The Tecpro Building,
Clonshaugh Business & Technology Park,
Dublin 17, Ireland.

T: + 353 1 847 4220
F: + 353 1 847 4257
E: info@awnconsulting.com
W: www.awnconsulting.com

COMAH LAND USE PLANNING ASSESSMENT OF PROPOSED RESIDENTIAL DEVELOPMENT AT NEWTOWN, DROGHEDA, CO. LOUTH

Technical Report Prepared For

Ravala Ltd.

Technical Report Prepared By

Maeve McKenna BEng MEngSc CEng MIEI AMIChemE

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Cork Office
Unit 5, ATS Building,
Carrigaline Industrial Estate,
Carrigaline, Co. Cork.
T: +353 21 438 7400
F: +353 21 483 4606

AWN Consulting Limited
Registered in Ireland No. 319812
Directors: F Callaghan, C Dilworth,
T Donnelly, E Porter
Associate Director: D Kelly

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a	30 January 2019	Site layout revised	Executive Summary Section 2.1, 4.2.2, 4.4, 5.0
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Name	Maeve McKenna	Dr. Fergal Callaghan
Title	Principal Risk Consultant	Director
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EXECUTIVE SUMMARY

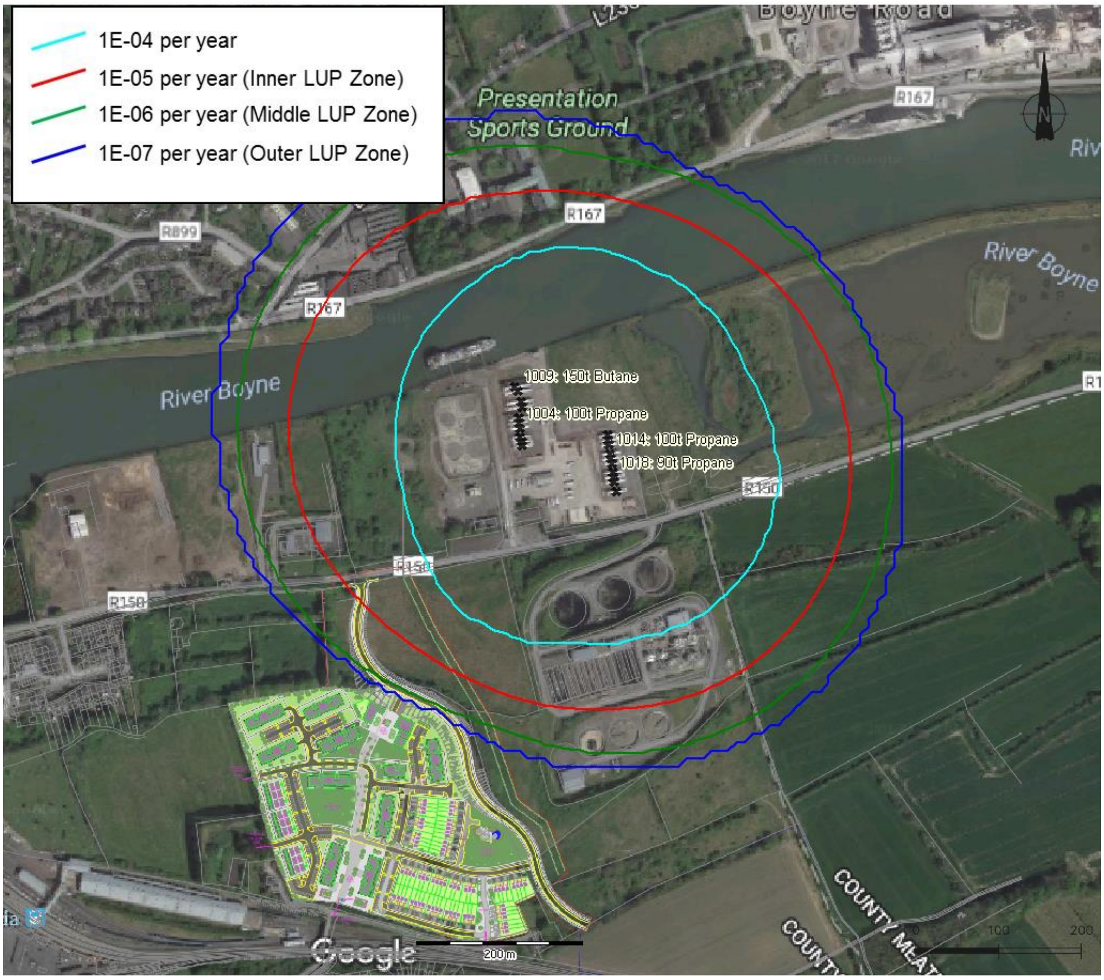
AWN Consulting Ltd. were instructed by Ravala Ltd. to complete a COMAH land use planning assessment of a residential development (primarily residential) at Newtown, Drogheda, Co. Louth. The proposed development site falls within the consultation distance surrounding the Flogas Ireland Ltd. LPG terminal at Marsh Road, Drogheda, Co. Louth. The LPG terminal is an Upper Tier COMAH establishment, and is subject to the provisions of the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015. The 2015 COMAH Regulations place restrictions on land use planning on the types of development that can take place in the vicinity of COMAH establishments.

This report identifies land use planning contours for the Flogas LPG Terminal. The individual risk contours are based on consequence assessment and risk modelling of an LPG BLEVE/fireball event at Flogas and the assessment has been completed in accordance with the *Policy and Approach of the Health and Safety Authority to COMAH Risk-based Land-use Planning, 2010* (HSA, 2010).

Consequence modelling was completed of LPG BLEVE and fireball events at the LPG vessels at the Flogas terminal. The assessment concludes that for the nearest vessel, the 1% mortality range extends to the footprint of the proposed development but not to any building or area outdoors that is likely to be normally occupied. All other vessels are at greater distances from the boundary of the proposed development site, and the 1% mortality hazard range does not extend to the development site for BLEVE events.

It is predicted that an LPG BLEVE at the Flogas Terminal will not result in any fatalities at the proposed development site.

TNO Riskcurves Version 10.1 modelling software was used to model the risk based land use planning contours for the Flogas LPG terminal. Risk contours for the proposed establishment corresponding to the boundaries of the inner, middle and outer risk based land use planning zones are illustrated as follows:



Individual Risk Land Use Planning Contours

It is concluded that the land use planning zones for the Flogas LPG terminal at Marsh Road do not extend to the proposed development site. The outer zone falls in close proximity to the development site boundary, but does not reach the site boundary.

It is concluded that the proposal comprises development with a mix of Level 2 and Level 3 sensitivities. With reference to the HSA's Land Use Planning Matrix, Level 2 developments are permissible in the Middle and Outer Zones, and Level 3 developments are permissible in the Outer Zone.

The proposed development lies outside of the outer zone.

Societal risk at the proposed development was assessed and the Scaled Risk Integral was calculated. It is concluded that the conservative SRI estimation for the proposed development at 11629 is significantly lower than the levels corresponding to serious public safety concern in the UK. The level of societal risk at the proposed development is negligible.

It is concluded that on the basis of both individual and societal risk, the development proposed is acceptable.

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1.0 INTRODUCTION

AWN Consulting Ltd. were instructed by Ravala Ltd. to complete a COMAH land use planning assessment of a proposed development (primarily residential) at Newtown, Drogheda, Co. Louth. The proposed development site falls within the consultation distance surrounding the Flogas Ireland Ltd. LPG terminal at Marsh Road, Drogheda, Co. Louth. The LPG terminal is an Upper Tier COMAH establishment, and is subject to the provisions of the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015. The 2015 COMAH Regulations place restrictions on land use planning on the types of development that can take place in the vicinity of COMAH establishments.

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The impacts of these land use planning zones on the proposed development at Newtown are assessed with reference to the HSA’s COMAH LUP Policy and Approach document (HSA, 2010).

This report contains the following:

- Introduction
- Description of proposed development and Flogas LPG terminal
- Assessment methodology and criteria
- COMAH Land Use Planning Assessment
- Conclusion

2.0 DESCRIPTION OF PROPOSED DEVELOPMENT AND FLOGAS LPG TERMINAL

2.1 Description of Proposed Development

The proposed development site is located at Newtown, Drogheda, Co. Louth. The footprint of the development site is located approximately 225 m south west of the Flogas Ireland Ltd. LPG Terminal at Marsh Road, Drogheda, Co. Louth. The location of the proposed development site and the Flogas LPG terminal are illustrated on Figure 2.1 (overleaf).

The proposed development comprises a gross site area of 9.68 ha and a net site development site area of 7.25 ha and includes for the construction of 450 units.

It is estimated that the 450 residential units will result in a total population of 1,260 persons. The creche is estimated to accommodate up to 120 children and 21 staff. The office block will have the potential to create employment for 127 workers and 54 in the commercial units.

The layout of the proposed development is illusrated on Drawing No. PL-01 Rev M (Site Plan) in Appendix A.

Figure 2.1 Location of Proposed Development Site and Flogas LPG Terminal

2.2 Description of Flogas Ireland Ltd. LPG Terminal

The FloGas Ireland Ltd. LPG terminal at Marsh Road, Drogheda, Co. Louth has been notified to the HSA as an ‘Upper Tier’ establishment under the 2015 COMAH Regulations. Information on the establishment was provided by the HSA in December 2017 in response to a request for information under the Access to Information on the Environment Regulations 2007 to 2014.

Information regarding the contents, capacity and storage pressure of the LPG vessels at Flogas is summarised in Table 2.1.

Tank	Substance	Capacity	Design Pressure
1010	Butane	150t	14.5 barg
1009	Butane	150t	14.5 barg
1008	Butane	150t	14.5 barg
1007	Butane	150t	14.5 barg
1006	Propane	120t	14.5 barg
1005	Propane	100t	14.5 barg
1004	Propane	100t	14.5 barg
1003	Propane	100t	14.5 barg
1002	Propane	100t	14.5 barg
1001	Propane	100t	14.5 barg
1011	Propane	100t	14.5 barg
1012	Propane	100t	14.5 barg
1013	Propane	100t	14.5 barg
1014	Propane	100t	14.5 barg
1015	Propane	100t	14.5 barg
1016	Propane	100t	14.5 barg
1017	Propane	90t	14.5 barg
1018	Propane	90t	14.5 barg
1019	Propane	110t	14.5 barg
1020	Propane	100t	14.5 barg

Table 2.1 Flogas LPG Tank Contents, Capacity and Design Pressure

Figure 2.2 overleaf illustrates the layout of the Flogas LPG terminal.

Figure 2.2 Layout of Flogas LPG Terminal

3.0 ASSESSMENT METHODOLOGY AND CRITERIA

3.1 Introduction

Trevor Kletz in his seminal work on the subject stated that the essential elements of quantitative risk assessment (QRA) are:

(i) how often is a Major Accident Hazard (MAH) likely to occur and
(ii) Consequence Analysis – what is the impact of the incident (Kletz, 1999)

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

- How often?
- How big?
- So what?

The “how often?” question is generally answered by using frequency analysis techniques such as Event Tree Analysis (ETA) and Fault Tree Analysis (FTA), as described in the TNO Red Book (CPR 12E) (Committee for Prevention of Disasters, 1997). In the current assessment, conservative frequency data specified by the HSA for land use planning purposes in *Policy and Approach of the Health and Safety Authority to COMAH Risk-based Land-use Planning* (HSA, 2010) are applied to representative worst case major accident scenarios.

The ‘how big’ element of the QRA was conducted using consequence modelling methodologies outlined in the HSA’S COMAH LUP Policy and Approach Document (HSA, 2010) to quantify the consequences arising from an LPG BLEVE scenario.

The “so what” element is perhaps the most contentious issue associated with QRA, as one is essentially asking what is an acceptable level of risk, in this case risk of fatality, posed by a facility. Individual and societal risk is quantified using TNO Riskcurves modelling software. The acceptability of the level of risk of fatality is assessed with reference to published acceptability criteria.

The Health and Safety Authority (HSA) in Ireland has specified a maximum level of individual risk of fatality of 1E-06 per year to residential type properties and 5E-06 per year to non-residential type neighbours (HSA, 2010).

3.2 Land Use Planning and Risk Assessment

The Seveso III Directive (2012/18/EU) requires Member States to apply land-use or other relevant policies to ensure that appropriate distances are maintained between residential areas, areas of substantial public use and the environment, including areas of particular natural interest and sensitivity and hazardous establishments. For existing establishments, Member States are required to implement, if necessary, additional technical measures so that the risk to persons or the environment is maintained at an acceptable level.

The HSA is the Competent Authority in Ireland as defined by 2015 COMAH Regulations which implement the Seveso III Directive. The HSA is responsible for ensuring that the impacts of facilities which fall within the remit of this legislation are taken into account with respect to land use planning. This is achieved through the provision of technical advice to planning authorities.

A risk-based approach to land use planning near hazardous installations has been adopted by the HSA and is set out in their COMAH LUP Policy and Approach document (HSA, 2010). This approach involves delineating three zones for land use planning guidance purposes, based on the potential risk of fatality from major accident scenarios resulting in damaging levels of thermal radiation (e.g. from pool fires), overpressure (e.g. from vapour cloud explosions) and toxic gas concentrations (e.g. from an uncontrolled toxic gas release).

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

10^{-5}/year	Risk of fatality for Inner Zone (Zone 1) boundary
10^{-6}/year	Risk of fatality for Middle Zone (Zone 2) boundary
10^{-7}/year	Risk of fatality for Outer Zone (Zone 3) boundary

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

- Identify the major accident scenarios and determine their consequences using the modelling methodologies described in the HSA LUP Policy and Approach Document (HSA, 2010);
- Determine the consequence/severity (probability of fatality) using the probit functions specified by the HSA;
- Determine the frequency of the accident (probability of event) using data specified by the HSA; and
- Calculate the individual risk of fatality as follows:

  Risk = Frequency x Severity

The 2010 HSA COMAH LUP Guidance document (HSA, 2010) provides guidance on the type of development appropriate to the inner, middle and outer LUP zones. The methodology sets four levels of sensitivity, with sensitivity increasing from 1 to 4, to describe the development types in the vicinity of a COMAH establishment.

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

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

Table 3.1 details the matrix that is used by the HSA to advise on suitable development for technical LUP purposes:

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

Table 3.1 LUP Matrix

3.3 Societal Risk

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

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

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

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

It is recognised that it is not necessary to restrict all access by people to such lands, but it is considered prudent to restrict the number and type of persons which could be impacted.

The HSA LUP Policy and Approach document (HSA, 2010) recommends that for some types of development, particularly those involving large numbers of people, it is likely that the deciding factor from the point of view of land use planning is the societal risk, i.e. the risk of large numbers of people being affected in a single accident. An upper societal risk criterion value of 1 in 5000 for 50 fatalities is specified. Above this level, the HSA will advise against the proposed development. In the broadly acceptable region (1 in 100,000 for 10 fatalities), the advice of the HSA is 'not against'. In the significant risk region between these two values, the HSA in providing advice to the planning authority will advise them of that fact and of the need to weigh this into their planning decision, using Cost Benefit Analysis (CBA) and taking into account any socioeconomic benefits as necessary.

Various methods for calculating societal risk as outlined in the HSA LUP Policy and Approach document (HSA, 2010).

3.4 Consequence Modelling

The impacts of physical effects of a BLEVE event were determined using the LPG BLEVE/fireball model described in Appendix 2.1 to the HSA LUP Guidance document (HSA, 2010).

3.4.1 BLEVE and Fireball

A BLEVE is an explosion which occurs when a storage vessel containing a liquid at a temperature significantly above its boiling point at normal atmospheric pressure, experiences a catastrophic failure.

Unlike a vapour cloud explosion, the liquid in question does not have to be flammable, however most of the BLEVEs recorded have been associated with facilities which stored flammable material. The catastrophic failure of a storage vessel and the subsequent rapid vaporisation of the liquid within the vessel produces an explosion overpressure.

A BLEVE involving flammable liquid produces both an explosion overpressure and, should the vapour be ignited, an overpressure associated with the vapour cloud explosion of the released vapour. A BLEVE involving a flammable liquid also produces a buoyant fireball, whose radiant energy can burn exposed skin and ignite nearby combustible materials.

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

3.4.2 Thermal Radiation Criteria

Fire scenarios (including fireballs) have the potential to create hazardous heat fluxes. Therefore, thermal radiation on exposed skin poses a risk of fatality. Potential consequences of damaging radiant heat flux and direct flame impingement are categorised in Table 3.2 (HSA, 2010, CCPS, 2000, EI, 2007 and McGrattan et al, 2000).

Thermal Flux (kW/m^2)	Consequences
1 – 1.5	Sunburn
5 – 6	Personnel injured (burns) if they are wearing normal clothing and do not escape quickly
8 – 12	Fire escalation if long exposure and no protection
32 – 37.5	Fire escalation if no protection (consider flame impingement)
31.5	US DHUD, limit value to which buildings can be exposed
37.5	Process equipment can be impacted, AIChE/CCPS
Up to 350	In flame. Steel structures can fail within several minutes if unprotected or not cooled.

Table 3.2 Heat Flux Consequences

In relation to persons indoors, the HSA have specified the thermal radiation consequence criteria (from an outdoor fire) detailed in Table 3.3 (HSA, 2010).

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

Table 3.3 Heat Flux Consequences Indoors

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

$$\text{Thermal Dose} = I^{1.33}\, t \qquad \text{(Equation 1)}$$

where the Thermal Dose Units (TDUs) are $(kW/m^2)^{4/3}.s$, I is thermal radiation intensity (kW/m^2) and t is exposure duration (s).

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

$$\text{Probit} = -14.9 + 2.56 \ln (I^{1.33}\, t) \qquad \text{(Equation 2)}$$

I Thermal radiation intensity (kW/m^2)
t exposure duration (s)

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

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y-5} \exp\left(-\frac{u^2}{2}\right) du \qquad \text{(Equation 3)}$$

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

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

$$P = 50\left[1 + \frac{Y-5}{|Y-5|}\, erf\left(\frac{|Y-5|}{\sqrt{2}}\right)\right] \qquad \text{(Equation 4)}$$

The relationship between Probit and percentage certainty is presented in Table 3.4 (CCPS, 2000).

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

Table 3.4 Conversion from Probits to Percentage

For long duration fires, such as pool fires, it is generally reasonable to assume an effective exposure duration of 75 seconds to take account of the time required to escape. With respect to exposure to thermal radiation outdoors, the Eisenberg probit relationship implies:

- 1% fatality – 966 TDUs (6.8 kW/m^2 for 75 s exposure duration) (Dangerous Dose)
- 10% fatality – 1452 TDUs (9.23 kW/m^2 for 75 s exposure duration)
- 50% fatality – 2387 TDUs (13.4 kW/m^2 for 75 s exposure duration)

For short duration fires such as fireballs, the fireball duration is used to calculate thermal dose and to estimate mortality hazard ranges. It is assumed that 100% mortality occurs within the fireball radius.

3.5 Modelling Parameters

Weather conditions at the time of a major-accident have a significant impact on the consequences of the event. Typically, high wind speeds slightly increase the impact of fires, particularly pool fires. It is noted that weather conditions (including ambient temperature, humidity, wind speed and direction) and atmospheric stability do not impact the consequences of fireball or BLEVE events.

3.6 Individual Risk Assessment Methodology

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

4.0 ASSESSMENT FOR FLOGAS LPG STORAGE FACILITY

4.1 Identification of Major Accident Scenarios

In relation to LPG storage facilities, the HSA state in their LUP Policy/Approach document (HSA, 2010):

> *"It is reasonable to assume that off-site risks for LPG storage will generally be dominated by large BLEVE events, as the majority of lesser events have much less impact."*

Therefore, it is assumed the distances to the boundaries of the risk-based land use planning zones surrounding the Flogas LPG terminal will be based on the aggregate risk from BLEVE (Boiling Liquid Expanding Vapour Explosion) events at each LPG vessel at the Flogas site.

4.2 Consequence Modelling

4.2.1 Model Inputs

The method for calculating the mass of material involved in a fireball is based the approach recommended by the CCPS (2010). If the adiabatic flash vaporisation of the fuel exceeds 1/3 of the released inventory, the mass of fuel involved in the fireball equals the total mass of fuel released. Otherwise, the mass involved equals three times the adiabatic flash vapour mass fraction. This accounts for the mass contributed to the released vapour cloud as a result of entrained liquid droplets following a BLEVE.

Equation 2.168 of the TNO yellow book (Committee for Prevention of Disasters, 2005) calculates the vapour fraction after flashing following an instantaneous release (approximating adiabatic conditions) of a pressurised liquefied gas as follows:

$$\phi_{m,f} = \frac{\phi_{m,0}\dfrac{L_{v,0}}{T_0} + S_{0,L} - S_{f,L}}{\dfrac{L_{v,f}}{T_f}}$$

Equation 5

$\phi_{m,0}$ and $\phi_{m,f}$	Initial and final vapour mass fractions, respectively
$L_{v,0}$ and $L_{v,f}$	Latent heat of the chemical at storage and boiling temperature, respectively (J/kg)
$S_{L,0}$ and $S_{L,f}$	Entropy of the liquid chemical at storage temperature and pressure and boiling temperature and ambient pressure, respectively (J/(kg.K))
T_0 and T_f	Storage and boiling temperature of chemical, respectively (K)

If no detailed data on entropies are available, this can be approximated by:

$$\phi_{m,f} = \phi_{m,0}\frac{T_f}{T_0} + \frac{T_f}{L_{v,f}}C_{p,L}\ln\frac{T_0}{T_f}$$

Equation 6

Cp,L	Specific heat of the liquid	(J/(kg.K))

The adiabatic flash vapour fraction calculation is detailed in Table 4.1 as follows:

Parameter		Units	Propane	Butane
$f_{m,0}$	Initial vapour mass fraction	-	0	0
T_f	Final (boiling temperature)	K	230.9	272.65
T_0	Initial (storage) temperature	K	282.75	282.75
$L_{v,f}$	Final latent heat	J/kg	426134.8	388409
Cp,L	Specific heat (liquid)	J/(kg.K)	2413.51	2292.45
$f_{m,f}$	Final vapour mass fraction	-	0.26	0.06

Table 4.1 Flash Vapour Fraction Calculation

Information on final latent heat and specific heat were obtained from the TNO Yellow book for propane and from the DIPPR database (2015) for butane.

The mass of fuel involved in a BLEVE is calculated in Table 4.2 for each vessel size/contents at Flogas.

Substance	Inventory kg	Flash vapour fraction	Mass of fuel involved kg
Propane	90000	0.26	71529.13
Propane	100000	0.26	79476.81
Propane	110000	0.26	87424.49
Propane	120000	0.26	95372.17
Butane	150000	0.06	26340.38

Table 4.2 Calculation of Mass of Fuel Involved in Fireball

For the purposes of calculating the heat radiation from a fireball, the Surface Emissive Power was conservatively taken as 270 kW/m^2.

4.2.2 Model Outputs

Table 4.3 details the diameter, radius and fireball duration results obtained using the HSA's LPG fireball model.

Parameter	Units	90t propane tank	100t propane tank	110t propane tank	120t propane tank	150t butane tank
Fireball diameter, D	m	240	248	256	264	174
Fireball radius, R	m	120	124	128	132	87
Fireball duration, T	s	16.6	16.9	17.2	17.5	13.5
No. of vessels	No.	2	12	1	1	4

Table 4.3 HSA LPG Fireball Model Results: Fireball Diameter, Radius and Duration

Thermal radiation vs. distance is illustrated on Figure 4.1.

The probability of fatality outdoors with distance with calculated using the Eisenberg probit equation described in Section 3.4.2. The fireball duration (see Table 4.3) was used as the exposure duration. See Figure 4.2 for probability of fatality vs. distance. It is assumed that the probability of fatality within the fireball radius is 100%.

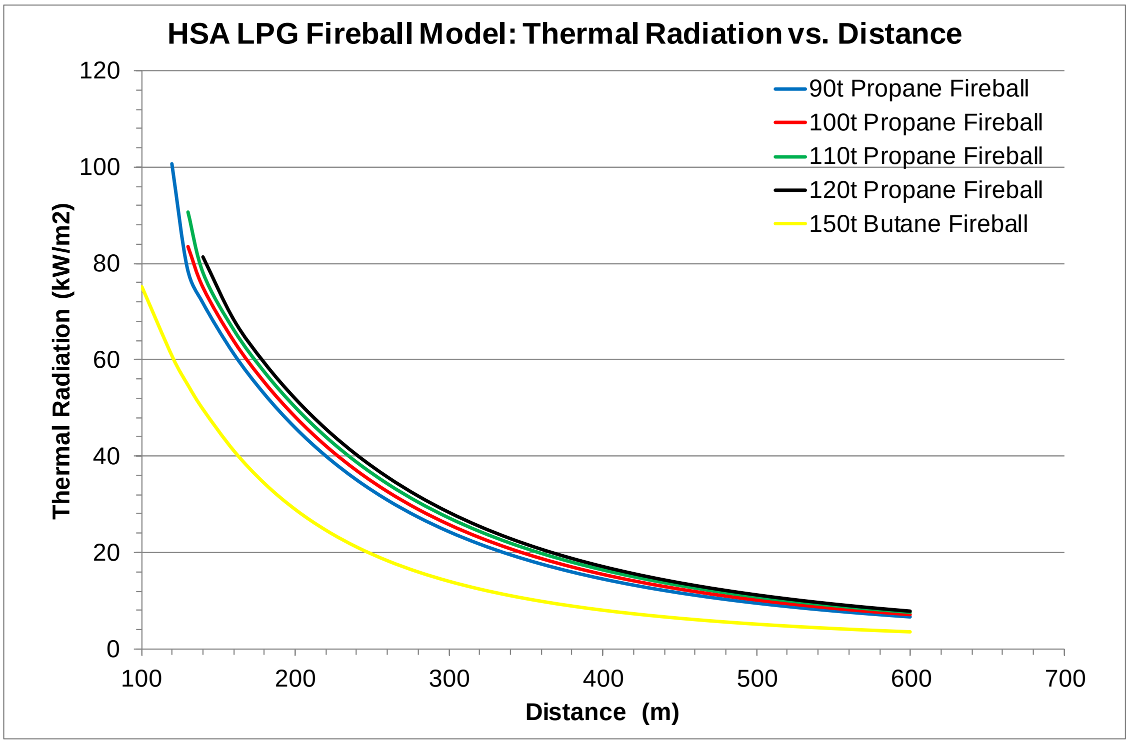


Figure 4.1 LPG Fireball Thermal Radiation vs. Distance

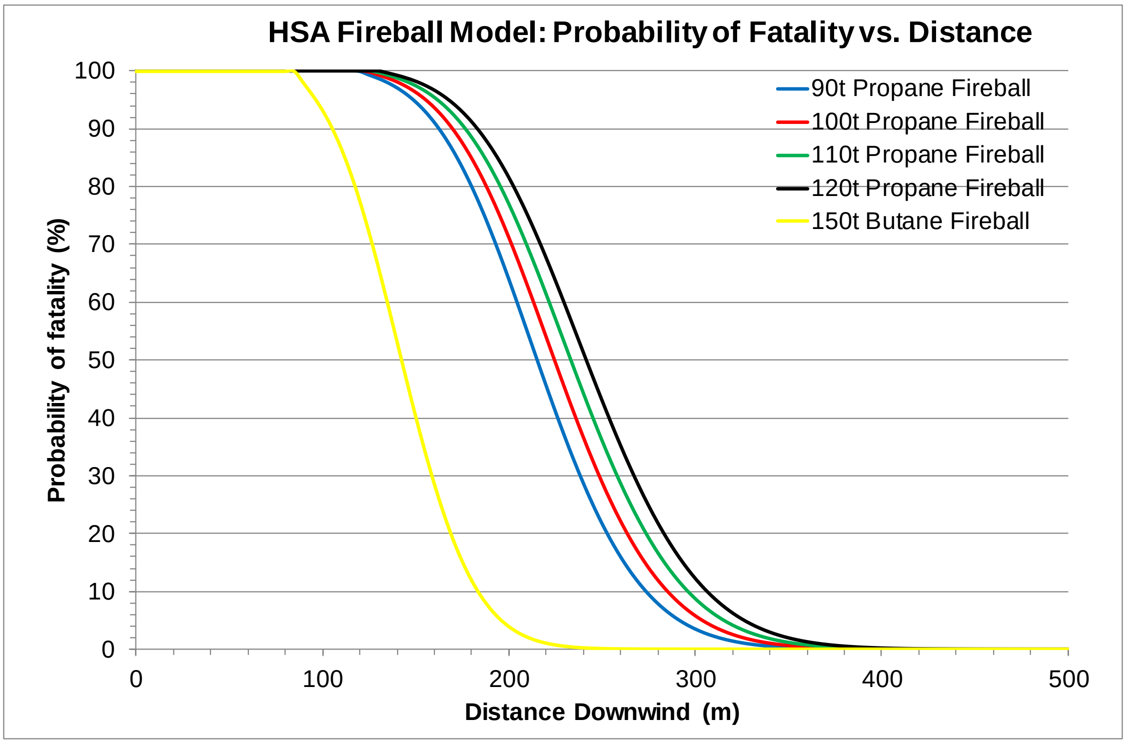


Figure 4.2 LPG Fireball Probability of Fatality Outdoors vs. Distance

Distances to specified mortality levels (outdoors) are sumamrised as follows:

Parameter	Units	90t propane tank	100t propane tank	110t propane tank	120t propane tank	150t butane tank
100% mortality outdoors (fireball radius)	m	120	124	128	132	87
50% mortality outdoors	m	215	225	233	243	143
10% mortality outdoors	m	274	285	296	307	184
1% mortality outdoors	m	327	341	354	366	221

Table 4.4 HSA LPG Fireball Model: Distances to 1%, 10%, 50% and 100% Mortality Levels

Table 4.5 summarises the distances to the nearest LPG vessels at the Flogas terminal, the vessel contents and 1% mortality hazard range (see Table 2.1 and Figure 2.2 in Section 2.2 for vessel contents and locations).

Vessel	Contents	Distance to boundary of proposed development	Fireball radius	1% mortality hazard range
1001	100 tonne propane	340 m	124 m	341 m
1002	100 tonne propane	342 m	124 m	341 m
1019	110 tonne propane	357 m	128 m	354 m
1020	100 tonne propane	351 m	124 m	341 m

Table 4.5 Summary of BLEVE Impacts from Nearest Vessels

In the event of a BLEVE at Flogas LPG Vessel 1001, the 1% mortality range extends beyond the boundary of the proposed development site (by 1 m) but not to any building or area outdoors that is likely to be normally occupied. All other vessels are at greater distances from the boundary of the proposed development site, and the 1% mortality hazard range does not extend to the development site for BLEVE events.

A BLEVE event at vessel 1001 has the greatest consequence level in at the proposed development site. Figure 4.3 illustrates the mortality contours for LPG Vessel 1001.

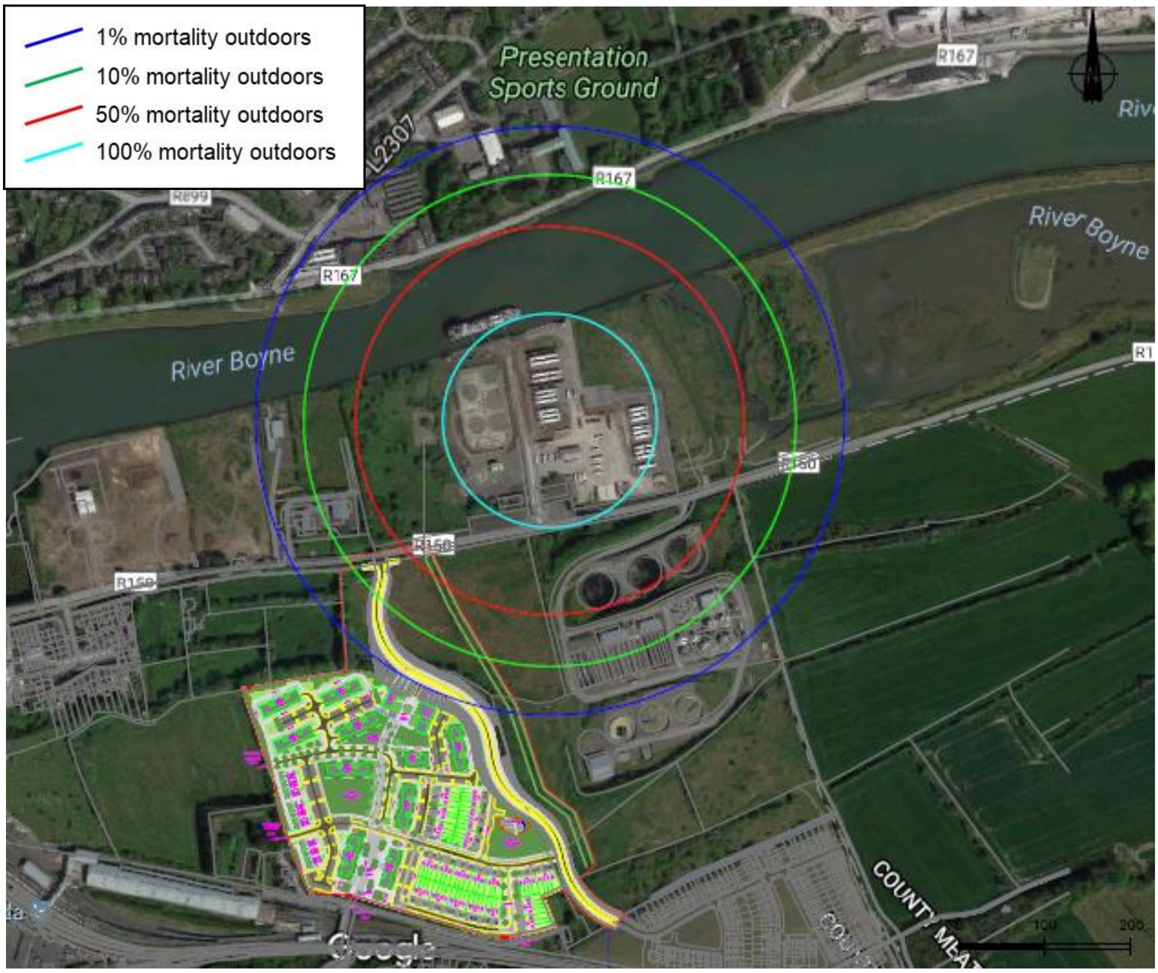


Figure 4.3 LPG Fireball at Vessel 1001: Mortality Contours

It is concluded that the 1% mortality contour extends to the footprint of the development but does not reach any building or normally occupied area. It is predicted that an LPG BLEVE at the Flogas Terminal will not result in any fatalities at the proposed development site.

4.3 BLEVE Frequency

As outlined in Section 3.1 herein, the HSA recommends the use of conservative frequency values for a small number of representative major accident scenarios, for land use planning assessments (HSA, 2010). A frequency value of 1E-05 per year per vessel is applied to an LPG BLEVE scenario.

4.4 Land Use Planning Risk Contours

Risk is the product of frequency and severity (or consequence). The frequency of an LPG BLEVE is taken as 1E-05 per year per vessel (as described in Section 4.3). The consequence results are detailed in Section 4.2.

TNO Riskcurves Version 10.1 modelling software was used to model the risk based land use planning contours for the Flogas LPG terminal.

The consequence results and frequencies of major accident hazards were input to the software.

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

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

Risk contours for the proposed establishment corresponding to the boundaries of the inner, middle and outer risk based land use planning zones are illustrated on Figure 4.4.

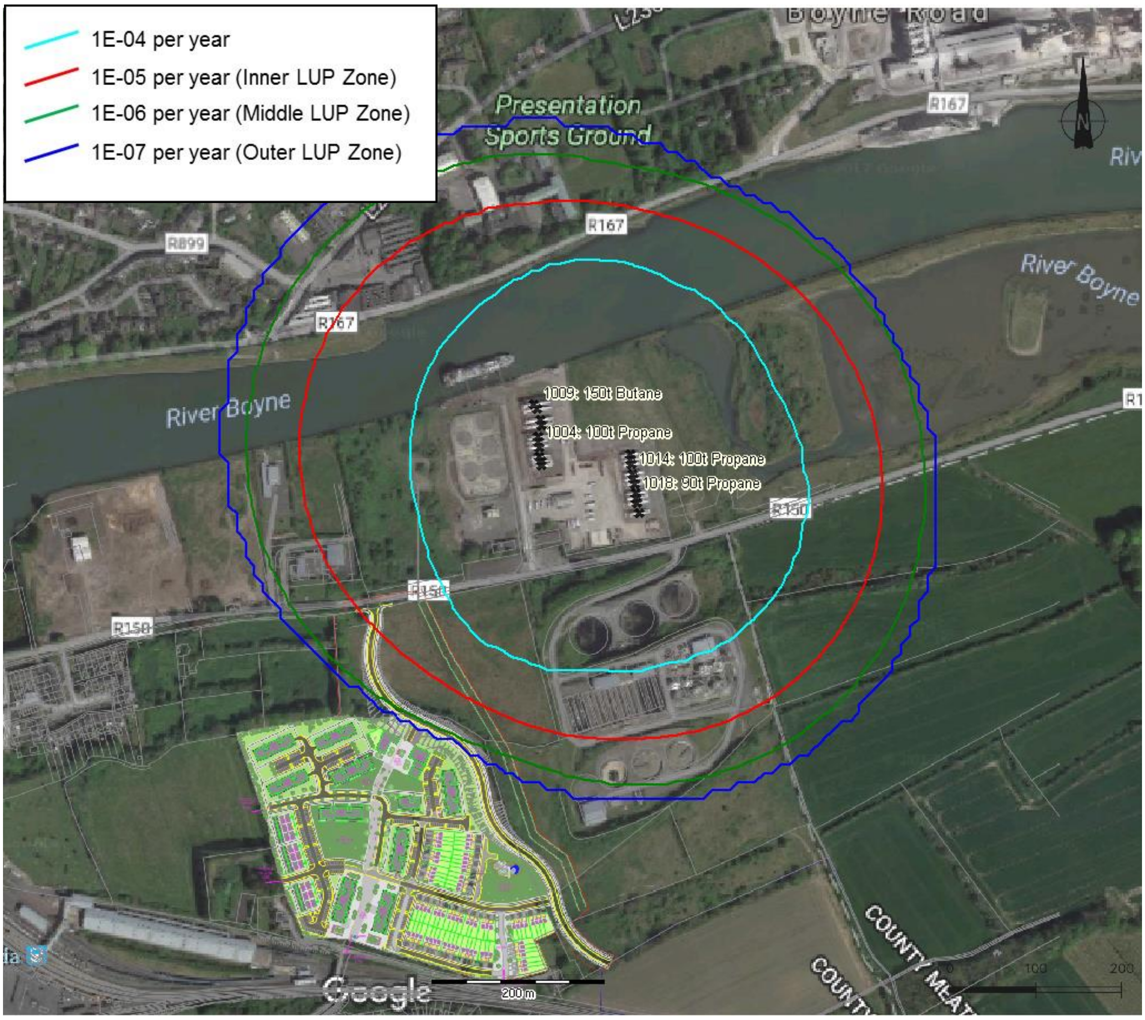


Figure 4.4 Individual Risk Land Use Planning Contours

It is concluded that the land use planning zones for the Flogas LPG terminal at Marsh Road do not extend to the proposed development site. The outer zone falls in close proximity to the development site boundary, but does not reach the site boundary.

4.5 Societal Risk Assessment

The Scaled Risk Integral (SRI) approach is recommended by the HSA in the COMAH LUP Policy and Approach document (HSA, 2010) for quantifying societal risk at developments in the vicinity of COMAH establishments.

The SRI is calculated as follows:

$$SRI = \frac{P \times R \times T}{A} \quad \textit{(Equation 7)}$$

$$P = \frac{n + n^2}{2} \quad \textit{(Equation 8)}$$

SRI	Scaled Risk Integral
P	population factor
n	number of persons at the development
R	average estimated level of risk in cpm
T	proportion of time development is occupied by n persons
A	area of the development in hectares

An allowance for the sensitivity of different population groups is incorporated by scaling ‘n’ by, for example, 0.25 for a working population, and 4 for a sensitive population.

The individual risk (IR) contour corresponding to 1E-07 per year (boundary of the outer LUP zone) does not reach the proposed development. The Riskcurves model described in Section 4.4 was used to model IR contours corresponding 1o 1E-10 and 1E-15 per year. See Figure 4.5 for the location of these contours in relation to the proposed development site.

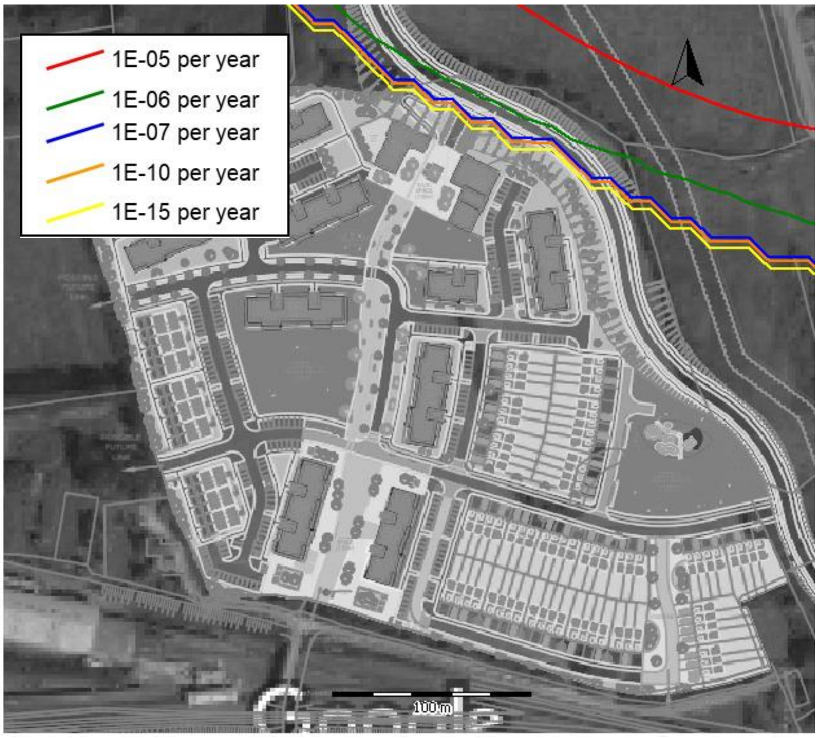


Figure 4.5 Individual Risk Contours

It can be seen from Figure 4.5 that the maximum level of IR at the proposed development is less than 1 E-15 per year.

In order to demonstrate that societal risk at the proposed development is negligible, a conservative approach is adopted and an average level of individual risk of 1E-07 per year (or 0.1 cpm per year) is used in calculating the SRI. See Table 4.6 for societal risk calculations for the proposed development.

Parameter	Residential	Office	Commercial	Creche	Source
n (number of persons at the development)	1,260	127	54	141	Scheme's architects
scaling factor	1	0.25	1	4	HSA Guidelines (HSA, 2010)
scaled n	1,163	32	54	564	-
P (population factor)	794,430	520	1,485	159,330	-
R (average estimated level of risk in cpm per year)	0.1	0.1	0.1	0.1	As described above
T (proportion of time development is occupied by n persons)	1	0.3	0.5	0.3	HSA Guidelines (HSA, 2010)
A (area of the development in hectares)	7.25	7.25	7.25	7.25	Scheme's architects
Scaled Risk Integral	10958	2	10	659	
Total SRI	**11629**				

Table 4.6 Societal Risk Calculation

The HSA does not cite acceptability criteria that applies to the SRI value for new developments in the vicinity of COMAH establishments in the COMAH LUP Policy and Approach Document (HSA, 2010).

In the UK, the Health and Safety Executive have published SRI criteria in their Criteria document for Land Use Planning cases of serious public safety concern, SPC/TECH/GEN/49 (UK HSE, 2017). The UK HSE consider serious public safety concern to arise where the SRI is between 500,000 and 750,000, and societal risk to be intolerable where the SRI exceeds 750,000.

The conservative SRI estimation for the proposed development at 11629 is significantly lower than levels corresponding to serious public safety concern in the UK.

It is concluded that the level of societal risk at the proposed development is negligible.

4.6 Suitability of Proposed Development to LUP Zones

The proposed development at Newtown, Drogheda, Co. Louth comprises residential (450 units), offices, neighbourhood uses (8 No. uses) and a creche (1 No. unit) type development.

The sensitivity level of each aspect of the development is summarised in Table 4.7. Sensitivity levels are assigned with reference to Appendix 1 of the HSA COMAH LUP Policy and Approach document (HSA, 2010).

Type	Density	Sensitivity Level
Residential	450units in 7.25 ha or 62 units per hectare	Level 3 (> 40 units/ha)
Office block	1 No. 4 storey office block	Level 2 (> 3 storeys)
Commercial units	8 No. ground floor units in Blocks 9/10, total floor space 1,278 m^2	Level 2 (250 m^2 to 5000 m^2)
Creche	3 storey creche	Level 3

Table 4.7 Sensitivity Levels of Proposed Development

It is concluded that the proposal comprises development with a mix of Level 2 and Level 3 sensitivities. With reference to the Land Use Planning Matrix in Table 3.1 (Section 3.2), Level 2 developments are permissible in the Middle and Outer Zones, and Level 3 developments are permissible in the Outer Zone.

The proposed development lies outside of the outer zone. Therefore, it is concluded that on the basis of individual risk it is an acceptable development proposal.

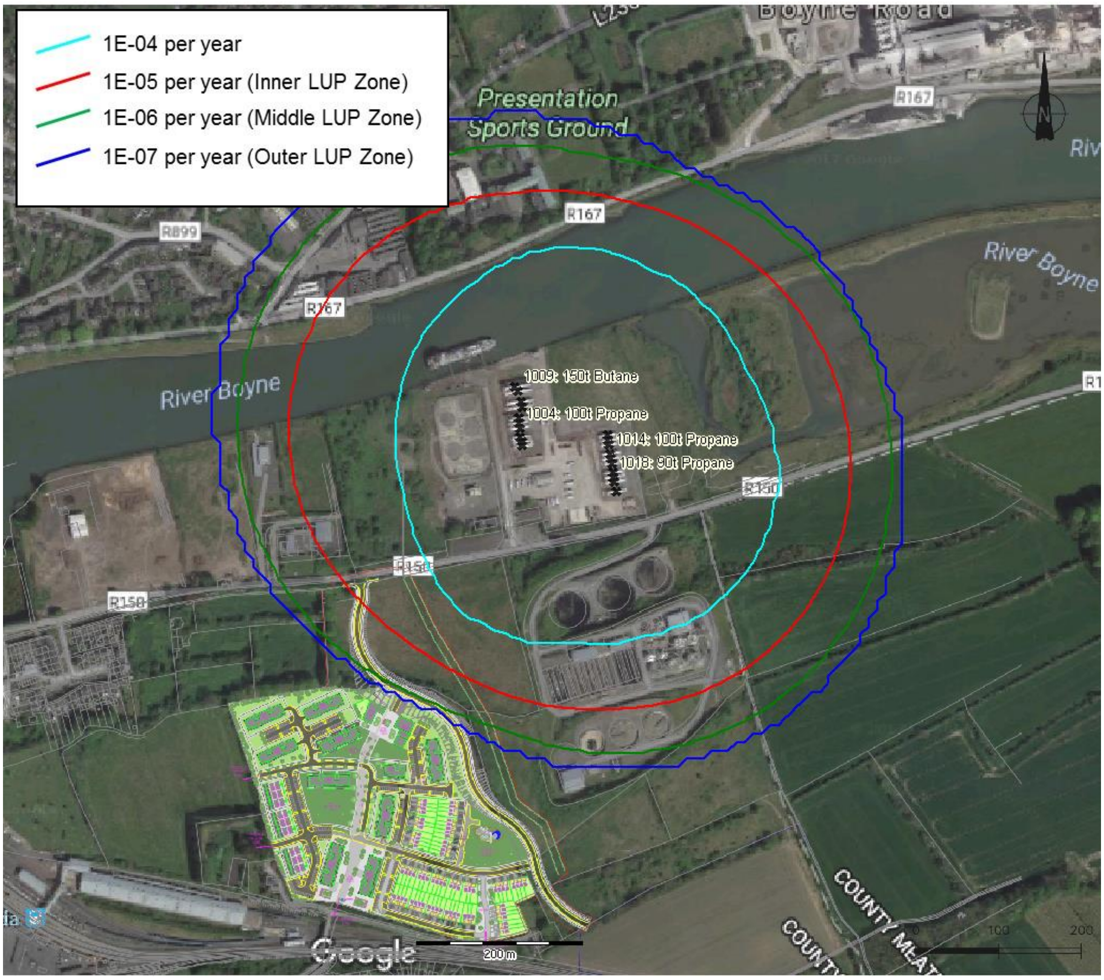
5.0 CONCLUSION

A COMAH land use planning assessment was completed of a proposed development (primarily residential) at Newtown, Drogheda, Co. Louth. The proposed development site falls within the consultation distance surrounding the Flogas Ireland Ltd. LPG terminal at Marsh Road, Drogheda, Co. Louth. The LPG terminal is an Upper Tier COMAH establishment, and is subject to the provisions of the COMAH Regulations 2015 which place restrictions on land use planning and the types of development that can take place in the vicinity of COMAH establishments.

Consequence modelling was completed of LPG BLEVE and fireball events at the LPG vessels at the Flogas terminal. The assessment concludes that for the nearest vessel, the 1% mortality range extends to the footprint of the proposed development but not to any building or area outdoors that is likely to be normally occupied. All other vessels are at greater distances from the boundary of the proposed development site, and the 1% mortality hazard range does not extend to the development site for BLEVE events.

It is predicted that an LPG BLEVE at the Flogas Terminal will not result in any fatalities at the proposed development site.

TNO Riskcurves Version 10.1 modelling software was used to model the risk based land use planning contours for the Flogas LPG terminal. Risk contours for the proposed establishment corresponding to the boundaries of the inner, middle and outer risk based land use planning zones are illustrated as follows:



Individual Risk Land Use Planning Contours

It is concluded that the land use planning zones for the Flogas LPG terminal at Marsh Road do not extend to the proposed development site. The outer zone falls in close proximity to the development site boundary, but does not reach the site boundary.

It is concluded that the proposal comprises development with a mix of Level 2 and Level 3 sensitivities. With reference to the HSA's Land Use Planning Matrix, Level 2 developments are permissible in the Middle and Outer Zones, and Level 3 developments are permissible in the Outer Zone.

The proposed development lies outside of the outer zone.

Societal risk at the proposed development was assessed and the Scaled Risk Integral was calculated. It is concluded that the conservative SRI estimation for the proposed development at 11629 is significantly lower than the levels corresponding to serious public safety concern in the UK. The level of societal risk at the proposed development is negligible.

It is concluded that on the basis of both individual and societal risk, the development proposed is acceptable.

6.0 REFERENCES

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APPENDIX A SITE LAYOUT PLAN

END OF REPORT