broken.
3	Limited minor structural damage
3.5-7	Large and small windows usually shattered; occasional damage to window frames
5	Minor damage to house structures
8	Partial demolition of houses, made uninhabitable
7-15	Corrugated asbestos shattered. Corrugated steel or aluminum panels fastenings fail, followed by buckling; wood panel (standard housing) fastenings fail; panels blown in
10	Steel frame of clad building slightly distorted
15	Partial collapse of walls and roofs of houses
15-20	Concrete or cinderblock walls, not reinforced, shattered
18	Lower limit of serious structural damage 50% destruction of brickwork of houses
20	Heavy machines in industrial buildings suffered little damage;steel frame building distorted and pulled away from foundations
20-28	Frameless, self-framing steel panel building demolished; rupture

	of oil storage tanks
30	Cladding of light industrial buildings ruptured
35	Wooden utility poles snapped; tall hydraulic press in building slightly damaged
35-50	Nearly complete destruction of houses
50	Loaded tank cars overturned
50-55	Unreinforced brick panels, 25-35 cm thick, fail by shearing or flexure
60	Loaded train boxcars completely demolished
70	Probable total destruction of buildings; heavy machine tools moved and badly damaged

Table 2: Damage Produced by Blast

Source: Guidelines for Evaluating Characteristics of Vapor Cloud Explosions, Flash fires and BLEVEs, CCPS 1994, ISBN 0-8169-0474-X, based on the work of Glasstone (1977)).
(Note 1 kPa = 10 mbar)
The Second Canvey Report has a table for overpressure effects on humans:

O/Pressure (psi)	O/pressure (mbar)	O/Pressure (kPa)	Human Effects
5	340	34	Threshold of eardrum damage
10	690	69	Threshold of lung damage
40	2760	276	Threshold of mortality

Table 3: Effects of Overpressure on Humans

2.4.2 Effects of Thermal Radiation

Similarly, the effects of heat radiation can be listed:

Radiation Intensity (kW/m²)	Structural Damage
37.5	Sufficient to cause damage to process equipment
25	Minimum energy to ignite wood at indefinitely long exposures (non-piloted)
12.5	Minimum energy for piloted ignition of wood, melting of plastic tubing.
9.5	Pain threshold reached after 8 sec; second degree burns after 20 seconds
4	Sufficient to cause pain to personnel if unable to reach cover in 20 sec., secondary burns likely, 0% lethality.
1.6	Will cause no discomfort for long exposure

Table 4: Effects of Thermal Radiation (World Bank, 1985)

2.4.3 Threshold Levels of concern (Dangerous Dose)

The threshold 'levels of concern' used by the Authority is:

Consequence	Level of Concern
Contamination of air	Dangerous Dose (Concentration varies with substance & exposure length)
Overpressure wave Missiles	600 mbar, 140 mbar, 70 mbar Distance travelled by 80% of projectiles
Heat Flux, Thermal Dose	1800, 1000, 500 TDU

Table 5:Levels of Concern used by H.S.A.

A dangerous dose is defined as one where there is severe distress to almost everyone. A substantial fraction requires medical attention. Highly susceptible people might be killed. It assumes that most people are/can go indoors and will be less likely to suffer a dangerous dose therein (with the exception of overpressure, where in certain circumstance they may be more at risk due to building damage).
Where a full risk-based approach is taken, the levels of concern are:

Consequence	Level of Concern
Contamination of air with toxic	Dangerous Dose (Concentration varies with substance)
Overpressure wave Missiles	Dangerous Dose = 140 mbar Distance specific to event: 80% travel distance
Heat Flux, Thermal Dose	Dangerous Dose = 1000 TDU (75s exposure for Pool & Jet Fire, Fireball duration for BLEVE)

Table 6: Dangerous Dose for different consequences

A thermal dose unit (TDU) is a measure of the heat flux and its duration. 1000 TDU is taken as the 'dangerous dose' based on research work commissioned by the HSE (CRR 285 of 2000- Thermal Radiation Criteria for Vulnerable Populations).
The 140mbar side-on overpressure figure is taken as the 'dangerous dose' for overpressure, and the 70mbar figure is the limit for sensitive developments i.e. no fatalities even for sensitive developments (Safety Cases for Consultation Distances For Major Hazard Installations, P97)
To calculate the distances from the source at which these endpoints could be expected, commercial software is used. The modelling software typically used by the Authority includes PHAST (DNV Technica), ALOHA (US EPA), TSCREEN (US EPA), methods from the American Institute of Chemical Engineers' Centre for Chemical Process Safety and the Yellow Book.
To determine how likely it is that these effects will happen, other software is used, most usually RISKPLOT.
The output of all this analysis is a series of individual risk profiles overlaid on a map of the establishment and its surroundings, illustrating the individual risk of receiving a dangerous dose.

2.5 Tolerable Risk

The following table, taken from The Second Canvey Report lists some common risks of accidental fatality:

Event	No. of Fatalities	Chance of the Average Individual Being Killed
Motor vehicle accidents	7,219	1.3 chances in 10 000 a year*
Accidents in the home	6,717	1.2 chances in 10 000 a year*
Accidents at work	753	0.3 chances in 10 000 a year**
Others	3,646	0.6 chances in 10 000 a year*
Total	18,335	

* Averaged over the total population of Great Britain.
** Averaged over 22 million employees.

Table 7: Risk of death from accidents

The risk of death from natural causes for different age-groups is shown in the following table:

Risk of death from natural causes in age groups	
Age	Risk
0- 4	34.4 in 10 000 a year
5-14	1.9 " " "
15-24	3.0 " " "
25-34	4.8 " " "
35-44	16.2 " " "
45-54	55.0 " " "
55-64	147.7 " " "
65-74	422.3 " " "
75-84	1, 073.0 " " "
85+	2, 023.5 " " "

Table 8: Risk of death from natural causes

Statistics available from the HSA on occupational fatality rates:

Economic sector	Fatalities Total 2002	Fatalities Worker 2002	Total at work (QNHS 2002)	Rates per Million
A - Agriculture, Forestry and Hunting	13	11	121,700	115
B - Fishing	3	3		
C – Mining and Quarrying	2	2	310,400	22.5
D - Manufacturing	7	5		
E – Electricity, Gas and Water Supply	2	0		
F- Construction	21	20	183,200	109.1
G – Wholesale and Retail	1	0	249,100	0
H – Hotels and Restaurants	0	0	108,700	0
I - Transport, Storage, Communication	8	7	108,900	64.2
J - Financial Intermediation	0	0	226,400	4.4
K – Real Estate, Renting and Business Activities	1	1		
L - Public Admin, Defense and Social Security	2	2	82,000	24.3
M – Education,	0	0	260,000	0
N – Health and Social Work	0	0		
O - Other	1	1	94,900	10.5
Total	61	52	1,745,500	34.9

Table 9: Fatality Rates per million Workers

Risk that is broadly acceptable is that which is trivial in comparison to the risk experienced in daily life. At the other end of the scale there clearly is a level of risk that is unacceptable. In deciding on LUP criteria the HSA concluded that for the general residential public an individual risk of dangerous dose greater than 1×10^{-5} (i.e. 1 in 100,000) per year would not be tolerable for developments around existing establishments, and for new establishments it should not exceed 1×10^{-6} (i.e. 1 in 1,000,000).

2.6 Criteria Used in other countries for Land-Use Planning

The following are some of the better-developed criteria:

UK HSE	
Maximum tolerable worker individual risk	1 in 1,000 per annum
Maximum tolerable public individual risk	1 in 10,000 per annum
Benchmark for new plant and developments	1 in 100,000 per annum
Broadly acceptable public individual risk	1 in 1,000,000 per annum
Land-use Planning - Residential development unrestricted	1 in 1,000,000 per annum (Dangerous Dose)
Netherlands	
Maximum tolerable public individual risk for existing situations	1 in 100,000 per annum
Maximum tolerable public individual risk for new developments	1 in 1,000,000 per annum
Maximum tolerable public individual risk around airports, above which re-housing is required.	1 in 20,000 per annum
Broadly acceptable public individual risk	1 in 1,000,000 per annum
Australia	
Acceptable risk to the public in residential zones from hazardous industries	1 in 1,000,000 per annum
Hospital, Schools, Child-care	0.5 in 1,000,000 per annum
Acceptable total risk within hazardous industrial zones	1 in 10,000 per annum

Table 10: Various National risk criteria (fatality unless otherwise stated)

2.7 Presentation of Risk

Risk figures can be confusing. The following figure show some of the different ways that risk can be presented.

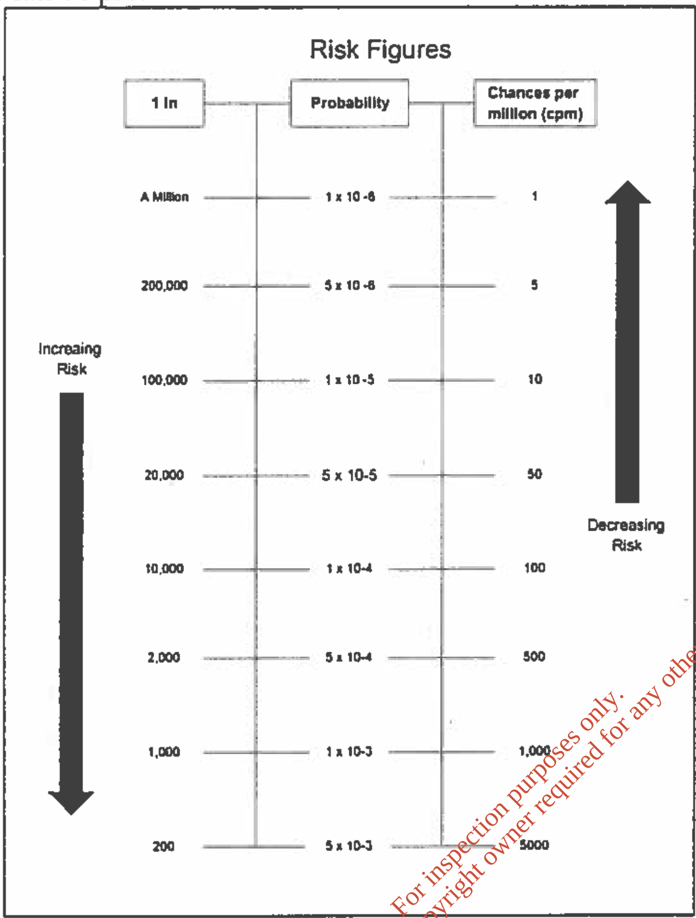


Figure 2: Ways of Presenting Risk

2.8 Classification of Development Types

In giving LUP advice, the HSA classify developments under one of the following categories:

- Residential
- Retail and catering
- Commercial
- Industrial
- Sensitive e.g. hospital, some schools, outdoor leisure complexes etc., developments of nature are subject to special analysis

The following table sets out the risk zones that are estimated for the purposes of offering land-use planning advice:
(figures are individual risk of dangerous dose per year)

Zone	Risk (R)
Zone 1.	$> 1 \times 10^{-5}$ (i.e. > 10 cpm)
Zone 2.	$1 \times 10^{-6} < R < 1 \times 10^{-5}$ (i.e. 1 - 10 cpm)
Zone 3.	$0.3 \times 10^{-6} < R < 1 \times 10^{-6}$ (i.e. 0.3 – 1 cpm)

Table 11: Risk zones for LUP

The LUP advice for the different zones is as follows:

Zone 1:	Advise against residential, office and retail, permit occasionally occupied developments e.g. pump houses, transformer stations. Consult with H.S.A re. Industrial development.
Zone 2:	Permit workplace development. Permit residential densities from 28 to 90 persons /ha., density increasing as risk decreases across the zone in developed areas and 22 to 70 persons/ha. in less developed areas. Permit modest retail and ancillary local services Advise against shopping centres, large-scale retail outlets, undue concentration of restaurant/pub facilities.
Zone 3:	No restrictions except for sensitive developments, which would be subject to consultation if inside the consultation range and should not be at a risk greater than $0.3.10^{-6}$ Sensitive developments include crèches, schools, hospitals, and nursing homes. Locations of major public assembly will be subject to individual assessment.

Table 12: LUP Advice zones based on Risk

The advice with respect to housing density in Zone 2 is based on consideration of the analysis given in "A Worst Case" Methodology for Risk Assessment of Major Accident Installations" in Process Safety Progress [Vol. 19, No. 2].

Use of the criteria as outlined above will provide a basis for the advice on the acceptability of a new 'Seveso' establishment and for justifying a separation distance between Seveso establishments and off-site developments. These criteria do not guarantee an absence of risk but suggest a tolerable level, given that major accidents with offsite damage are relatively uncommon. They represent an attempt to balance a potential for harm against a social requirement that large tracts of land should not be unnecessarily sterilised for future development.
The criteria will be subject to on-going review and revised in the light of new knowledge and ongoing experience.

2.9 Societal Risk

The approach as set out above includes an element of societal risk in terms of the advice for each of the zones ('residential densities from 28 to 90 persons per ha.' 'modest retail', 'large-scale' etc.). In most cases no further assessment of societal risk is necessary. However, for very-high density developments or for developments in the vicinity of highly populated areas a separate societal risk assessment may be necessary. This can be carried out by inputting local population data into the RISKPLOT programme and examining the calculated societal risk in relation to established UK and Dutch criteria.

3. Major Accidents, Environmental Effects and Land Use Planning Advice

The Authority's technical advice to the planning authority deals with the potential effects of major accidents. It is only concerned with environmental effects related to major accidents and does not consider routine emissions which are subject to license by the local authority or EPA.

Currently, there is no common approach within the EU on suitable scenarios or endpoints for the assessment of Major Accidents to the Environment (MATTEs) within the framework of the Seveso II directive. Consequently, such assessment is less developed than the previously described approach concerning major accidents and the potential effect on human receptors. This is due to the variable nature and sensitivity of environmental receptors, allied to the lack of suitable sensitivity data for all receptors.

The approach of the HSA, in consideration of environmental effects associated with Seveso II designated sites, is also conscious of the requirements placed on operators (current or proposed) by Regulation 9 of S.I. No. 476 of 2000.
In assessing the consequences of potential worst-case credible accidents and their impacts on the environment, the HSA concentrates on Regulation 9(2)(e), requiring operators to use best practicable means –
to prevent a major emission into the environment from any part of the establishment of dangerous substances resulting from uncontrolled developments in that establishment, and
for **rendering harmless and inoffensive** such substances as may be so emitted.
The Seventh Schedule to S.I. 476 of 2000 lists the criteria for notification of accidents to the Commission. Major accident hazards should have this type of potential in order to be considered.

A major accident must have the potential to result in serious danger to the environment and the occurrence will be unexpected and unplanned. There must be a potential serious danger of significant damage to the natural or man-made environment. This damage may sometimes be relatively long lasting but not necessarily irreversible. The time taken for unassisted natural recovery to a state close to the original is an important factor that is taken into account. Recovery of habitats can take considerably longer depending on the dangerous substance in question. In summary, the assessment of major accidents to the environment focuses on the specific risks to sensitive receptors within the local environment, the extent of consequences to such receptors, and on the ability of such receptors to recover. More practical information on what might constitute a major accident to the environment is given in guidelines from the HSA in relation to major accidents to the environment and from the UK DETR.

HSA Approach
The approach of the Authority, therefore, is to assess impacts to the environment from the identified credible major accident hazards and satisfy itself that appropriate 'best

practicable means' are/will be in place to prevent such impacts where these could cause a MATTE, and that appropriate remedial measures can be initiated promptly.

The potential for initiating a major accident due to flooding is assessed. The effect of heavy rainfall events is considered (at a frequency of at least '1 in 50 years') in relation to its potential effect on storage tanks and storage areas, as well as important site utilities, for example. The operator must demonstrate that other potential initiators have been considered (lightning for example) and control/mitigation measures employed where required.

While the 'best practicable means' standard is also applied to control of gaseous loss of containment events (e.g. suitably-sized catch pots for reaction vessels), the consequences of such releases are examined as part of the general major accident scenarios described previously.

Article 12 of the Directive requires Member States to 'take account of the need to maintain appropriate distances between establishments … and areas of public use ... (recreational areas) … areas of particular natural sensitivity or interest...'

The Authority looks for such areas in the vicinity of establishments and, if found, will undertake further analysis to satisfy itself that an appropriate distance can be maintained. A separation distance is currently considered appropriate if it is sufficient to enable the installation of suitable mitigation measures or is such that the risk of serious damage is low in the event of a major release.

Appendix 4 Quantified Risk Assessment(Shell/DNV)

A Quantified Analysis of the Process Hazards at the Proposed Bellanaboy Bridge Terminal

for

Amec/Shell E&P Ireland Ltd

DET NORSKE VERITAS

SUMMARY

Shell E&P Ireland Ltd (SEPIL) is planning to develop the Corrib gas field located some 70km off the west coast of Ireland. Part of this development involves the construction of a gas terminal at Bellanaboy Bridge, County Mayo. SEPIL is currently preparing a planning application for submission to Mayo County Council for the construction of the terminal. The Health and Safety Authority (HSA) has requested that SEPIL prepare a detailed consequence and risk assessment of the proposed terminal for submission to the HSA in conjunction with SEPIL's proposed planning application. DNV has prepared a quantified risk assessment (QRA) of the terminal as presented in this report.

The purpose of this document is to provide sufficient information for the HSA to give technical advice on the risks arising from the proposed terminal to Mayo County Council.

The terminal facilities are described in Section 2, and the consequence and frequency methodology is summarised in Section 3. The main predictions are presented in Section 4. Technical details, contour plots and supplementary information are presented in the Appendices.

The quantities of hazardous materials held on the site make the proposed terminal a lower tier site under the Seveso II Directive, but all materials that are considered capable of giving a major accident hazard have been included in the quantified analysis which comprised three main elements:

- hazard identification;
- consequence analysis; and
- frequency analysis.

The HSA has indicated that it will consider risks in terms of a 'dangerous dose', which for the proposed terminal is the combination of explosion overpressure in excess of 140mbar, a thermal radiation dose in excess of $1000(kW/m^2)^{1.333}$ s (defined in Section 3) and flash fires to half the lower flammable limit. Dangerous dose contours are included as Appendix XV.

The main findings of the analysis are that in the event of a fire or an explosion:

- The onsite buildings would not be subject to overpressures in excess of the dangerous dose.
- The onsite buildings could potentially be subject to a thermal radiation dose in excess of the dangerous dose, but this would be at low frequency (of the order of once in a million years).
- The offsite buildings would be subject to overpressures, but the highest level would be less than one fifth of the dangerous dose. However, the likelihood of an explosion is very low, and the overpressure from most explosions would be well below this level. Consequently the likelihood of this overpressure level being experienced is extremely low.
- The road and the offsite buildings would not be subject to a thermal radiation dose in excess of the dangerous dose. The maximum dose predicted at the nearest building is less than one third of the dangerous dose.

A Quantified Analysis of the Process Hazards at the Proposed Bellanaboy Bridge Terminal

Issue Log

Revision	Issue Date	Prepared by	Reviewed by	QA Checked by	Approved by	Comments
0	November 2003	P Crossthwaite	R Whitehead	F Watson C Convery	P Crossthwaite	For client comments
1	March 2003	P Crossthwaite	R Whitehead	F Watson	P Crossthwaite	Incorporating additions as requested by the HSA.

GLOSSARY OF TERMS

bbl/MMSCF	Barrels per million standard cubic feet
BGE	Bord Gais Eireann
BLEVE	Boiling Liquid Expanding Vapour Explosion
COMAH	Control of Major Accident Hazards Regulations 1999
ESDV	Emergency shutdown valve
HSA	Health and Safety Authority
HSE	Health and Safety Executive (UK)
IDLH	Immediately Dangerous to Life and Health
PFD	Process Flow Diagram
OIR-12	Offshore Industry Hydrocarbon Release Database (1999)
QRA	Quantified Risk Assessment
SEPIL	Shell E&P Ireland Ltd
TDUs	Thermal Dose Units $(kW/m^2)^{1.333}$ s
TNO	The Netherlands Organisation of Applied Scientific Research
UKOPA	The Association of UK Onshore Pipeline Operators

Contents

Appendices

1. INTRODUCTION

Shell E&P Ireland Ltd (SEPIL) is planning to develop the Corrib gas field located some 70km off the west coast of Ireland. Part of this development involves the construction of a gas terminal at Bellanaboy Bridge, County Mayo. SEPIL is currently preparing a planning application for submission to Mayo County Council for the construction of the terminal. The Health and Safety Authority (HSA) has requested that SEPIL prepare a detailed consequence and risk assessment of the proposed terminal for submission to the HSA in conjunction with SEPIL's proposed planning application. DNV has prepared a quantified risk assessment (QRA) of the terminal as presented in this report.

1.1 Purpose of this Document

The purpose of this document is to provide sufficient information to enable the HSA to give technical advice on the risks arising from the proposed terminal to Mayo County Council.

1.2 Structure of this Document

The terminal facilities are described in Section 2, and the consequence and frequency methodology is summarised in Section 3 (a detailed summary of the methodology is contained in Appendix II). The main predictions are presented in Section 4. Technical details, contour plots and supplementary information are presented in the Appendices.

2. THE TERMINAL

The Corrib field is a gas field located in the Slyne Trough, under Licence Nos. 2/93 and 3/94 some 70 km off the County Mayo coastline in 350 m of water. The Corrib field contains a dry sweet gas with an expected condensate yield of less than 0.5 bbl/MMSCF, 0.3% carbon dioxide and no hydrogen sulphide.

The Corrib field is to be developed as a long-range sub-sea tieback to the shore. The gas will be received and treated to meet sales gas specification in the onshore terminal; sales gas will then be delivered into an export pipeline and then to end users via the Bord Gais Eireann (BGE) gas transmission system.

A location plan and plot plan are contained in Appendix I.

2.1 Main Process Facilities

The onshore terminal will be a grass roots facility with process and utility equipment to produce sales gas and will be operated by SEPIL. It will consist of the following process facilities necessary to meet the export gas specification:

- inlet reception;
- gas conditioning;
- sales gas compression;
- metering; and
- odorisation.

With the following process support systems:

- condensate stabilisation;
- methanol regeneration and injection; and
- mercury removal.

The following utility systems will also be provided:

- fuel gas;
- condensate fuel;
- diesel;
- heating medium (TEG/water);
- produced water treatment and disposal);
- open and closed drains;
- instrument and plant air;
- nitrogen;
- potable water;
- firewater;
- flare;
- chemicals;
- storage; and
- power generation (including emergency power).

The facility will also provide the necessary chemical injection, control and power requirements to the subsea facilities via an umbilical.

A plan of the proposed terminal is given in Appendix I.

2.2 Hydrocarbon Processing Facilities

2.2.1 General

The facility is designed to produce 350 MMSCFD of sales gas. A simplified process schematic of the hydrocarbon facilities is included in Appendix I.

2.2.2 Process Facilities

The fluids arriving at the terminal will comprise hydrocarbon gas, condensate, aquifer and condensed water together with hydrate inhibitor. In addition, the fluids will contain corrosion inhibitor.

The gas will initially pass through the slugcatcher (D-1002) where the bulk liquid separation will take place, then an inlet separator (D-1003) where there will be further separation, and then via a heat exchanger to the cold separator (D-2007). The gas will then be compressed (K-2002), metered and odorised before export to the BGE transmission system.

Odorant (a mixture of tertiary butyl mercaptan and dimethyl sulphide) will be stored in a double skinned stainless steel tank (T-2002B). The odorant will be imported by road tanker (estimated to be 4 per year during the early years and reducing with decline in production) and injected into gas as it leaves the terminal.

2.2.3 Condensate Stabilisation

Hydrocarbon condensate produced by the gas dew pointing system, together with any condensate separated in the slugcatcher and inlet separator, will pass to the condensate stabilisation system. This will comprise a two stage flash system (medium pressure D-3001, and low pressure D-3002) with intermediate heating (E-3001). The stabilised condensate will be air cooled and sent to storage (T-3001A/B/C). The condensate will be used as fuel within the terminal. It is estimated that all condensate produced will be used as fuel and that there will be no surplus. If there were to be a surplus, it would be exported by road tanker. At worst this export would comprise one road tanker per day for seven days per year, declining to zero soon after gas production falls below plateau.

2.2.4 Hydrate Inhibitor Regeneration

The methanol/water mix recovered from the slugcatcher will pass through a particulate filter into the methanol flash drum (D-4001) where it will be combined with streams from the other separators. From there it will pass to the raw methanol storage tanks (T4001A/B/C). Any condensate that separates out in the methanol flash drum will be directed to condensate stabilisation.

The methanol/water mix will be pumped from storage to the methanol still (C-4001) via the methanol feed/bottoms exchanger (E-4001) and the methanol feed coalescer (D-4003). The column overhead vapour product will be condensed in a forced draught air cooled methanol condenser (E-4002), collected in the methanol reflux drum (D-4002), and will then be pumped to the product methanol storage tanks (T-4002A/B). Waste water effluent will be pumped to the produced water treatment facility.

Fresh methanol for make-up will be imported to the product methanol storage tanks by road tanker (maximum 2-3 road tankers per week and reducing as gas production declines).

2.3 Ignition Sources

In common with facilities of this type, ignition sources will be strictly controlled under the permit to work system within the terminal boundary (security) fence. The only 'strong' ignition source[1] on the plant at low level will be the fired heater located to the south east of the main process facilities. This will be "on-line" whenever the plant is operational. There are no permanent strong ignition sources outside the terminal boundary (security) fence within the wooded area surrounding the terminal north of the R314 road.

2.4 Population

2.4.1 Onsite

A number of buildings will be located close to the main entrance to the plant. These are shown on the plot plan (Appendix I). The likely normal day and shift populations in the various buildings and on the plant are given in Appendix IV. All the buildings except for the control building will be portal frame construction with non load bearing infill. The control building will be of reinforced concrete (frame, walls and roof) to give two hour fire resistance and 200mbar blast resistance.

2.4.2 Offsite

The terminal is in a sparsely populated area. The nearest building is some 40m to the south of the R314 which runs some 200m to the south of the terminal boundary (security) fence. There are no public areas[2] in the vicinity of the terminal. In order to understand the potential offsite risks, the hazard frequencies have been determined at a number of offsite locations. A map showing the terminal and the surroundings and the location of these points is given in Appendix IV.

2.5 The Environment

2.5.1 Meteorological Data

The windrose used for low momentum releases is the same as that used for the Environmental Impact Statement (Belmullet). This is shown in Appendix V.

Information about the windspeed/stability combinations is not currently available, so it has been assumed that these could be represented by F2 (Pasquill stability F-stable, windspeed 2m/s) and D5 (Pasquill stability D-neutral, windspeed 5m/s). It has further been assumed that

[1] i.e. an open flame, or a suction air inlet to a system where combustion is taking place.
[2] i.e. an area where members of the public congregate, such as a market or sports stadium.

D5 occurs for 85% of the time. In order to determine the risks that would be associated with different meteorological conditions, a sensitivity analysis has been carried out which has assumed that F2 conditions occur for 30% of the time (the balance being D5 conditions).

3. ANALYSIS OF THE PROCESS HAZARDS

The analysis comprises three main elements:

- hazard identification;
- consequence analysis; and
- frequency analysis.

The method of analysis is summarised below. A more detailed account of the methodology is contained in Appendix II.

3.1 Hazard Identification

The materials in the process which have hazardous properties (i.e. are flammable, may explode or are toxic) are presented in Appendix VI. The quantities of hazardous materials held on the site make the proposed terminal a lower tier site under the Seveso II Directive Council Directive 96/82/EC. Some of these materials e.g. diesel and some other materials given below have not been considered in this report because they are adjudged not to have major accident hazard potential. Relevant properties of the main materials are given in Table 3.5 (flammable) and Table 3.6 (toxic). The potential impact of the materials on the environment is considered in Appendix VII.

3.1.1 Odorant

The odorant is a highly flammable liquid (flash point below °C) but is not considered to present a major flammable accident hazard because of the small quantity (9te). It is not especially toxic by inhalation (although dimethyl sulphide is listed (NIOSH) as having an inhalation hazard, the LC50 for rats is >40,000ppm and butyl mercaptan has an IDLH level[3] of 500ppm). Evaporation from a leak into the bund (area 26m^2) gives dispersion distances to this level of less than 30m. Although the facility is only some 25m from the terminal security fence, it is over 200m from any occupied onsite building and so is not considered to present a major toxic accident hazard.

3.1.2 Methanol

Methanol is a highly flammable liquid (flash point 10°C), and is mildly toxic (IDLH 6000ppm). The fire effects have been analysed, but the toxic effects have been discounted because it is not considered to pose a major toxic accident hazard.

3.1.3 Hydrochloric Acid

Hydrochloric acid is received as a 30% solution in an IBC and is then transferred to a day tank prior to use in the process. The IBC and day tank are within a bund which has a surface area of 5m^2 and is within a building. A spillage into the bund will cause the generation of hydrogen chloride. A method proposed by Evans, Jones and Overstreet has been used to predict the evaporation rate from a spillage contained by the bund (0.001kg/s) and ***PHAST*** has been used to disperse this rate, assuming that the source is in the open air. The dangerous

[3] IDLH. The IDLH level is set to ensure that a worker could escape without injury or irreversible effects in the event of the failure of respiratory protection equipment based on a 30 minute exposure to the IDLH level.

dose[4] for hydrogen chloride is 800ppm for a 30 minute exposure (HSE, 2001). This compares with two predictions for 1% fatality from probit equations, assuming the same exposure duration, of 1690ppm (Purple Book) and 580ppm (PHAST, Perry and Articola). These are, however, significantly above the IDLH level (50ppm). Dispersion predictions (m) for 0.001kg/s HCl are presented in Table 3.1 for F2 and D5 conditions.

Although the evaporation of hydrogen chloride is likely to be greater in both damp and wet conditions, as the facility is located indoors spillage into a wet environment has not been considered. As the location of the hydrochloric acid facility is more than 150m from both occupied buildings onsite and from the site boundary, it has been judged that the hydrochloric acid will not give rise to a major accident and toxic hazards from hydrochloric acid have not been considered further.

Table 3.1 Predicted Dispersion for Clouds of HCl

Concentration	Dispersion Distance (m) F2	Cloud Height (m)	Dispersion Distance (m) D5	Cloud Height (m)
800ppm	14	0.5	<5	0.3
50ppm	70	2	15	1

3.1.4 Quantified Analysis

In order to carry out the consequence and frequency analysis, the parts of the terminal which contain hazardous material which are considered to have the potential to give a major accident are characterised by a finite number of discrete scenarios of various sizes. These are considered to adequately represent the whole spectrum of possible hazardous outcomes associated with the process materials. The scenarios included are presented in Appendix VIII.

3.2 Consequence Analysis

This part of the analysis involves the following:

- Allocation of a release type (liquid, vapour, two phase etc) or hazard type (fire, fireball etc) to each scenario.
- Determination of release rate for each scenario representing a loss of containment. Standard release rate equations with a coefficient of discharge of 0.65 were used. Releases from streams immediately downstream of a pump were either assumed to be limited by the equipment to 150% of normal flow or were based on the calculated liquid discharge rate, (if the latter was less than the former). For releases through large holes in the high pressure parts of the plant directly connected to the inlet or export pipelines, a pipeline model was used to determine the (reducing) release rate with time.
- Allocation of durations for loss of containment from the various streams. This allocation is based on the detection and isolation times given in the methodology (Appendix II).
- Association of each scenario with the type(s) of hazardous event that could occur should there be ignition (i.e. pool fire, jet fire, fireball, flash fire and explosion).

[4] Defined in Section 3.2.

- Determination of the consequences. These have been determined using DNV software product ***PHAST,*** except for fireballs and vapour cloud explosions. Fireball properties have been determined using the models proposed by the IChemE Working Party and Bilo and Kinsman and explosion effects have been determined using the TNO Multi Energy method proposed by van den Berg.

In the determination of the hazardous envelope(s) associated with each scenario, consequence end points need to be defined for each hazard type. Although at present there are no Irish standards for the determination of land use planning advice, the HSA is currently refining criteria that may be used for such advice based on risk. In order to establish a common basis for sites that present a combination of hazards, the authority will consider the risks associated with a 'dangerous dose'. A 'dangerous dose' is one which will:

- Cause severe distress to almost everyone.
- Require a substantial fraction to be given medical attention, with some suffering irreversible effects.
- Cause fatalities in highly susceptible members of the population (most vulnerable 1%).

Dangerous dose levels for the hazards that are posed by the proposed terminal are as follows:

- Overpressure – 140mbar.
- Thermal radiation – $1000(kW/m^2)^{1.333}$ s (referred to as Thermal Dose Units or TDUs).
- Travel distance for a 'rocketing' drum.
- Flash fires – to half the lower flammable limit.

Travel distances for 'rocketing drums' are not presented as the frequency of a missile hitting a specified target has been determined to be very low (see Section 3.7).

In addition to these end points, the HSA has requested information on other levels. These end points and those which have been used to assess the impact on trees are shown in Table 3.2.

Table 3.2 Consequence End Points

Hazard Type	End Points
Overpressure	140, 70 and 20mbar
Long Duration Fire	20, 12, 6 and $4kW/m^2$ (1)
Short Duration Fire (Fireball)	Fireball, distance to spontaneous ignition of wood, 1000 and $500(kW/m^2)^{1.333}$ s (termed 1000 and 500TDUs)
Flash Fire	Lower Flammable Limit

(1) For an exposure duration of 75 seconds a thermal flux of $7kW/m^2$ is approximately 1000TDU and a thermal flux of $4kW/m^2$ is approximately 500TDU. In this report $6kW/m^2$ has been used to represent 1000TDU.

In the development of the analysis, if the consequences of certain releases are deemed to be small, the releases have not been taken through to the frequency analysis. Exclusion of certain scenarios is considered appropriate on the grounds of low potential impact on people for the following:

- High pressure gas releases through small holes. If the release rate is below 1kg/s, the releases have not been analysed. Relevant consequence properties are given in Table 3.3 for 1kg/s.

Table 3.3 Consequence Predictions for 1kg/s Releases

Hazard/Cloud Property	Consequence Prediction
Cloud Volume	$27m^3$
Distance To $4kW/m^2$	17m
Flash Fire Distance (F2)	14m
Flash Fire Distance (D5)	14m

- Liquid releases less than 1kg/s. This release is predicted to form a burning pool of liquid some 4m diameter, which is considered too small to give a hazard to people.
- Releases from the low pressure fuel gas system (5barg). Much of the system is 50mm diameter, and the initial release rate is 1.5kg/s. The consequences from such a release are similar to the above, and so this part of the facility has not been analysed further.

3.3 Frequency Analysis

This part of the analysis involves the allocation of failure frequencies for each scenario, the consequences of which have been analysed as summarised above, and the allocation of conditional probabilities. Details are given in Appendix II, but some relevant points are repeated below:

- Failure frequencies used for most loss of containment events in this analysis have been derived from the OIR 12 data (offshore) as analysed by BP for vessel holes and pipework,. Equipment failures are derived from the same database. Details of the frequencies used are given in Appendix II. Frequencies from this data set are assumed to represent all failure modes and would therefore include lapses due to human factors, impacts including dropped objects etc.
- Rather than carry out a complete equipment count a typical number of valves, flanges and small bore fittings per unit length of piping has been derived from a previous analysis of an onshore facility. This relationship has been used to determine the frequency of failure associated with these items and this frequency has been added to the frequency of failure of piping and other equipment for each pipe length in the process area.
- Use of the piping failure frequency directly at existing installations has given failure frequencies for welded inter unit piping runs considerably above experience. Consequently, in order to align the predicted frequency with historical onshore experience, the failure frequency for piping of this type has been reduced by one order of magnitude.

The application of failure frequencies from offshore experience to onshore plant is not ideal. However, in the view of DNV, the OIR 12 database is the highest quality database available for leak frequency determination, and the high quality of the data more than offsets the potentially inappropriate application to onshore facilities. The overall leak frequencies used are, incidentally, higher than those used by DNV from earlier onshore sources, higher than those applied by the UK HSE (Planning Assessment Guidance) and higher than those in the Netherlands (Purple Book).

Conditional probabilities for ignition and explosion have been allocated as given below:

- Ignition probabilities were derived from Cox, Lees and Ang, for both vapour and flashing releases (using the gas data, with a maximum of 0.3) and liquids (maximum 0.08). For vapours, the ignition probability was partitioned equally into immediate and delayed ignition.
- Explosion probabilities were derived from Cox, Lees and Ang with a minimum of 0.04 and a maximum of 0.9.

Certain frequencies are not available from the OIR 12 data. Assumptions for such frequencies are given below:

- Failure of road tanker connection (methanol or condensate). A release frequency of 4E-6 per transfer has been assumed for the loss of containment events based on the assumption that there are two pullaway prevention measures (wheel chocks and barriers) with hose inspection and leak test prior to transfer (Gould and Anderson). An ignition probability of 0.1 has been assumed. For the estimation of consequences, it has been assumed that all releases are contained within the tanker standing area.
- Bund fire. A fire frequency of 6E-5 per tank year has been assumed (Lastfire) for the atmospheric storage tank bunds. The odorant tank is double skinned and is within a small bund. The consequences of a fire in the odorant bund have not been analysed.
- Pig Traps. Although OIR12 contains data on pig traps, the data set is quite small and no catastrophic failures are included, although such failures are known to have occurred. The OIR 12 data do however indicate that the leak frequencies of pig launchers and pig receivers are similar. A catastrophic failure of a pig trap is partly dependent on the inherent failure frequency of the trap itself, but more influenced by the operator. A frequency of 1E-4 per operation has been assumed for an error, with one in ten leading to a catastrophic failure. Pigging frequencies are anticipated as one pig every five years for the import line and one pig per year for the export line.

3.4 Specific Scenarios

The OIR 12 data have been applied directly to the high pressure gas system except for the sections below:

- Inlet gas pipeline upstream of the first ESDV. This is the end of the line from the subsea facilities as it rises above ground and enters the terminal (approximately 5m in length above ground). Design in accordance with BS 8010 Part 2 results in a pipe wall thickness of 27mm (including 1mm corrosion allowance). A recent analysis of failures in European gas pipelines (Bolt R) indicates that the major causes of pipe rupture are external interference (third party activity) and ground movement. However, there is a strong relationship between releases caused by third party interference and the pipe wall thickness, and there have been no failures due to third party activity for pipelines with wall thickness exceeding 15mm. Earlier research by British Gas (Jones and Fearnehough) indicated that excavators cannot give a hole of 80mm diameter in pipe which has a thickness of more than 12mm, which led to the conclusion that proximity distances (in IGE/TD/1) should not be defined on the basis of a major puncture (or rupture) and that a 3m separation (for operational reasons) would be adequate because if a failure occurred it would be very small and would not propagate. Recent work by WS Atkins on behalf of HSE (Planning Assessment Guidance) using data supplied by UKOPA has enabled the HSE to allocate frequencies of rupture for pipelines. Failure modes used are third party activity, mechanical (material or weld defects), natural, corrosion and other. For pipe rupture these are as shown in Table 3.4. The most significant failure mode for pipelines, third party activity, is not relevant for the part of the pipeline within the terminal fence. Although it is recognised that site activities could damage the pipeline, there will be no large mechanical diggers (of the type that have the potential to damage pipelines) in the vicinity and any lifting operations (which will be infrequent) will be the subject of the permit to work system. With respect to landslip, the import pipeline will be supported on firm ground, the export pipeline support may be enhanced by mini piles. The standard of support is therefore higher than that used for a normal cross country pipeline, so application of the frequency in Table 3.4 will give a conservative estimate. Applying the frequencies in Table 3.4 to a length of 5m gives a negligible frequency for pipeline rupture.

Table 3.4 Pipeline Rupture Frequencies

Failure Mode	Frequency (per m per year)
Third Party Activity	Variable, dependent on the design factor, the wall thickness and the diameter
Mechanical	8E-12
Natural	2E-09
Corrosion	3.7E-12
Other	0

As an operational pipeline, rapid depressurisation may cause a low temperature which in turn could lead to brittle fracture (this failure mode is not explicitly recorded in pipeline failure data, so a specific frequency cannot be derived). Depressurisation controls embodied in the pipeline blowdown procedure will ensure that low temperature will not occur. On the basis of the above, DNV consider that a large failure or rupture in this section of the pipeline is substantially lower than the generic frequency and is of such a low probability that it can be neglected for the purposes of this analysis.

- Slugcatcher. The slugcatcher has a wall thickness of 60mm, and has been designed to ANSI B31.3. This code gives a greater wall thickness than other codes considered for the design (vessel and pipeline codes). There are a number of slugcatchers in operation worldwide, but the number of years operation without a failure is insufficient to derive a statistically valid failure frequency. Although it would be inappropriate to apply the failure frequencies derived for pipelines which have wall thicknesses much less than the slugcatcher, if these frequencies are applied to the plan length of the slugcatcher (rather than the actual length because of the major failure mode), the frequency of rupture would be 2E-07per year. Because of its thickness and its resistance to external impact or operational loadings, and the non propagation of a hole to a rupture, this frequency is adjudged to be an overestimate, and consequently DNV consider that a large failure or rupture in the slugcatcher is of such a low probability that it can be neglected in this analysis. The slugcatcher is provided with two manholes at the southern end for internal inspection. If all controls fail, then there could be a failure of the manhole following an internal inspection. The frequency of this event has been set at once every 100,000 operations, with an internal inspection every 10 years.

- Bund Overtopping. There have been a number of failures of atmospheric storage tanks that have resulted in the contents of the tank being released in such a way that some of the contents have spread over the bund wall (Wilkinson A). Appendix IX contains a frequency and consequence evaluation. Because of the low frequency of failure (less than 2E-07per tank year) and the modern design/construction/inspection of the tanks DNV consider that this mode of failure can be neglected.

- Catastrophic failure of a road tanker. In certain circumstances there could be a major failure of a road tanker whilst on the site. As this type of failure is extremely rare (less than 1E-08per year, see Appendix IX) this scenario has not been included. Consequence information for a major release from a road tanker, e.g. during transfer, is presented in Appendix IX. Another scenario is a fire beneath a road tanker containing methanol or condensate which could result in the failure of the road tanker due to flame impingement. Such a failure would not give a 'traditional' fireball, but a relatively small release of low pressure vapour. This is because the material in the road tanker is liquid (rather than a liquefied flammable gas) and the tankers have a thin wall construction rather than the thicker wall pressure vessel construction.

3.5 External Hazards

As stated above, the OIR 12 data include failures from all types of initiating events. However, as they are based on offshore failures, certain failure modes normally considered for onshore plant may not be included. A consideration of a number of external hazards is contained in Appendix X. One specific external hazard which is relevant for the proposed terminal is considered in more detail in the next section.

3.6 Effect of the Trees around the Terminal

The terminal will be surrounded by trees for visual impact reasons; the layout of the tree banks is shown in Appendix I. The presence of trees may affect the hazard potential associated with the terminal in the following ways:

- Fire spread from the trees to the terminal.
- Ignition of the trees from a fire at the terminal.
- Increase in explosion potential because the trees act as a region of congestion.

There are examples of existing hazardous installations within areas of trees in Appendix XI. In all cases the trees are present because the installation is in a rural area and there is a requirement to provide a screen to limit the visual impact of the installation. The distances between the control buildings and the trees and between the plant and the trees are indicated, and it can be seen that these distances are as low as 15m for the control building and a similar distance for the plant. This compares with 40m for the proposed control building-tree distance and 85m for the proposed plant – tree distance.

Codes of practice contain guidance on minimum separation distances between process plant (normally storage facilities) and site boundaries etc. A summary of some relevant separation distances is also contained in Appendix XI.

The frequency of tree fires in the west of Ireland is not known. Based on UK data, the frequency of any particular location in a wooded environment being engulfed by fire is 2E-04per year.

3.6.1 Impact of Fire Spread from the Trees to the Terminal

This has been considered by calculating the thermal radiation levels at (1) the plant and (2) the control building should the trees adjacent to these areas be on fire. This calculation has used a solid flame method. Assuming that the control building and the tree fire are parallel vertical surfaces, the vertical plane view factor (Yellow Book) can be used. The absorption due to the atmosphere has been calculated using the average value for the formulae given in Bilo and Kinsman and Lees FP. The temperature of the tree fire was derived to be 812°C (1085K), which is equivalent to a surface emissive power of 79kW/m^2, based on the received thermal radiation flux levels given in Cohen and Butler, assuming an emissivity of unity. The trees immediately to the south of the control building are some 11-11.5m high, and separated from the building by 40m (this is a distance beyond which ignition of a structure from thermal radiation is unlikely to occur). To derive a flame height, it has been assumed that the ratio of tree height to flame height is 2.5 (Stocks et al). This relationship is for dense 65 year old jack pine 12m high with a black spruce understory, a fuel ideally suited to the generation of high intensity crown fires, so may be conservative for the trees to the south of the control building which are mature conifers (Sitka spruce) planted in 1959 at 2m intervals in rows 3m apart (typical Coillte Teo planting). The duration of a tree fire, and hence the likelihood that the thermal radiation will cause ignition of structures some distance away from the trees is typically one to two minutes (Cohen and Butler). For an exposure of two minutes, the thermal flux required to cause ignition of such structures would be approximately 25kW/m^2.

3.6.2 Impact of a Fire at the Terminal on the Ignition of the Trees

The potential impact of the terminal on the trees has been considered using the thermal radiation frequency contours for 25kW/m^2 for jet fires (25kW/m^2 would be capable of igniting trees if the exposure duration was very long) (Bilo and Kinsman), although a slightly lower level is suggested by Cohen and Butler. For short duration fires, the distance to the spontaneous ignition of wood has been calculated and used (Bilo and Kinsman).

3.6.3 Effect on Explosions

There have been several incidents where there has been a release of hydrocarbon from a pipeline in a rural environment and subsequent ignition has caused the generation of overpressure (thought to be assisted by trees in the vicinity of the release). The hydrocarbons involved in these incidents (propane and NGLs natural gas liquids) produce vapours that are heavier than air. The terminal will be handling natural gas, which is lighter than air and during the dispersion following a loss of containment will tend to rise above trees rather than accumulate at a low level. A recent study of incidents (Casella) involving high pressure natural gas pipeline failures reported 'no significant free air explosions' although there was an explosion when a release ignited in a confined space (in houses). Further, the HSE has concluded that significant overpressures are not generated in the event of a rupture of a natural gas pipeline followed by ignition, and no overpressures are therefore predicted in the model they use for pipeline risk evaluation. On the basis of the incident experience and the conclusion reached by the HSE, DNV considers that a release of natural gas which disperses in the trees around the terminal and is ignited will not generate significant overpressures during the combustion in the trees (i.e. any overpressure generation will be local rather than throughout the cloud).

3.7 Missiles

Missiles can be produced in the event of a catastrophic failure of a pressure vessel. They rarely cause injury directly and so are not normally included in QRAs. An analysis of missiles that could potentially be generated based on Scilly and Crowther has indicated that the likelihood of a specific target 500m from the process area being hit is less than one in 10 million years. This is considered sufficiently remote that missiles are not considered further.

3.8 Domino and Escalation

These terms are sometimes used interchangeably. In this report, the following interpretations have been used:

Domino – The domino effect occurs if the likelihood or consequences of a major accident on an installation could be increased because of the location and proximity of another installation (or 'establishment' using the terminology of the Seveso II Directive) and the dangerous substances present there (HSE Guidance on COMAH Regulation 16). From this, it can be seen that the domino effect is not relevant for the proposed terminal.

Escalation – An escalation occurs if a small incident leads to a second incident that has more severe consequences. The most common escalation event is the Boiling Liquid Expanding Vapour Explosion (BLEVE) which occurs if a flame impinges on a vessel containing a liquefied flammable gas causing the vessel to fail and release the contents. The potential for escalation is considered in Appendix XII.

Table 3.5 Material Properties (Flammable)

Material	Molecular Weight (kg/kmol)	Boiling Point °C	Flash Point °C	Autoignition Temperature °C	Heat of Combustion J/kmol	Flammable Limits LFL % V/V	UFL % V/V
Gas (1)	16	-161		538	8.0E+08	5	15
Condensate (2)	58	-1	<0	365	2.7E+09	1.8	8.4
Methanol	32	65	10	455	6.4E+08	7	36
Tertiary Butyl Mercaptan	90		2				
Dimethyl Sulphide	62	37	<0	205	1.74E+09	2.2	19.7

(1) Treated as methane in this analysis.
(2) A mixture of hydrocarbons (C5's and above).

Table 3.6 Material Properties (Toxic)

Material	Vapour Density kg/m3	IDLH ppm	ERPG3 ppm
Hydrogen chloride (present as hydrochloric acid)	1.5 (20°C)	50	100
Methanol	1.6	6000	
Tertiary Butyl Mercaptan (1)	3.9	500	
Dimethyl Sulphide (2)	2.7		

(1) Present as part of the odorant (80%)
(2) Present as part of the odorant (20%)

The IDLH level is set to ensure that a worker could escape without injury or irreversible effects in the event of the failure of respiratory protection equipment based on a 30 minute exposure to the IDLH level.

The ERPG 3 level is set so that nearly all individuals can be exposed to it for up to 1 hour without developing life threatening effects.

4. PREDICTIONS

Predictions for hazard frequencies in contour format overlaid onto a plan of the site are presented in Appendix XIII. Information on hazards excluded from the QRA but which may be considered by the HSA are given in Appendix IX. A composite plot for dangerous dose is included as Appendix XV. Contour plots for thermal radiation hazards which take into account certain control measures are shown in Appendix XVI.

The predictions are presented in numerical format, e.g. 1E-06per year, which is the same as 1×10^{-6} per year, or a likelihood of one in one million per year.

4.1 Hazard Predictions at Onsite Locations

4.1.1 Overpressure

The control building is not impacted at an overpressure level in excess of 110mbar and the buildings close to the main gate are just beyond the range to 70mbar. The frequency of impact by overpressures in the 70mbar range is in the order of 1E-06 to 1E-07 per year. For the lowest overpressure level plotted (20mbar) the onsite buildings are within the 1E-04 per year contour. Specific overpressure frequency values at point locations on the onsite buildings are given in Table 4.1.

Table 4.1 Overpressure Frequencies at Onsite Buildings

Location	Frequency of more than 20mbar but less than 70mbar	Frequency of more than 70mbar but less than 110mbar
Control Building	1.38E-04	9.30E-06
Administration Building	1.33E-04	0.00E+00
Canteen	1.32E-04	0.00E+00
Laboratory	1.33E-04	0.00E+00

4.1.2 Thermal Radiation

The control building is not impacted at thermal radiation levels in excess of 12kW/m². Most of the onsite buildings are just within the range to 6kW/m². The frequencies of thermal radiation impact at point locations on the onsite buildings are given in Table 4.2.

Table 4.2 Jet Fire Frequencies at Onsite Buildings

Location	Frequency of Flash Fire	Frequency of Thermal Radiation from Jet Fires (20kW/m2)	Frequency of Thermal Radiation from Jet Fires (12kW/m2)	Frequency of Thermal Radiation from Jet Fires (6kW/m2)	Frequency of Thermal Radiation from Jet Fires (4kW/m2)
Control Building	2.36E-06	0	0	3.69E-07	1.2E-06
Administration Building	6.55E-07	0	0	1.12E-08	2.28E-07
Canteen	6.36E-09	0	0	0	1.42E-07
Laboratory	1.16E-08	0	0	1.50E-08	2.54E-07
Warehouse	1.56E-06	0	0	2.25E-08	2.87E-07

4.2 Hazard Predictions at Offsite Locations

4.2.1 Overpressure

The hazard frequency contours for 70mbar show that they do not extend south of the onsite building area, which is some 150m north of the R314. The 20mbar contours are more extensive, with the road being just outside the 1E-04per year contour. The nearest offsite buildings are in the region where the frequency contours are dropping rapidly, with the closest buildings being subject to this overpressure level at frequencies of the order of 1E-05per year, buildings slightly further away are subject to this level of overpressure at frequencies of the order 1E-06 to 3E-07per year.

4.2.2 Thermal Radiation

Some of the higher consequence level pool fire contours (20 and 12kW/m^2) extend offsite across the north western terminal security fence boundary, but none impacts the trees outside the security fence. None of the lower levels (more relevant for people than trees) extend significantly further outside the security fence.

Jet fire exposure extends outside the security fence boundary at low frequencies for both 20 and 12kW/m^2; there is a small area of trees to the south east that is subject to a thermal radiation level above 12kW/m^2 at a frequency between 1E-06 and 3E-07per year. The lower levels of thermal radiation (6 and 4kW/m^2) extend well beyond the security fence, but do not reach the road or occupied offsite buildings.

The flash fire contours extend over some of the tree banks in all directions at frequencies up to 1E-05per year, but again do not reach the road or occupied offsite buildings.

The higher levels of short duration fireball type events impact some areas of trees at frequencies in excess of 1E-05per year, but again the lower levels do not reach the road or occupied offsite buildings.

The frequencies at which the fire and explosion hazards are experienced at certain points around the terminal (identified in Appendix IV) are given in Table 4.3.

Table 4.3 Hazard Frequencies for Offsite Locations

Location	Frequency of >20mbar but <70mbar	Frequency of Flash Fire	Frequency of >1000TDU	Frequency of >500TDU
Building 1	1.84E-05	0	0	1.12E-08
Building 2	1.47E-05	0	0	0
Building 3	9.34E-06	0	0	0
Road 1	4.46E-05	9.55E-09	0	4.28E-07
Road 2	8.28E-05	0	0	3.74E-09
Road 3	5.38E-05	0	0	0
Intersection NW	1.32E-04	6.07E-07	3.12E-05	1.47E-04
Intersection NE	8.14E-05	1.68E-07	1.64E-06	7.30E-06

4.2.3 Major Failures

The scenarios that cause the highest level of overpressure or thermal radiation at the closest building to the terminal (Building 1 on the map) are identified below:

- Overpressure. Full bore failure of the slugcatcher outlet, with the cloud directed towards the main process area, and delayed ignition gives an overpressure at Building 1 of 26mbar.
- Thermal radiation. Failure of the sales gas export line, with the release directed towards Building 1 with immediate ignition gives a thermal radiation level of $11kW/m^2$ or 300TDU for a 13s duration fireball.

An overpressure of 26mbar would be expected only to crack or break windows (crack small windows, break large windows). The glass breakage would not be particularly forceful and high velocity shards of glass would not be produced. No building damage would be anticipated, and no fatalities would be anticipated. A thermal radiation level of $11kW/m^2$ would cause pain on exposed skin in approximately six seconds; but even if exposure was for the whole of the duration of the fireball type combustion, the levels are too low to give fatal injuries.

4.3 Trees

4.3.1 The Potential for a Tree Fire to Affect the Terminal

The predicted level of thermal radiation at the control building, from tree block B some 40m away is $18kW/m^2$. This level of thermal radiation would be required to exist for some 10 minutes before buildings would be expected to ignite. This is considerably longer than the anticipated fire exposure duration of 1-2 minutes. The control building is designed with an external construction of two hours fire resistance. A tree fire is therefore adjudged not to present a hazard to the control building or the control functions within the building.

The minimum separation between the process areas and a tree bank is some 80m (to the tree bank to the east). This gives a predicted thermal radiation level of $8kW/m^2$, which is too low to affect the integrity of the equipment, or the control functions.

4.3.2 The Potential for an Incident on the Terminal to affect the Trees

The jet fire contours for $20kW/m^2$ do not extend over any trees that will remain after the terminal has been constructed. The jet fire contours for $12kW/m^2$ at a frequency between 1E-06 and 3E-07per year cover a small area of the tree bank to the west of the terminal and the tree bank to the south of the terminal.

Based on the initial operating conditions (Appendix XIII), the frequency at which a fireball could impact the trees is approximately 1E-05per year (tree bank to the east). The banks to the north and west border the 3E-07per year contour. Levels of thermal radiation sufficient to ignite the trees are predicted to occur just less than 1E-04per year (bank to the east and to the north), and around 1E-06per year for the bank to the west.

The HSA asked for clarification on the potential effects of terminal fires on the surrounding woodland, so the thermal radiation calculations were repeated, but this time incorporated the effect of certain control facilities, and the decrease in flowrate and operating pressure throughout the life of the terminal. These revised contour plots (shown in Appendix XVI) are considered to more realistic than those in Appendix III.

4.4 Sensitivity Analysis

A sensitivity analysis has been carried out which considered low windspeed conditions to exist for 30% of the time (rather than 15% as assumed for the base case analysis). Hazard contours for this sensitivity are presented in Appendix XIV. Comparison of these contours with those in Appendix XIII shows that increasing the proportion of low windspeed conditions has negligible effect on either the overpressure or the flash fire contours. This is not too surprising as although the clouds are wider in low windspeed conditions, they have shorter downwind distances along the ground (because of lift off).

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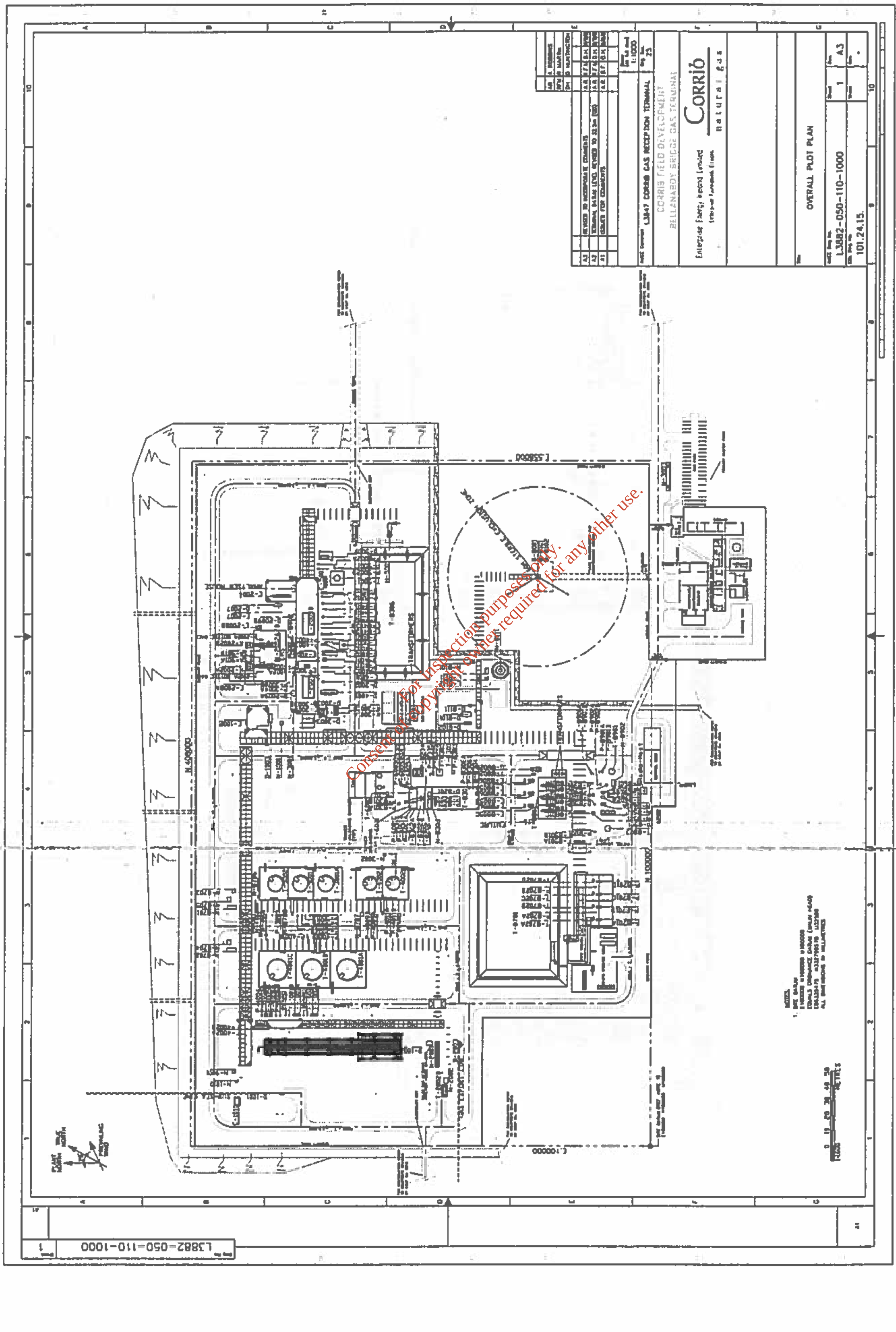
APPENDIX I

Process Flow Diagram, Plot Plan and Location Plan

CONTENTS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CORRIB FIELD DEVELOPMENT
BELLANABOY BRIDGE GAS TERMINAL
CORRIB
natural gas
OVERALL PLOT PLAN
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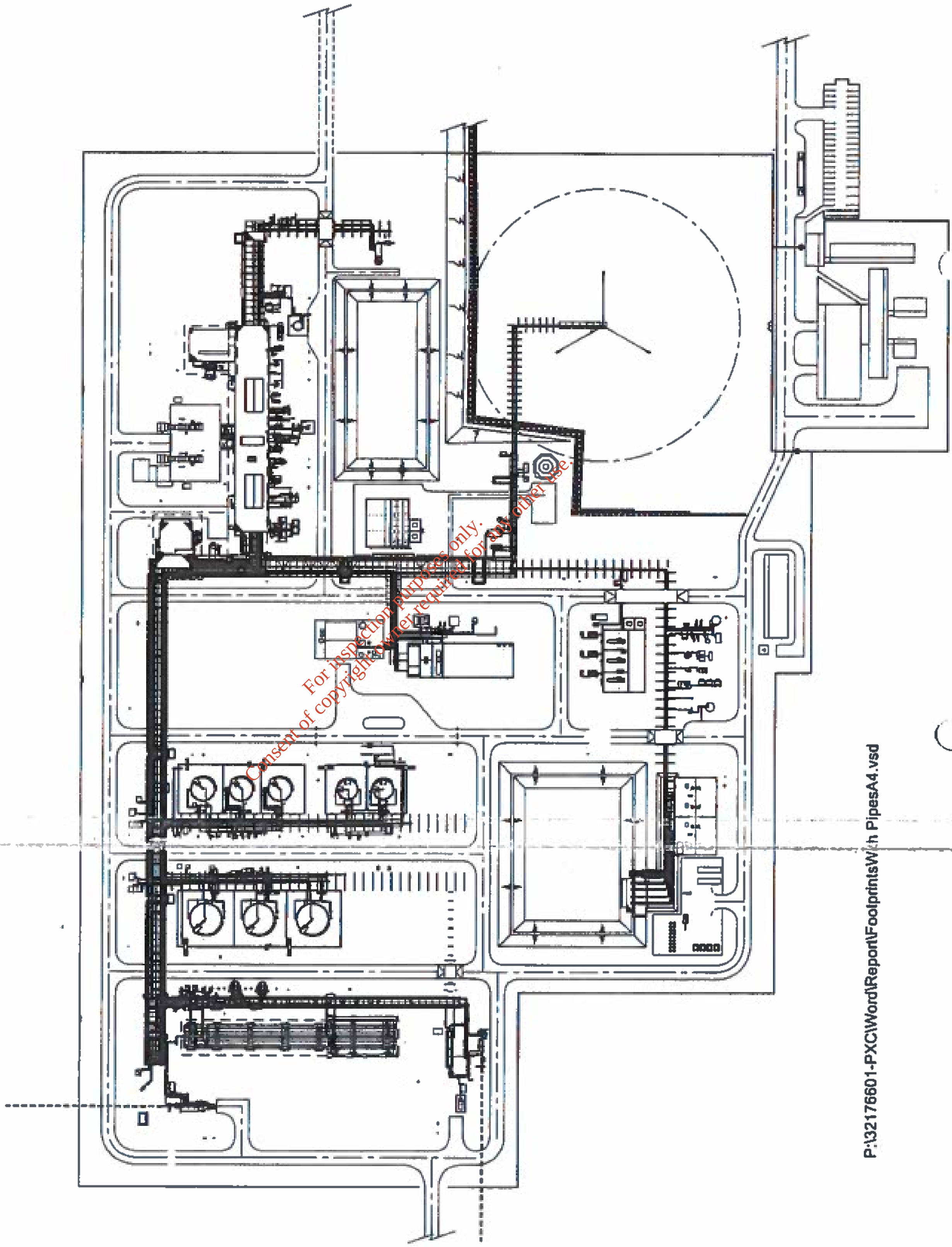

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Location Plan

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APPENDIX II

Methodology

CONTENTS

II. METHODOLOGY

II.1 Introduction

The methodology assumptions for carrying out this analysis are given below in terms of:

- Release rate type and duration type.
- Frequency data.
- Ignition and explosions.
- Consequence analysis.

The methodology below is similar to that used for the preliminary QRA carried out for Amec prior to the ABP Oral Hearing but the interpretation of the frequency data for QRAs has been updated.

II.2 Release Type and Duration Type

The release types and assumptions made for the calculation of release rate are given in the following table.

Location of Release	Conditions	Assumptions for Release Rate
High pressure gas pipeline either import, on site or export.	Calculated rate using standard discharge rate equation is higher than NFR, and rate decreases significantly with time. Hole size 200mm and above).	Forward flow is calculated according to a gas pipeline depressurisation model (PHAST). The mass released in the periods 0-60s, 60-120s, 120-360s, 360-600s,600-900s and 900-1200s is determined and the average release rate over each time period is used.
	Calculated rate is lower than NFR.	The release is as calculated using standard release rate equation with discharge coefficient of 0.65.
High pressure gas pipeline downstream of compressor, but upstream of last NRV.	Calculated rate using standard discharge rate equation is higher than NFR.	Inventory in the system is reasonably low and release rate is assumed to be a maximum of 1.5 times the NFR.
	Calculated rate is lower than NFR.	The release is as calculated using standard release rate equation with discharge coefficient of 0.65.
Liquid offtake from a vessel.		As calculated using standard release rate equation with discharge coefficient of 0.65 for a duration determined by the vessel inventory. Max duration 1800s. For the vessels associated with the high pressure gas system gas breakthrough is assumed to occur if there is a major failure of the liquid offtake line.
Vapour offtake from a vessel.	Vessel contains material with BP>ambient at a low pressure (e.g. less than 10barg) or at a high pressure with hole size less than 100mm.	Release rate is as calculated, with duration determined by the flash mass from all vessels connected by a vapour line to the point of release plus the NFR for the same duration.
Liquid filled pipeline.	Large inventory (pipelines between process area and slugcatcher or storage).	Release rate is calculated using standard release rate equation with discharge coefficient of 0.65 and a head of 2m.
	Small inventory (pipelines within process area).	Release rate is assumed to be a maximum of 1.5times the NFR.

NFR. Normal flow rate.

The assumptions regarding the duration of a release are given in the following table.

Ref	Description	Duration for Detection and Isolation (s)
FGAI	Gas detector which auto closes ESD/automatic valve (XSFV).	120
FGBV	Gas detector with isolation by manual valve closure.	960
FGCV	Gas detector with isolation by remotely operated closure of control valve.	660
FGMO	Gas detector with isolation by remotely operated closure of ESD.	360
PAAI	Process trip which auto closes ESD.	360
PABV	Process alarm with isolation by manual valve closure.	1200
PACV	Process alarm with isolation by remotely operated closure of control valve.	900
PAINVCV	Process alarm with isolation of feed by remotely operated closure of control valve. Duration determined by either inventory of material (max 1800s) or valve closure time (900s).	Max 1800
PAINVMO	Process alarm with isolation of feed by remotely operated closure of ESD. Duration determined by either inventory of material (max 1800s) or valve closure time (600s).	Max 1800
PAMO	Process alarm with isolation by remotely operated closure of ESD.	600
RABV	Detection by field operator, remote area, with manual isolation.	2700
	Detection by field operator, remote area, with isolation by remotely operated control valve.	2400
RAMO	Detection by field operator, remote area, with isolation by remotely operated ESD.	2100
RPBV	Detection by field operator routine patrol, with manual isolation.	1500
RPCV	Detection by field operator routine patrol, with isolation by remotely operated control valve.	1200
RPINVCV	Detection by field operator routine patrol, with isolation by remotely operated control valve. . Duration determined by either inventory of material (max 1800s) or valve closure time.	1200
RPINVMO	Detection by field operator on routine patrol with isolation of feed by remotely operated closure of ESD. Duration determined by either inventory of material (max 1800s) or valve closure time.	900
RPMO	Detection by field operator on routine patrol, with isolation by remotely operated ESD.	900

II.3 Frequency Data

Failure frequencies have been taken from offshore data (OIR12 and HSE 2000), except for failures given in Section II.3.1. Details of the derivation from the offshore data are included as an Annex to this Appendix. These data have been applied to the following:

- Piping.
- Pumps.
- Compressors.
- Heat exchangers.
- Flanged joints.
- Valves.
- Small bore fittings.

The first four items have been included specifically as in the Annex.

The last three items have used a relationship based on generic values for the number of items per m of piping, (see below) for piping in the process area only.

Piping Size	No Flanges per m	No inline Valves per m	No 50mm Valves per m	No Small Bore Fittings per m
300mm and above	0.118	0.083	0.02	0.033
75mm to 250mm	0.136	0.116	0.03	0.133
50mm and less	0.714	0.1	0	0.133

For welded piping between units which runs on a rack (e.g. from the slugcatcher to the process area) a modification factor of 0.1 has been applied to the piping frequencies determined from the OIR 12 data. This is because direct use of the OIR 12 data gives failure frequencies that are not experienced in practice for this type of piping, and a reduction factor of 0.1 brings the predicted frequencies closer to experience (based on no failures).

II.3.1 Other Frequencies

The OIR 12 data do not contain any catastrophic vessel or tank failures. Data contained in a document authored by the UK Health and Safety Executive have therefore been used (HSE 2000, Planning) for vessels in the process area. For pressure vessels the range in that reference is 2E-06 to 6E-06per year. As the vessels will be newly manufactured and use modern design and verification methods the lower value in the above range has been used.

For tanks, the data in Lastfire have been used for a major bund fire (6E-05per tank year).

Although OIR12 contains data on pig traps, the data set is quite small and no catastrophic failures are included, although such failures are known to have occurred. The OIR 12 data do however indicate that the leak frequencies of pig launchers and pig receivers are similar. A catastrophic failure of a pig trap is partly dependent on the inherent failure frequency of the trap itself, but more influenced by the operator. A frequency of 1E-4 per operation has been assumed for an error, with one in ten leading to a catastrophic failure. Pigging frequencies are anticipated as one pig every five years for the import line and one pig per year for the export line.

The slugcatcher is fitted with a manhole, and there is the potential for this to fail. A frequency of 1E-07per year has been used (based on a frequency of opening of once in 10 years, and a probability of incorrect replacement of 1 in 100,000 per operation).

For transfer operations a release frequency of 4E-06 per transfer has been assumed based on the assumption that there are two pullaway prevention measures (wheel chocks and barriers) with hose inspection and leak test prior to transfer (Gould and Anderson).

II.4 Ignition and Explosion

The ignition model has been based on the Classification of Hazardous Locations (Cox AW, et al) (Figure 15.1). Releases which give a vapour cloud used the vapour cloud rate and the "gas" line with a minimum value of 0.05 and a maximum value of 0.3. Releases which did not give a vapour cloud used the liquid discharge rate and the "liquid" line with a minimum value of 0.05 and a maximum value of 0.1. The value for liquids was applied directly to a liquid pool (see later). The value for vapour was equally divided into "immediate ignition" and "delayed ignition". The "immediate ignition" value was used directly. The "delayed ignition" value comprised a base (minimum) value which was enhanced if the cloud covered the identified "strong" ignition source (fired heater).

Instantaneous releases (from vessel ruptures) were assigned an ignition probability which was equal to the ignition probability for a release from the main line either into or out of the vessel (generally 0.15).

II.4.1 Explosion Probability

The values for 'explosion given ignition' were based on Figure 16.1 (Cox et al) which relates the explosion probability to the release rate. This gives a minimum value of 0.04 for release rates of 0.05kg/s and below and the value increases linearly (log/log scale) to a value of 0.3 for 100kg/s and a maximum value of 0.9 (1800kg/s). Ruptures used the surrogate release rate to determine the explosion probability. If the congested cloud volume was less than 1000m^3 (approximately 80kg of fuel in a stoichiometric mixture), the cloud was considered too small to explode. In accordance with the multi energy explosion framework, if the cloud does not cover a region of congestion, then the explosion probability was assumed to be 0.

II.5 Consequence Analysis

The consequences were categorised as one of the following:

- Pool fire.
- Jet fire.
- Flash fire.
- VCE.
- Fireball.

The consequence analysis was mainly carried out using the latest version of ***PHAST* (v6.21)**. For cloud dispersion, the releases were defined in terms of the release rate, the final velocity, the duration and the droplet size or liquid fraction if the release was a flashing release. This input was used to generate horizontal vapour cloud releases. 67% of releases were assumed to be horizontal, 33% were assumed to lose momentum at source and adopt a cylindrical shape centred at the release location. Releases were generally modelled as steady state. When the release rate was predicted to vary significantly over time, e.g. from the outlet gas pipeline, the release was modelled as six "linked" release rates determined from the time varying release output from the long pipeline model in ***PHAST***.

II.5.1 Immediate Ignition

II.5.1.1 Ruptures

A fireball radius, duration and distances to the radiation level that corresponds to spontaneous ignition of whitewood were determined according to the model published by the I Chem E. For pipeline only releases, the surface emissive power (SEP) was taken as 270kW/m^2 (Bilo and Kinsman). When the release included condensate the SEP was taken as 350kW/m^2.

II.5.1.2 Holes

Releases were assumed to form either a jet (if the release was vapour or a 2 phase release with a flash fraction above 0.9) or a pool (if the release was liquid or 2 phase with a flash fraction less than 0.9). For horizontal immediately ignited jet releases with release durations >30s, the predicted hazard area was taken directly from the output from the jet flame model (Shell). The edge of the hazard area was located at the release location. If the release duration was <30s it was modelled as a fireball. For pools, the hazard range was determined assuming a steady state pool, with SEP of 40kW/m^2. For (jet) releases with loss of momentum the hazard area was equated to the hazard area for the horizontal jet fire but was assumed to be circular and centred at the release location.

II.5.2 Delayed Ignition

The consequence envelope (to LFL) defined by ***PHAST*** for horizontal vapour cloud releases was used directly for horizontal (directional) releases (flash fires and explosions).

These predictions were also used to generate the non-directional clouds (assumed to be cylindrical and located at the release location).

II.5.2.1 Overpressures

Overpressures were calculated within ***BLAST*** (an internal DNV program), assuming:

- Start overpressures of 1barg (Multi Energy line 7) in the process area and 200mbarg (Multi Energy line 5) in the slugcatcher area (considered to be a less congested region).
- The cloud shape from ***PHAST*** was used by ***BLAST*** to determine a cloud energy for the part of the cloud which is within any region of congestion assuming that the concentration is stoichiometric.

II.6 Impact Analysis

In order to determine the impact of the various hazards, fatality probabilities as given in Appendix IV were used. For the impact of overpressure, the building design was characterised in accordance with the classification contained in BEAST. Fatality probabilities were assigned according to Oswald and Baker, with an assumption that 'all serious or life threatening injuries' lead to fatalities.

Annex – Onshore Process Equipment Leak Frequencies

The text below is taken directly from an internal BP document which was written to describe the analysis of the OIR 12 data that BP carried out in order to derive release frequencies for use in QRAs. The table at the end of this section gives the failure frequencies used in this analysis.

Following the Piper Alpha accident UK North Sea operators were required to record data on incidents involving the release of hydrocarbons on offshore installations and submit these data for compilation by the UK Health and Safety Executive (HSE). These submissions are compiled and published by the HSE each year in a document called the 'Offshore Industry Hydrocarbon Release (OIR12) Database'. The database covering the years 1992 to 1999 inclusive (OTO 1999) has been analysed on behalf of the UK Offshore Operators Association (UKOOA) by AEA Technology (AEA Technology 2001).

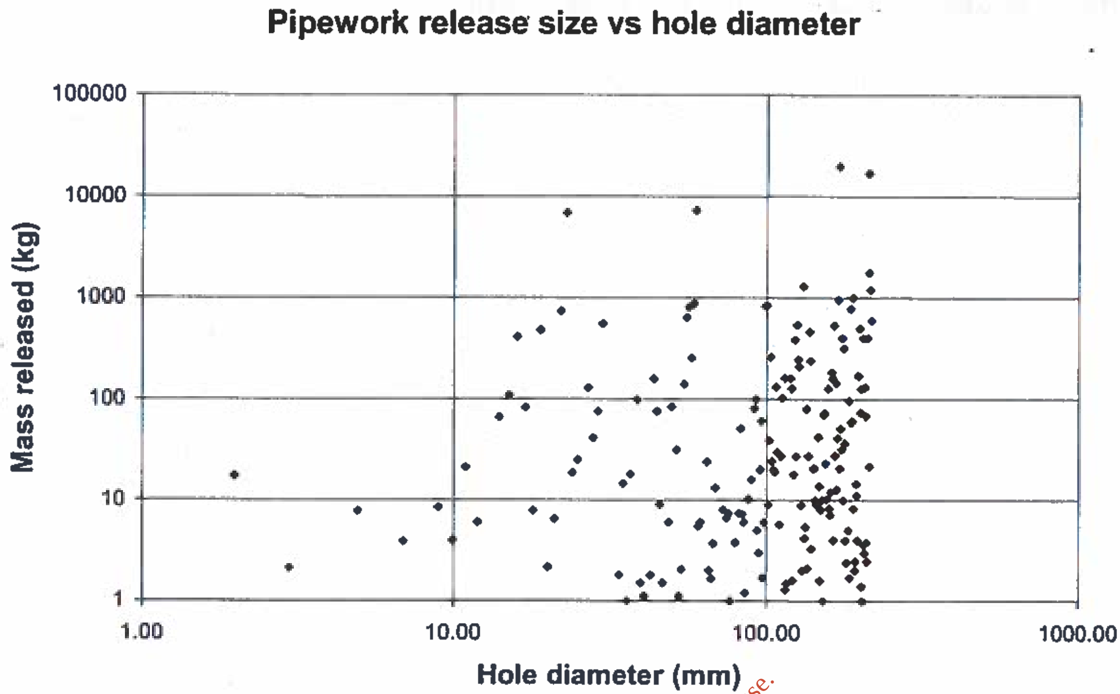
After considering the original database and the AEA Technology report BP has decided to perform its own analysis of the database to derive appropriate values of generic leak frequency / release size relationships for use by BP operations when performing risk assessment studies.

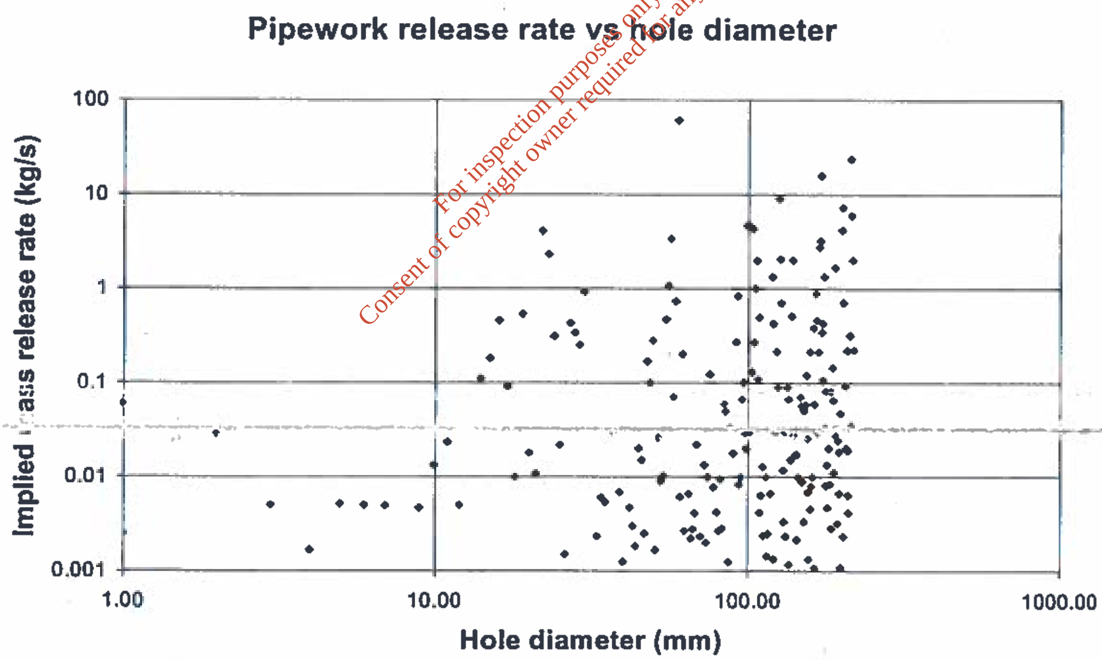
The OIR12 Database

The database considered lists 1545 incidents involving hydrocarbon process fluids. For each incident it gives the type of process fluid, estimated hole diameter, operating pressure of the system, the mass released and the release duration and many other parameters and we believe it to be the most comprehensive database of its kind.

In the risk assessment process it is typical practice to use generic incident data to estimate the likelihood of a release of hydrocarbon. This is often categorized in terms of the annual frequency at which a hole of a certain size will occur in the specific item of equipment. The data are presented for each hole size category in terms of the frequency per unit equipment year. The size of hole is used in combination with the normal operating pressure of the equipment to estimate the release rate and mass of fluids released to the atmosphere. Various effects such as fire and explosion are then modelled dependent on the type of fluid and its release rate. These effects are combined with their frequency of occurrence to give estimations of risk.

In this methodology a relationship must exist between parameters such as the quantity of material released in an incident and the size of the hole which occurs in the equipment. However inspection of the database indicates that the real data do not reflect this. For example the information for pipework incidents taken directly from the database is shown overleaf - it appears to be almost a random scatter.





The rules for reporting of incidents require that the duration of the incident is represented by the time between detection and cessation of a release and the mass is the total estimated mass released in the incident. Hence it might be surmised that in some incidents the release will start and not be immediately detected. This is more likely to happen in small incidents than large. In this case the duration may be underestimated and hence the release rate would be overestimated – i.e. directionally away from the relationship assumed in QRA studies between hole size and release rate.

Equipment category	Equipment type	Failure frequency (per year) by representative hole size (mm)				
		2mm	12mm	25mm	75mm	FBR
		(0mmto 2.8mm)	(2.8mm to 16.7mm)	(16.7mm to 31.1mm)	31.1mm to 101mm)	
Valves	Valve <3"	3.0E-04	1.4E-04	1.9E-05	0.0E+00	2.05E-06
	Valve >3"	5.6E-04	7.7E-05	1.8E-05	0.0E+00	1.9E-06
Flanges	Flange <3"	3.1E-05	1.2E-05	1.1E-06	0.0E+00	0.0E+00
	Flange >3"	4.7E-05	1.7E-05	2.1E-06	0.0E+00	1.4E-06
Steel Pipework	Steel piping <3" (per m)	1.2E-04	4.8E-05	0.0E+00	0.0E+00	6.3E-06
	Steel piping >3" (per m)	4.8E-05	1.3E-05	5.6E-07	5.6E-07	5.6E-07
Vessels		2.4E-03	1.7E-03	2.4E-04	2.4E-04	0.0E+00
Heat Exchangers & Coolers	Heat exchanger, HC in shell	2.7E-03	1.3E-03	6.9E-04	1.8E-04	1.5E-04
	Heat exchanger, HC in tube	1.4E-03	7.1E-04	3.6E-04	9.4E-05	8.1E-05
	Heat exchanger, plate	7.0E-03	3.4E-03	1.8E-03	4.3E-04	3.9E-04
	Fin fan cooler	1.9E-03	9.5E-04	4.9E-04	1.2E-04	1.1E-04
Instruments & Fittings		4.1E-04	2.0E-04	0.0E+00	0.0E+00	2.6E-06
Pumps		6.6E-03	2.8E-03	1.2E-03	0.0E+00	3.9E-04
Compressors		7.8E-02	3.1E-02	1.2E-02	2.3E-03	7.4E-04

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CONTENTS

APPENDIX VII

Environmental Hazards

Notes:

Extremely flammable	Risk phrase 12.
Highly flammable	Risk phrase 11.
Flammable	Risk phrase 10.
Toxic	Risk phrases 23,24,25 and 48.
Highly flammable (7a)	Risk phrase 11 and 17 or flash point < 55degC and remain liquid under pressure.
Highly flammable (7b)	Risk phrase 11 and flash point < 21degC.
Methanol toxic hazard	All inventories of greater than 10% concentration are counted. This includes the raw methanol storage tanks.
Methanol flammable hazard	The raw methanol storage tanks are included as a highly flammable liquid (7b).
Methanol hazard to the environment	Methanol is identified as dangerous to the environment in high concentrations.
Condensate inventories	Condensate in the process stream (slug catcher, MP separator) contain substances which remain liquid under pressure, i.e. a Part 2 category 7a substance. The stored condensate is a fuel gas oil with a flash point less than 22.8°C, i.e. a Part 1 named substance – a 'Petroleum spirit'.

VI. HAZARDOUS MATERIALS ON THE SITE

This Table is reproduced from Amec document I 3847-000-110-0114 (Lower Tier Site Justification).

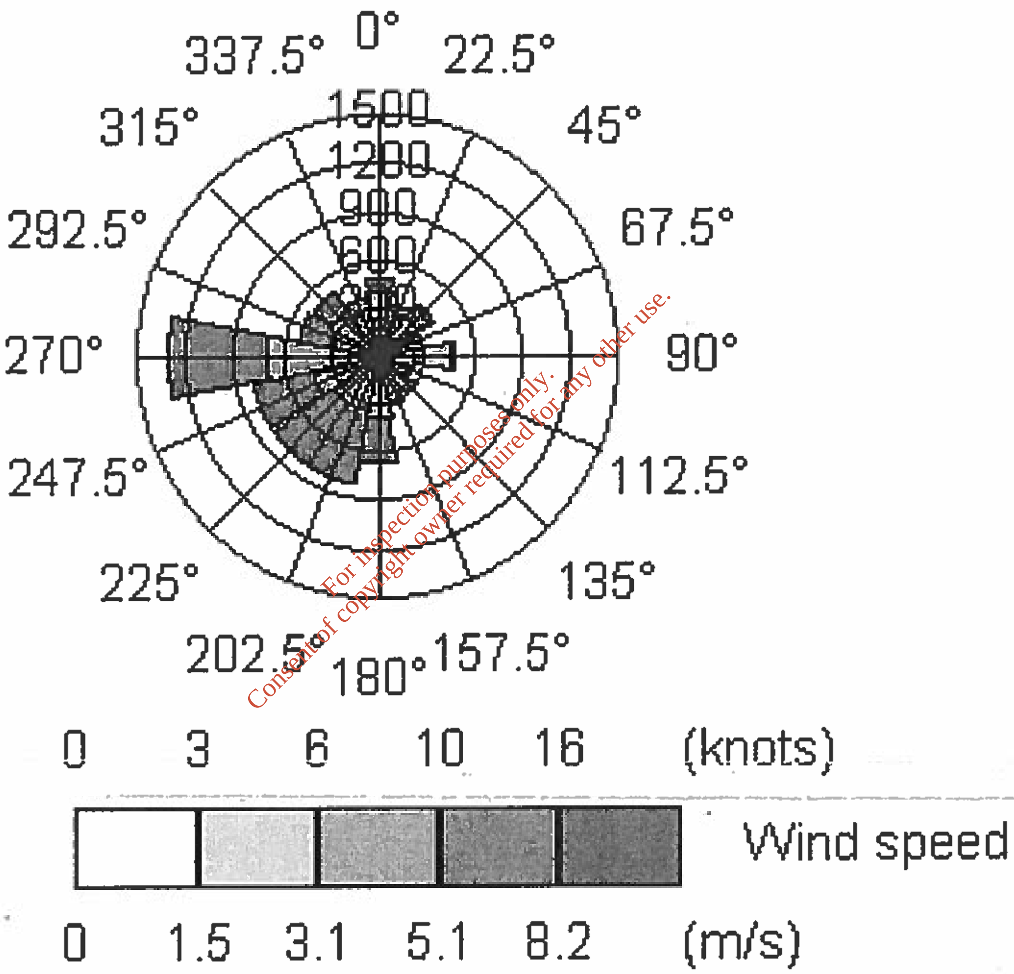
HAZARDOUS SUBSTANCES INVENTORY							
Description	Hazard	Inventory (tonnes)	Qualifying inventory	Qualifying inventory	Aggregation of inventories	
			Articles 6 & 7	Article 9	Arts 6&7	Art 9
Substances contributing to flammable hazards						
Hydrocarbon gas (natural gas)	Part 1 substance. Extremely flammable	25	50	200	0.50	0.13
Stabilised condensate (petroleum spirit)	Part 1 substance. Highly flammable liquid	1078	5000	50000	0.22	0.02
Unstabilised condensate	Highly flammable liquid (7a)	11	50	200	0.22	0.06
Propane	Liquified extremely flammable gas	1	10	50	0.02	0.01
Methanol (product)	Part 1 substance. Highly flammable liquid	773	500	5000	1.55	0.15
Methanol (raw)	Part 1 substance. Highly flammable liquid (7b)	2856	5000	50000	0.57	0.06
Diesel	Flammable	66	5000	50000	0.01	0.00
Lubricating Oils	Flammable	1	5000	50000	0.00	0.00
Odorant	Highly flammable (7b)	9	5000	50000	0.00	0.00
PURASPEC ™ Absorbent 1156	Highly flammable (7b)	8	5000	50000	0.00	0.00
					3.09	**0.42**
Substances contributing to toxic hazards and dangerous for the environment						
Stabilised condensate (petroleum spirit)	Part 1 substance. Toxic /dangerous for the environment	1078	5000	50000	0.22	0.02
Unstabilised condensate	Toxic /dangerous for the environment	11	50	200	0.22	0.06
Mercury	Toxic /dangerous for the environment	0.4	50	200	0.01	0.00
Methanol (product)	Part 1 substance. Toxic /dangerous for the environment	773	500	5000	1.55	0.16
Methanol (raw)	Part 1 substance. Toxic	2856	500	5000	5.71	0.57
Diesel	Toxic / dangerous for the environment	66	500	2000	0.13	0.03
Hydrochloric Acid	Toxic / dangerous for the environment	3	50	200	0.06	0.02
PURASPEC ™ Absorbent 1156	Toxic	8	50	200	0.16	0.04
					8.06	**0.89**

V. METEOROLOGICAL DATA

Stability Category "A" to "F"	Wind Speed	Angle 1	Angle 2	Angle 3	Angle 4	Angle 5	Angle 6	Angle 7	Angle 8	Total
F	2	0.0130	0.0122	0.0122	0.0092	0.0245	0.0276	0.0352	0.0161	0.1500
D	5	0.0737	0.0694	0.0694	0.0520	0.1388	0.1561	0.1995	0.0911	0.8500

Angle 1 is from plant N.

V.1 1995 Windrose for Belmullet



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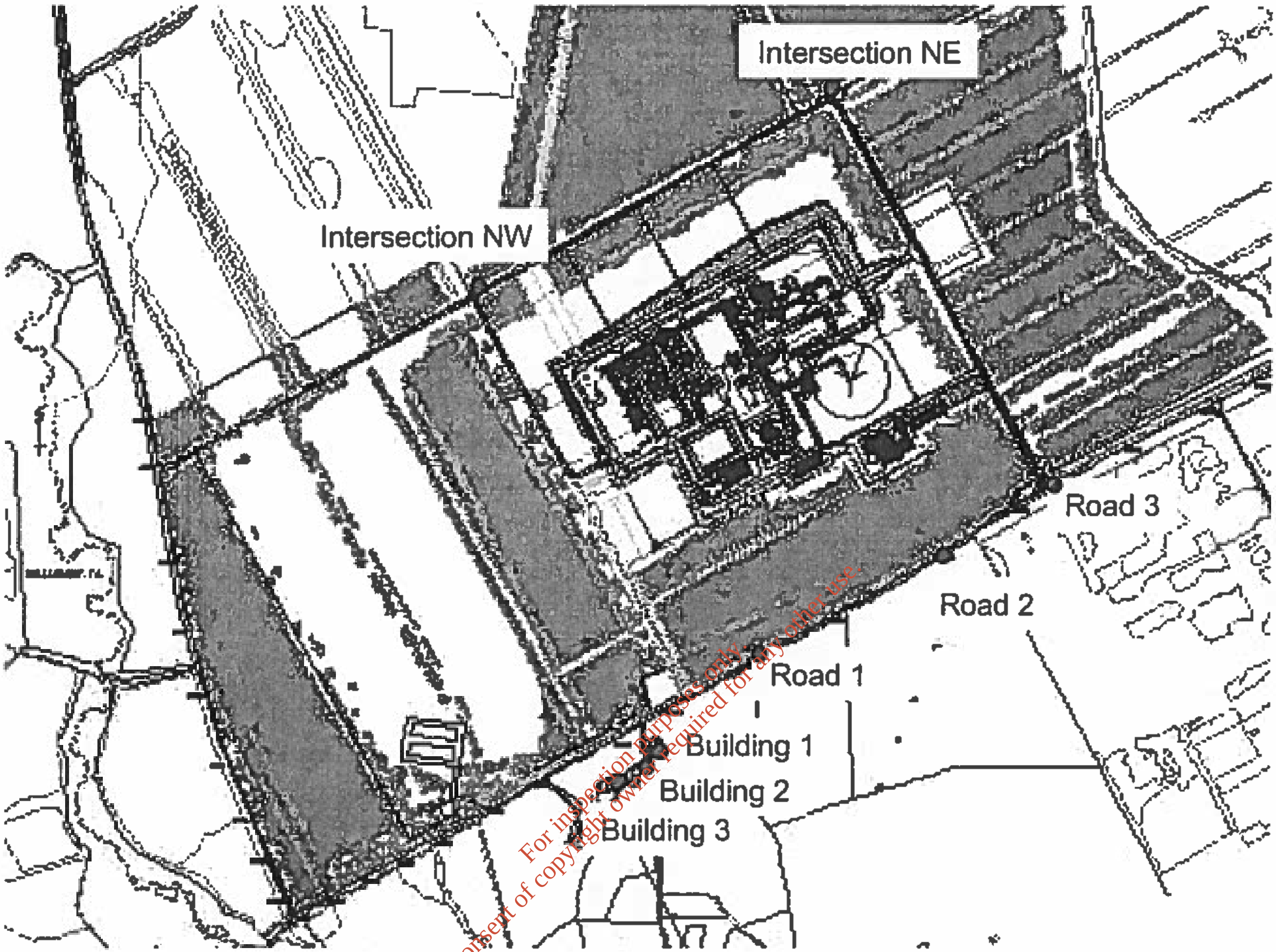
APPENDIX V

Meteorological Data

Figure IV.2 Location of Offsite Points (for hazard frequencies and individual risk)



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Location	Structural Configuration	BEAST Category	Fatality Probability Pool Fire 6-20kW/m2	ity ility ion bar	Fatality Probability Flash Fire	No People Day	No People Night	Presence Factor Day	Presence Factor Night
Guard House	1	Beast3	0.05	).788	0.02	2	2	0.9	0.9
Block B	1	Beast3	0.01	).788	0.02	6	0	0.7	0
Control Room	2	Beast12-200	0.01	0.8	0.02	2	2	1	1
Canteen	1	Beast3	0.01	).788	0.02	26	8	0.125	0.0625
Admin Building	1	Beast3	0.01	).788	0.02	11	0	0.2	0
Laboratory	1	Beast3	0.05	).788	0.02	1	1	1	0.0625
Warehouse	3		0.01	).788	0.02	11	1	0.4	0.03125
Main Plant	Outdoors		0.01	).065	0.3	9	2	0.75	0.75

1. Portal Frame Building, Non Load Bearing Infill Rei
2. Reinforced Concrete Frame, RC Walls and RC Roo
3. Portal Frame Building, Non Load Bearing Infill Rei

The location of the buildings is shown in Appe

Figure XI.6 Wells and First Stage Separation

Figure XI.5 Wells and First Stage Separation

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APPENDIX VI

Hazardous Materials on the Site

Figure XI.3 Gas Process Facilities

Figure XI.4 Gas Process Facilities (with slugcatchers)

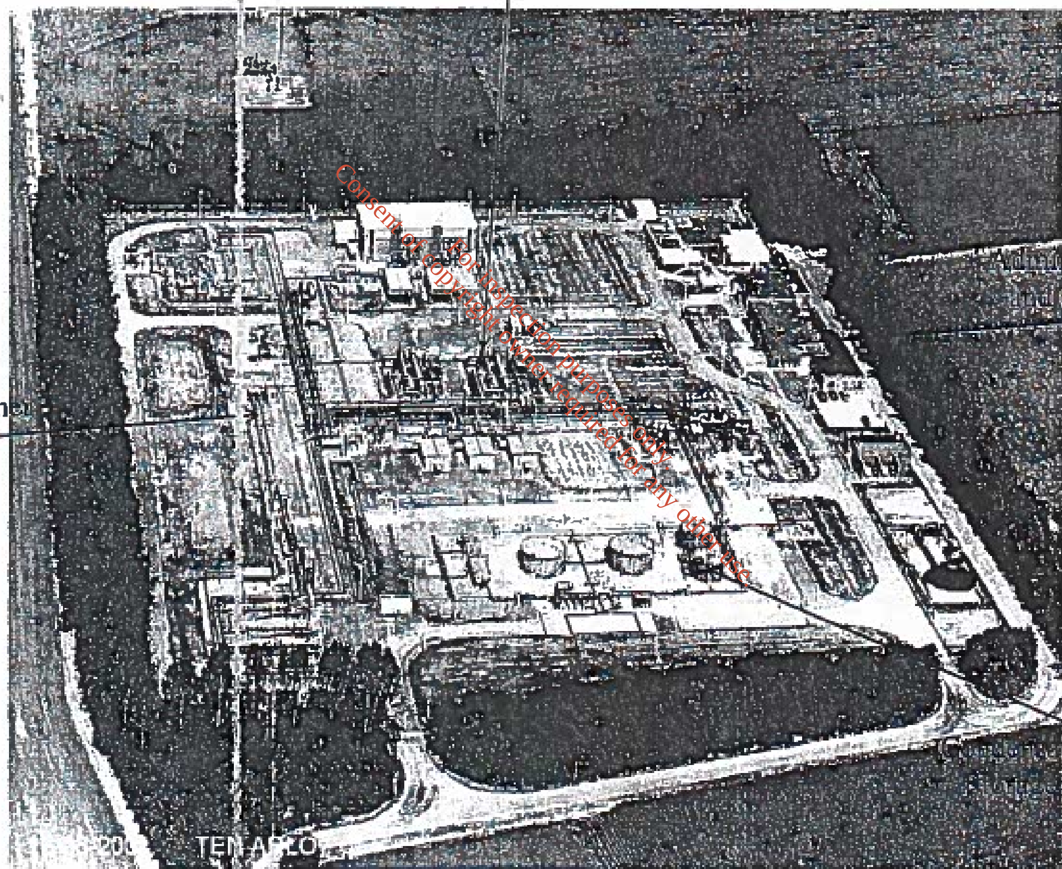


Figure XI.2 Well and First Stage Process Facilities

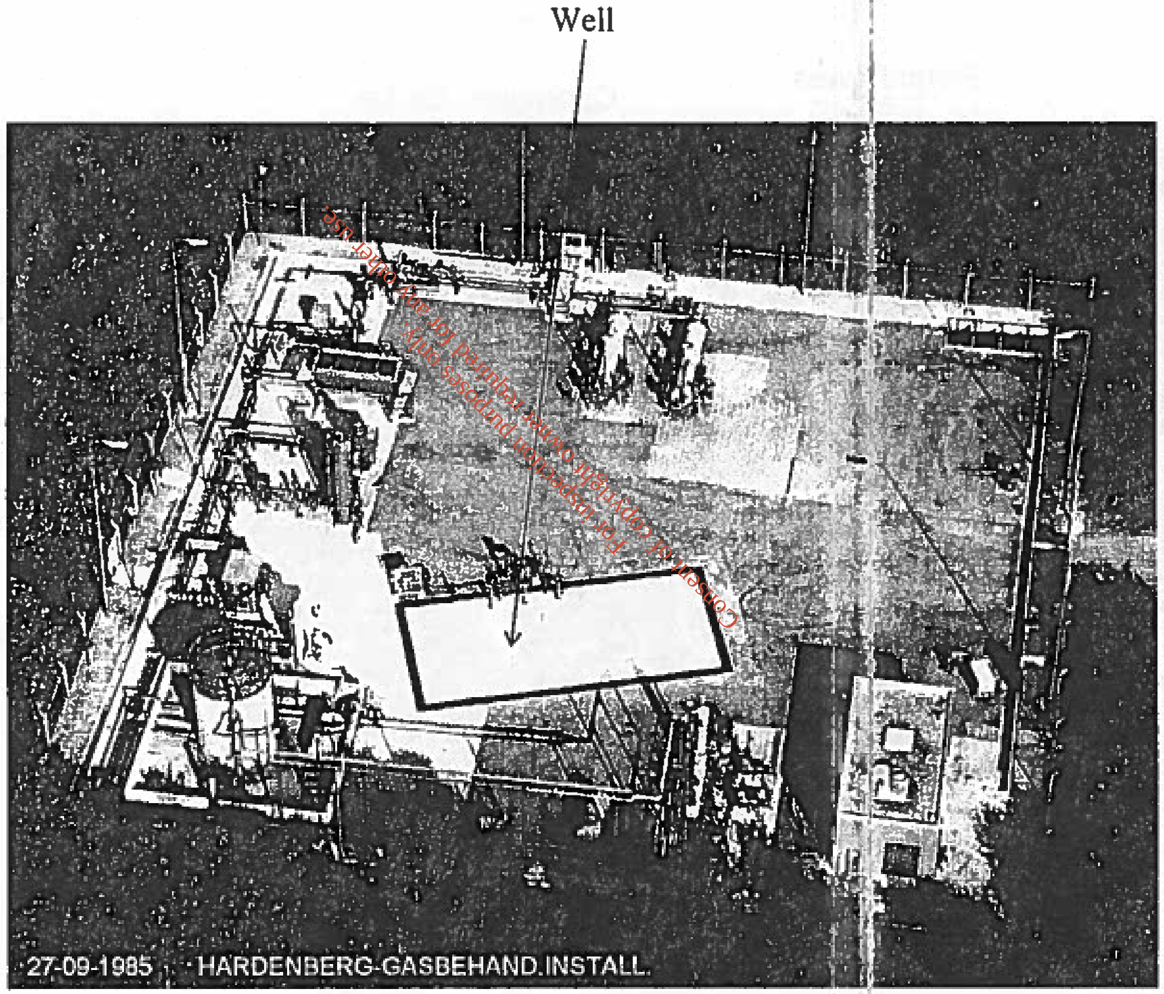
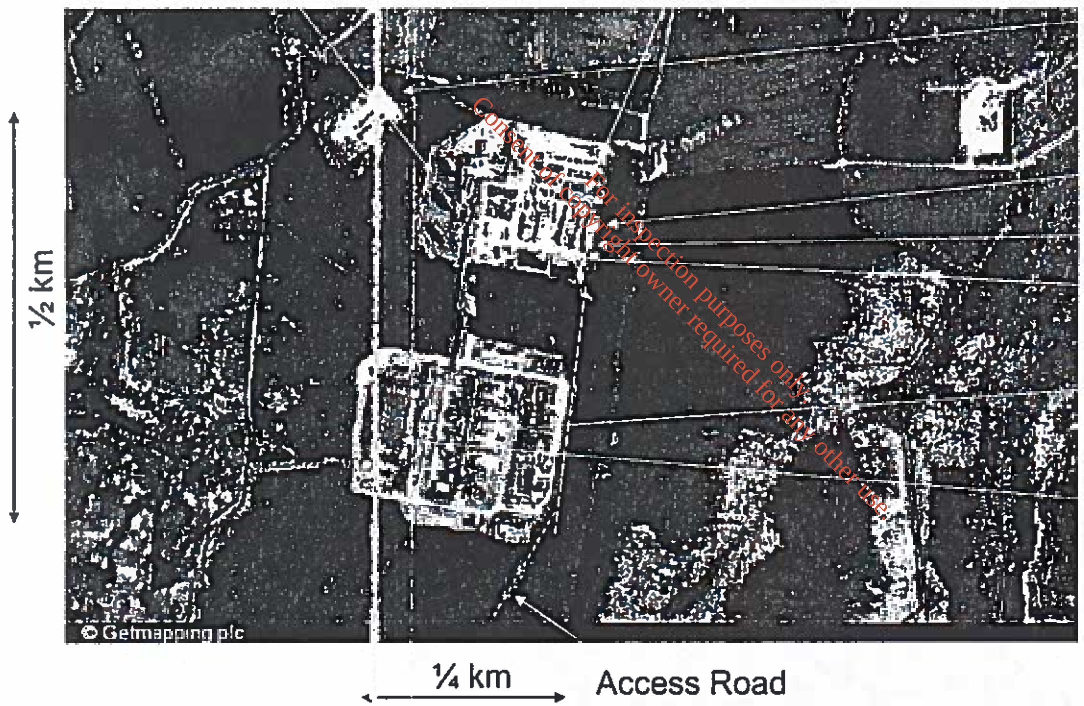


Figure XI.1 Site Plan- Oil Separation, UK



Description	Applicable to	Separation Distance (m)	Reference
Separation distance between building and vessel containing LPG	Buildings.	Sufficient so that thermal radiation from building does not exceed 10kW/m2 on the LPG vessel.	AS/NZS 1596:1997 (Storage and handling of LP Gas.
Separation distance between public place (i.e. a place open to the public) and vessel containing LPG	Vessels above 500kL (approximately 250te).	22	AS/NZS 1596:1997 (Storage and handling of LP Gas.
Separation distance between protected place (i.e. a building or open area where people may assemble in large numbers, or people are employed) and vessel containing LPG	Vessels above 500kL (approximately 250te).	45	AS/NZS 1596:1997 (Storage and handling of LP Gas.

Note that the distances quoted above are the 'minimum separation distances'.

XI. SEPARATION DISTANCES

This Appendix contains some examples of hazardous installations in rural areas where trees have been used to provide screening for visual impact purposes. One example is of an oil separation facility in the UK, and the others are gas reception facilities in the Netherlands.

Also shown in Table XI.2 is a list of separation distances that are contained in codes of practice that are in common usage (these distances are minimum separation distances).

Table XI.1 Examples of Separation Distances for Process Plants

Location	Plant	Distance (m) from control building to trees	Distance (m) from process facility to trees	Other
Oil separation facility, UK	Oil/gas separation in forest/heath area.	15	60	22m separation for ground flares. 55m separation between LPG storage and trees.
Westerveld, Netherlands	Gas processing with thin tree screen.	15	25	Condensate/water storage 25m from trees.
Hardenberg, Netherlands	Well and initial processing.		10-15	Unmanned installation.
Ten Arlo, Netherlands	Gas processing with thin tree screen	15	20-25 to slugcatcher	
Roden, Netherlands	Well and initial processing.	20	15	15m between condensate/water storage tanks and forest. Installation close to golf course.
Tietjerk, Netherlands	Well and initial processing with thin tree screen.	15	40	Normally unmanned installation.

Table XI.2 Examples of Separation Distances from Codes of Practice

Description	Applicable to	Separation Distance (m)	Reference
Separation from buildings, boundaries and property line	Vessels containing more than 150te LPG.	30	HS(G)34 (published in 1987 but now withdrawn. HSW 30, HS(G) 15, LPGIA Code of Practice No 1, Shell LPG Installations.
Separation from outer boundaries	Fixed and floating roof tanks containing more than 250m^3 highly flammable liquids.	15	HS(G) 52 (published in 1991). The Storage of Flammable Liquids in Tanks.
Separation from buildings, boundaries and property line	Pressurised storage of ethylene.	60	ICI Engineering Code.
	Refrigerated storage of ethylene.	90	ICI Engineering Code.

APPENDIX VIII

Individual Risk Contours

VIII. INDIVIDUAL RISK CONTOURS

APPENDIX XI

Separation Distances

CONTENTS

Shell Exploration & Production

Shell E&P Ireland Limited
Corrib House
52 Lower Leeson Street
Dublin 2
Ireland
Tel +353 1 669 4100
Fax +353 1 669 4101

Mr. John Sheeran,
Health and Safety Authority,
10 Hogan Place,
Dublin 2

29th January 2004

Ref: COR-L-16-718

Dear Mr. Sheeran,

In reply to your e-mail of 20-Jan-2004 :

Item 1 : 'The global stability review of the terminal site' : this report was submitted as a technical appendix to the EIS (Appendix 1, Volume 1 : geology, hydrogeology and global stability).

Item 2 : With reference to the request for the following documents :

COR-15-PLN-0004 (development phase audit review schedule)
COR-15-PLN-0005 (Quality plan)
COR-15-PLN-0006 (Verification scheme)

All of these documents are scheduled for revision, to reflect the revised execution plan for the Corrib project. These revised procedures will demonstrate an equal level of rigour/standard with respect to the management of verification (including third party).

Notwithstanding the above, section 4 of 'The National Authority for Occupational Safety and Health (NAOSH) – briefing document' outlines the approach that will be taken with regard to project management of Quality Assurance including third party verification

It is planned that these documents will be revised if / when planning permission is granted and before work recommences.

Item 3 : Please find enclosed 4 copies of all the even numbered pages of Appendix 11 of the QRA.

Item 4 : The lower tier site justification (document number L3847-000-110-0114) was issued on the 20/06/'03, at which time Enterprise Energy Ireland Limited was the name of the company. Subsequent to that date, and as a result of the takeover of Enterprise Oil by the RoyalDutch/Shell Group, the name of the company has been changed to Shell E&P Ireland Limited. I trust this explains the apparent discrepancy in company titles , to your satisfaction.

Registered Office
Corrib House,
52 Lower Leeson Street,
Dublin 2, Ireland.
Registered in Ireland
Number: 316588
VAT Number: I.E.6336588 P

Item 5 : As requested, please find enclosed 4 copies of an overall risk profile for the site .

Item 6 : Planned frequency of using the pig receiver : baseline survey to be performed in the early years of operation, thereafter, nominally, 5 yearly inspections . Regarding frequency of usage of the BGE pig launcher , please find enclosed 4 copies of emails in response to this request.

Yours Sincerely,

Gerry Costello

X. EXTERNAL HAZARDS

External hazards comprise any hazard initiator from a source that is not within the terminal boundary. The hazards from the trees in the vicinity of the terminal have been analysed (see main report); other external hazards are considered below.

Natural hazards, which comprise a significant proportion of the external hazards, cause some 2% of accidents (Rasmussen), (where accidents in this context are incidents that are recorded on either the TNO FACTS or the HSE MHIDAS databases). In processing units specifically, natural hazards cause 12% of accidents, and in storage facilities 31%. Overall in Europe some 30% of accidents are caused by natural hazards. Most accidents attributed to natural hazards in processing or storage facilities are caused by lightning (61%), while 'outside temperature' causes 15% and earthquakes cause 9% of these accidents. Wind, rain, soil erosion, ground subsidence and landslip together account for 13% of accidents attributed to natural hazards.

The normal way to prevent accidents caused by natural hazards is to design in accordance with recognised codes, and to operate with a good safety management system. The design features that are relevant in reducing the likelihood of accidents caused by natural hazards are given below.

X.1 Lightning

Lightning protection has been provided in the design of the terminal facilities in accordance with the requirements of BS 6651, Code of Practice for Protection of Structures against Lightning. The earthing system is designed to BS CP 1013;1965, and all the storage tanks will be electrically grounded. Once the plant is in operation, resistance tests will be carried out annually as part of the planned maintenance programme. The design will provide adequate protection of the computer controlled plant against lightning strike. Typical frequency for a lightning strike in this part of Europe is 1E-07per year (one in ten million per year).

X.2 Ambient Temperature Extremes

The plant has been designed to cope with the maximum temperature extremes anticipated (-15 to +28°C). For low temperatures caused by operational events (e.g. during blowdown) appropriate service materials have been chosen for equipment and piping based on protective measures contained in Trident Consultants' Corrib Depressurisation System - Dynamic Simulation. These measures include low temperature carbon steel and stainless steel for piping, stainless steel sleeves and stainless steel blow down valves located close to vessels.

X.3 Wind/Snow

The plant has been designed to BS CP 3 1997. Historical meteorological data indicate that the most severe storm is 172.24 km/h (maximum instantaneous gust). Design for snowfall is to BS 6399 Part 3.

X.4 Earthquake

The area is not known to be subject to seismic activity (typical frequency for a severe earthquake is 1E-06 to 1E-07per year, i.e. between one in a million and one in ten million per year).

X.5 Storm/Flooding

The site is some 33.4 m above sea level (Malin) and will not be subject to flooding by sea. Torrential rain can, however, give rise to flash floods. The site drainage system has been designed to a one in 100 year rainfall event (31 mm in one hour). It has also been verified for a 45mm in one hour extreme event (such recent flooding events have been experienced at Pollotomish and Derrybrien).

X.6 Landslip/Subsidence

No mining has taken place at the Terminal site. A global stability review of the terminal site has been carried out and has demonstrated that the terminal site is stable.

X.7 Aircraft Impact

As the proposed site is more than 3km from an airport, the crash rate is the local background rate. No special measures are to be incorporated.

Appendix 5 References

1. Position Paper on the provision of Land-Use Planning Advice in the context of the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, 2000 (S.I. No. 476 of 2000).

2. Guidelines for Evaluating the Characteristics of Vapour Cloud Explosions, Flash fires and BLEVEs, AICHE, CCPS, 1994.

3. Guidelines for Consequence Analysis of Chemical Releases, AICHE, CCPS, 1999.

4. 'Guidelines for Quantitative Risk Assessment – CPR 18E', First Edition, 1999, Committee for Prevention of Disasters (Netherlands -'Purple Book').

5. 'Methods for the Calculation of Physical Effects – CPR 14E', Third Edition, 1997, Committee for Prevention of Disasters (Netherlands -'Yellow Book').

6. Guidelines for Evaluating the Effects of Vapour Cloud Explosions using a TNT Equivalency Method, FM Global, 1994.

7. Scilly NF and Crowther JH. Methodology for Predicting Domino Effects for Pressure Vessel Fragmentation. International Symposium on Process Safety, Orlando 1992.

8. Assessment of Dangerous Toxic Load for Specific Level of Toxicity & Significant Likelihood of Death, Hazardous Installations Division, Health & Safety Executive.

9. The SFPE Handbook of Fire Protection Engineering, 3rd Edition, 2002.

10. Weather Data Supplied by Met Eireann for the synoptic Weather Station at Belmullet.

11. HSE (2002), 'Offshore Hydrocarbon Release Statistics, 2001', HID Statistics Report HSR 2001 002.

12. Evans M, Jones R and Overstreet R. Modelling Hydrochloric Acid Evaporation in Aloha. Report No. Hazmat 93-3. July 1993.

13. Guidance for the Location and Design of Occupied Buildings on Chemical Manufacturing Sites, Chemical Industries Association, 1998. ISBN 1 85897 077 6.

14. Cohen JD and Butler BW. Modelling Potential Structure Ignitions from Flame Radiation Exposure with Implications for Wildland/Urban Interface Fire Management. 13th Fire and Forest Methodology Conference, Lorne Australia, 1996.

15. Draft guidance Note to Industry – requirements for Fire Water Retention Facilities (LC10) – Environmental Protection Agency

16. Design of Containment Systems for the prevention of water pollution from Industrial Incidents – Construction Industry Research and Information Association (CIRIA)

17. Managing Firewater and Major Spillages: PPG18 – Scottish Environment Protection Agency, Environment Agency, and Environment and Heritage Service

18. Guidance on the Interpretation of Major Accident to the Environment for the purposes of the COMAH Regulations

19. HSA Guidance on Interpretation of Major Accident to the Environment

20. Contaminated Firewater Retention Report for Corrib Field Development:Bellanaboy Bridge Gas Terminal – No. L3847-000-110-0042, submitted as response to request for further information for the HSA.

21. Personal Communication – draft guidance on Transfer of Materials for Scheduled Activities from Environmental Protection Agency

22. Guidance on Land Use Planning as Required by Council Directive 96/82/EC (ISBN 92-828-5899-5)

23. Safety Cases for Consultation Distances for Major Hazard Installations, P97, RP Pape from Safety Cases within the CIMAH Regulations 1984, Edited by F.P. Lees & M.L. Ang, Butterworth 1989

24. Murgatroyd I, 'Forest and Moorland Fire Suppression' Technical Note 3, Forestry Commission, Edinburgh, 2002

Appendix 6 Additional Information

CONTENTS

APPENDIX X

External Hazards

scenario has therefore not been included in the QRA. The consequences of a failure of a road tanker during a transfer operation could cause 18te to be released, and give a pool which could be ignited and therefore result in a pool fire. The consequences have been modelled for the information of the HSA as given in Table IX.2.

Table IX.2 Consequence Distances (m) - Major Failure of a Road Tanker

Thermal Radiation Level (kW/m2)	Windspeed 2m/s	Windspeed 5m/s	Windspeed 15m/s
20	27	30	32
4	45	42	42

IX. BUND OVERTOPPING AND CATASTROPHIC ROAD TANKER FAILURE

The HSA indicated that explanations for the exclusion of the following events together with an indication of the event consequences should be included in the QRA report.

IX.1 Bund Overtopping

A few failures of atmospheric storage tanks have resulted in the contents of the tank being released in such a way that some of the contents have spread over the bund wall (Wilkinson A). These failures have been attributable to either brittle failure or failure following a fire in the bund or external explosion, but are very rare. Most of the brittle failures have been in old crude oil tanks, and the escalation incidents have been due to ignition by lightning, involved heated tanks or terrorist activities. If only failures in atmospheric tanks containing oil products are considered, Wilkinson reported two failures in 20years in the USA. The tank population was 600,000 tanks giving a failure frequency of 2E-07per tank year. As this report was based on data up to 1988, with 15 further years with only one reported bund overtopping incident for a general purpose liquid tank, the derived failure frequency becomes 1.4E-07per tank year. As the storage tanks will be built to modern standards, are not heated and have internal floating roofs with inert blanketing, DNV considers that the bund overtopping failure will be even lower, and hence this mode of failure can been neglected. Historically, a failure of a tank followed by a failure of the bund is more likely to occur than a bund overtop, but the consequences could be similar depending on how extensive the bund failure is.

It is often assumed that a typical bund overtop will be 50% of the tank capacity (HSE, HFL SRAG). However, taking account of the design of the tanks proposed for the storage of condensate and methanol, the predicted overtop for vertical bund walls is 62% of the contents (Atkins 2001). The (circular) pool size of the liquid which overtops the bund varies according to the assumption about substrate as given in Table IX.1.

Table IX.1 Bund Overtopping – Predicted Circular Pool Diameters

Tank Type	Pool Diameter (m) for Concrete	Pool Diameter (m) for Wet Soil	Pool Diameter (m) for Dry Soil
Condensate	236	136	105
Raw Methanol	270	156	121
Methanol	191	110	85

IX.2 Catastrophic Failure of a Road Tanker

In certain circumstances there could be a major failure of a road tanker containing either condensate or methanol whilst a tanker is on a customer site. The frequency for methanol deliveries is estimated as 2-3 transfers per week (150 per year), for condensate is 7 per year (but only starting in year 5) and for odorant is once per quarter (4 per year). Using data from ACDS on petroleum tankers, and assuming that the tankers travel 1km within the terminal fence, are ten times less likely to have an incident in the terminal than on the UK roads (because of low speeds etc) and applying a historical ignition probability to the spill (0.03), the frequency of a large release from a road tanker whilst on the site is approximately 1E-08per year for methanol, and considerably lower for the odorant and the condensate. This

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APPENDIX IX

Bund Overtopping and Road Tanker Failure

Stream No	From	To	Material Released	Scenarios	Comments	Dispersion Distance(m) to LFL at ground level F2	Dispersion Distance(m) to LFL at ground level (Largest Failure D5)	Distance(m) to 6kW/m2 or 1000TDU
1004	FCV	C-4001	MeOH-0.3	Full bore and 25,mm holes				20
6	C-4001	E-4002	MeOH-0.98	None				
7	E-4002	D-4002	MeOH-0.98	None				
1005	D-4002	P-4003A/B	MeOH-0.98	Full bore and 25,mm holes				22
8	P-4003A/B	C-4001	MeOH-0.98	Full bore and 25, and 12mm holes				19
1006	P-4003A/B	LCV-D-4002	MeOH-0.98	50 and 12mm holes				16
9	LCV-D-4002	T-4002A/B	MeOH-0.98	50 and 12mm holes				15
Catastrophic Failures								
D-1003	Inlet Separator					59	59	324
D-2007	Cold Separator					61	61	346
D-2009A	Sales Gas Compressor Suction Drum					61	61	346
D-2009B	Sales Gas Compressor Suction Drum					61	61	346
D-3001	MP Flash Drum					11	11	44
D-4001	Methanol Flash Drum					11	11	51
Specific Failures								
Road loading/offloading			MeOH					24
Pigging			CH4			142	191	301
Odorant			Odorant					24
Tank fire								
Bund fire								60

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Stream No	From	To	Material Released	Scenarios	Comments	Dispersion Distance(m) to LFL at ground level F2	Dispersion Distance(m) to LFL at ground level (Largest Failure D5)	Distance(m) to 6kW/m2 or 1000TDU
260a	D-4001	LCVC-D-4001	Condensate	75 25 and 12mm holes				36
260	LCVC-D-4001	#206a	Condensate	None Low flow				
261a	D-4003	LCVC-D-4003	Condensate	None Low flow				
261	LCVC-D-4003	#260	Condensate	None Low flow				
302	SC Manifold	FCVM-SC Man	Condensate	12mm holes				30
1	FCVM-SC Man	D-4001	MeOH-0.3	Full bore and 75, 25, and 12mm holes				31
310	D-1003	LCVM-D-1003	MeOH-0.3	12mm holes				29
310a	LCVM-D-1003	#1	MeOH-0.3	None				
320	D-2007	LCV-D-2007	Condensate	12mm holes				17
320a	LCV-D-2007	#1	Condensate	None Low flow				
330a	D-3001	LCVM-D-3001	MeOH-0.3	50 and 12mm holes				36
330/2	LCVM-D-3001	#1	MeOH-0.3	None				
450b	D-4001	LCVM-D-4001	MeOH-0.3	Full bore and 75, 25, and 12mm holes				76
450c	LCVM-D-4001	T-4001A/B/C	MeOH-0.3	Full bore and 75, and 25mm holes				74
1000	T-4001A/B/C	P-4001A/B	MeOH-0.3	Full bore and 75, and 25mm holes				66
1001	P-4001A/B/C	FCV	MeOH-0.3	Full bore and 25, and 12mm holes				23
1002	FCV	E-4001	MeOH-0.3	Full bore and 25, and 12mm holes				23
1003	E-4001	D-4003	MeOH-0.3	Full bore and 25, and 12mm holes				23
3	D-4003	FCV	MeOH-0.3	Full bore and 25, and 12mm holes				29

Stream No	From	To	Material Released	Scenarios	Comments	Dispersion Distance(m) to LFL at ground level F2	Dispersion Distance(m) to LFL at ground level (Largest Failure D5)	Distance(m) to 6kW/m2 or 1000TDU
206	D-3001	LCVC-D-3001	Condensate	Full bore and 75, 25, 12 and 2mm holes				36
206a	LCVC-D-3001	E-3001	Condensate	None Low flow				
207	E-3001	D-3002	Condensate	None Low flow				
209	D-3002	P-3004A/B	Condensate	Full bore and 75mm holes				21
210	P-3004A/B	E-3002	Condensate	None Low flow				
211	E-3002	N-3001	Condensate	None Low flow				
211a	N-3001	LCV-D-3002	Condensate	None Low flow				
211b	LCV-D-3002	T-3001A	Condensate	Full bore and 75mm holes				24
211c	T-3001B	P-3001A/B	Condensate	Full bore and 75mm holes				24
211d	P-3001A/B	Tanker Loading	Condensate	Full bore and 75 mm holes				14
220	D-1003	LCVC-D-1003	Condensate	12mm holes				18
220a	LCVC-D-1003	#203	Condensate	75 and 25mm holes				18
228	D-2007	LCVC-D-2007	Condensate	12mm holes				17
230	D-2009A	LCV-D-2009	Condensate	12mm holes				16
231	LCV-D-2009	#203	Condensate	50 and 12mm holes				13
233	LCVC-D-2007	E-2007	Condensate	75 25 and 12mm holes				51
234	E-2007	#203	Condensate	None Low flow				
250	D-3003A	LCV-D-3003A	Condensate	50mm holes				13
250a	LCV-D-3003A	D-3001	Condensate	None Low flow				

Stream No	From	To	Material Released	Scenarios	Comments	Dispersion Distance(m) to LFL at ground level F2	Dispersion Distance(m) to LFL at ground level (Largest Failure D5)	Distance(m) to 6kW/m2 or 1000TDU
120b	NRV (Process Area)	NRV (Meter Area)	CH4	Full bore and 75, 25, 12 and 2mm holes		49	78	295
120c	NRV (Meter Area)	FCV	CH4	Full bore and 75, 25, 12 and 2mm holes		49	78	295
121	FCV	Sales Gas Export Line NRV	CH4	Full bore and 75, 25, 12 and 2mm holes		49	78	295
121b	Sales Gas Export Line NRV	Onshore Pipeline	CH4	75, 25, 12 and 2mm holes	Larger hole sizes discounted as 'not credible'	142	191	301
900/1	#120b	E-8403	CH4	Full bore and 25, 12 and 2mm holes		51	78	86
4	E-8403	D-8402	CH4	Full bore and 25, 12 and 2mm holes		33	52	50
3	D-8402	GT Driver	CH4	Full bore and 25, 12 and 2mm holes		33	52	50
2 phase gas releases								
202a	Slug Catcher Oulet	SC Manifold	2 phase gas	Full bore and 75, and 25mm holes		292	431	390
202	SC Manifold	FCVC-SC Man	2 phase gas	Full bore and 75, and 25mm holes		261	328	317
220	D-1003	LCVC-D-1003	2 phase gas	Full bore and 25mm holes		214	282	152
228	D-2007	LCVC-D-2007	2 phase gas	Full bore and 25mm holes		288	276	144
230	D-2009A	LCV-D-2009	2 phase gas	Full bore		277	183	106
302	SC Manifold	FCVM-SC Man	2 phase gas	Full bore and 75, and 25mm holes		256	314	243
310	D-1003	LCVM-D-1003	2 phase gas	Full bore and 25mm holes		231	291	155
320	D-2007	LCV-D-2007	2 phase gas	Full bore		282	196	111
Liquid releases								
202a	Slug Catcher Oulet	SC Manifold	Condensate	12mm and 2mm holes				19
202	SC Manifold	FCVC-SC Man	Condensate	12mm and 2mm holes				19
203	FCVC-SC Man	D-3001	Condensate	Full bore and 75, 25, 12 and 2mm holes				20

Table VIII.1 Scenarios and Consequence Information

Stream No	From	To	Material Released	Scenarios	Comments	Dispersion Distance(m) to LFL at ground level F2	Dispersion Distance(m) to LFL at ground level (Largest Failure D5)	Distance(m) to 6kW/m2 or 1000TDU
High Pressure Gas System								
100a	Sealine	ESDV	CH4	75, 25, 12 and 2mm holes	Larger hole sizes discounted as 'not credible'	65	100	106
100	ESDV	Slug Catcher Inlet	CH4	Full bore and 75, 25, 12 and 2mm holes		142	191	301
100b	Slug Catcher Inlet	Slug Catcher Outlet	CH4	75, 25, 12 and 2mm holes	Larger hole sizes discounted as 'not credible'	65	100	106
101	Slug Catcher Oulet	PCV	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
103	PCV	D-1003	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
104a	D-1003	Mercury Removal	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
104	Mercury Removal	E-2004	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
108	E-2004	Propane Refrig (Future)	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
109	Propane Refrig (Future)	PCV	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
112	PCV	D-2007	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
113	D-2007	E-2004	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
117	E-2004	D-2009A	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
118	D-2009A	K-2002A	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
119	K-2002A	E-2005A	CH4	Full bore and 75, 25, 12 and 2mm holes		138	188	295
120	E-2005A	NRV (Process Area)	CH4	Full bore and 75, 25, 12 and 2mm holes		51	79	295
120a	E-2005A	D-2009A	CH4	Full bore and 75, 25, 12 and 2mm holes		26	38	295

VIII. SCENARIOS AND CONSEQUENCE INFORMATION

A list of scenarios and consequence information is given in Table VIII.1.

CONTENTS

APPENDIX VIII

Scenarios and Consequence Information

Source / Scenario / Scale of Effect	Prevention, Control and Mitigation	Likelihood (NC/L/M/H)	Impact/Significance	MATTE (Y/N)
30% HYDROCHLORIC ACID (HCL): The 3te of 30% hydrochloric acid solution is the total inventory of three containers. This scenario involves the release of 1.5 tonnes maximum of HCl solution (one full container and one half full). Release of HCL vapour due to evaporation of spilled material.	Hydrochloric acid is transferred via Intermediate Bulk Carrier (IBC) units and these are designed in accordance with UN standard. See above for collection of liquids spilled onto paved or unpaved areas. Any leaks will be neutralised in the local sump. From there it will be routed to the surface water treatment system.	L	Spillage of hydrochloric acid in kerbed area or unpaved area. Infiltration of HCl solution into the soil is likely to occur. The presence of firewater and water in the soil will influence the rate of chemical movement. During transport through the soil, HCl solution will dissolve some of the soil material, in particular those of a carbonate base. The acid will be neutralised to some degree. However, quantities of acid may remain in transport and enter the underlying aquifer. However due to the relatively small quantities involved in this scenario and the effects of dilution it is unlikely to constitute a MATTE. Any release of HCl solution to the watercourse will undergo further dilution and is unlikely to constitute a MATTE. Any evaporation from a HCl pool is likely to result in localised short-term impact. Dilution is assumed to be relatively rapid.	N

Source / Scenario / Scale of Effect	Prevention, Control and Mitigation	Likelihood (NC/L/M/H)	Impact/Significance	MATTE (Y/N)
ODORANT: Catastrophic failure of a full odorant storage tank resulting in the release of the entire inventory of 9te. This release could overtop the bund (or cause the bund to fail). Overtopping or bund failure could lead to a pool of some 13m diameter outside the bund (assuming 40% overtopping). 1. Spillage to paved and unpaved ground. 2. Evaporation from a spillage of odorant. 3. Ignition of odorant release. 4. Firewater/foam.	1. See comment in Stabilised Condensate section with respect to tank and bund design etc. Odorant storage tank is designed in accordance with A.D.Merkblatter design codes (German Code). The vessel is constructed of stainless steel with double skin to provide additional mitigation against leaks etc. The vessel is located within a bund of 130 % of the vessel capacity. If an odorant spill of this size enters the on-site drainage system it will flow to the open drains sump. 2. Dispersion of vapour from a leak into the bund gives a maximum of 200m to 1ppm of dimethyl sulphide and 300m to 1 ppm tertiary butyl mercaptan. Spillage would be neutralised by operational staff with wearing breathing appratus. 3. There are no ignition sources in the vicinity of the odorant storage. Any ignited pool would be quickly extinguished using foam, so the quantity of combustion products would be small. 4. See comments above for releases to paved and unpaved areas.	NC	1. Any odorant released to the receiving watercourse may raise the COD in excess of a few days and may therefore constitute a MATTE. 2. Release of VOC. Tertiary butyl mercaptan released in air degrades photochemically to produce hydroxyl radicals (estimated half-life 1.6days). The odour is likely to be nuisance only. 3. Combustion Products (Ignited odorant has the potential to produce large quantities of smoky combustion products. Other toxic decomposition products may occur in cases of incomplete combustion).	Y N N

Source / Scenario / Scale of Effect	Prevention, Control and Mitigation	Likelihood (NC/L/M/H)	Impact/Significance	MATTE (Y/N)
MERCURY: Mercury absorbers fail releasing the solid absorbent and associated mercury sulphide. 1. Release of absorbent to atmosphere. 2. Ignition following release.	1. Mercury removal is carried out by a solid bed system. Spent absorbent bed is removed by Licensed Contractor for offsite disposal. Mercury absorbent is contained in vessels designed, manufactured, tested and inspected in accordance with ASME VIII. Vessels are also subject to integrity check in accordance with PED. Any spillage would be cleared up by operational staff. The mercury is 'bonded' to the absorbent and will remain 'bonded to this material on release to atmosphere. 2. Absorbent and mercury sulphide are not combustible, and it is not anticipated that the mercury would be released in the event of the natural gas being ignited.	L	1. Release of absorbent to atmosphere, and eventual deposition on the ground or in water courses. 2. Combustion products released to atmosphere.	N (NC)

Source / Scenario / Scale of Effect	Prevention, Control and Mitigation	Likelihood (NC/L/M/H)	Impact/Significance	MATTE (Y/N)
METHANOL (RAW): Catastrophic failure of a full raw methanol storage tank resulting in the release of the entire inventory of 1022te of methanol/water mix. This release could overtop the bund (or cause the bund to fail). Overtopping or bund failure could lead to a pool of some 155m diameter outside the bund.	See comment under stabilised condensate section with respect to tank and bund design etc. See under methanol section for methanol/water mixtures.	NC	Although the release is only 30% methanol in water the inventory is greater than that for pure methanol, and the release may therefore have a similar MATTE potential as for the methanol release scenario, due to the difficulties that would be encountered with remediating contaminated aquifers.	Y
DIESEL: Catastrophic failure of a full diesel storage tank resulting in the release of the entire inventory of 60te. This release could overtop the bund (or cause the bund to fail). Overtopping or bund failure could lead to a pool of some 40m diameter outside the bund..	See comment in Stabilised Condensate section with respect to tank and bund design.	NC		
1. Diesel to unpaved ground.	1. Any overflow from the tank is routed to open drains system via paved area.	L	1. Diesel released to unpaved ground could migrate through the soil and enter surface or groundwater. Any diesel released to the receiving watercourse may raise the COD in excess of a few days although the quantity may be too small to constitute a MATTE.	N
2. Evaporation from a spillage of diesel.	2. Spills would be cleared up by quickly by operational staff. Diesel has low volatility.		2. Release of VOCs to atmosphere. The concentration of VOC released to atmosphere following a release of diesel will have a localised short-term impact.	N?
3. Ignition of diesel release.	3. Diesel has a flash point well above ambient temperature and so ignition of a spillage is very unlikely. Fire fighting facilities onsite will enable any fire to be quickly extinguished. Foam will be used to extinguish the fire.		3. Combustion products to atmosphere and deposited on the ground/water. (ignited diesel has the potential to produce large quantities of smoky combustion products). Fallout is likely to occur in the prevailing wind direction with deposition occurring somewhere downwind.	N?
4. Foam used during the extinguishment of diesel fire.	4. As per 1. above. Foam and any firewater can be contained within the open drain sump and used fire water pond (capacity 5000m3).		4. Release of contaminated firewater to watercourses or groundwater.	N?

Source / Scenario / Scale of Effect	Prevention, Control and Mitigation	Likelihood (NC/L/M/H)	Impact/Significance	MATTE (Y/N)
METHANOL: Catastrophic failure of a full methanol storage tank resulting in the release of the entire inventory of 380 te. This release could overtop the bund (or cause the bund to fail). Overtopping or bund failure could lead to a pool of some 115m diameter outside the bund. 1. Liquid could pass into the open drain system or onto unpaved ground. 2. Pooled methanol would evaporate to air. 3. Ignition of methanol release. 4. Firewater may be used to control/extinguish a fire in the bund, and this could cause bund overtopping.	See comment under Stabilised Condensate section with respect to tank and bund design etc. 1. Methanol contaminated water from the open drain sump (spillage onto paved area) will be routed through the raw methanol storage tanks to the methanol still for regeneration or taken away for disposal by a licensed waste contractor. If the mixture were spilled on an unpaved area, it would pass through the peat to the interceptor. This would take hours/days rather than seconds/minutes, and the valve on the outlet from the interceptor would be closed (manual operation). Material collected in the interceptor would be pumped back to the open drain sump for treatment. Open drain sump has a capacity (346 m3) in excess of a methanol tank. 2. Spilled methanol will be quickly covered and recovered by operational staff to minimise evaporation. 3. Sources of ignition are strictly controlled, and extensive fixed fire fighting facilities are provided. 4. Firewater/methanol mix onto paved/unpaved area. See above for bund overflow capacity and for liquid spillages onto paved or unpaved areas.	NC	1. Methanol is completely miscible in water and is highly mobile in soil. Therefore any release to unpaved ground has the potential to permeate the subsoil and enter the underlying aquifer. As methanol is fully miscible with water, remediation of the aquifer would be complex if not impossible, and as such would constitute a MATTE as an incident requiring large scale and long term remediation of an aquifer. 2. The concentration of vapour which would pass into the atmosphere following a release will be very low because of the vapour pressure of methanol. There will not be more than a localised short-term impact offsite, and this element of an incident alone would not constitute a MATTE. 3. Combustion products released to air (methanol burns cleanly without soot formation, but will generate oxides of carbon, and water). 4. Release of contaminated firewater to watercourses or groundwater.	Y N N N

Source / Scenario / Scale of Effect	Prevention, Control and Mitigation	Likelihood (NC/L/M/H)	Impact/Significance	MATTE (Y/N)
UNSTABILISED CONDESATE /METHANOL/WATER: Catastrophic failure of the liquid offtake from the slugcatcher resulting in the release of a maximum of 10 te condensate. Condensate liquid could pass through the open drains system or be released to unpaved areas.	The slugcatcher and associated pipework are designed, manufactured and tested in accordance with ASME B31.3. The areas beneath flanged connections are paved. Any leakage is routed to the open drains sump and thereon to be treated in the surface water treatment system. Any liquid spilt onto unpaved areas would pass through the peat to the interceptor. The capacity of the interceptor is 10 m3.	L	Condensate released to unpaved ground may contaminate the surface and/or groundwater. Any condensate released to the receiving watercourse may raise the Chemical Oxygen Demand (COD) in excess of a few days and may therefore constitute a MATTE, although the small quantities of condensate involved mean that this unlikely.	N (NC)
Ignition of the released condensate.	Sources of ignition are strictly controlled, and extensive fire fighting facilities are provided for liquid fires in all affected parts of the terminal.		Release of combustion products of ignited condensate to atmosphere. The mixture would be expected to burn cleanly (unlikely to produce sooty combustion products) with generation of heat (thermal radiation).	N

Source / Scenario / Scale of Effect	Prevention, Control and Mitigation	Likelihood (NC/L/M/H)	Impact/Significance	MATTE (Y/N)
STABILISED CONDENSATE: Catastrophic failure of a full condensate storage tank resulting in the release of the entire inventory of 520 t. If the bund overtopped or failed it could lead to a pool of some 140m diameter outside the bund. Liquid could pass into the open drain system or onto unpaved ground.	All storage tanks are designed, manufactured, inspected and tested in accordance with BS 2654. Bunds are designed in accordance with NFPA 30 to contain at least 110 % of the maximum capacity of one tank. Bund design and construction also satisfies the recommendation of UK EA Pollution Prevention Guidelines (PPG2) and provides 250mm of free board over the 110% capacity to overcome dynamic effects such as over topping due to waves etc. A hole in the tank, which is more likely than a catastrophic failure followed by a bund overtop, would be contained within the bund. Each bund is built of reinforced concrete and is designed to withstand any sort of release from a tank failure however sudden or catastrophic. The bund design incorporates an overflow pipe which would direct liquid to the open drains system where the spill would be contained. The open drains system has a capacity in excess of that required to contain any overflow from the bund. Condensate collected in the open drain sump will be removed for disposal by licensed waste contractors.	NC	Condensate released to unpaved ground may contaminate the surface and/or groundwater. Any condensate released to the receiving watercourse may lower the COD for more than one month and may therefore constitute a MATTE.	N (NC)
Ignition of condensate release will generate products of incomplete combustion (including oxides of carbon and nitrogen, soot, and other partial combustion products).	Sources of ignition are strictly controlled, and extensive fixed and mobile fire fighting facilities are provided. This will enable any ignited release to be quickly extinguished. Tanks within the range of a condensate tank fire will be deluged with fire water to keep them cool and prevent the local fire igniting their contents.		Combustion products of an ignited condensate release may contaminate ground, and surface/groundwater in the surrounding area, but is unlikely to constitute a MATTE.	N

Table VII.1 Environmental Hazards

Note NC = Not Credible

Source / Scenario / Scale of Effect	Prevention, Control and Mitigation	Likelihood (NC/L/M/H)	Impact/Significance	MATTE (Y/N)
HYDROCARBON GAS: Loss of containment from terminal plant: 1. Release 2. Ignition 3. Firefighting	Gas leaks or fires lead to shutdown (ESD): 1. The subsea pipeline is designed to IS 328 and DNV 2000 codes. All pressure containing equipment are designed, manufactured, inspected and tested to BS 5500 or ASME VIII design code. The piping systems are designed, manufactured, inspected and tested to ASME B 31.3. Additionally, Corrib pressurised systems are subject to an integrity check in design, manufacture and construction process by application of the European "Pressure Equipment Directive (PED)". There is a very short length of thick wall pipeline before the terminal ESD which is not anticipated to fail (see main report). All other equipment is downstream of the terminal ESD. In the event of a release this valve would be closed either automatically by the fire and gas system or remotely from the control building. 2. Control of ignition sources through zoning and safety management system. 3. Used firewater routed via open drain system to the used firewater pond for monitoring and possible treatment before discharge or re-use.	Upstream of ESD NC Downstream of ESD L	1. Release of hydrocarbon vapour, primarily methane, to atmosphere limited in extent and duration . 2. Release of combustion products to atmosphere. Ignited methane would be expected to burn cleanly (unlikely to produce sooty combustion products) with generation of heat (thermal radiation) and possibly overpressure. 3. Release of contaminated firewater to watercourses or groundwater.	N N N

VII. ENVIRONMENTAL HAZARDS

Some of the materials handled in the plant could cause an impact on the environment of the development. The potential for impact on the environment is covered in detail in the Environmental Impact Statement. This Appendix indicates releases of material that may have the potential to cause a Major Accident To The Environment (MATTE). The table below includes the source of leakage, with a short description of the scenario, measures to prevent, control or mitigate the scenario, an indication of the likelihood, and the potential impact should the measures fail. The information in the column headed 'Prevention, Control, Mitigation' in the table below has been provided by Amec, and that in the column headed 'Impact/Significance' has been provided by RSK. The list is not an exhaustive list of possible scenarios but is representative of a range of low frequency events (and associated high consequence) for the various hazardous materials on the site.

Representative Hole Diameter (mm)	Equivalent Hole Diameter Range (mm)
2	0 to 2.83
12	2.83 to 16.7
25	16.7 to 31.1
75	31.1 to 101.4
Full Bore Rupture	>101.4

* A 75mm hole in items of equipment with diameters of 3" or less has been categorized as Full Bore Rupture.

For each of the equipment categories the number of incidents in each range over the 8 year period studied was divided by the relevant equipment "population". This gives the failure frequency of the equipment per year.

The types of equipment in the database can be differentiated by those which are an item or unit; such as a pump or a compressor, and those which are continuous such as pipework. In the case of the former the population is defined in terms of the number of unit years, in the latter as the number of metre years. Hence the failure frequency of pumps is given per pump year and the failure frequency of pipework is given per metre year.

When the pipework data were considered it was decided to use two categories; those below 3" diameter and those above 3" diameter. A finer categorization as in the AEA Technology report was not used because it was concluded that the data did not support this as the frequency distribution in the hole size ranges shown for categories of pipework in the ranges 3" to 11" and >11" categories was very similar.

When deriving the piping frequencies, DNV has made the following adjustments:

- For pipework with diameters less than 3" (75mm), there were no full bore failures, but there were failures in the 25mm hole size range. As the full bore failure of pipework cannot be entirely ruled out, it was decided to use the 25mm hole size frequency as the failure frequency and adjust the 25mm frequency to zero, thus keeping the overall failure frequency in line with the data.
- For welded pipework running on pipe supports outside the process areas, a reduction factor of 10 was applied as described in Section II.3.

The following table gives the frequencies used by DNV in the risk analysis of the gas terminal at Bellanaboy Bridge.

One explanation for the randomness of the actual data would be that the majority of release events do not occur at the operating pressure of the leaking system. For example they occur during maintenance, start-up after maintenance, or other non-steady state operating condition. Though for the purposes of this exercise it is not necessary to understand why this apparent randomness is occurring.

For a QRA analysis of an offshore installation or other facility we want to achieve assumptions that accurately reflect the release size / frequency distribution seen in reality. Use of the actual recorded hole size data and assuming that these holes occur in systems which are at normal operating pressures will not achieve this goal, instead it will give an analysis which shows a far higher percentage of large releases than is actually the case in reality. Hence for use in QRA work it is recommended that BP operations do not use the hole size / frequency distribution given in the AEA Technology report, but instead use the following analysis.

The BP Analysis Methodology

For each incident BP has taken the implied average release rate (mass released divided by duration) and the operating pressure of the system in which the release occurred and derived a hole size consistent with these two parameters. Standard release rate equations have been used for this comparison, differentiating between fluids described as "Gas" in the database and all other process fluids ("process oil", "2-phase", "condensate", etc) which have been considered as "Liquids".

The equations used to derive the equivalent hole area A and hence equivalent diameter were:

For Gas: Flowrate (kg/s) = $587 \times A \times \sqrt{\rho \times (22.4/273) \times P}$

For Liquid: Flowrate (kg/s) = $Cd \times A \times \sqrt{2 \times 10^5 \times \rho \times P}$

Where:
P = Pressure (barg)
A = Area (m^2)
ρ = Density (kg/m^3)
Cd = Discharge coefficient *(0.8 implied for gas and 0.6 for liquid)*

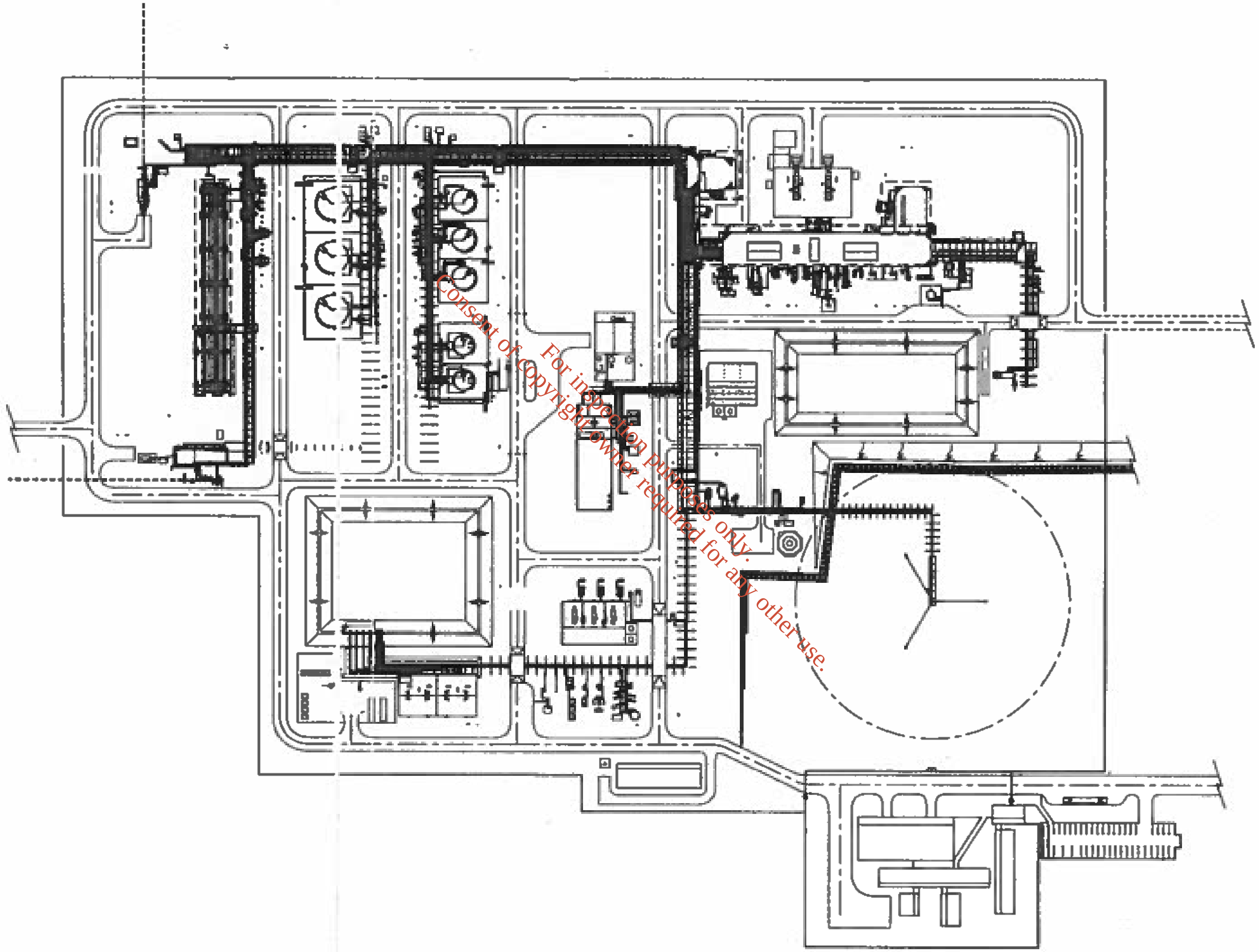
Having established an equivalent hole size for each of the incidents in the database which is consistent with a release at operating pressure, these "equivalent" hole sizes were grouped in the following ranges. The representative hole diameter for each range is selected to be that which represents the average area of the range.

APPENDIX III

Regions of Congestion

CONTENTS

III. REGIONS OF CONGESTION



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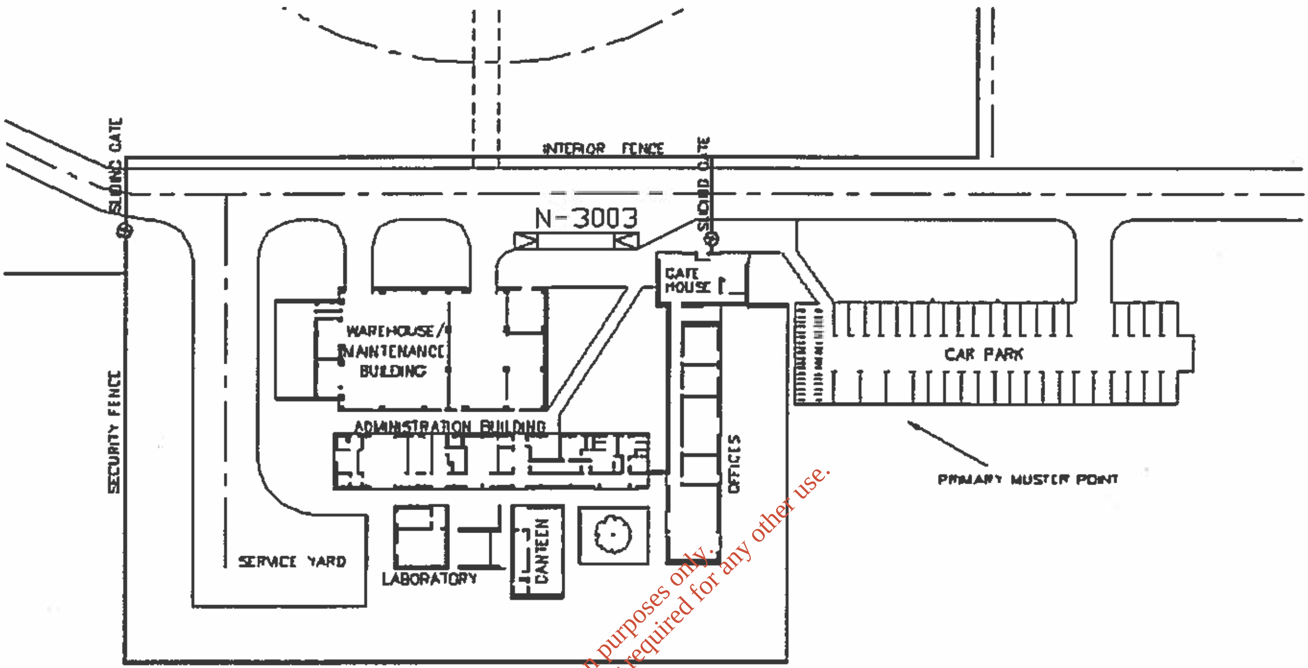
APPENDIX IV

Offsite and Onsite Populations

CONTENTS

IV. ONSITE POPULATION

Figure IV.1 Onsite Buildings near the Terminal Entrance



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CONTENTS

XIV. CONTOURS PLOTS FOR THE S[illegible]NSITIVITY ANALYSIS (30% F2 WEATHER)

Figure X[illegible]V.1 Frequency of Overpressures in Excess of 500mbar

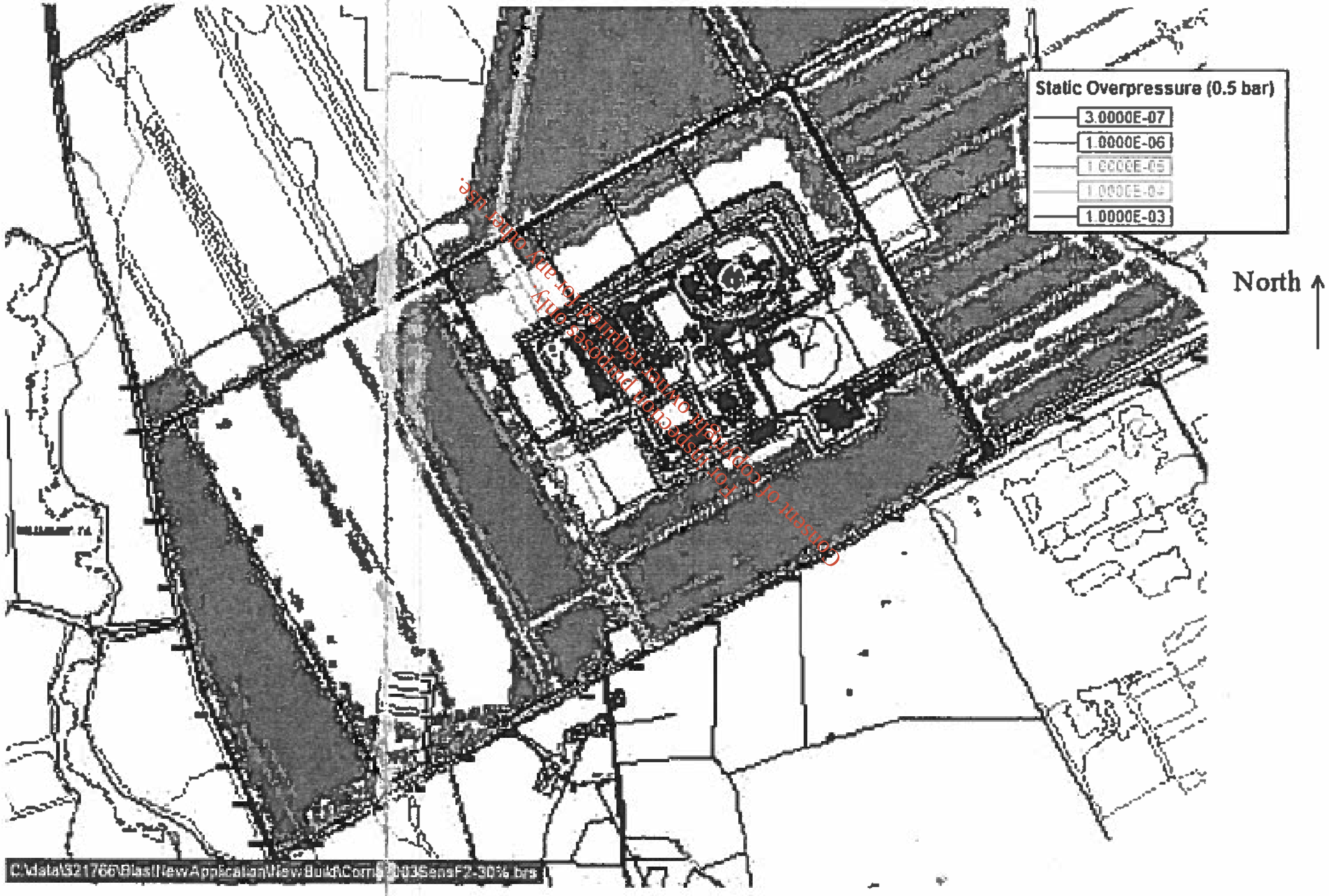


Figure XIV.3 Frequency of Overpressures in Excess of 140mbar

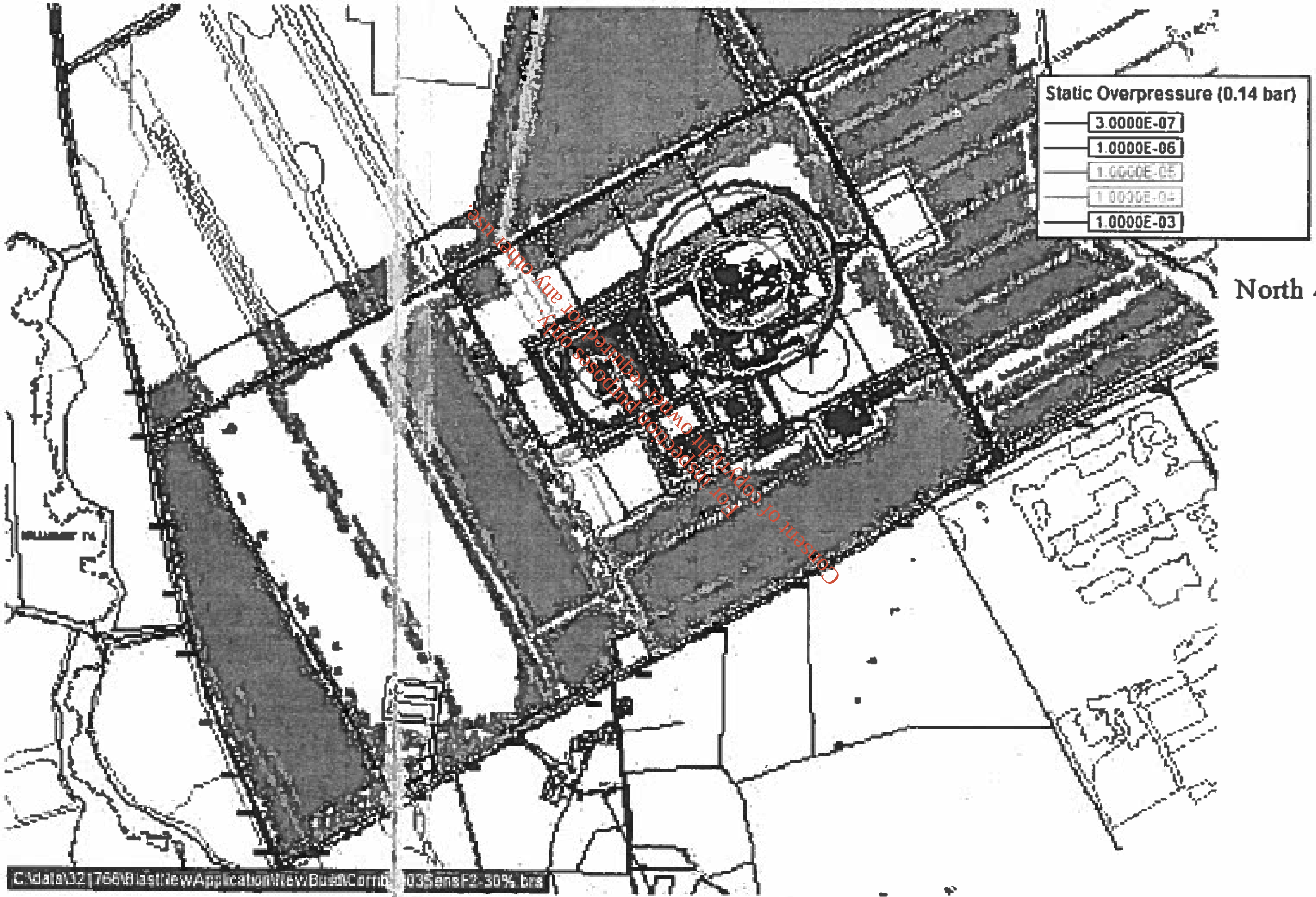


Figure XIV.2 Frequency of Overpressures in Excess of 300mbar

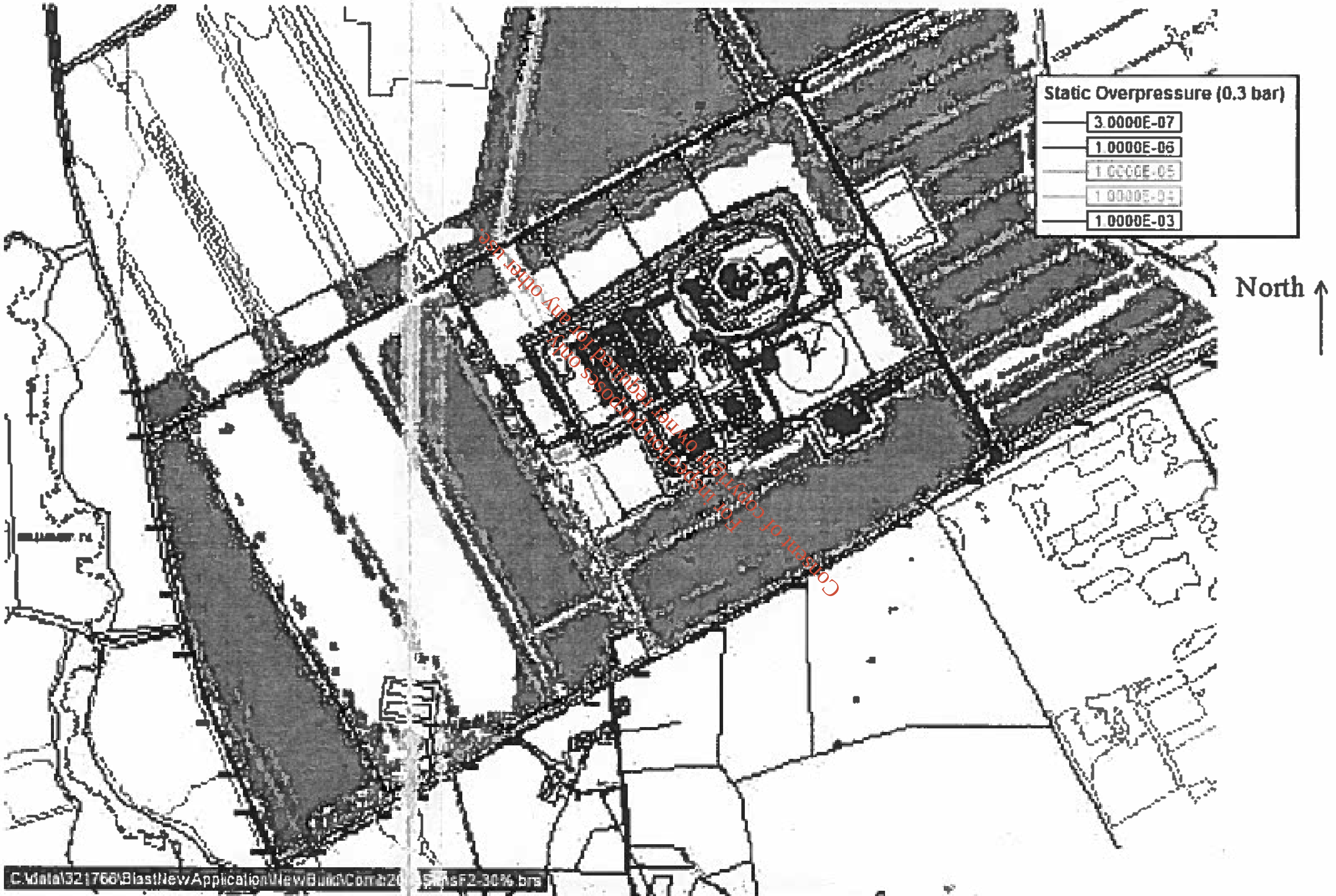


Figure XIV.4 Frequency of Overpressures in Excess of 110mbar

Figure XIV.5 Frequency of Overpressures in Excess of 70mbar

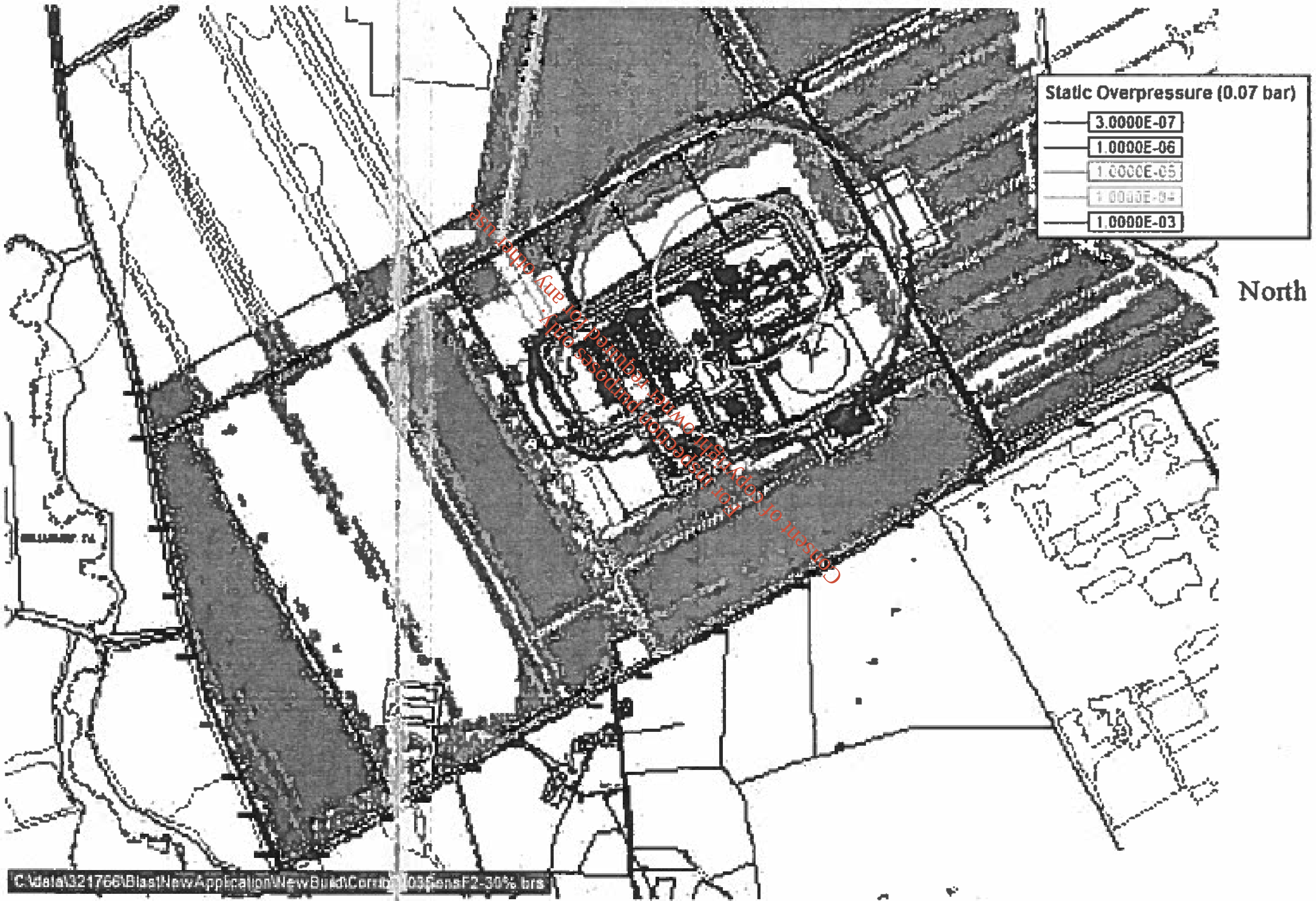


Figure XIV.6 Frequency of Overpressures in Excess of 20mbar

Figure XIV.7 Frequency of Flash Fires

APPENDIX XV

Frequency Contours for Exceeding a Dangerous Dose

CONTENTS

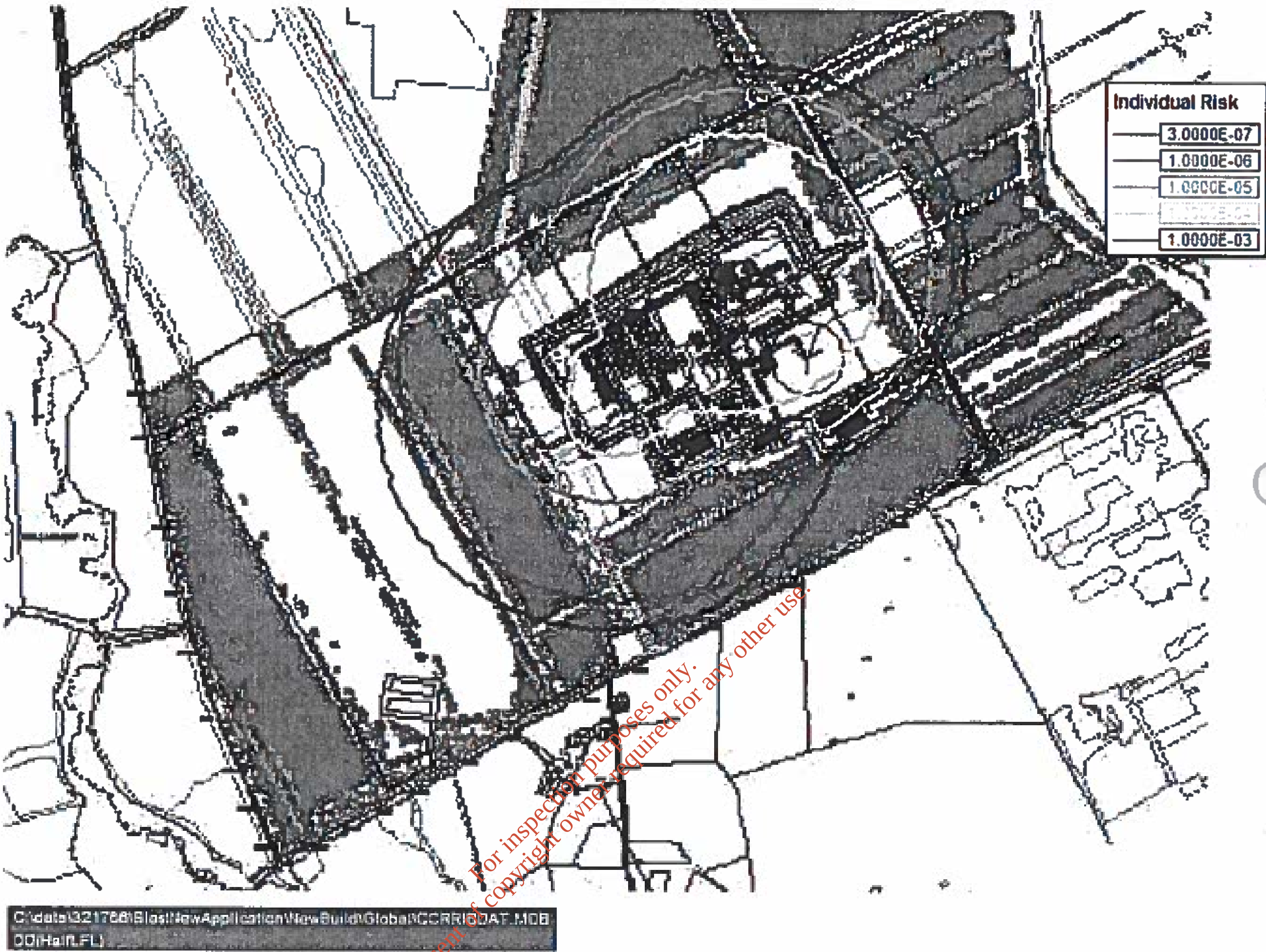
XV. DANGEROUS DOSE

The contour plots in Appendix XIII of this report show various hazards and different consequence levels. The HSA has requested that a composite contour plot is compiled to show the frequency of exceeding a Dangerous Dose. This plot combines the following:

- Frequency of overpressure in excess of 140mbar
- Frequency of thermal radiation from jet fires and fireballs that is in excess of $1000(kW/m^2)^{1.333}$ s
- Frequency of flash fires (using a concentration of half of the lower flammable limit to define the cloud)

The plot is shown in Figure XV.1. This contour plot uses the plots in Appendix XIII, and therefore the thermal radiation contribution is conservative as it does not take into account the factors incorporated in the contour plots presented in Appendix XVI (ie does not take account of factors such as the decrease in pressure and flowrate, the effect of ESDs etc). Further, in determining the flash fire impact, it has been assumed that delayed ignition ignites a cloud which is been defined by a concentration which is half of the lower flammable limit, and these clouds are also used for the overpressure effects.

Figure XV.1 Frequency of Exceeding a Dangerous Dose



APPENDIX XVI

External Fire Hazards

CONTENTS

XVI. EXTERNAL FIRE HAZARDS

The contour plots in Appendix XIII of this report show a plot for thermal radiation levels that could cause the trees around the terminal to be ignited (Figure XIII.14). This indicates that, although there is no risk to people living around the terminal, there is a potential for an incident at the terminal to give rise to a tree fire at a frequency of the order of once in 10000 years (1E-04per year) (see section 4.3.2 of the main report). The HSA has asked DNV to provide more details about this statement.

The assumptions used to construct the plots were conservative, in that they did not take into account the effect of either the pressure control equipment or the ESD valves or the reduction in operating pressure during the life of the terminal. Although this was known at the time of issue of the report, the assumptions were not refined at that time because there was no hazard to people. However, because of the interest expressed by the HAS, the potential for external fire hazards has been re-analysed to give a more accurate hazard frequency contour plot which is given below. This contour plot includes all high pressure gas events that are immediately ignited (to give either a jet flame or a fireball).

The re analysis has taken into account the following:

- The effect of the pressure control equipment in the process stream.
- The fire and gas detection system which automatically closes the emergency shutdown (ESD) valves at various points throughout the process train.
- The reduction in operating pressure and flowrate throughout the lifetime of the terminal.

The analysis has used the pressures at the years indicated in Table XVI.1.

Table XVI.1 Operating Conditions

Year	Plant Throughput (kg/h)	Operating Pressure in section before compressor (barg)
1	301000	70
5	215000	55
10	90000	34
15	52000	20

In deriving the revised hazard contour plots it has been assumed that:

- There is no change to the consequences if there is a failure of the pipeline upstream of the inlet ESD.
- A full bore failure allows the whole contents of the particular section plus 30 seconds of normal flow to be released which then burns as a fireball, but the ESD closes after 30 seconds.
- Holes allow a stable flame to establish.

- The consequence level for jet flames is 25kW/m2 (the lowest level for spontaneous ignition of wood according to Bilo and Kinsman).
- The consequence level (incident thermal flux) for fireballs is dependent on the fireball duration in accordance with the following relationship (Bilo and Kinsman):

$$K_s = (I - I_s) \times t^{0.8}$$

Where

$K_s = 167.6\ kJ/m^2\ s^{0.2}$
I = incident thermal flux kW/m^2
$I_s = 25.6\ kW/m^2$
t = duration of fireball s

Using these assumptions, the hazard frequency contours for the conditions given in Table XVI.1 have been determined together with an overall contour plot assuming 5 years operation at each condition. These are shown in Figures XV.1 to XV.5.

The composite contour plot (Figure XVI.5) now shows that the trees around the terminal are exposed to the level of thermal radiation that could ignite the trees at frequencies below 1E-05per year (approximately once in 100,000 years). This is considered to be a more realistic prediction than the prediction included in Appendix XIII which embodied conservative assumptions. UK data indicates that the frequency of any particular location in a wooded environment being engulfed by fire is 2E-04per year. The addition of the frequency of ignition due to the possible events at the terminal therefore makes a relatively small increase to the background frequency for the ignition of trees. It should also be recognised that even if an incident at the terminal did result in the ignition of trees in the vicinity, there would be a negligible risk to people.

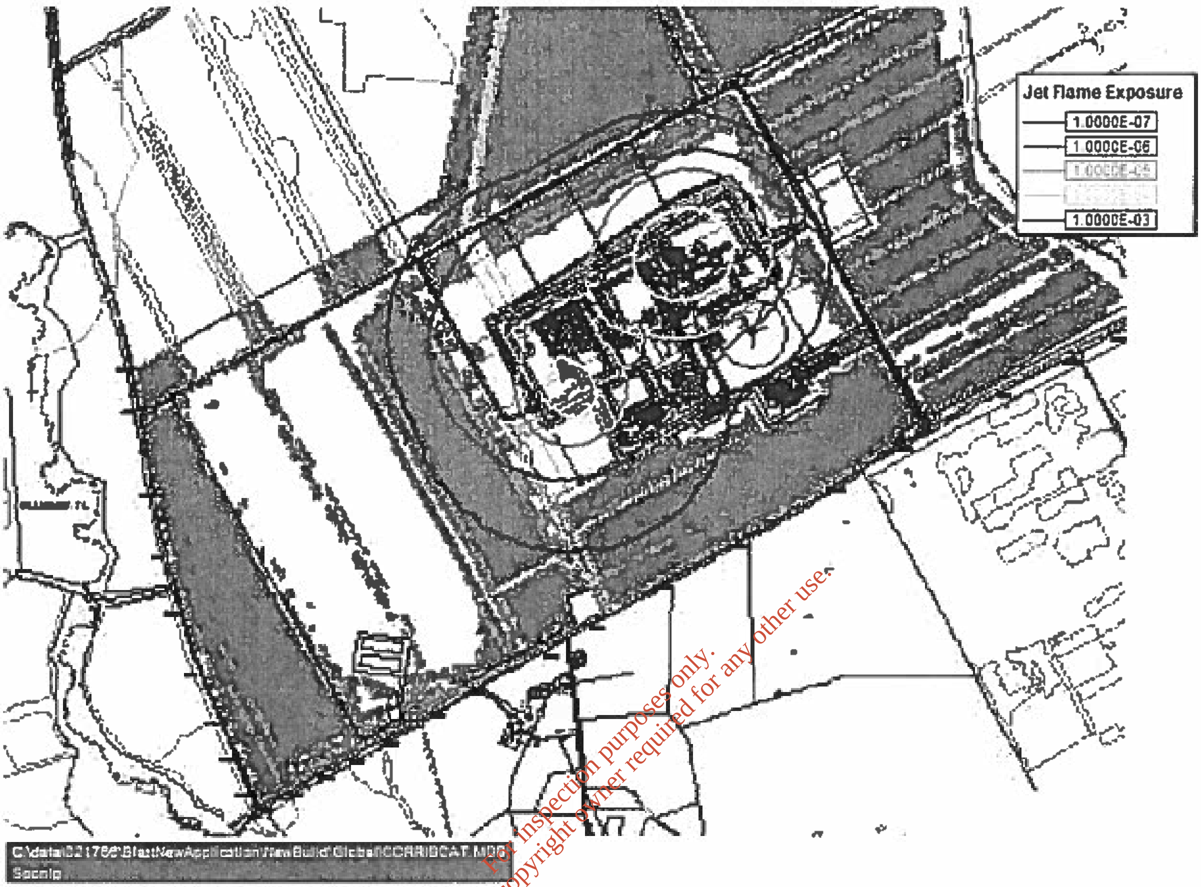
Figure XVI.1 Frequency of Thermal Radiation (Spontaneous Ignition of Wood) – Year 1

Figure XVI.2 Frequency of Thermal Radiation (Spontaneous Ignition of Wood) – Year 5

Figure XVI.3 Frequency of Thermal Radiation (Spontaneous Ignition of Wood) – Year 10

Figure XVI.4 Frequency of Thermal Radiation (Spontaneous Ignition of Wood) – Year 15

Figure XVI.5 Frequency of Thermal Radiation (Spontaneous Ignition of Wood) – Overall for 20 years operation



APPENDIX XI

Plant Separation Distances

CONTENTS

XI. SEPARATION DISTANCES

This Appendix contains some examples of hazardous installations in rural areas where trees have been used to provide screening for visual impact purposes. One example is of an oil separation facility in the UK, and the others are gas reception facilities in the Netherlands.

Also shown in Table XI.2 is a list of separation distances that are contained in codes of practice that are in common usage (these distances are minimum separation distances).

Table XI.1 Examples of Separation Distances for Process Plants

Location	Plant	Distance (m) from control building to trees	Distance (m) from process facility to trees	Other
Oil separation facility, UK	Oil/gas separation in forest/heath area.	15	60	22m separation for ground flares. 55m separation between LPG storage and trees.
Westerveld, Netherlands	Gas processing with thin tree screen.	15	25	Condensate/water storage 25m from trees.
Hardenberg, Netherlands	Well and initial processing.		10-15	Unmanned installation.
Ten Arlo, Netherlands	Gas processing with thin tree screen	15	20-25 to slugcatcher	
Roden, Netherlands	Well and initial processing.	20	15	15m between condensate/water storage tanks and forest. Installation close to golf course.
Tietjerk, Netherlands	Well and initial processing with thin tree screen.	15	40	Normally unmanned installation.

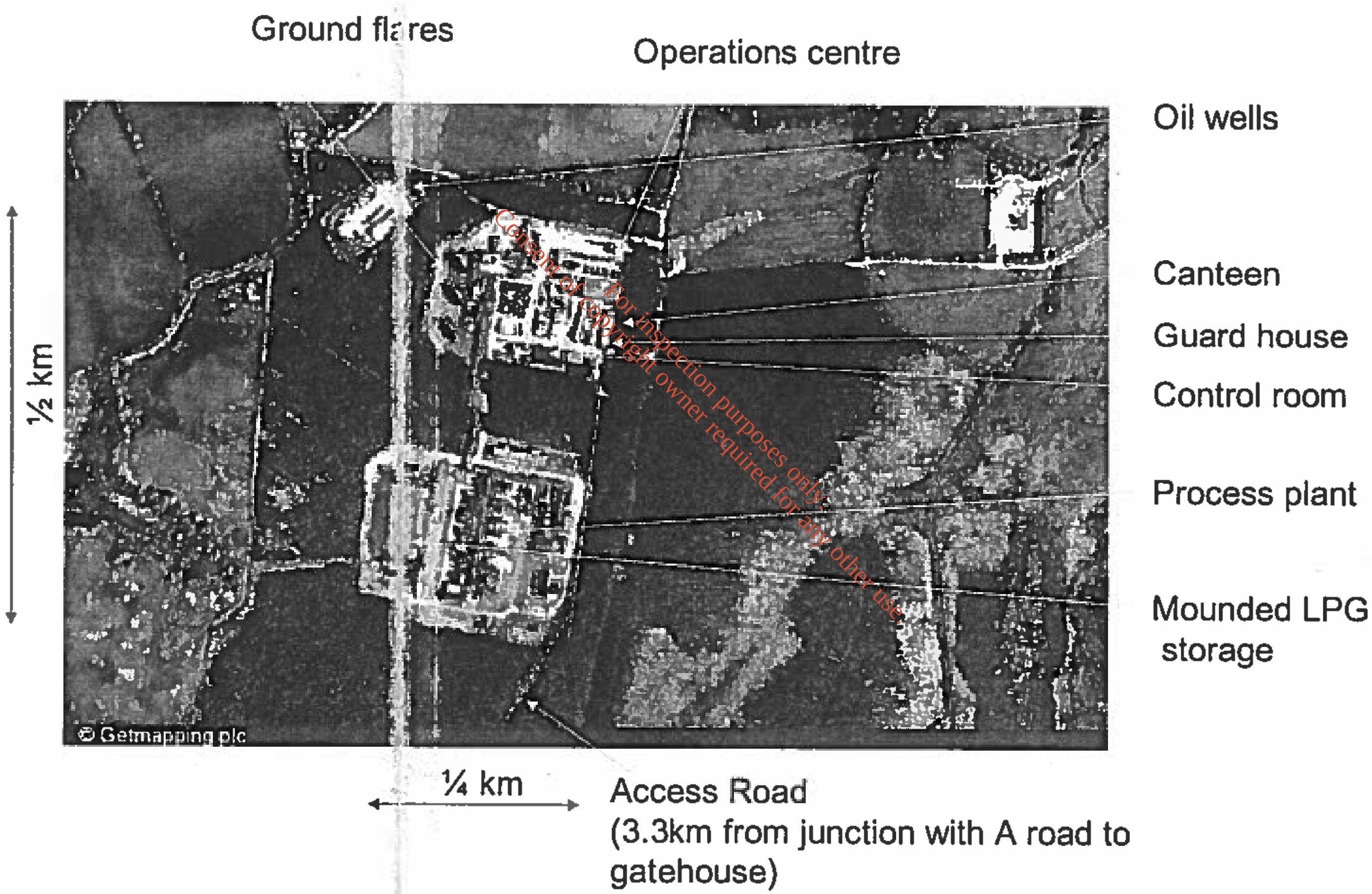
Table XI.2 Examples of Separation Distances from Codes of Practice

Description	Applicable to	Separation Distance (m)	Reference
Separation from buildings, boundaries and property line	Vessels containing more than 150te LPG.	30	HS(G)34 (published in 1987 but now withdrawn. HSW 30, HS(G) 15, LPGIA Code of Practice No 1, Shell LPG Installations.
Separation from outer boundaries	Fixed and floating roof tanks containing more than 250m^3 highly flammable liquids.	15	HS(G) 52 (published in 1991). The Storage of Flammable Liquids in Tanks.
Separation from buildings, boundaries and property line	Pressurised storage of ethylene.	60	ICI Engineering Code.
	Refrigerated storage of ethylene.	90	ICI Engineering Code.

Description	Applicable to	Separation Distance (m)	Reference
Separation distance between building and vessel containing LPG	Buildings.	Sufficient so that thermal radiation from building does not exceed 10kW/m2 on the LPG vessel.	AS/NZS 1596:1997 (Storage and handling of LP Gas.
Separation distance between public place (i.e. a place open to the public) and vessel containing LPG	Vessels above 500kL (approximately 250te).	22	AS/NZS 1596:1997 (Storage and handling of LP Gas.
Separation distance between protected place (i.e. a building or open area where people may assemble in large numbers, or people are employed) and vessel containing LPG	Vessels above 500kL (approximately 250te).	45	AS/NZS 1596:1997 (Storage and handling of LP Gas.

Note that the distances quoted above are the 'minimum separation distances'.

Figure XI.1 Site Plan- Oil Separation, UK



Fi ure XI.2 Well and First Stage Process Facilities

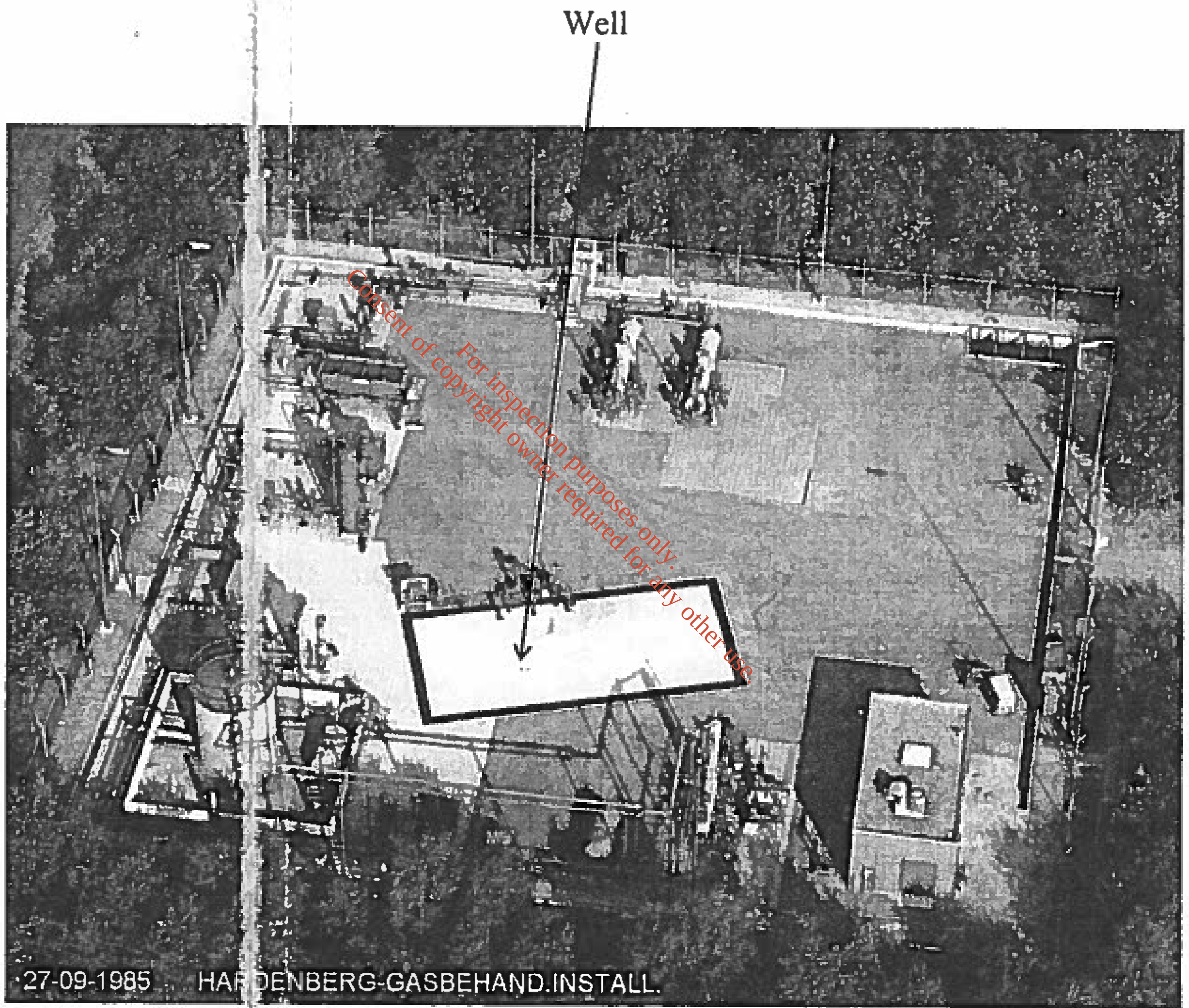


Figure XI.3 Gas Process Facilities

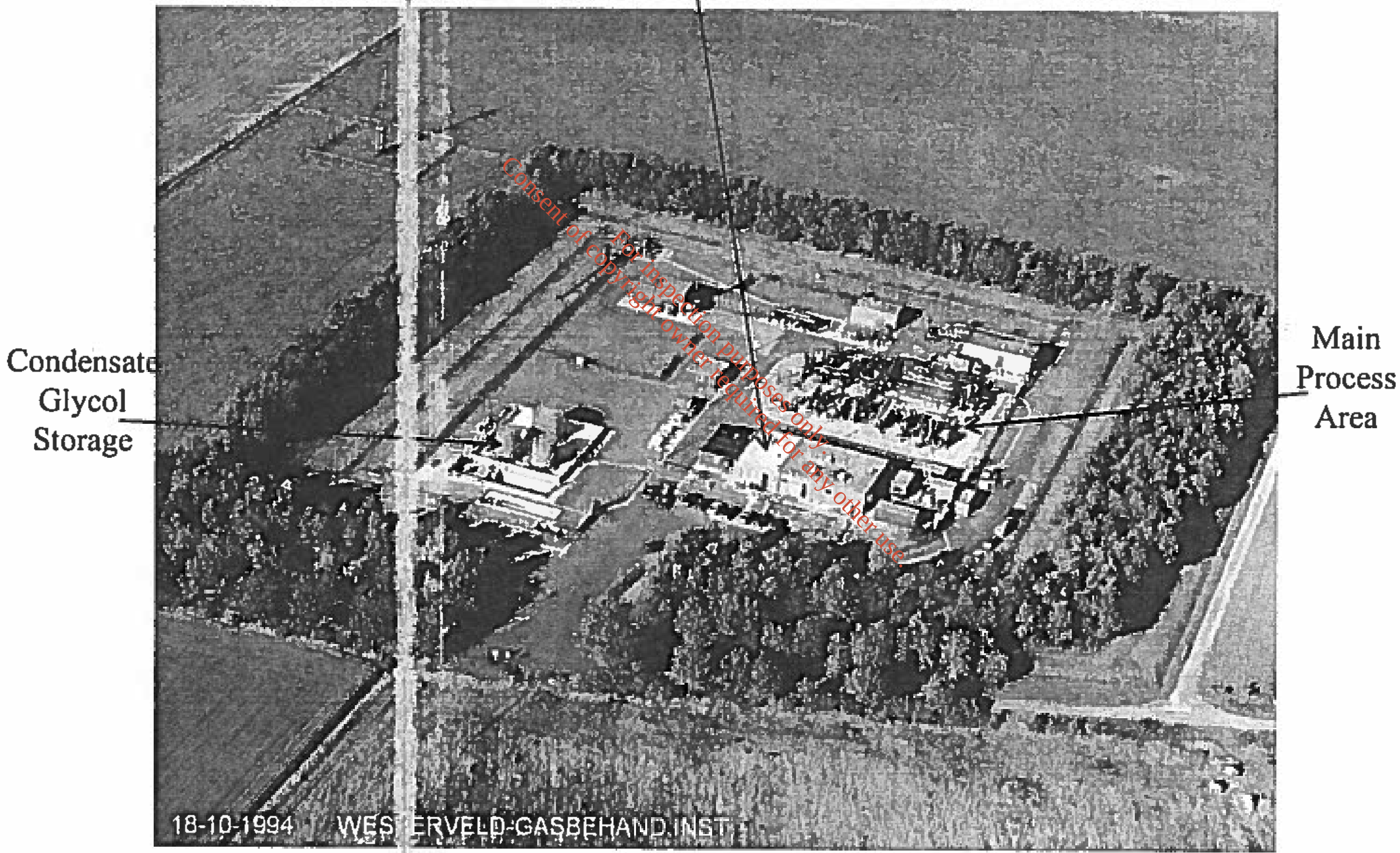


Figure XI.4 Gas Process Facilities (with slugcatchers)

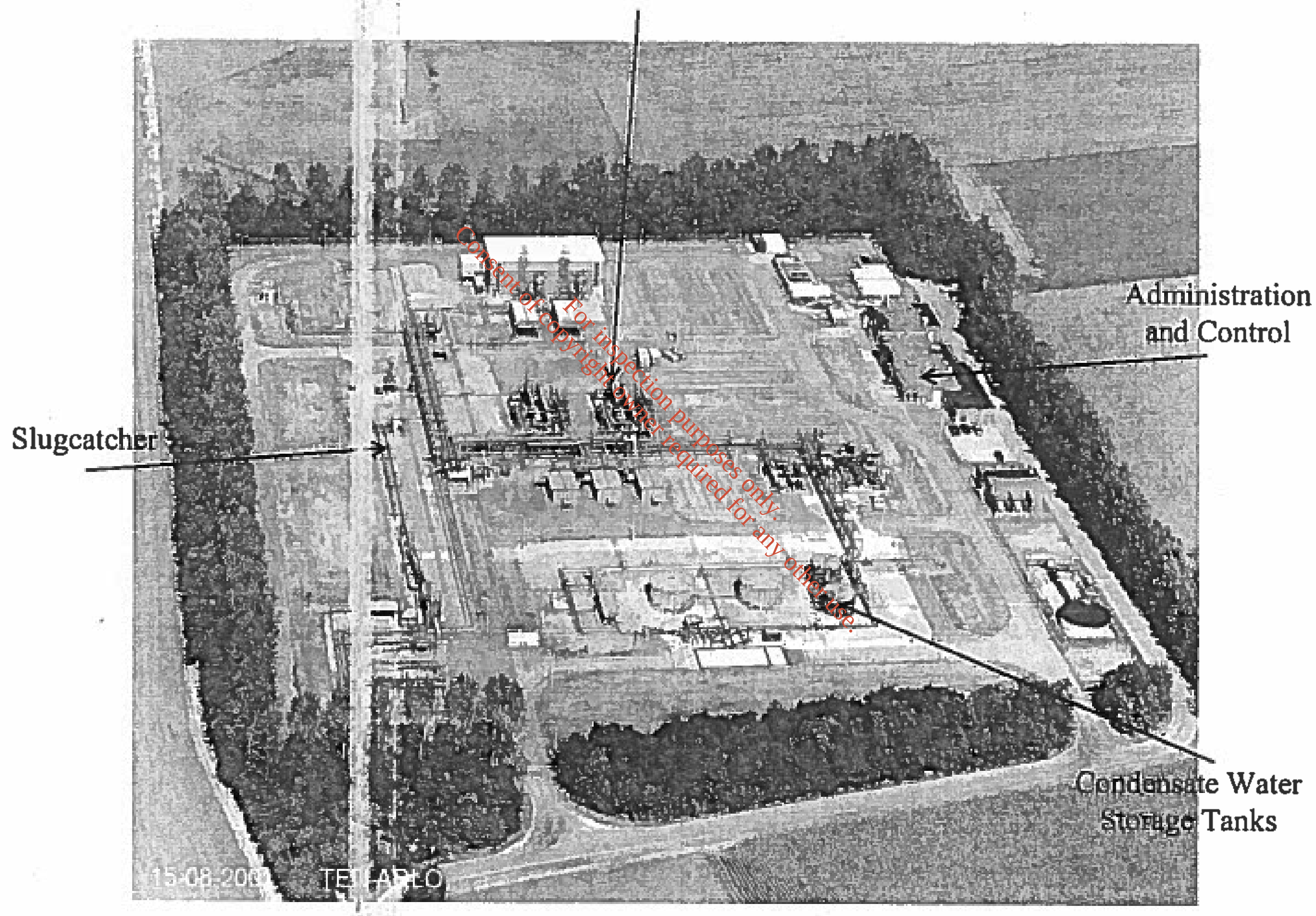


Figure XI.5 Wells and First Stage Separation

'igure XI.6 Wells and First Stage Separation

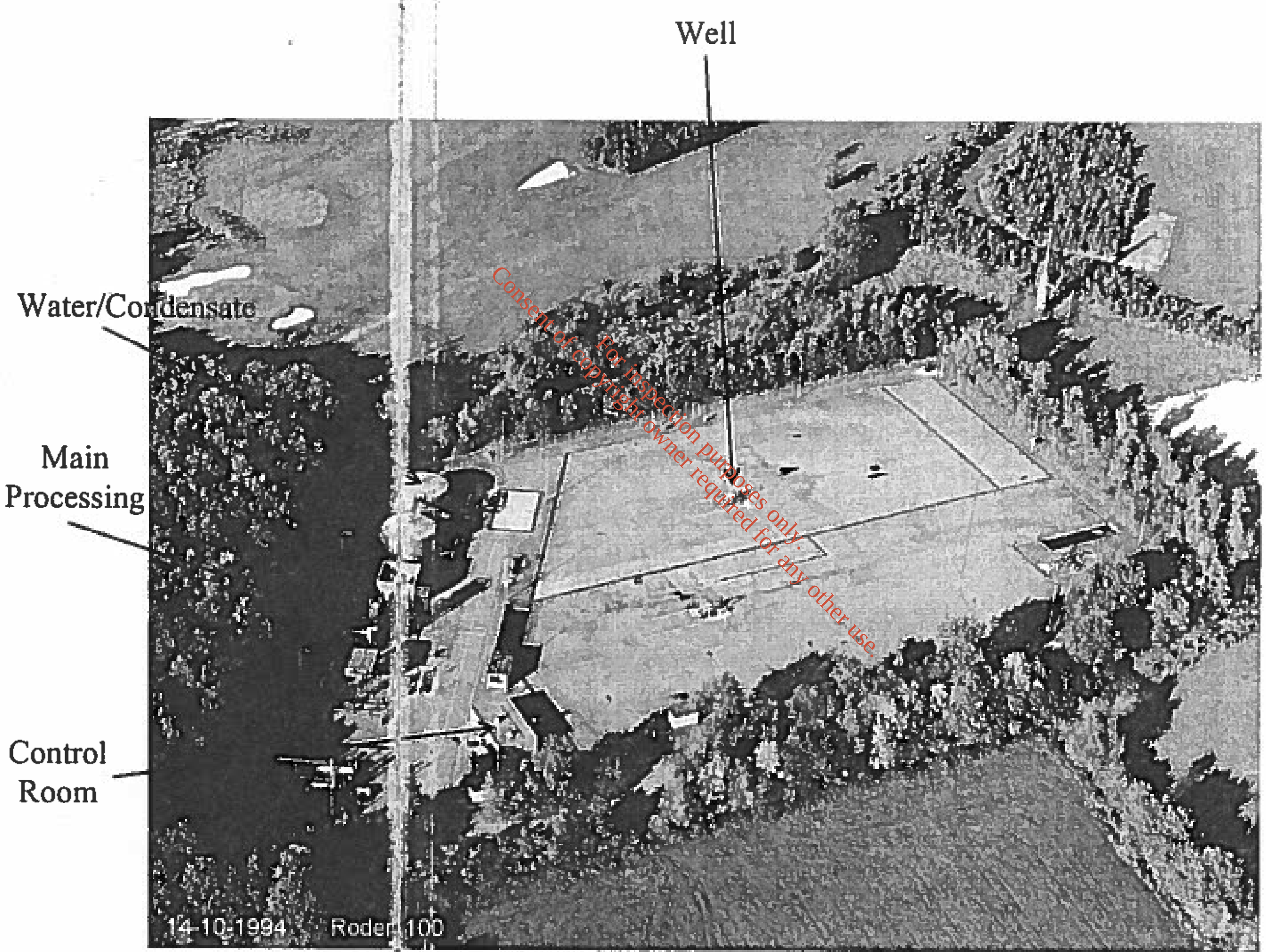
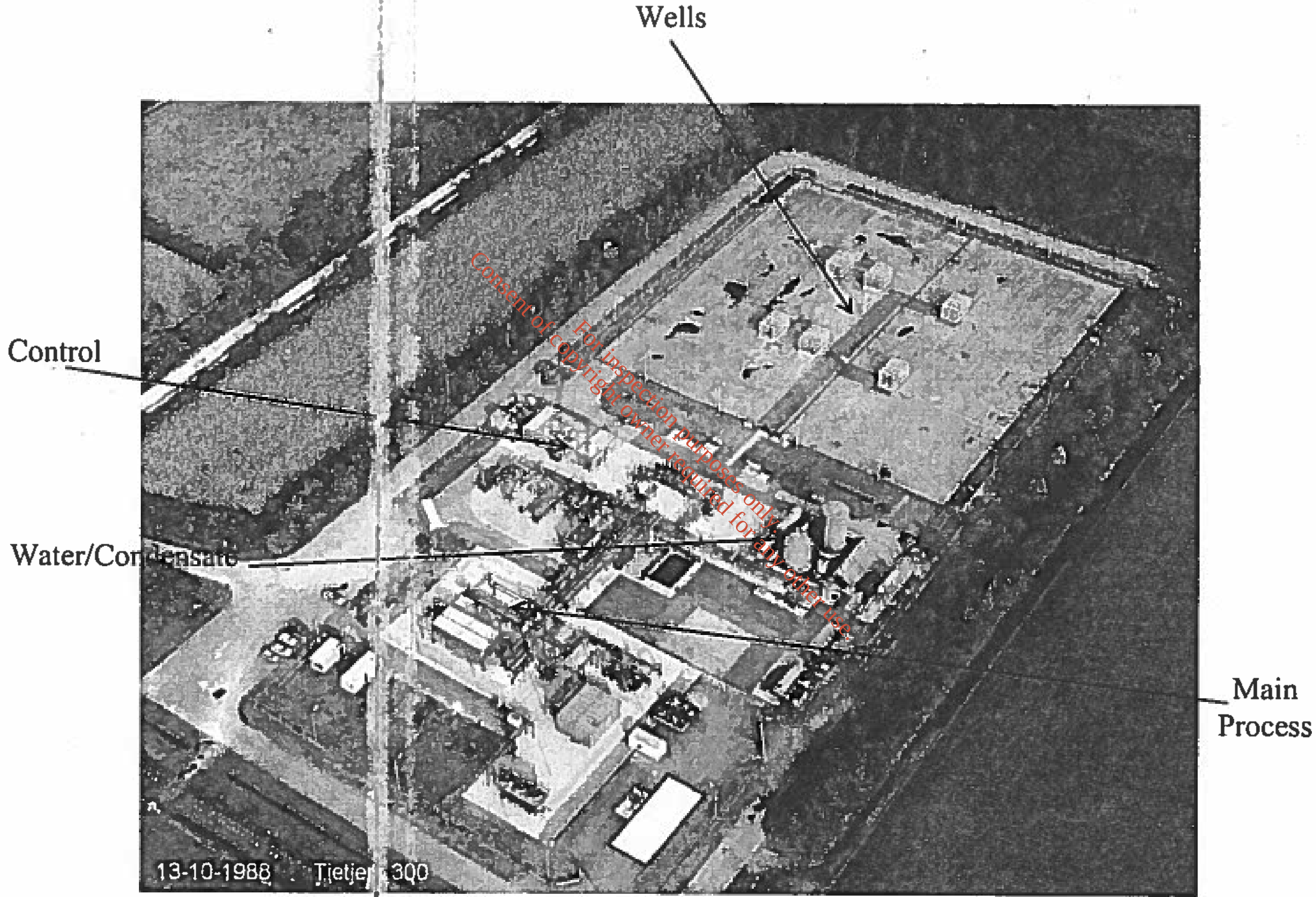


Figure XI.7 Wells and First Stage Processing



APPENDIX XII

Potential Escalation Events

XII. POTENTIAL ESCALATION EVENTS

Escalation occurs if a small release, usually an ignited release, causes a larger release to occur, usually by flame impingement. Typically a flame from a small leak could impinge on a vessel or piping, and this could subsequently fail allowing the contents of the vessel or piping to be released. On a plant which has been constructed, the normal way to analyse potential escalation is to identify the vessels that have a large inventory of flammable material, especially those vessels containing liquefied flammable gas, and then identify plant or equipment in the vicinity that has the potential to give an ignited flame which could impinge on the receptor. For the proposed plant the most likely source for escalation has been taken as the high pressure gas system. A distance within which a potential receptor would be at risk has been determined for a range of hole sizes, together with an indication as to where these may be relevant. These are given in Table XII.1.

Table XII.1 Jet Flame Escalations

Pressure in Gas System	Hole Size (mm)	Hazard Distance (m)	Comment
135	2	4	Applicable to import system including the slugcatcher.
	5	8	
	12	16	
	25	29	
	50	51	
106	2	3	Applicable to D-1003 and mercury removal directly and other vessels in the vicinity of piping upstream of D-2007.
	5	7	
	12	14	
	25	26	
	50	46	
70	2	3	Applicable to D-2007 and D-2009, directly and other vessels in the vicinity of piping between D-2007 and the compressors.
	5	6	
	12	12	
	25	22	
	50	39	
88	2	3	Applicable to the system downstream of the compressors and vessels in the vicinity of this piping, e.g. odorant storage.
	5	7	
	12	13	
	25	24	
	50	43	
10	2	1	Applicable to the flare line upstream of D-8101.
	5	3	
	12	6	
	25	10	
	50	18	

This table can be used to indicate the hole size in the high pressure gas system that could cause escalation to equipment in the vicinity. The consequences following failure have been included in the QRA, as major failures of all equipment items (except those specifically listed in Section 3.4) have been included.

APPENDIX XIII

Hazard Frequency Contours

CONTENTS

XIII. HAZARD FREQUENCY CONTOURS

Figure XIII.1 Frequency of Overpressure in Excess of 140mbar

Figure XIII.2 Frequency of Overpressure in Excess of 70mbar

Figure XIII.3 Frequency of Overpressure in Excess of 20mbar

Figure XIII.4 Frequency of Thermal Radiation from Jet Flames (20kW/m²)

Figure XIII.5 Frequency of Thermal Radiation from Pool Fires (20kW/m^2)

Figure XIII.6 Frequency of Thermal Radiation from Jet Flames (12kW/m²)

Figure XIII.7 Frequency of Thermal Radiation from Pool Fires (12kW/m²)

Figure XIII.8 Frequency of Thermal Radiation from Jet Flames (6kW/m^2) (1000Thermal Dose Units)

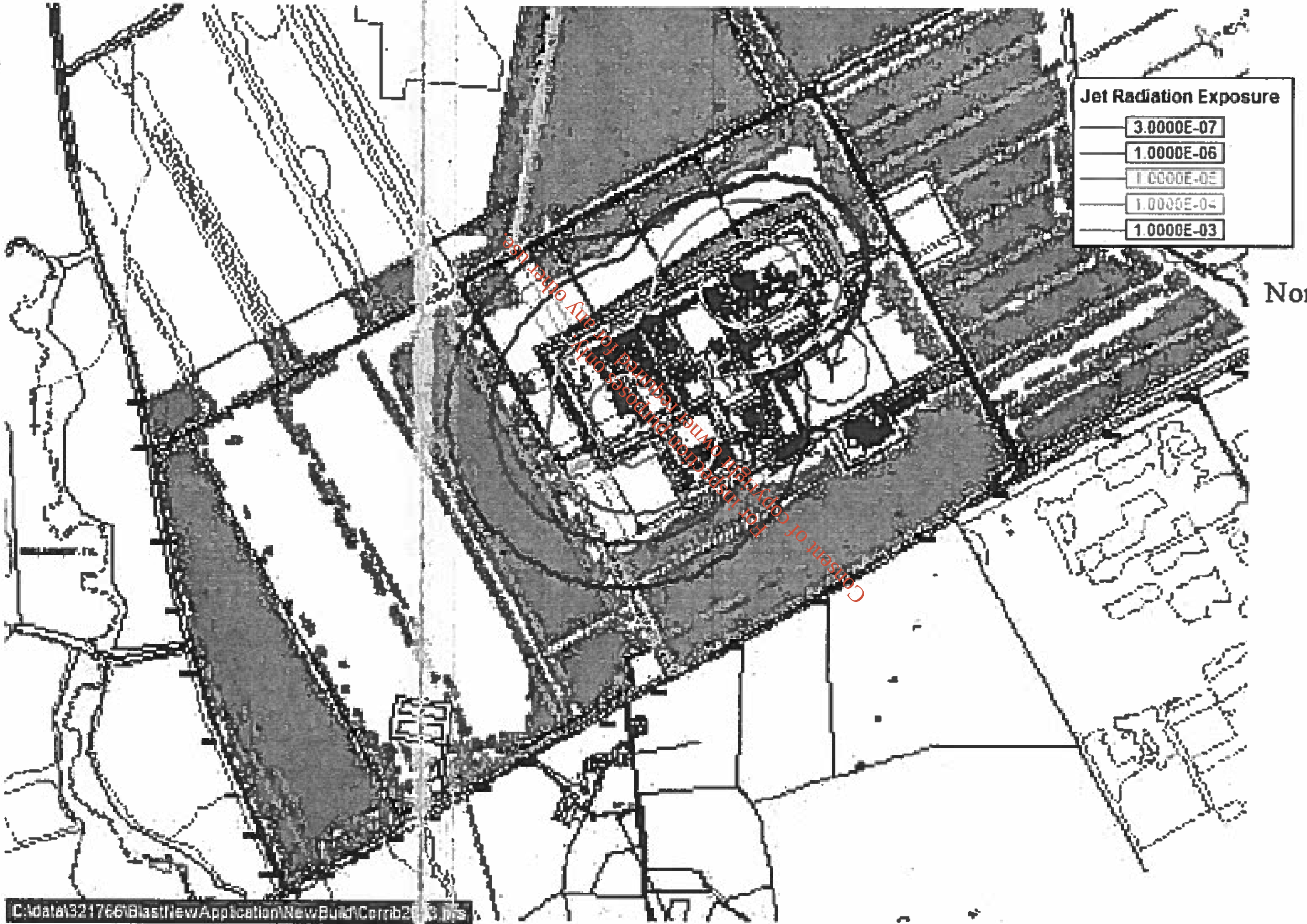


Figure XIII.9 Frequency of Thermal Radiation from Pool Fires ($6kW/m^2$) (1000Thermal Dose Units)

Figure XIII.10 Frequency of Thermal Radiation from Jet Flames (4kW/m²) (500Thermal Dose Units)

Figure XIII.11 Frequency of Thermal Radiation from Pool Fires ($4kW/m^2$) (500Thermal Dose Units)

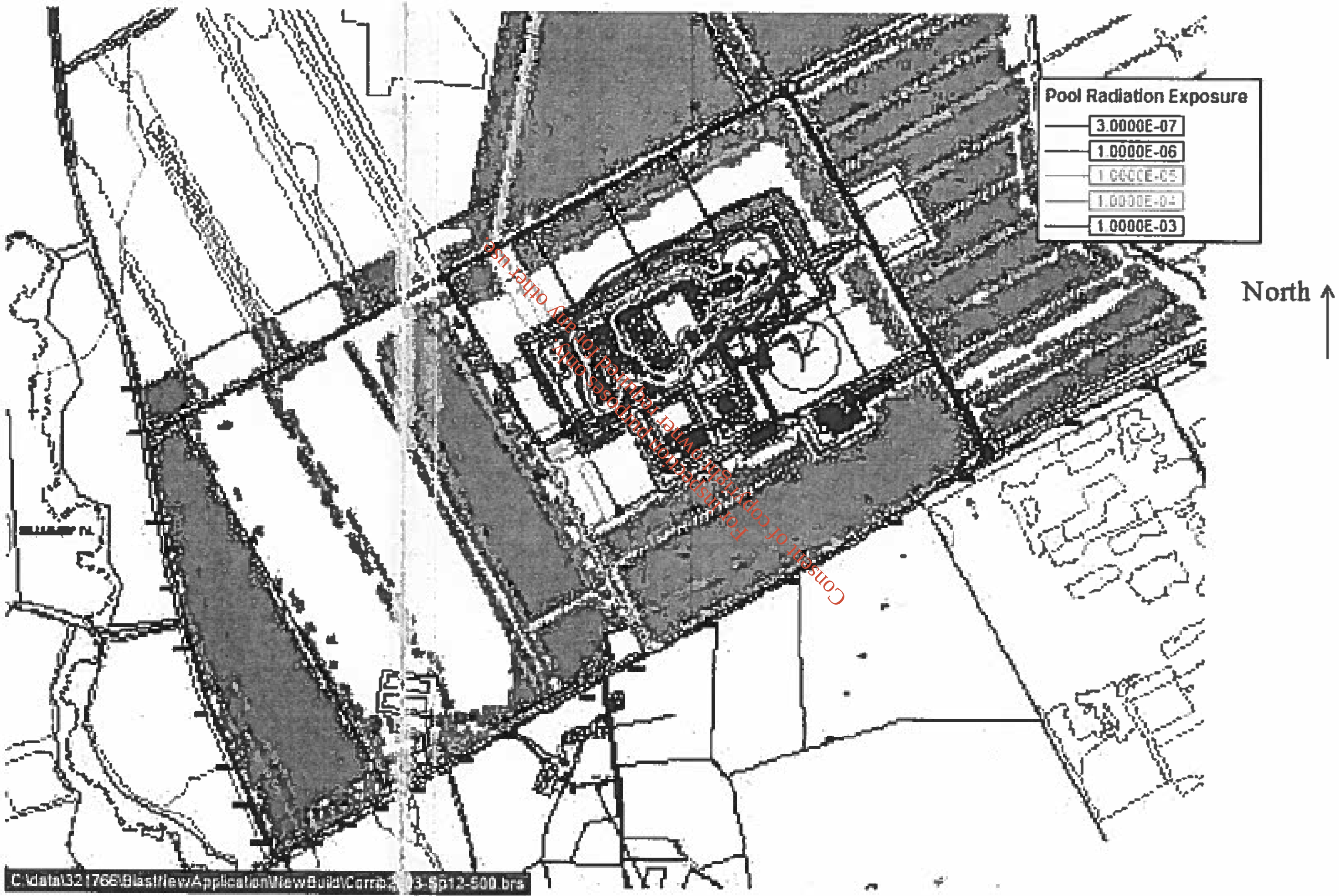


Figure XIII.12 Frequency of Flash Fires

Figure XIII.13 Fr quency of Short Duration Thermal Radiation Events (Fireball)

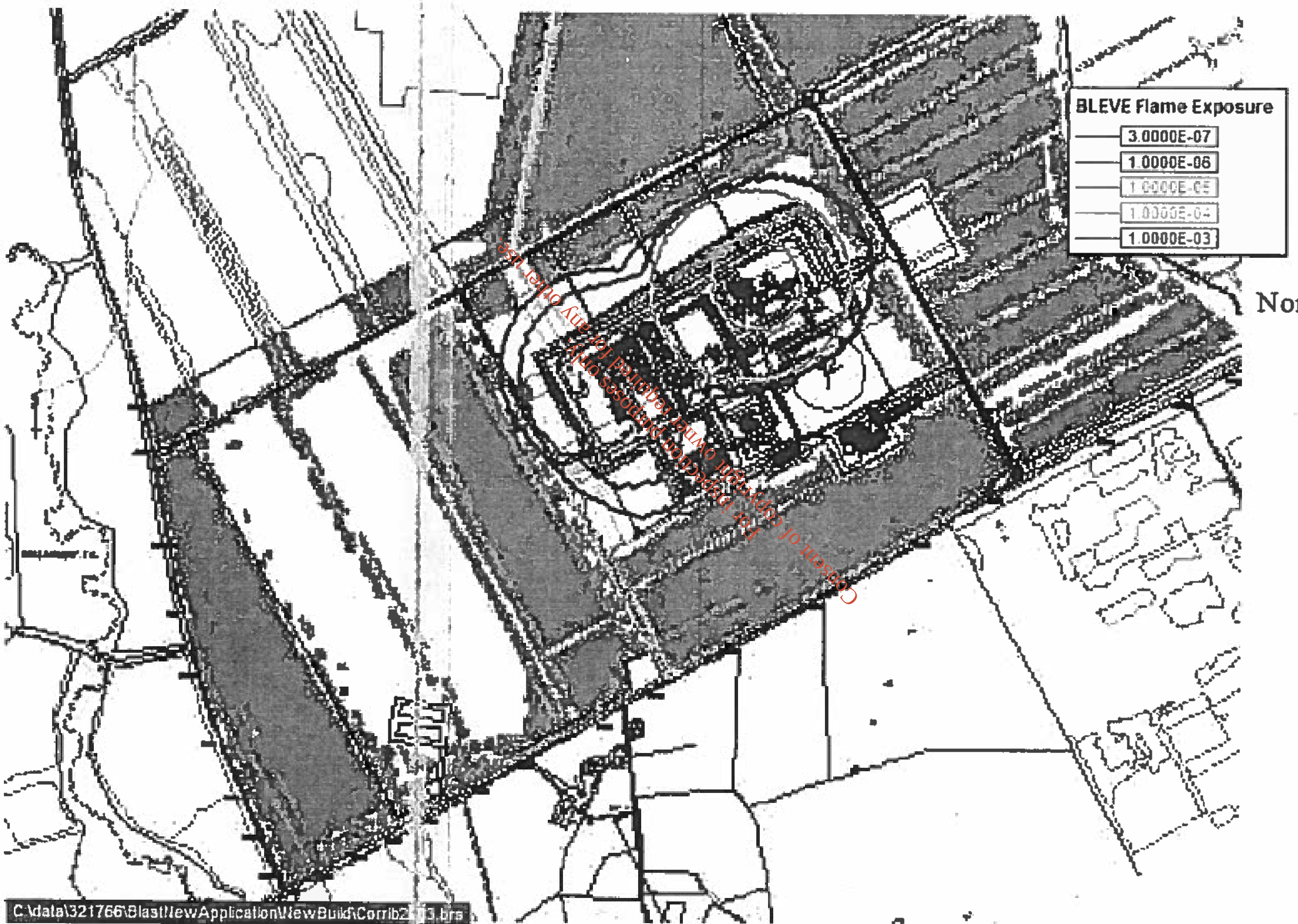


Figure XIII.14 Frequency of Short Duration Thermal Radiation Events (Spontaneous Ignition of Wood)

Figure XIII.15 Frequency of Short Duration Thermal Radiation Events (1000 Thermal Dose Units)

Figure XIII.16 Frequency of Short Duration Thermal Radiation Events (500 Thermal Dose Units)

APPENDIX XIV

Contour Plots for the Sensitivity Analysis

DET NORSKE VERITAS

Det Norske Veritas Limited
DNV Consulting

Highbank House
Exchange Street
Stockport SK3 0ET
United Kingdom

Tel :+ 44 (0) 161 477 3818
Fax :+ 44 (0) 161 477 3819
E-mail: stockport @dnv.com

Registered in England
No.: 1503799

A Quantified Analysis of the Process Hazards at the Proposed Bellanaboy Bridge Terminal

A Report

for

AMEC/SHELL E&P IRELAND LTD

Approved by:.............................
Phil Crossthwaite
Principal Engineer

Job No. 32176601A
Revision 1
April 2004

Shell Exploration & Production

TAD: KEVIN BUCKLEY

Shell E&P Ireland Limited
Corrib House
52 Lower Leeson Street
Dublin 2
Ireland
Tel +353 1 669 4100
Fax +353 1 669 4101

Dear Mr. Sheeran,

In reply to your email of 02-02-'04 :

1) the contaminated firewater retention pond has been designed in accordance with the EPA draft guidance note 'fire-water retention facilities (draft) guidance note to industry on the requirements for fire-water retention facilities'. Accordingly, I can confirm that the design capacity of the contaminated firewater retention pond is sufficient to retain: a) all firewater to quench a worst credible fire, b) associated spilled material generated by a worst credible fire, c) associated rainwater runoff from paved/unpaved areas in the event of heavy rainfall during a worst credible fire, and d) bund overflow resulting from a worst credible fire scenario.

2) with respect to query 3, the design of the plant is such that hazardous material cannot spill onto any unpaved area. Section 2.5.11 of the EIS gives an overview of the drainage systems for the terminal.

3) For clarification, the following tanks will have internal floating roofs :
   T3001 A/B Condensate storage tanks
   T4001 A/B/C Raw methanol storage tanks
   T4002 A/B Product methanol storage tanks

Yours sincerely

Gerry Costello (Corrib project director)

Registered Office:
Corrib House,
52 Lower Leeson Street,
Dublin 2, Ireland.
Registered in Ireland
Number: 316588
VAT Number: IE 6336588 P

Enterprise Oil	ASI CORRIB JV	Corrib natural gas

ASI Project L3847	Enterprise Contract No. 101.24.15

CORRIB FIELD DEVELOPMENT: BELLANABOY BRIDGE GAS TERMINAL

DOCUMENT TITLE: CONTAMINATED FIREWATER RETENTION REPORT

DOCUMENT NUMBER: L3847-000-110-0042

SHEET NO.: 1 of 7

EEIL DOCUMENT NUMBER :

REV	DATE	DESCRIPTION	BY	CHK	APP
REVISIONS			APPROVALS		

CONTENTS

1.0 INTRODUCTION

In the event of fire, firewater may become contaminated with hydrocarbon products and any material used to fight the fire such as AFFF. To protect the environment in view of the uncertain level of contamination of the used firewater, the operating philosophy will be to collect this water initially in the Open Drains Sump T-8301 and then to pump to the proposed new Contaminated Firewater Pond T-8306 using the Firewater Transfer Pump P-8304. This sump will be located West of the Flare Stack outside the sterile area.

The purpose of this note is to define the controlling fire scenario and corresponding firewater demands to enable P-8304 and T-8306 to be sized and to prevent any possibility of T-8301 and/or T-8306 overflowing during an emergency leading to contamination of the surface water system.

2.0 DESIGN CASE FIRE SCENARIO

The following assumptions are made in this assessment:

- The contaminated firewater to be retained follows the draft Environmental Protection Agency guidance note and is based on the maximum water likely to be used in fighting a fire. The proposed retention requirements assume a maximum fire emergency of six hours at the controlling deluge rate of 1200 m^3/h, which corresponds to the capacity of the firewater pond provided at the Terminal .
- Based on EPA guidance, the maximum volume of rainfall should be based on at least 50 mm of rainfall or if significantly different the 20 year, 24 hour rainfall event. In this report, a maximum daily rainfall of 67.8 mm over 24 hours equivalent to 2.828 mm/h has been used based on the General Information Specification L3847-010-110-0001 Rev A1 which is more stringent than EPA.
- Firewater deluge rate 1200 m^3/h over 2, 4 or 6 hours.
- Controlling firewater scenario of 1200 m^3/h is based on a condensate tank fire.
- Condensate bund capacity is 899 m^3.
- Paved areas 13,000 m^2, Condensate bund area 1185 m^2.
- Firewater Pond T-8701. Capacity 7,200 m^3.
- Both T-8301 and T-8306 will be at low level at start of event. This should be covered by operational procedures.

The design or extreme fire case scenario is based on a condensate tank fire with simultaneous deluge on the affected tank and adjacent tanks, the latter requirement to prevent escalation. It is assumed that the duration of the fire would last six hours at the peak demand . The deluge water application rate is based on the 'NFPA 15' recommended rate of 10.2 l/min/m² for storage tanks. Also in this scenario it is assumed that three monitors would be utilised continuously during the fire. This design case scenario gives a peak firewater demand of 1200 m3/hr as detailed in Table 4 plus for comparative purposes the water demand for a product methanol tank and process area fires.

This peak demand is supplied from four 50% diesel driven fire pumps each sized for 600 m^3/h. Normally two would operate with one on standby and one under maintenance. Also there are two electrically driven jockey pumps each of 60 m^3/h capacity being 5% of fire pump capacity and sufficient for two hydrants.

3.0 CONTAMINATED FIREWATER

Contaminated firewater from the various collection points is routed to the Open Drains Sump T-8301 via the open drains collection system. In the event of a confirmed fire, the strategy would be to automatically start P-8304 to ensure T-8301 is kept at the lowest possible level to prevent any possibility of used firewater over-flowing to the surface water system. P-8304 should be on the emergency board and hence available throughout an emergency.

4.0 FIREWATER DEMANDS

The firewater demands for fires in the bulk storage area and the process area are given in Table 4.

Table 4

	Fire Scenario		
	Condensate Tank Fire	Product Methanol Tank Fire	Process Area Fire
Firewater Demand	m3/h	m3/h	m3/h
Deluge	818.7	430.0	-
Foam	38.2	26.9	-
Monitors	342 (3 off)	342 (3 off)	456 (4 off)
Total demand	1200	800	456

A condensate tank fire corresponds to the maximum firewater demand of 1200 m3/hr.

5.0 RAINWATER

The rainwater handling capacity given in Table 5 is based on the maximum daily rainfall of 67.8 mm over 24 hours given in the General Information Specification (L3847-010-110-0001 Rev A Page 4).

Table 5

	Paved Areas	Condensate Tanks Bund	Total
Area m2	13,000	1185	14,185
Rainfall m^3/h (2.825 mm)	36.7	3.35	40.05 m^3/h

6.0 REQUIRED PUMP CAPACITY

The required size of pump P-8304 to prevent the Open Drain Sump T-8301 overflowing for fire scenarios lasting 2, 4 and 6 hours respectively are given in Table 6.

Table 6

Duration of Fire (h)	2	4	6	
In flow to T-8301 from:				
- Paved areas	73.4	146.8	220.2	220.2
- Condensate Bund *	1504	3911	6318	5618
- Total (m^3)	1577	4058	6538	5838
Required pump rate (m^3/h)	280	870	1010	885

The last column of Table 6 gives the required pump rate when taking into account allowances of 200 m^3 and 500 m^3 for open drains hold up and evaporation losses respectively over the six hour event.

In all cases the condensate bund will overflow after 0.75 h from initiation of deluge.

*Values for inflow from condensate bund derived by: (Fire duration – Bund overflow duration) x (Deluge application rate + Rainfall rate).

7.0 REQUIRED RETENTION VOLUME OF T-8306

The required retention volume of the Contaminated Firewater Sump Tank T-8306 should cater for the assumed fire-fighting scenarios of 2, 4 and 6 hours at peak capacity and the assumed maximum daily rainfall of 67.8 mm over 24 hours.

Table 7

Overall event duration (h)	2	4	6	
Pumping time (h)	1.25	3.25	5.25	5.25
Total firewater (m^3)	1500	3900	6300	5800
Total rainwater (m^3)	77.6	157.7	237.8	237.8
	1577	4058	6538	6038
Less retained capacity of T-8301 (m3)	1200	1200	1200	1200
Less holdup capacity in Drains Systems, (m^3)	-	-	-	200
Rainwater falling in T-8306 (m3)	16	32	47	47
Hence required volume of T-8306 (m^3)	393	2890	5385	4685

The last column in Table 7 gives the required volume of the Contaminated Firewater Pond taking into account evaporation losses of 500 m^3 , estimated by EEIL, and an open drains hold up volume of 200 m^3 over six hour event.

8.0 PUMPING REQUIREMENTS

To prevent the Open Drains Sump T-8301 overflowing in any circumstances, the following pump capacities should be installed in T-8301 (see Table 8.1). The effective head difference between P-8304 and T-8306 is estimated to be 16 metres including frictional losses and an efficiency of 70% is assumed.

Table 8

General event duration (hrs)	2	4	6	
Pumping Capacity (m^3/hr)	280	870	1010	885
Line Size T-8301 to T-8306	8"	12"	14"	12"
Pumping power (kw)	13	44	49	47

9.0 MANAGEMENT OF CONTAMINATED FIREWATER

During normal operation, the Open Drains Sump T-8301 will be kept at low level by intermittent use of the Tilted Plate Separator Feed Pumps P-8306 A/B, i.e. a capacity of 1200 m^3 will always be available. In the event of a confirmed fire, the proposed Firewater Transfer Pump P-8304 will take over and be used to prevent T-8301 overflowing. The size of P-8304 depends on the duration of the time the condensate tank firewater deluge system has to be used. The overall duration is limited by the capacity of the firewater pond T-8701 which is 7200 m^3, i.e. 6 hours at 1200 m^3/hr.

The Contaminated Firewater Pond T-8306 has sufficient capacity to contain any contaminated firewater pumped from T-8301. At the end of an emergency, contaminated firewater will be distributed between the condensate bund, T-8301 and T-8306 as indicated in Table 7.

Following an emergency, the strategy will be to empty the affected bund by gravity to T-8301 and pump forward to T-8306 using P-8304. The disposal route of the contents of T-8306 will depend on the degree of contamination, i.e. on site treatment and return to firewater pond or disposal offsite. Based on the capacity of the water treatment plant (2 x 30 m^3/hr), it is estimated that the contaminated fire water could be treated in 50, 90 and 130 hrs for a fire event lasting 2, 4 and 6 hours respectively.

10.0 SUMMARY

The Firewater Transfer Pump P-8304 will have a capacity of 1000 m^3/h and the Contaminated Firewater Pond T-8306 a capacity of 5000 m^3 , both figures including a 10% allowance.

Additionally, P-8304 will be on the Emergency Board so that it is always available.

Watters, Keith G SEPIL-EPE-T-IP

From: Carrigy, Mark W SEPIL-EPE-T-IP
Sent: 26 January 2004 10:52
To: Watters, Keith G SEPIL-EPE-T-IP
Subject: FW: BGE and pigging

-----Original Message-----
From: **Gallagher, Paul T SEPIL-EPE-T-IP**
Sent: 23 January 2004 14:15
To: 'Peter Clarke'; Eoghan Lynch - ARUP; Brendan Mangan
Cc: Carrigy, Mark W SEPIL-EPE-T-IP
Subject: RE: BGE and pigging

Peter,
Thanks a lot for that. It helps a lot.
Regards
Paul

Paul Gallagher
Onshore Pipeline Engineer
Shell E&P Ireland Ltd.
Corrib House, 52 Lower Leeson Street, Dublin 2, Ireland
Telephone: 353-(0)1-603-4810
Mobile: 353-(0)86-837-5879
E-mail: paul.gallagher@shell.com

-----Original Message-----
From: **Peter Clarke [mailto:PCLARKE@bge.ie]**
Sent: 23 January 2004 13:55
To: Gallagher, Paul T SEPIL-EPE-T-IP; Eoghan Lynch - ARUP; Brendan Mangan
Cc: Carrigy, Mark W SEPIL-EPE-T-IP
Subject: RE: BGE and pigging

Paul,
see attached wording
regards
Peter Clarke

-----Original Message-----
From: Gallagher, Paul T SEPIL-EPE-T-IP [mailto:paul.gallagher@shell.com]
Sent: 23 January 2004 13:07
To: Eoghan Lynch - ARUP; Brendan Mangan - BGE; Peter Clarke - BGE
Cc: Carrigy, Mark W SEPIL-EPE-T-IP
Subject: FW: BGE and pigging

Eoghan / Brendan,

We recently received a request from the HSA as to the frequency of pigging of the BGE Linkline from the Corrib terminal. We would like to respond to this request in writing before Mayo County Council determines our Planning Application. Please confirm if we could send a response along the lines of the following:

"BGE would carry out an initial pigging survey of the pipeline after installation and commissioning, which would determine a base line condition of the pipeline. Thereafter the Operations and maintenance of the pipeline would be undertaken in accordance with the recommendations of IS 328. Currently the frequency of internal inspection does not exceed 10 years but this is subject to ongoing review taking into account the good operating history on existing pipelines which have been internally inspected to date ."

Please advise if this is acceptable or alternate wording.
Regards
Paul

Paul Gallagher
Onshore Pipeline Engineer
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Corrib House, 52 Lower Leeson Street, Dublin 2, Ireland
Telephone: 353-(0)1-603-4810
Mobile: 353-(0)86-837-5879
E-mail: paul.gallagher@shell.com

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Fax +353 1 669 4101

Mr. John Sheeran,
Health and Safety Authority,
10 Hogan Place,
Dublin 2
23rd February 2004

Our Ref : COR-L-16-727

Dear Mr. Sheeran,

In response to your e-mail of 5-02-'04 regarding peat/gabion stability in the event of an explosion overpressure :

- The gabion wall design complies with Eurocode 7: Geotechnical Design and BS 8002 - Earth Retaining Structures, as outlined in section 4.6 of technical appendix 2 ('earthworks') of the EIS. The maximum overpressure that is predicted at any part of the gabion wall is 300 mbar. At this level of overpressure, the combination of horizontal and vertical pressures on the peat and the design of the gabion walls are such that , peat destabilization will not occur.

In response to your e-mail of 13-02-'04 :

1) With reference to the document : 'Forestry Protection Guidelines Nov 2002 (Dept Communications, Marine and Natural Resources)' , I can confirm that :

- The planned firebreak distance between the terminal security fence, and the adjoining forest, is in excess of that recommended in said document. Moreover, internal firebreaks, within our landholding, will be developed and maintained to the satisfaction of Mayo County Fire Brigade.

- A fire plan will be developed in conjunction with, and to the satisfaction of, Mayo County Fire Brigade.

2) With reference to the document : Chief Inspectors Guidance Note Series 2 (S2) Process Subject to IPC, S2 1.09 Gasification Processes: Refining of Natural Gas (Her Majestys Inspectorate of Pollution Nov 1995).

- Gas samples have been recovered from the development wells drilled in the Corrib Field. All the samples show a high degree of consistency in terms of gas composition, no H_2S and small amounts of CO_2 (as outlined in section 2.4 of the EIS) were encountered in any of the aforementioned gas samples. There will be no water injected into the Corrib reservoir (as a means of providing

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Number: 316588
VAT Number: IE 6336588 P

reservoir support), accordingly, there is no mechanism whereby 'sour' gas can be produced by the Corrib reservoir in its latter years of production.

Please, find enclosed 4 copies of a revision to page VII.4 of the QRA.

Your Sincerely

Gerry Costello (Corrib Project director)

UNSTABILISED CONDENSATE /METHANOL/WATER Catastrophic failure of the liquid offtake from the slugcatcher resulting in the release of a maximum of 10 te condensate. Condensate liquid could pass through the open drains system or be released to unpaved areas. Ignition of the released condensate.	The slugcatcher and ıssociated pipework are designed, manufactured and tested in accordance with ASME B31.3. Th areas beneath flanged connections are paved. N oreover, the orientation of the instrument connec ions are such that any leakages from said fitti gs will be contained via paved areas. Any leaka e is routed to the open drains sump and ther on to be treated in the surface water treatment system. A leakage from any oth art of the slugcatcher that would result in condensate/Methanol being discharged outside of e terminal fence is not credible. Any liquid spilt onto u paved areas would pass through the peat to the interceptor. The capacity of the interceptor is 10 m³. Sources of ignition ar strictly controlled, and extensive fire fighting acilities are provided for liquid fires in all affected parts of the terminal.	L	Condensate released to unpaved ground may contaminate the surface and/or groundwater. Any condensate released to the receiving watercourse may raise the Chemical Oxygen Demand (COD) in excess of a few days and may therefore constitute a MATTE, although the small quantities of condensate involved mean that this unlikely. Release of combustion products of ignited condensate to atmosphere. The mixture would be expected to burn cleanly (unlikely to produce sooty combustion products) with generation of heat (thermal radiation).	N (NC) N

UNSTABILISED CONDENSATE /METHANOL/WATER Catastrophic failure of the liquid offtake from the slugcatcher resulting in the release of a maximum of 10 te condensate. Condensate liquid could pass through the open drains system or be released to unpaved areas. Ignition of the released condensate.	The slugcatcher and associated pipework are designed, manufactured and tested in accordance with ASME B31.3. The areas beneath flanged connections are paved. Moreover, the orientation of the instrument connections are such that any leakages from said fittings will be contained via paved areas. Any leakage is routed to the open drains sump and thereon to be treated in the surface water treatment system. A leakage from any other part of the slugcatcher that would result in condensate/Methanol being discharged outside of the terminal fence is not credible. Any liquid spilt onto unpaved areas would pass through the peat to the interceptor. The capacity of the interceptor is 10 m³. Sources of ignition are strictly controlled, and extensive fire fighting facilities are provided for liquid fires in all affected parts of the terminal.	L	Condensate released to unpaved ground may contaminate the surface and/or groundwater. Any condensate released to the receiving watercourse may raise the Chemical Oxygen Demand (COD) in excess of a few days and may therefore constitute a MATTE, although the small quantities of condensate involved mean that this unlikely. Release of combustion products of ignited condensate to atmosphere. The mixture would be expected to burn cleanly (unlikely to produce sooty combustion products) with generation of heat (thermal radiation).	N (NC) N

UNSTABILISED CONDENSATE /METHANOL/WATER Catastrophic failure of the liquid offtake from the slugcatcher resulting in the release of a maximum of 10 te condensate. Condensate liquid could pass through the open drains system or be released to unpaved areas. Ignition of the released condensate.	The slugcatcher and associated pipework are designed, manufactured and tested in accordance with ASME B31.3. The areas beneath flanged connections are paved. Moreover, the orientation of the instrument connections are such that any leakages from said fittings will be contained via paved areas. Any leakage is routed to the open drains sump and therein to be treated in the surface water treatment system. A leakage from any other part of the slugcatcher that would result in condensate/Methanol being discharged outside of the terminal fence is not credible. Any liquid spilt onto unpaved areas would pass through the peat to the interceptor. The capacity of the interceptor is 10 m³. Sources of ignition are strictly controlled, and extensive fire fighting facilities are provided for liquid fires in all affected parts of the terminal.	L	Condensate released to unpaved ground may contaminate the surface and/or groundwater. Any condensate released to the receiving watercourse may raise the Chemical Oxygen Demand (COD) in excess of a few days and may therefore constitute a MATTE, although the small quantities of condensate involved mean that this unlikely. Release of combustion products of ignited condensate to atmosphere. The mixture would be expected to burn cleanly (unlikely to produce sooty combustion products) with generation of heat (thermal radiation).	N (NC) N

UNSTABILISED CONDENSATE /METHANOL/WATER Catastrophic failure of the liquid offtake from the slugcatcher resulting in the release of a maximum of 10 te condensate. Condensate liquid could pass through the open drains system or be released to unpaved areas. Ignition of the released condensate.	The slugcatcher and associated pipework are designed, manufactured and tested in accordance with ASME B31.3. The areas beneath flanged connections are paved. Moreover, the orientation of the instrument connections are such that any leakages from said fittings will be contained via paved areas. Any leakage is routed to the open drains sump and thereon to be treated in the surface water treatment system. A leakage from any other part of the slugcatcher that would result in condensate/Methanol being discharged outside of the terminal fence is not credible. Any liquid spilt onto unpaved areas would pass through the peat to the interceptor. The capacity of the interceptor is 10 m³. Sources of ignition are strictly controlled, and extensive fire fighting facilities are provided for liquid fires in all affected parts of the terminal.	L	Condensate released to unpaved ground may contaminate the surface and/or groundwater. Any condensate released to the receiving watercourse may raise the Chemical Oxygen Demand (COD) in excess of a few days and may therefore constitute a MATTE, although the small quantities of condensate involved mean that this unlikely. Release of combustion products of ignited condensate to atmosphere. The mixture would be expected to burn cleanly (unlikely to produce sooty combustion products) with generation of heat (thermal radiation).	N (NC) N

Copy 1

Shell Exploration & Production

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6 April 2004

Health and Safety Authority,
10 Hogan Place
Dublin 2
Ireland.

For the attention of Mr. J. Sheeran.

Dear Mr. Sheeran,

Further to the minutes of the meeting of 03-03-'04 between members of staff of the Health and Safety Authority and Shell E&P Ireland Limited, here with please find enclosed 4 copies of responses to issues 1 through to 8e. Four copies of the revised QRA were couriered today to the Health and Safety Authority offices, at 10 Hogan Place, Dublin2. This revised QRA addresses issue 8f, as minuted in the aforementioned meeting.

Should you require any further information, please do not hesitate to contact me.

Yours sincerely,

Gerry Costello
Corrib Project Director

Registered Office:
Corrib House,
52 Lower Leeson Street,
Dublin 2, Ireland.
Registered in Ireland
Number: 316588
VAT Number [illegible]

HSA query 1 : Global stability under accident conditions.

1.0 INTRODUCTION

1.1 Summary

Assessments have been conducted to assess the integrity of gabions and peat adjacent to the terminal under accident conditions.. These assessments demonstrate that the integrity of both the gabions and the peat, adjacent to the terminal footprint, will not be undermined as a result of an overpressure event (with an event frequency of 1 in 10,000 years). The gabions have a factor of safety of 1.23 and the peat has a minimum factor of safety of 1.25 in the event of such an overpressure.

1.2 Supporting Work to this Submission

In order to support this submission further expert advice in particular technical fields was sought. The following parties have provided advice to this submission.

(1) Arup Consulting Engineers. Principal earthworks designers for Bellanaboy Bridge Terminal assessed the effect of the pressure wave on the gabion retaining structure around the northern perimeter of the site.

(2) Applied Ground Engineering Consultants Ltd (AGEC). Geotechnical advisors to Shell assessed the stability of existing peat slopes due to blast loading.

(3) APEX Geoservices Ltd. APEX, an Irish based geophysical company with experience in peat areas, advised on propagation of pressure waves through peat.

(4) QinetiQ. QinetiQ is Europes largest science and technology organisation and formerly an agency of the British Ministry of Defence. QinetiQ are world renowned experts in research into blast effects and have provided technical advice in this regard.

2.0 DEFINITIONS

2.1 Definition of Accident Conditions

A quantified analysis of risks associated with the processes at the gas terminal has been carried out by Det Norske Veritas (DNV) (2003).

With respect to accident loading of geotechnical structures based on DNV (2003) the relevant potential hazard arises from an explosion of a gas/air cloud following a gas leak. The blast results in pressure a wave which expands outward from the centre of the blast. The pressure wave, measured as over-pressure, applies an external load to the surrounding geotechnical structures.

Eurocode 1 refers to the use of probability of $1x10^{-4}$ per year as appropriate for accidental actions, accordingly, loadings as a result of an explosion associated with $1x10^{-4}$ per year frequency, i.e. a one in ten thousand year event, have been used for analysis purposes. While factors of safety for blast related loading are not available in geotechnical standards those referred to in Eurocode 1 (National Standards Authority of Ireland (NSAI), 1999) are used.

2.2 Critical Geotechnical Structures

The geotechnical structures that could be affected by the resulting pressure wave are as follows:

(1) Gabion retaining structure around northern perimeter of terminal site, and

(2) Existing peat slopes surrounding the terminal site.

The location of these geotechnical structures with respect to the blast is shown schematically in Figure 1.

3. RESULTS

3.1 Gabion Retaining Structure

Gabion walls supporting the slopes around the perimeter of the terminal platform will be a minimum 3 m wide, founded within the 'mineral' soil horizon, underlying the peat. The DNV report advises that the horizontal (lateral) pressure against a solid wall (face) will rise to twice that of the vertical pressure, due to 'reflection' effects. However, given the open-textured nature of the gabion walls (essentially stone-filled baskets), there will be substantial dissipation of the lateral air pressure as it hits the wall, so that the maximum lateral pressure is likely to be less than twice the vertical pressure. This pressure is resisted by the mass (weight) of the wall, and the passive resistance of the retained peat.

The gabion wall design complies with Eurocode 7: Geotechnical Design and BS 8002 - Earth Retaining Structures, as outlined in section 4.6 of technical appendix 2 ('earthworks') of the EIS. The overpressure that is predicted, at a frequency of 1 in 10,000, at any part of the gabion wall is 102 mbar incident (204 mBar reflected) compared to a design load of 250 mBar. Accordingly, at this level of overpressure, the gabion walls have a design factor of 1.23 and accordingly, destabilization of the gabions will not occur.

Applying the load generated by DNV from blast analysis does not destabilise the gabion wall or adjoining peat.

3.2 Existing Peat Slopes Surrounding Terminal Site

Peat Characteristics

The characteristics of the peat have been assessed based on comprehensive ground investigation at the site. This has included an assessment of peat thickness, inclination of potential basal failure plane and undrained peat strength.

Analysis

The global stability of peat in the area surrounding the Bellanaboy Bridge Terminal has been analysed using 200m by 200m grids for over-pressure loadings based on the DNV report. The over-pressure is assumed to work as a uniformly distributed static load applied vertically to the peat surface. Analysis has taken into account previous work by Arup (2003).

For each grid the calculated Factor of Safety against global stability failure was determined before and during the brief period of applied loading.

Results

Results of the analysis are attached in Figure 3. These show the results for the following:

Normal condition - stability prior to blast loading, and

Accident condition - stability during blast loading.

During the brief period of loading, as represented by accident condition, failure is not reached in any of the cells, that is, the Factor of Safety is greater than 1.0 (Figure 3), with the minimum factor of safety being 1.25 during the event. Following the blast event and the dissipation of over-pressure load the ground will return to its normal condition. Accordingly, the global peat stability will not be undermined under accident events which have a frequency of 1 in 10,000 years.

Other areas

The impact of the air pressure wave on the terminal platform and exposed soil/rock slope will be predominantly perpendicular to the surface. This will result in compression of the surface face. Given the stable conditions and inherent strength of these surfaces, the explosion event will not create any undue risk to ground stability.

4.0 References

Arup Consulting Engineers (2003). Geology, Hydrogeology and Global Stability Planning Report.

Det Norske Veritas (DNV) (2003). A Quantified Analysis of the process Hazards at the proposed Bellanaboy Bridge Terminal for AMEC/Shell E&P Ireland Ltd. December 2003.

National Standards Authority of Ireland (NSAI) (1999). Eurocode 1: Basis of design and Actions on Structures – Part 2-7. Actions on Structures –Accidental Actions due to Impact and Explosions.

Seed, H. B. (1987). Design Problems of Soil Liquefaction. ASCE, Jl. of Geot. Enging., Vol. 113, No. 8, pp. 827-845.

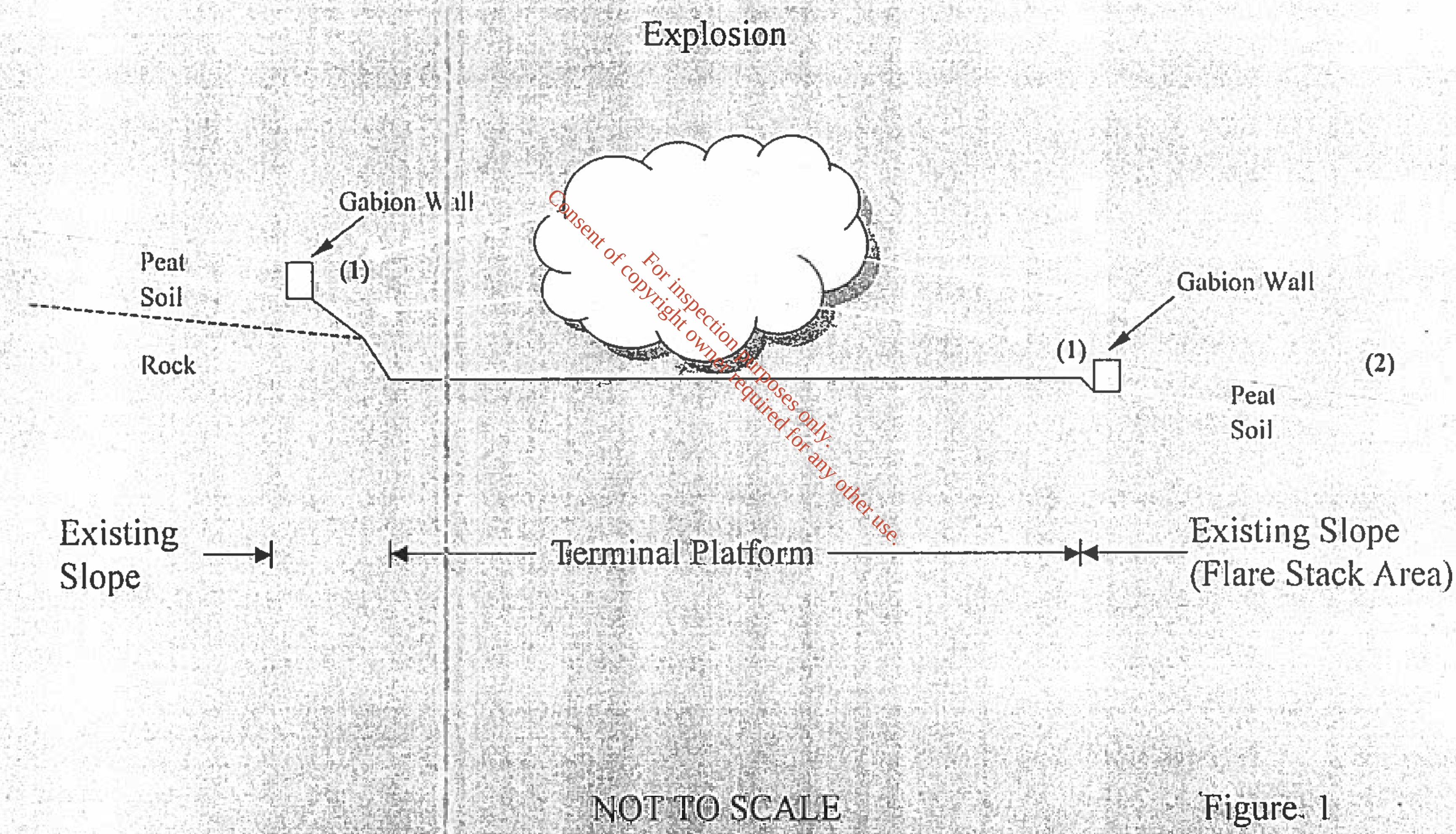
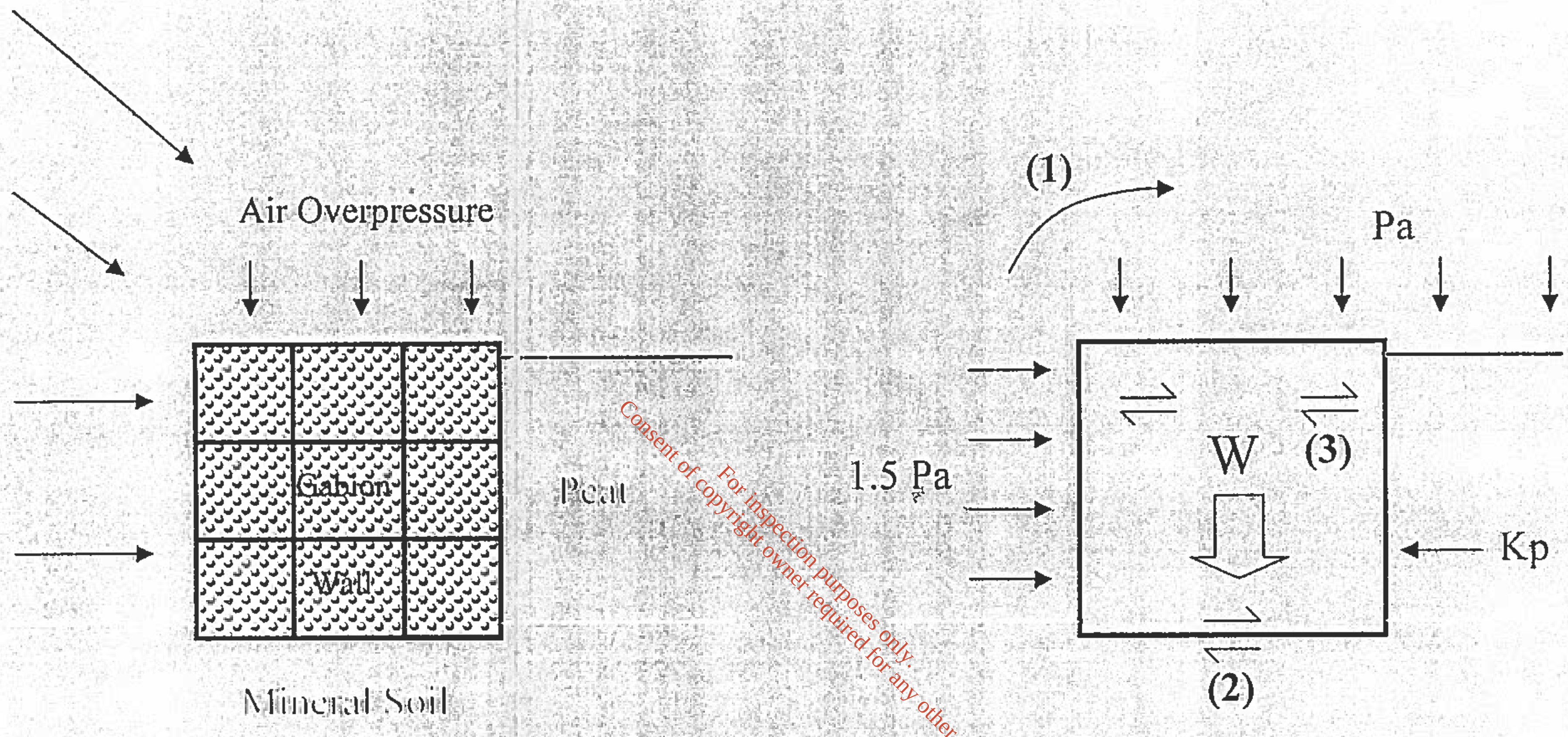

Explosion
Gabion Wall
(1)
Peat
Soil
Rock
Gabion Wall
(1)
(2)
Peat
Soil
Existing
Slope
Terminal Platform
Existing Slope
(Flare Stack Area)
NOT TO SCALE

Figure. 1



Deformation / Failure Mechanisms

(1) Overturning

(2) Base Sliding

(3) Internal Shearing

Pa - Static Air Pressure

W - Weight of Gabion Wall

Kp - Passive Resistance of Peat

NOT TO SCALE

Figure 2

Figure 3 Factor of Safety for Peat Sliding using 200 by 200m Cells under Normal and Accident Conditions

HSA Issue 2 Notification (AMEC Rev 5)

a. Justification required for raw methanol flammable threshold value
b. Consideration should be given to waste inventories that may be classified as dangerous substances
c. Statement requested on impact of Seveso amendment on terminal status

Response

a. The Raw Methanol (Aqueous Methanol) for the Corrib terminal ranges from 18 - 40 wt% methanol in water. The Raw Methanol will be more concentrated in the early years of production, becoming more diluted in later years. The flashpoint of Raw Methanol ranges between 43 °C and 29 °C. Therefore under the Seveso Directive, Raw Methanol will be classified as a Part 2 flammable liquid (6) with a qualifying inventory as per (Articles 6 & 7) of 5,000 tonnes and a qualifying inventory as per (Article 9) of 50,000 tonnes, as indicated in Table 2 of Hazardous Substances Inventory. Table 1 indicates the existing Hazardous Substances Inventory that is given in the Lower Tier Site Justification Report (Doc. no. L3847-000-110-0114 Rev A2) amended to incorporate the above. The diesel inventory has also been removed as it not considered flammable. Table 1 supersedes Hazardous inventory table on Doc. No. L3847-000-110-0114 Rev. A2 and QRA Doc. No. 32176601A, Rev.1.

b. A review of waste inventories was made by Shell. No further dangerous (waste) substances were found to be present other than that already identified in the Lower Tier Site Justification Report. A list of potentially dangerous waste substances that are derived from the gas processing and utility systems is given below:

Proppant 1280 kg/year from the Slug catcher (D-1002)

Aqueous Methanol Filters (F-1001A/B)

HP Condensate Filters (F-1002A/B) and Inlet Separator (D-1003).

Puraspec 1156 from the Feed Gas Mercury Removal Bed (N-1001)

Puraspec 5158 from the Condensate Mercury Removal Bed (N-3001)

Produced water from the Methanol Still (C-4001) to Water Treatment Plant for treatment.

Filter-cake from the Water Treatment Plant (collected in a skip and disposed offsite).

Recovered oil pumped to Offspec Condensate Tank (T-3002) for re-treatment.

Treated water from the Treated Water Sumps (T-8302A/B) discharged to outfall line.

Offspec water pumped to the Raw Methanol Storage Tanks (T-4001A/B/C) for re-treatment.

Closed Drains - Stream is sampled - Hydrocarbon stream returned to MP Flash

Drum (D-3001) and Methanol stream returned to Methanol Flash Drum (D-4001). This is accounted for in the general inventories.

Open Drains - Contaminated water is treated in Surface Water Treatment Plant

Firewater overflow is pumped from the open drains sump to the Used Firewater Pond. Typically, the firewater is then treated, sampled and discharged to offshore.

Of all of the above waste products, only Puraspec1156 is required to be part of the dangerous substance inventory given in the Tables 1 and 2 below. All other waste materials that have been identified are either included in the general inventories, or are outside the requirements of the Seveso Directive.

c. A review of the Seveso Directive Amendment 2003/105/EC was made by Shell. The findings were as follows:

1. Annex 1 2(d) the entry relating to 'Automotive and other petroleum spirits' including diesel and stabilised condensate is replaced by a qualifying inventory (Articles 6 & 7) of 2500 tonnes and a qualifying inventory (Article 9) of 25000 tonnes.
2. Annex 1 3(b) the entry relating to risk phrases R51/R53 diesel replaced by a qualifying inventory (Articles 6 & 7) of 200 tonnes and a qualifying inventory (Article 9) of 500 tonnes.
3. Substances that are toxic and dangerous to environment are to be separated.

This is indicted in Table 2 of the Hazardous Substances Inventory.

Based on the inventories indicated in Table 2, the terminal remains a Lower Tier Site under the Seveso Directive Amendment 2003/105/EC.

TABLE 1 EXISTING HAZARDOUS SUBSTANCES INVENTORY (To Seveso Directive 96/82/EC)						
Description	Hazard	Inventory (tonnes)	Qualifying inventory	Qualifying inventory	Aggregation of inventories	
			Articles 6 & 7	Article 9	Arts 6&7	Art 9
Substances contributing to flammable hazards						
Hydrocarbon gas (natural gas)	Part 1 substance. Extremely flammable	25	50	200	0.50	0.13
Stabilised condensate (petroleum spirit)	Part 1 substance. Highly flammable liquid	1078	5000	50000	0.22	0.02
Unstabilised condensate	Highly flammable liquid (7a)	11	50	200	0.22	0.06
Propane	Liquified extremely flammable gas	1	50	200	0.02	0.01
Product Methanol	Part 1 substance. Highly flammable liquid	773	500	5000	1.55	0.15
Raw Methanol (Aqueous Methanol)	Part 1 substance. Flammable liquid (6)	2856	5000	50000	0.57	0.06
Lubricating Oils	Flammable	1	5000	50000	0.00	0.00
Odorant	Highly flammable (7b)	9	5000	50000	0.00	0.00
PURASPEC ™ Absorbent 1156	Highly flammable (7b)	8	5000	50000	0.00	0.00
					3.08	0.42
Substances contributing to toxic hazards and dangerous for the environment						
Stabilised condensate (petroleum spirit)	Part 1 substance. Toxic /dangerous for the environment	1078	5000	50000	0.22	0.02
Unstabilised condensate	Toxic /dangerous for the environment	11	50	200	0.22	0.06
Mercury	Toxic /dangerous for the environment	0.4	50	200	0.01	0.00
Methanol (product)	Part 1 substance. Toxic /dangerous for the environment	773	500	5000	1.55	0.16
Methanol (raw)	Part 1 substance. Toxic	2856	500	5000	5.71	0.57
Diesel	Toxic / dangerous for the environment	66	500	2000	0.13	.0.03
Hydrochloric Acid	Toxic / dangerous for the environment	3	50	200	0.06	0.02
PURASPEC ™ Absorbent 1156	Toxic	8	50	200	0.16	0.04
					8.06	0.89

TABLE 2 REVISED HAZAI DOUS SUBSTANCES INVENTORY (To Seveso Directive Amendment 2003/105/EC)						
Description	Hazard	Inventory (tonnes)	Qualifying inventory	Qualifying inventory	Aggregation of inventories	
			Articles 6 & 7	Article 9	Arts 6&7	Art 9
Substances contributing to flammable hazards						
Hydrocarbon gas (natural gas)	Part 1 sub ance. Extremely flammable	25	50	200	0.50	0.13
Stabilised condensate (petroleum spirit)	Part 1 sub ance. Highly flammable liquid	1078	2500	25000	0.43	0.04
Unstabilised condensate	Highly fla umable liquid (7a)	11	50	200	0.22	0.06
Propane	Liquified xtremely flammable gas	1	10	50	0.02	0.01
Product Methanol	Part 1 sub ance. Highly flammable liquid	773	500	5000	1.55	0.15
Raw Methanol (Aqueous Methanol)	Part 1 sub ance. flammable liquid (6)	2856	5000	50000	0.57	0.06
Diesel	Flammabl	66	2500	25000	0.03	0.00
Lubricating Oils	Flammabl	1	5000	50000	0.00	0.00
Odorant	Highly fla nmable (7b)	9	5000	50000	0.00	0.00
PURASPEC ™ Absorbent 1156	Highly fla nmable (7b)	8	5000	50000	0.00	0.00
					3.32	0.44
Substances contributing to toxic hazards						
Stabilised condensate (petroleum spirit)	Part 1 sub ance. Toxic	1078	5000	50000	0.22	0.02
Unstabilised condensate	Toxic	11	50	200	0.22	0.06
Mercury	Toxic	0.4	50	200	0.01	0.00
Methanol (product)	Part 1 sub ance. Toxic	773	500	5000	1.55	0.16
Methanol (raw)	Part 1 sub ance. Toxic	2856	500	5000	5.71	0.57
Diesel	Toxic	66	500	2000	0.13	.0.03
Hydrochloric Acid	Toxic	3	50	200	0.06	0.02
PURASPEC ™ Absorbent 1156	Toxic	8	50	200	0.16	0.04
					8.05	0.89
Substances contributing to dangerous for the environ ent						
Diesel	Toxic / d ngerous for the environment	66	200	500	0.33	0.13

HSA Query 3 : Sweet / sour gas.

Gas samples have been recovered from the development wells drilled in the Corrib Field. All the samples show a high degree of consistency in terms of gas composition, no H2S and small amounts of CO2 (as outlined in section 2.4 of the EIS) were encountered in the aforementioned gas samples.

For a field like Corrib, produced solely under depletion drive (possibly with some aquifer support) there is no known mechanism for generating H2S where there was no H2S initially present in the reservoir. Thus no souring is expected in Corrib.

No souring has been seen in any dry gas fields in the North Sea or elsewhere that have been produced purely by depletion. Where hydrocarbon fields have turned sour during production, the H2S has always been linked to fluids injected into the reservoir (e.g. water injected for pressure support in oil fields or gas injected in underground gas storage fields). Since there will be no injection into the Corrib reservoir, it is highly unlikely that H2S / 'sour' gas can be produced by the Corrib reservoir in its latter years of production.

Nevertheless, gas composition will be frequently monitored and procedures will be in place to safeguard operations should any H2S be detected anywhere in the production stream.

HSA Issue 4 Rainwater Management (Shell Rev 3)

Shell to provide a detailed description and explanation of the management and control of effluents arising from rainwater from bunds under the PTW system

Response

All storage tanks are located within a secondary containment area i.e. a bund. The purpose of the bund is to prevent pollution by ensuring that liquid spillage from the tanks is contained within a walled compound. The purpose of the bund drainage system is to allow the bund to be drained of liquid, including rainwater, into the terminal oily water system for treatment prior to sampling and discharge offshore. This arrangement is in accordance with the requirements of The Institute of Petroleum 'Refining Safety Code' MCSP Part 3 (IP3) and Section 6 of the EPA – Guidance Note on Storage and Transfer of Materials for Scheduled Activities.

A typical drainage schematic of a bund is shown in Figure 1.

During normal operation the valve draining the tank bund is locked closed providing positive isolation between the bund and combined drainage system, and is only opened under the strict control of the terminal permit to work (PTW) system. Any rainwater that accumulates in the bund will be removed at regular intervals.

When the valve is opened the bund drains directly into the terminal oily water system. The oily water system is a piped system that gravity drains into the open drain sump, and is then treated in the water treatment plant. All treated water is discharged from the terminal site via an outfall pipeline to sea.

The bund also includes an overflow system, which is set above the maximum liquid level for tank spillage. The purpose of this overflow is to allow firewater deluge to drain directly into the open drain sump, ensuring that the bund does not overflow.

The PTW system is a recognised industry standard method of ensuring safe practices and safe systems of work for the management and control of all operations on plant. The objective for the PTW system is for a suitably qualified and experienced authorised person – who will ultimately approve the PTW certificate – to pre-assess [with all the necessary technical assistance] the hazardous circumstances involved with the management and disposal of any rainwater contaminants on plant.

FIGURE 1 TANK BUND DRAINAGE PHILOSOPHY (TYPICAL FOR ALL TANKS)

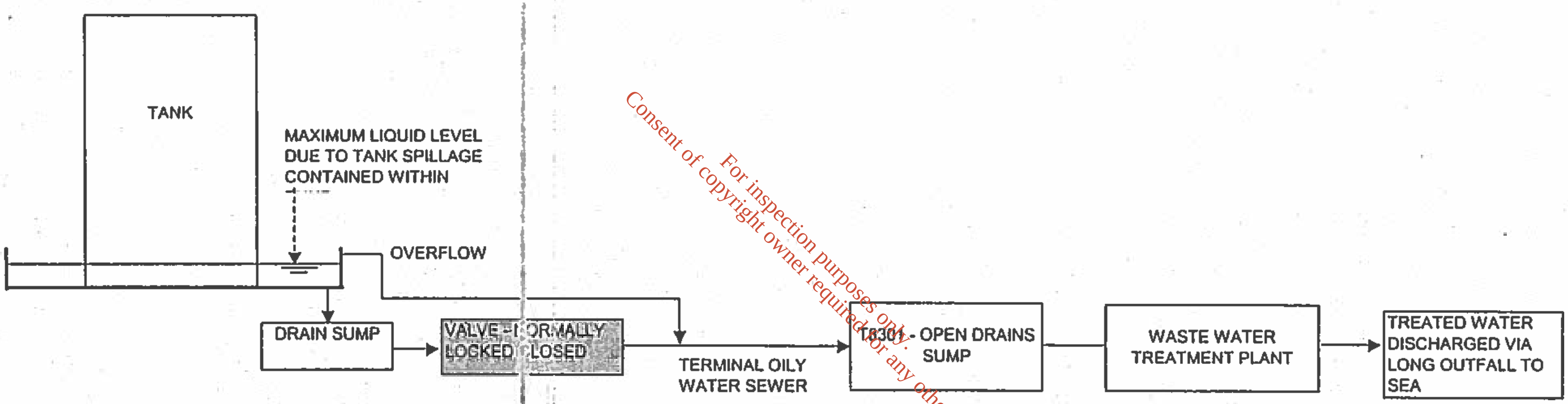


FIGURE 1 - SCHEMATIC OF BUND DRAINAGE SYSTEM

HSA Issue 5 Fire fighting Capability/Sizing of Firewater Pond (AMEC Rev 5)

Shell were requested to

a. Submit justification for choice of NFPA standards
b. Submit justification for worst case fire (Condensate/Methanol/Process Area)
c. Submit calculation details for 1200 meters cubed per hour of water
d. Submit justification for 6hrs of firewater (no escalation)
e. Submit table with tank and bund volumes
f. Justify bund volume 110%

Response

a. The following design codes for 'fire protection' were selected as the most applicable and current oil and gas industry best practice:

- Industrial Risk Insurers information IM.2.5.2 ' Oil and Chemical Plant Layout and Spacing' to provide guidance on the separation of plant areas and storage tanks.

- Institute of Petroleum (IP) 'Refinery Safety Code'-Model Code of safe Practice (MCSP) part 3 to provide a general guide to safe practice in the layout, design, construction and operation of oil and gas installations.

- Institute of Petroleum (IP) Fire Precautions at Petroleum and Bulk Storage Installations MCSP part19 to define the type of fire protection and determine the fire water quantity calculations based on fire areas and water densities.

- National Fire Protection Association (NFPA) national fire codes for defining specific fire protection requirements, such as Foam extinguishing systems (NFPA 11), Water spray fixed systems (NFPA 15), Centrifugal fire pumps (NFPA 20) and Flammable and combustible liquids code (NFPA 30).

The national fire codes, published by the National Fire Protection Association (NFPA) of the USA are widely recognised as the most authoritative codes for the design and installation of fire protection systems. In general codes, such as those developed by IP, do not cover detailed design, hence reference must be made to specialist publications such as the codes of the NFPA. In fact, organisations such as IP, IRI, Chemical Industries Association (CIA), American Petroleum Institute (API) and the UK Health & Safety Executive (HSE) take cognisance of the NFPA publications in the development of their respective codes and standards, and are duly referenced.

b. A number of fire scenarios were developed such as a slug catcher pool fire, a condensate and methanol storage tank fire and process area pool fire, to establish a worst-case fire scenario. These scenarios are indicated in the following table. The table indicates fire scenarios and corresponding water/ foam flow-rate required to extinguish or control a fire in the designated area. In addition, estimated fire duration and foam application duration is included.

Firewater & Foam Calculations

Area	Code	Fire Area m^2	Rate lpm/m^2	Water Required by Code m^3/h	Actual Water supplied m^3/h	Foam m^3/h	Time to extinguish or control (mins)
On site Pipeline	IP19	100	4	24	114		<120 Note 7
Slug Catcher	IP19	2000	4	480	570		<120 Note 7
Flare KO Drums	IP19	100	4	24	114		<120 Note 7
Road Tanker Loading	NFPA 15	260	10.2	160	160		<120 Note 7
Metering	IP19	400	4	96	228		<120 Note 7
Process	IP19	3000	4	720	798		<120 Note 7
Condensate Storage Bund	IP19	975	4	234		234	30 Note 6
Condensate Storage Tank Top	NFPA 11	79	4.1	20		20	55 Note 6
Condensate Storage Deluge	NFPA 15	811	10.2	496	496		55 Note 6
Total Firewater for Condensate Storage					800 (inc. 2 hose streams at 50 m^3/h)		
Product Methanol Bund	IP19	659	4	158		158	30 Note 6
Product Methanol Storage Tank Top	NFPA 11	56	4.1	14		14	55 Note 6
Product Methanol Storage Deluge	NFPA 15	639	10.2	391	391		55 Note 6
Total Firewater for Product Methanol Storage					613 (inc. 2 hose streams at 50 m^3/h)		
Raw Methanol Bund	IP19	1371	4	329		329	20 Note 6
Raw Methanol Storage Tank Top	NFPA 11	143	4.1	36		36	30 Note 6
Raw Methanol Storage Deluge	NFPA 15	1135	10.2	694	694		30 Note 6
Total Firewater for Raw Methanol Storage					1109 (inc. 2 hose streams at 50 m^3/h)		

The firewater and foam calculations in above table are based on the following:

1. The fire area relates to the equipment area exposed to radiation from the fire.

2. For storage bunds, the fire area is the net area of the bund excluding the tank areas.

3. For storage deluge, the fire area is half the surface area of the two adjacent tanks plus the surface area of the tank on fire.

4. For the storage tank top, the fire area is the liquid surface area in the tank.

5. The total firewater demand is a sum of the bund, storage tank top, storage deluge and two additional hose streams of 25 m^3/h.

6. The duration is the estimated time to extinguish the fire using foam based on NFPA 11.

7. The estimated time for gasoline pool to burn out, based on a burn rate of 0.05 $kg/m^2/s$ (Ref. NFPA Fire Protection Handbook).

c. The above table indicates the Raw Methanol Storage as having the largest firewater demand of 1109 m^3/h. This provides the basis for the fire pump duty of 1200 m^3/h and fire pond sizing. However, the Condensate Storage represents the most severe liquid fire hazard, since raw methanol is between 18 and 40 % aqueous mixture.

d. The Institute of Petroleum Codes IP3 and IP19 give firewater storage requirements ranging from 10 hours to 2 hours, respectively. Typically a gas processing facility would be provided with 2 hours of firewater storage and a refinery with complex units and large storage facility would be provided with10 hours firewater storage. Considering the remote location of this terminal from the nearest emergency services, along with its relatively low inventory of flammable material, the provision of 6 hours firewater storage was considered appropriate. A gross safety margin of 4 hours [200% over capacity] has therefore been used as the basis for design. A total of 6 hours storage of firewater is provided in the firewater pond. The firewater pond is sized for the full design flow rate of 6 hours at 1200 m^3/h which equals 7200 m^3. Make-up water is from the local Town's water supplies at a rate of 300 m^3/h. In addition, there is a 5000 m^3 used firewater pond from where firewater may be recycled for further use, if necessary.

e. Table of storage tank and bund volumes.

	Condensate Storage Tanks (3)	Product Methanol Tanks (2)	Raw Methanol Tanks (3)	Acid Wash Tank	Heating Medium Tank	Diesel Tank
	T-3001A/B & T-3002	T-4002 A/B	T-4001A/B/C	T-4003	T-5001	T-8803
Diameter (m)	10.0	[illegible].4	13.5	2.0	4.0	4.0
Height (m)	10.4	10.0	10.0	3.7	5.0	6.0
Cross sectional area (m^2)	78.6	[illegible]5.4	143.2	3.1	12.6	12.6
Volume at overflow height of largest tank (m^3/tank)	739	[illegible]88	1203	10	60	74
25% of contents of all tanks within bund (m^3)	554	244	902	N/A	N/A	N/A
Gross bund capacity (m3)	1292	759	2259	22	85	101
Net bund capacity (m^3)	1002	549	2089	18	76	94
Excess capacity %	36	33	45	85	26	28
Average bund wall height (m)	1.24	1.17	1.44	0.925	1.55	1.58
Liquid height (m)	0.881	0.813	1.02	0.477	1.143	1.141
Freeboard (m)	0.209	0.207	0.27	0.298	0.257	0.289
Rainfall at max hourly event (m/h)	0.031	0.031	0.031	0.031	0.031	0.031

Notes: 1. Bund capacities range from 126% to 185% of the nominal capacity of the largest tank.
2. Excess firewater is removed via the bund overflow to the contaminated firewater pond.

f. Codes differ in their recommendations on bund capacity, which vary between 75% and 110% of the nominal capacity of the container protected. In some countries, this aspect of design is covered by pollution control legislation. The Environmental Protection Agency (Ireland) draft IPC Guidance Note on Storage and Transfer of Materials for Scheduled Activities recommends that all storage tanks are located within a bunded area, with the bund capacity being at least 110% of the tank volume or 25% of the total volume of all the tanks in the bund (whichever is the largest). This is the basis of design (BOD) given in the Corrib Environmental Impact Statement (Ref: Table 17.5 of the EIS).

The HSE Safety Guidance Notes (HS (G) 50 & 52) recommend calculating the bund capacity using the 110% rule.

The Scottish Environmental Protection Agency (SEPA) Pollution Prevention Guidelines for above ground storage tanks PPG2 recommends 110%. The 10% margin is intended to take account of a range of factors including:

- Loss of total contents due to vandalism or accident
- Sudden tank failure or leaks
- Overfilling
- Containment of fire fighting agents
- Dynamic factors such as overtopping caused by surge and wave action following tank failure
- An allowance for rain water in the bund

IP19 indicates for a single tank in a bund, it should be capable of holding a volume equal to the maximum operating capacity of the tank. Where two or more tanks in a bund, it should be capable of containing the largest tank or 10% of the total contents of all tanks standing in the bund, whichever is the greater.

It is noted that the Construction Industry Research and Information Association (CIRIA) offer an alternative methodology for bund design, based on risk. This approach is discussed in our response regarding paving.

The table above indicates criteria are met by providing freeboard for rainwater, firewater and overtopping.

HSA Issue 6 Paving Area/ Slugcatcher leak off site (Shell Rev 3)

Shell to provide more detail on potential Slugcatcher leak scenarios and to clarify the fate of liquid releases to unpaved areas. The figure of 10 tonnes (of condensate) is to be explained. Also, Shell to address bund overtopping and spigot flow in tank farm areas.
Response

Slugcatcher Leak Scenarios

A large failure or rupture of the Slugcatcher is considered to be of such a low probability, the risk is negligible. Reference DNV QRA Section 3.4.

A small bore (50mm dia.) leak could occur from the piping and instrument connections associated with the boot of the Slugcatcher. This will result in a liquid throw at a normal operating pressure of 110 barg, to approximately 45m from the release point, which is within the terminal site boundary. Liquid collected on the paved area will be collected and drained to the open drains system for treatment. Liquid collecting on the gravel areas outside the paved areas will be recovered in accordance with the terminal emergency procedures (to be developed).

Slugcatcher Volume

The volume of condensate in the boot of the Slugcatcher, between the normal interface level and the normal condensate level, is 8.7m^3. Using the density range of 755 kg/m^3, the mass of condensate in the Slugcatcher is 6.6 tonnes. This was added to other medium pressure condensate from other vessels, which equals approximately 10 tonnes .

Storage and Transfer Facilities

The storage and transfer facilities are designed to the Institute of Petroleum (IP) (1981) Refining Safety Code - MCSP Part 3 and recommendations from the Environment Agency (PPC2) and the HSE guidance notes (HS (G) 50 and 51).

The resulting bund capacities range from 126% to 185% of the nominal capacity of the largest tank within the bund and include allowances for rainfall, firewater and surge. Excess firewater is removed via an overflow to the contaminated firewater pond. Table e (HSA Issue 5) provides details on storage tank and bund volumes.

Bund overtopping as described in the DNV QRA is related to incidents where the storage tank fails catastrophically by brittle failure or failure following a fire in the bund or external explosion. Most examples of the brittle failures were in old crude oil tanks and escalation incidents occurred through ignition by the lighting, heated tanks or terrorist activity. The storage tanks in this terminal will be built to modern standards, are not heated and have internal floating roofs with nitrogen blanketing, therefore reducing the risk of ignition from lighting. It is therefore concluded that tank failure is considered negligible. With regard to bund design, these are constructed from reinforced concrete and have been designed to withstand hydrostatic load.

The Construction Industry Research and Information Association (CIRIA) produced a report: "Design of containment systems for the prevention water pollution from industrial incidents" (1997) RP 164. This report reviewed the legislation, standards and codes in force at the time, made comparisons between the various codes and offered a number of alternative methodologies and recommendations. The Terminal 'containment system' is designed to IP3 and meets the requirements of the Environmental Protection Agency (Ireland). There appear to be three main differences between CIRIA RP 164 and IP3/EPA (Ireland) IPC Guidance Notes (Draft) on Storage and Transfer of Materials for Scheduled Activities.

These are:

1. An alternative method for assessing containment capacity (as opposed to the 110% rule).
2. A different method of calculating bund capacity to prevent jetting over the bund wall.
3. A requirement to assess hydrodynamic loads as well as hydrostatic load.

The first point is discounted by the negligible failure rate of tanks built to BS 2654:1989 Specification for manufacture of vertical steel welded non-refrigerated storage tanks with butt welded shells for the petroleum industry. The DNV QRA indicates a failure rate of 1.4E-07 for this type of tank.

The second point is discounted, as there are no tank connections above the bund wall height, except for connections at the top of the tank, which are above the highest liquid level. The storage tanks will be regularly inspected visually for weld seam leaks and emergency action would be taken to deflect jets of liquid into the bund.

The third point is partially addressed by the bund wall design being suitable for a static head to the brim of the bund, which equates to a freeboard in excess of the 250mm recommended by CIRIA RP 164. This is commonly known as the dynamic factor and is not to be confused with hydrodynamic load. If a sudden catastrophic failure of the tank wall occurs, and a large release of liquid follows, the bund is subject to a dynamic load of 3 to 6 times of that due to hydrostatic load and the wall may fail. However, this is a very low frequency event and is therefore discounted.

HSA Issue 7 Control Building (AMEC Rev 5)

Shell to submit details on what heat flux the control room can withstand.

Response

The location of the Control Building is some 200m south of the Process Area and 40m north of the surrounding tree line. The DNV QRA indicates the maximum heat flux at the Control Building from a tree fire is approximately 18 kW/m^2 (equivalent to a surface temperature of 410 °C) for a period of 2 minutes, 11 kW/m2 fireball for 13 seconds and a continuous heat flux of 6 kW/m^2 of approximately 30 minutes during flaring.

The design for the Control Building is in accordance with the Irish Building Regulations 1997 and will be required to have a valid fire certificate. It is constructed of reinforced concrete construction, with reinforced concrete walls and roof. The Control Building is blast rated for 0.2 bar static over pressure (blast) Openings in the building envelope are limited to the access doors, which are all blast rated with a 120-minute fire rating.

The reinforced concrete was designed in accordance with BS8110 - "Structural use of concrete"

The blast design was based on the following:

1. Static load of 20 kN/m2 was applied to the walls and roof, equivalent to a blast overpressure of 0.2bar.

2. The material strength was increased by 20%

3. Blast load was combined with the self-weight of the reinforced concrete structure in combination with any services supported by the structure. No other load factors were applied.

4. The design was also checked using a 50% rebound case.

The fire resistance of a reinforced concrete structure is dependent on the size of the element, and the concrete cover to the reinforcement, as specified in BS8110: Part 1 "Structural use of concrete". The fire resistance is expressed in terms of time as determined in accordance with BS476-Part 8 in which the element is exposed to heating, which is controlled to follow a standard time/ temperature curve. (Refer to BS8110: Part 2 "Structural use of concrete code of practice for special circumstance")

For the Control Building all reinforcing has a minimum concrete cover of 35mm. The walls are 300mm thick, which will provide a fire resistance in excess of 2 hours. The roof is slab and beam construction; the slab is 250mm thick, which will provide a fire resistance 2 hours.

The fire resistance stated in BS8110 is not directly based on a heat flux. It is based on the standard time/temperature curve for building fires that is it will withstand a fire of up to 1000 °C for 2 hours. Therefore, the reinforced concrete structure will have a fire resistance of 2 hours. Also, the doors will have a 2 hour fire rating and fire integrity of the door and components will be maintained for 2 hours at the above stated temperature.

The building will remain habitable for at least two hours in the event of a fire. On detection of an external fire the fire dampers automatically close in the building ventilation system, the HVAC system then re-circulates the air within the building.

The building construction and ventilation system have been designed to allow personnel to safely operate within the control room, even in the event of an external fire or blast.

HSA Issue 8 AOB (AMEC Rev 5)

Shell to:

a. Confirm office building arrangements comply with CIA standard
b. Provide more narrative on access/egress/muster points for employees and emergency services
c. Confirm tanker area drains to closed drain system
d. Confirm firewater pumps in separate cells
e. Confirm pipes to hydrants are underground

Response

a. The location of the Administration and Maintenance Building is some 220m south of the Process Area and 20m north of the surrounding tree line. Extrapolation of data from the DNV QRA indicates a maximum heat flux at the Administration and Maintenance Building from a tree fire of approximately 25 kW/m^2 (equivalent to a surface temperature of 480 °C) in year 1 to approxmately 30 kW/m2 in year 15, for a period of 2 minutes, 11 kW/m2 fireball for 13 seconds and a continuous heat flux of 4 kW/m^2 of approximately 30 minutes during flaring.

The design for the Administration and Maintenance Buildings is in accordance with the Irish Building Regulations 1997 and will be issued with a fire certificate.

The Administration and Maintenance Buildings are of steel-framed construction, with brick and block infill panels, and profile metal roofing panels. There are no window or door openings on South (forest) side of the building. The buildings are of brick and block construction on the South side, which will provide protection to personnel, evacuating the building.

A review of the CIA Guidance for the Location and Design of Occupied Buildings on Chemical Manufacturing Sites (1998) was carried out. Based on the design information given above and using the conditions presented in the CIA guidance for explosion hazards the following calculations indicate Individual Risk levels below 1E-06 and therefore it is considered that the building meets the requirements of the CIA guide.

Building	Explosion Frequency	Vulnerability (see Note below)	Occupancy	Individual Risk
Administration Buildings	1E-04	<0.01	0.2	2E-07

Note: Vulnerability of <0.01 is based on overpressure at building is <10kPa or 0.1bar at a frequency of 1E-04 from DNV QRA and using CIA Guidance Fig 8.

With regard to thermal hazards, the Administration and Maintenance Building design give sufficient protection for the occupants to escape. Concerning escape from the buildings, the recommended radiation of 6.3 kW/m^2 is exceeded during a tree fire, however escape would be via doors at the north side of the buildings and protection will be provided by the building profile itself until the escape route along the roadway is reached.

b. Emergency plans will be in place prior to start up of the Terminal. These will provide action plans for plant, buildings and offsite hazards. Regular internal emergency response drills will be performed within the Terminal. Initially the Terminal manager will be responsible for co-ordinating emergency procedures for evacuation and first response of the on-site emergency services. Once the County Mayo Fire and Rescue Services arrive on site, they will take over the responsibility for co-ordinating emergency procedures.

The access/egress/muster points for employees and emergency services from terminal incidents is generally from the work area using the most direct route to the terminal road and then to the muster point in the car park just beyond the Guard House. Escape from the Administration Building to the muster point in the car park, is via the protected escape routes within the building itself. For incidents external to the Terminal such as a tree fire, the escape route is from the work area to the muster point in the car park, or if the car park is not available, there are two alternatives escape routes. One is to the eastern exit from the Terminal via the Terminal road between the process area and the contaminated firewater pond. The other is the western exit from the Terminal just beyond the export pipeline.

c. The tanker area is provided with a paved area and local sump sized to handle spills and normal rainfall. The sump outlet is provided with an isolation valve, which drains into the open drains system for treatment and disposal offshore. The open drains sump has a design capacity of 1346m which will contain the catastrophic failure of a road tanker

d. The 4x50% fire pumps are housed in pairs in 2-hour fire rated enclosures within the Fire Pump House. This arrangement gives an acceptable availability of 99.96%. Each fire pump is designed to NFPA 20 and can be operated to a maximum of 150% of rated flow.

e. The firewater ring main and all pipes connected to hydrants are underground.