APPENDIX 13.3 HAZARD TO LIFE ASSESSMENT FOR PROPOSED GREEN FILLING STATIONS

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1. INTRODUCTION

1.1 Background

1.1.1.1 This section identifies the hazardous scenarios associated with the operation of two green fuel stations (GFS), which are proposed to provide LPG filling services, during construction and operation of the Project, and presents the analysis and findings of the Quantitative Risk Assessment (QRA) undertaken.

1.1.1.2 The two GFSs store LPG in bulk quantities of less than 25 tonnes separately. They are Notifiable Gas Installation (NGI) under the Gas Safety Ordinance (Cap. 51)(GSO), but not Potentially Hazardous Installation (PHI) under Chapter 12 of the HKPSG. For planning the location of GFS with LPG filling facilities, Section 3.7 of Chapter 12 of the HKPSG has listed some general requirements, including the applicable separation distances between the LPG filling facilities and different types of land uses. Nonetheless, the suitability of incorporating LPG filling facilities in a filling station and the separation distance from other land uses are still subject to the outcome of a QRA.

1.2 Hazard to Life Assessment Objectives and Risk Criteria

1.2.1 Objectives

1.2.1.1 The Hazard to Life Assessment requirements for the two proposed GFS are shown below:

(a) Identify hazardous scenarios associated with operation of the two proposed GFS, and then determine a set of relevant scenarios to be included in a QRA;

(b) Execute a QRA of the set of hazardous scenarios determined in (a), expressing population risks in both individual and societal terms;

(c) Compare individual and societal risks with the criteria for evaluating hazard to life as stipulated in Annex 4 of the TM; and

(d) Identify and assess practicable and cost-effective risk mitigation measures.

1.2.2 EIAO-TM Risk Criteria

1.2.2.1 Annex 4 of the EIAO-TM specifies the Individual and Societal Risk Guidelines. The Hong Kong Risk Guidelines (HKRG) per the EIAO-TM Annex 4 states that the individual risk is the predicted increase in the chance of fatality per year to an individual due to a potential hazard. The individual risk guidelines require that the maximum level of individual risk should not exceed 1 in 100,000 per year i.e. 1×10^{-5} per year. Societal risk expresses the risks to the whole population. It is expressed in terms of lines plotting the cumulative frequency (F) of N or more deaths in the population from incidents at the installation. Two F-N risk lines are used in the HKRG that demark “Acceptable” or “Unacceptable” societal risks. To avoid major disasters, there is a vertical cut-off line at the 1000 fatality level extending down to a frequency of 1 in a billion years. The intermediate region indicates the acceptability of societal risk is borderline and should be reduced to a level which is “as low as reasonably practicable” (ALARP). It seeks to ensure that all practicable and cost-effective measures that can reduce risk are considered. The HKRG is presented graphically in **Plate 1.1**.

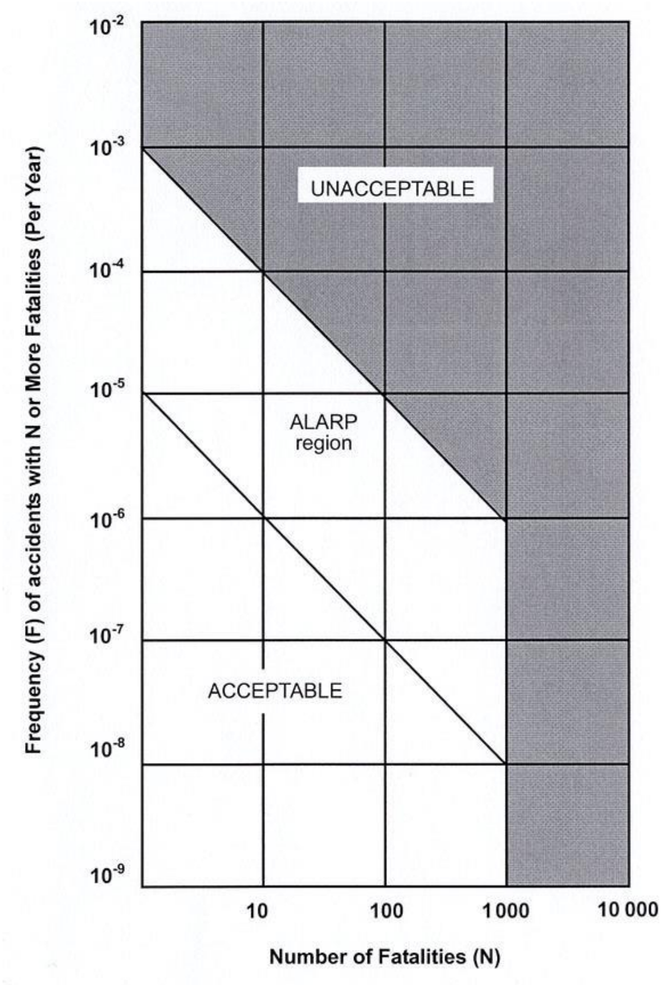

Plate 1.1 Societal Risk Guidelines

1.3 Scope of Work

1.3.1.1 The scope of this QRA is outlined as follows:

(a) to identify potential hazards and to estimate the associated frequencies by reviewing the LPG system design and historical data;

(b) to determine the level of risk posed by the two GFSs with a QRA;

(c) to present the QRA results in the form of iso-risk contours and “FN” curve for individual and societal risks respectively; and

(d) to compare the QRA results with the HKRG, and to propose risk mitigation measures if necessary.

1.3.1.2 The following boundaries have been set for this QRA:

(a) The consideration of risks associated with the transport of LPG by road tankers have been restricted to those related to their final approach to the GFSs; and

(b) The risk assessment has been limited to those events that have the potential of causing off-site fatalities.

1.4 Assessment Scenario

1.4.1.1 Based on the currently envisaged construction programme, the proposed GFSs will be commenced in 2031/32. The hazard assessment covers the following two scenarios:

(a) The risk imposed by the operation of the biogas facilities in the proposed EPP and two GFS, and the HP Gas Pipeline to the existing, committed and planned population in 2032. This scenario accounted for the commencement of the EPP and the two GFSs, and also the presence of the construction workers for areas of the proposed development located along the San Tam Road.

(b) Year 2039 (Operation phase) – The risk imposed by the operation of the biogas facilities in the proposed EPP and two GFSs, and the HP Gas Pipeline to the existing, committed and planned population in 2039. This scenario accounted for the ultimate situation with all the planned land users of the proposed development being considered.

2. SITE DESCRIPTION

2.1 Study Area

2.1.1.1 There are two GFSs proposed within the project site. Station #1 is proposed in the Planning Area 1 and Station #2 is proposed in the Planning Area 5. Study areas defined by extending 200m radius from each station, as shown in **Plate 2.1**, were adopted in this QRA.

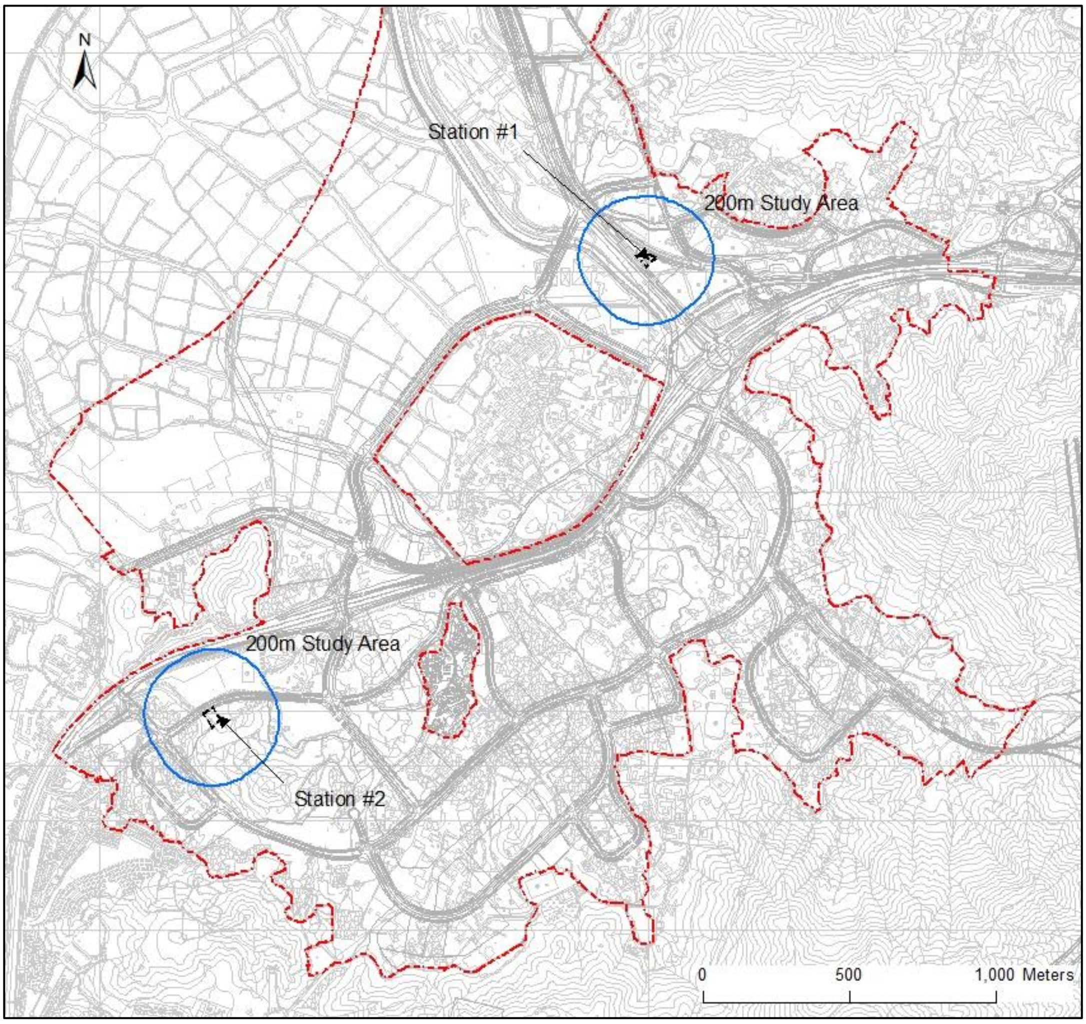

Plate 2.1 Location Plan of GFSs

2.2 The Green Fuel Stations

2.2.1.1 According to LPG throughput estimates, the LPG storage and filling facilities of the two GFSs are proposed to be identical. For each station, two 25.4kL (water capacity) underground LPG storage vessels, which will be filled to the maximum permissible level (85% of the maximum capacity), will be provided. There will also be six LPG dispensers and twelve dispensing nozzles for vehicle refuelling in each station.

2.2.1.2 The storage vessels will be designed, manufactured and tested in accordance with the requirements of the Gas Standard Office (GSO) of Electrical and Mechanical Services Department (EMSD). According to the gas safety requirements as stated in Section 3.7.2 of Chapter 12 in HKPSG, the vent pipes of pressure relief valves for the underground storage vessel will not be obstructed by any obstacles, and the discharge outlets of the vent pipes will be at least 4.5m from any openings of a building or any non-flameproof electrical equipment.

2.3 LPG Delivery and Transfer

2.3.1.1 LPG will be delivered to the GFSs by road tankers. The maximum capacity of each road tanker is about 9 tonnes. Based on the estimates, it is assumed that around 610 vehicles will use the LPG filling facilities of each station, the daily LPG consumption at each station will be around 17 tonnes and that 1-2 LPG deliveries will be necessary. Annual LPG deliveries of 730 were assumed for each station in this QRA.

2.3.1.2 Based on an LPG pumping rate of 200 L / minute, the LPG road tanker's residence time at each GFS will be around 85 minutes, including 70 minutes for LPG unloading and another 15 minutes spent on site for setting up and preparation.

2.3.1.3 The road tankers will be operated in accordance with the standard requirements of the stations' operator. The standard procedures for the LPG delivery are summarised as follows:

(a) Two persons, the driver and his assistant, will be present during the delivery operation;

(b) A dedicated unloading area will be available for the unloading operation. There is a possibility of a road tanker reversing in the unloading area. The road tanker will face towards run-out so that it may leave rapidly should it be required to do so;

(c) The condition of all connections and hoses will be checked by the driver;

(d) The storage vessel will be filled to a maximum of 85% of its liquid level capacity;

(e) During delivery, the driver will wait in close proximity to the "emergency-cut-off switch" while the assistant attends to the delivery process.

2.4 Population

2.4.1 Surrounding Populations

2.4.1.1 Societal risk is a measure of the consequence magnitude and the frequency of the hazardous events. To establish the impact of any release (the number of people likely to be affected) in the future, it is necessary to know the future surrounding population levels. These would include residential population, government and institutional population and transport population but exclude staff of the filling stations since they are considered as voluntary risk takers.

2.4.1.2 **Plate 2.2** and **Plate 2.3** show the location of population groups included in the QRA and the population within the study area is listed in **Table 2.1**. Details of population at different time modes are tabulated in **Annex A**.

<u>Land and Building Population</u>

2.4.1.3 Estimation of land and building populations was based on the latest information provided by Civil Engineering and Development Department (CEDD). The numbers of population were estimated based on the following assumptions:

(a) The amenity areas were assumed to be unmanned, while population in open areas were estimated based on a density of 100m^2/ person; and

(b) An average of 5% population was considered to be outdoor for residential, institution and industrial population, while 100% population was assumed to be outdoor for construction workers, users in open spaces and open storages area.

Table 2.1 Land and Building Population Data

ID	Description	Population	
		Year 2032 – Construction Phase	Year 2039 – Operation Phase
P03	G.5.3 - Existing Mai Po ESS	125	84
P04	G.5.1 - Sport Centre	125	1018
P06	RSc.2.2 - Public Housing	7603	7603
P07a	OU(EPP).5.3 - Food Waste Pretreatment Facilities	100	100
P07b	OU(EPP).5.3 - Effluent Polishing Plant	200	200
P09	G.5.2 - Reserve	0	0
P41	OU(I&T)3.1.7 - Information and Technology - Zone 3	3536	3536
P45	OU(I&T)2.1.1 - Information and Technology - Zone 2	2788	2788
P46	OU(ESS).1.4 - 132kV ESS	0	0
P47	A.1.4 - Amenity	0	0
P48	OU(MU)2.1.1 - Mixed use (Chau Tau Station)	80	17826
P57	OU(WRP).5.2 - Water Reclamation Plant	100	100
P60	GB.5.1 - Green Belt	0	0
P66	A.1.5 - Amenity	0	0
P67	OU(I&T)3.1.5 - Information and Technology - Zone 3	1135	1135
P68	OU(I&T)3.1.4 - Information and Technology - Zone 3	1580	1580
P69	A.1.3 - Amenity	0	0
P70	OU(I&T)3.1.6 - Information and Technology - Zone 3 (Government Data Centre)	240	240

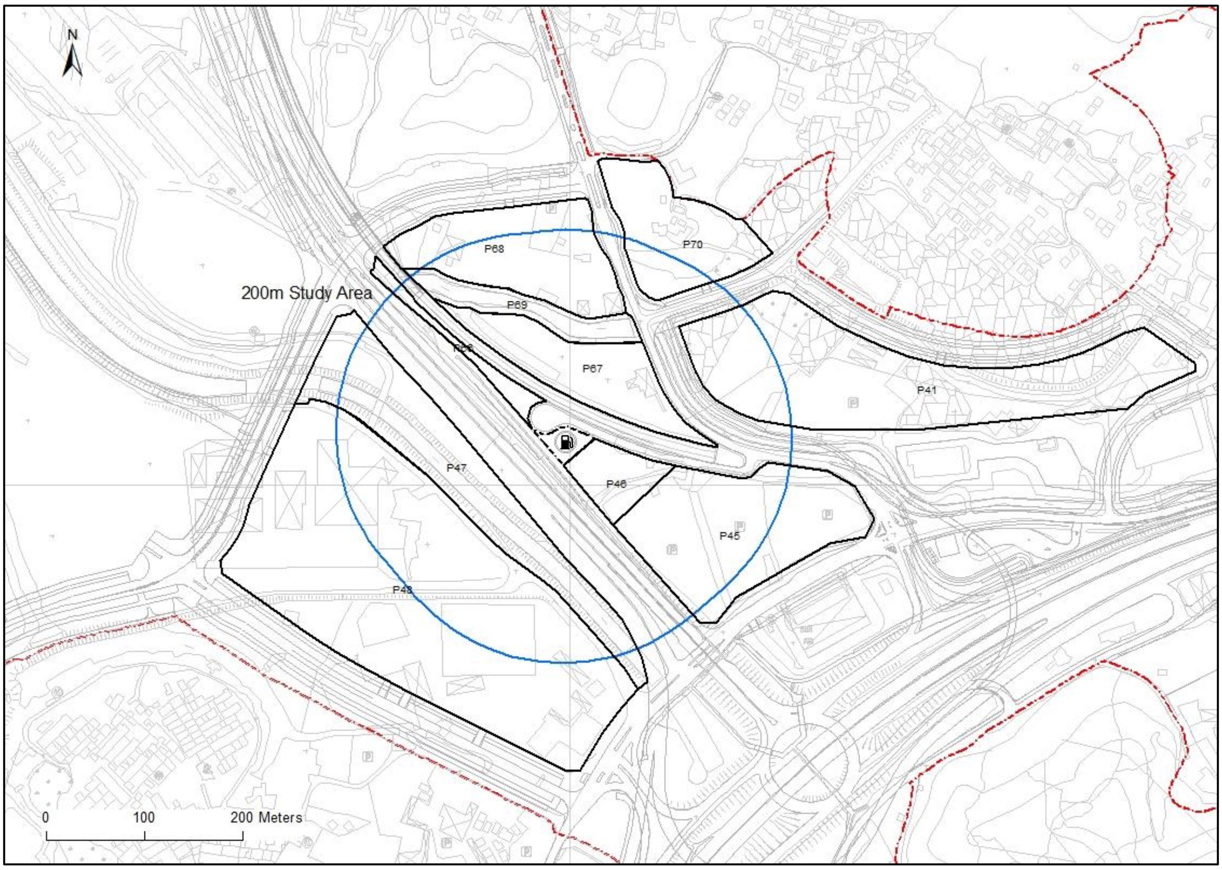

Plate 2.2 Population Groups Considered for Station #1

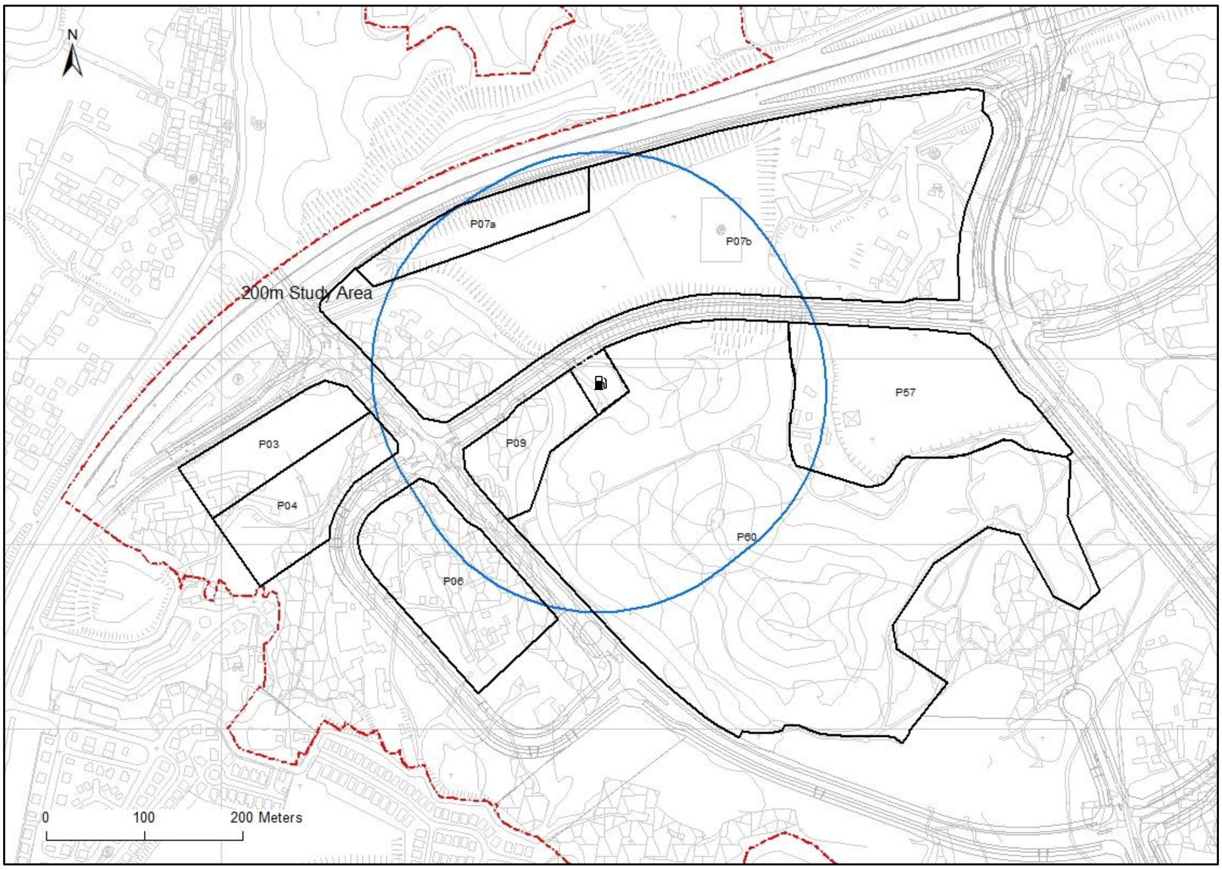

Plate 2.3 Population Groups Considered for Station #2

Traffic Population

2.4.1.4 The traffic data was based on the latest Annual Traffic Census (ATC) published by Transport Department (TD) [2] and the Traffic Impact Assessment (TIA) report prepared for this Assignment. The traffic population was predicted based on the following equation:

$$Traffic\ Population = \frac{No.of\ Person\ per\ vehicle \times No.of\ Vehicle\ per\ hour \times Road\ Length}{Speed}$$

2.4.1.5 Based on the latest ATC [2], the occupancies for each vehicle type and vehicle mix were taken at the core station no. 5016 (San Tin Highway, Castle Peak Road and San Tam Road (from Kam Tin Road to Fairview Park Boulevard) were selected to represent the road traffic for this assessment.

2.4.1.6 The traffic population considered in this assessment, which was assumed to be 100% outdoor, is summarized in **Table 2.2** and detailed in **Annex A**. The locations of roads considered for construction and operation phases are presented in **Plate 2.4**.

Table 2.2 Estimated Road Population

ID	Traffic Speed (km/hr)	Maximum Population			
		Year 2032		Year 2039	
		Daytime	Night-time	Daytime	Night-time
R1	50	18	12	24	14
R2	50	14	10	17	12
R3	50	9	7	20	11
R4	50	16	12	43	22
R5	50	22	13	24	13
R6	100	158	71	191	85
R7	100	148	66	166	73
R8	100	210	93	252	110
R9	100	115	53	129	60
R10	100	260	116	293	133
R11	50	49	26	58	30
R12	50	113	54	98	47
R13	50	20	13	27	15
R14	50	16	11	25	15
R15	50	13	9	20	12
R16	50	17	11	25	15
R17	50	16	11	13	9
R18	50	8	8	13	10
R19	50	35	21	39	22
R20	50	46	26	54	28
R21	50	40	23	47	25
R22	50	42	24	44	24
R23	50	66	35	67	35
R24	50	153	74	168	80
R25	50	176	85	170	81
R26	50	22	14	74	36
R27	50	21	14	77	38
R28	50	0	0	22	13
R29	50	0	0	21	13
R30	50	43	19	88	42
R31	50	45	21	64	29
R32	50	33	20	36	20
R33	50	36	21	51	26
R34	50	34	18	39	19
R35	50	24	15	27	16
R36	50	89	44	83	41
R37	50	7	7	7	7
R38	50	60	31	58	31
R39	50	119	58	149	71
R40	50	7	7	7	7

ID	Traffic Speed (km/hr)	Maximum Population			
		Year 2032		Year 2039	
		Daytime	Night-time	Daytime	Night-time
R41	50	7	7	7	7
R42	50	10	10	12	12
R43	50	20	20	24	24
R44	50	10	10	13	13
R45	50	9	9	10	10
R46	50	10	10	12	12

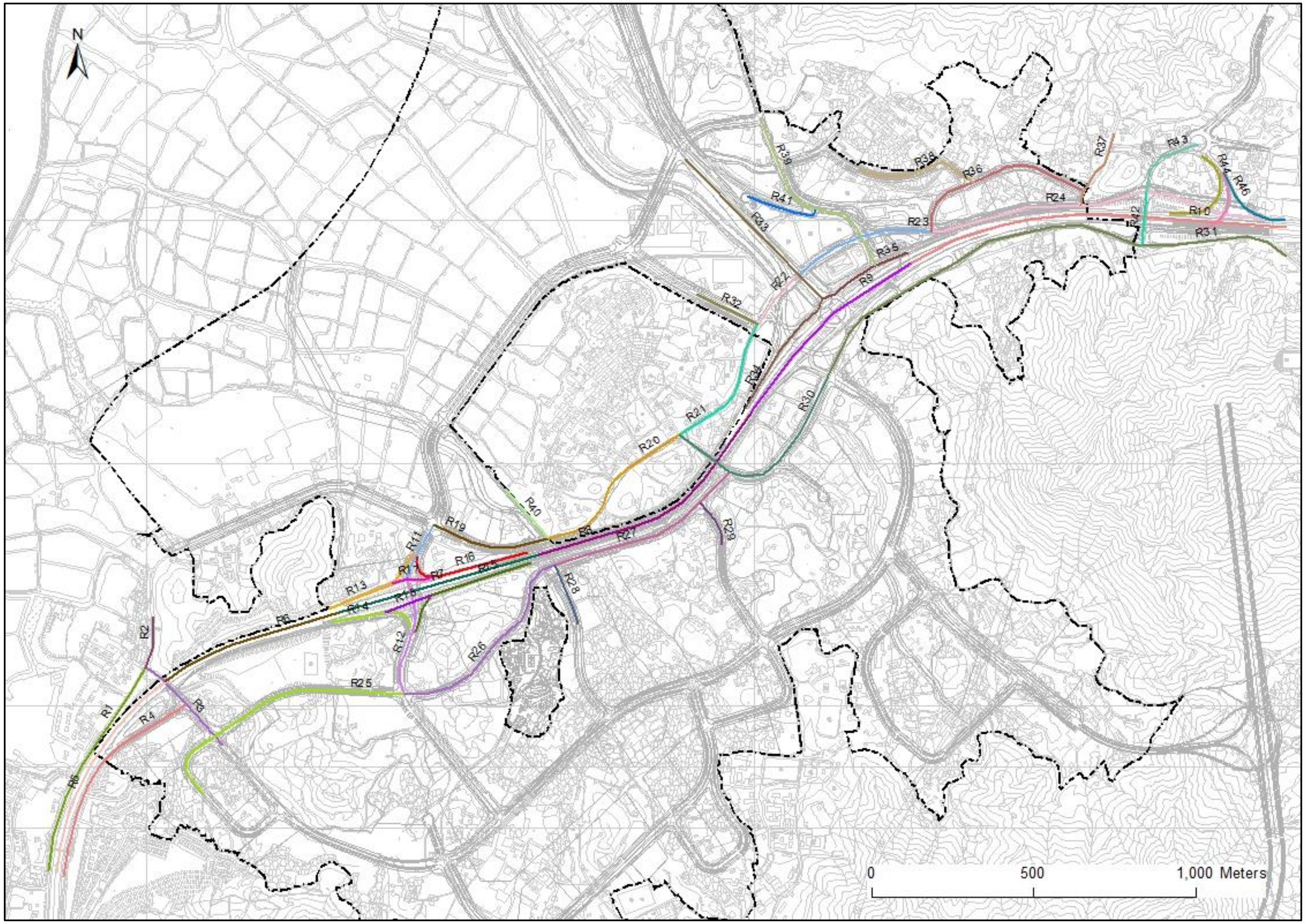

Plate 2.4 Locations of Road Population Groups

2.4.2 Time Modes and Occupancies of Population Groups

2.4.2.1 Four time modes as detailed in **Table 2.3** were applied in this hazard assessment to reflect the temporal distribution of population and to address the variation in levels of activities that could lead to a release and the variation in population in the assessment area with time.

Table 2.3 Definitions of Time Modes

Day Category	Time Period		Time Mode
Weekday	Daytime	(07:00 to 19:00)	35.71%
	Night	(19:00 to 07:00)	35.71%
Weekend	Daytime	(07:00 to 19:00)	14.29%
	Night	(19:00 to 07:00)	14.29%

2.5 Meteorology

2.5.1.1 Meteorological data is required for consequence modelling and risk calculation. Consequence modelling (dispersion modelling) requires wind speed and stability class to determine the degree of turbulent mixing potential whereas risk calculation requires wind-rose frequencies for each combination of wind speed and stability class.

2.5.1.2 Meteorological data was obtained from Wetland Park Weather Station (2021) where wind speed, stability class, weather class and wind direction are available. This data represented the weather conditions for the whole year in 2021 and has already taken into account seasonal variations and was therefore considered applicable for the assessment. **Table 2.4** shows the wind speed-stability frequencies.

Table 2.4 Stability Category-Wind Speed Frequencies at Wetland Park Weather Station

Daytime							
Wind Speed (m/s)	**A**	**B**	**C**	**D**	**E**	**F**	**Total (%)**
0.0-1.9	25.55	7.91	0.00	13.77	0.00	14.46	61.69
2.0-3.9	7.62	14.30	6.36	6.34	1.76	0.36	36.74
4.0-5.9	0.00	1.05	0.27	0.18	0.00	0.00	1.50
6.0-7.9	0.00	0.00	0.00	0.05	0.00	0.00	0.05
Over 8.0	0.00	0.00	0.00	0.02	0.00	0.00	0.02
All (%)	33.17	23.26	6.63	20.36	1.76	14.82	100.00
Night-time							
Wind Speed (m/s)	**A**	**B**	**C**	**D**	**E**	**F**	**Total (%)**
0.0-1.9	0.00	0.00	0.00	3.76	0.00	82.06	85.82
2.0-3.9	0.00	0.00	0.00	2.25	8.83	2.44	13.52
4.0-5.9	0.00	0.00	0.00	0.52	0.07	0.00	0.59
6.0-7.9	0.00	0.00	0.00	0.07	0.00	0.00	0.07
Over 8.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All (%)	0.00	0.00	0.00	6.60	8.90	84.50	100.00

2.5.1.3 According to **Table 2.4**, six combinations (2B, 1D, 3D, 6D, 2E and 1F) and five combinations (1D, 3D, 7D, 2E and 1F) of wind speed and stability class were chosen for daytime and night-time meteorological conditions respectively. These combinations were considered adequate to reflect the full range of observed variations in these quantities. It is not necessary and efficient to consider every combination observed. The principle is to group these combinations into representative weather classes that together cover all conditions observed.

2.5.1.4 Once the weather classes have been selected, frequencies for each wind direction for each weather class can then be determined. The frequency distributions for the daytime and night-time meteorological conditions are summarised in **Table 2.5**.

Table 2.5 Weather Class-Wind Direction Frequencies at Wetland Park Weather Station

Daytime							
Direction	**2B**	**1D**	**3D**	**6D**	**2E**	**1F**	**Total (%)**
0 – 30	4.53	1.99	0.82	0.00	0.55	3.21	11.10
30 – 60	6.01	1.30	1.89	0.10	0.60	1.10	11.00
60 – 90	12.03	2.02	3.96	0.02	1.00	1.02	20.05
90 – 120	3.59	1.47	2.69	0.00	0.65	1.49	9.89
120 – 150	2.47	0.50	1.30	0.00	0.42	0.67	5.36
150 – 180	5.58	0.82	2.96	0.00	0.72	1.02	11.10
180 – 210	6.19	0.42	2.59	0.00	0.57	0.62	10.39
210 – 240	3.64	0.12	0.52	0.00	0.07	0.15	4.50
240 – 270	2.07	0.20	0.15	0.00	0.00	0.15	2.57
270 – 300	2.67	0.45	0.17	0.00	0.05	0.20	3.54
300 – 330	4.04	0.32	0.12	0.00	0.00	0.22	4.70
330 – 360	4.11	0.57	0.37	0.00	0.00	0.75	5.80
All (%)	56.93	10.18	17.54	0.12	4.63	10.60	100.00

Night-time						
Direction	**1D**	**3D**	**7D**	**2E**	**1F**	**Total (%)**
0 – 30	0.83	0.32	0.00	1.52	20.93	23.60
30 – 60	0.48	1.47	0.11	2.96	4.32	9.34
60 – 90	0.48	0.37	0.00	2.06	4.46	7.37
90 – 120	0.32	1.15	0.00	4.46	7.98	13.91
120 – 150	0.08	0.27	0.00	1.23	5.37	6.95
150 – 180	0.16	0.03	0.00	7.29	12.01	19.49
180 – 210	0.13	0.21	0.00	6.41	5.47	12.22
210 – 240	0.05	0.05	0.00	0.35	0.43	0.88
240 – 270	0.03	0.00	0.00	0.03	0.27	0.33
270 – 300	0.00	0.00	0.00	0.03	0.29	0.32
300 – 330	0.08	0.03	0.00	0.03	0.72	0.86
330 – 360	0.51	0.19	0.00	0.27	3.76	4.73
All (%)	3.15	4.09	0.11	26.64	66.01	100.00

3. HAZARD IDENIFICATION AND ANALYSIS

3.1 Introduction

3.1.1.1 A hazard is described as the property of a material or activity with the potential to do harm. A release of flammable gas such as LPG has the potential to cause fire or explosion if ignited. Without ignition, the gas vapours will disperse harmlessly. Under normal conditions, the LPG at the GFSs will be stored and handled in contained and controlled manners. For LPG to pose a hazard to the people in the surrounding area, a release must occur as a result of a failure of that containment or as a result of faulty transfer procedures.

3.1.1.2 This section of the report summarises all possible failure cases and associated failure rates that could lead to a release of LPG. The failure rates adopted throughout this report are quoted from the paper "*Quantitative Risk Assessment for LPG Installations (Reeves, Minah and Chow, 1997)*" [1]. Furthermore, reference for certain frequencies was drawn from approved EIA Reports [3][12] and QRA studies [7][9] where necessary and appropriate. In addition, possible initiating events are identified.

3.2 Behaviour of LPG Releases

3.2.1.1 LPG is a mixture of butane and propane. The gas is twice as heavier as air. For a release of LPG, the nature of the combustion will depend on the timing of ignition and the size of the release.

3.2.1.2 Release of several tonnes of LPG, if ignited immediately, will produce a fireball. Initially, the gas concentration in the mixture will be above the Upper Flammable Limit (UFL). As burning occurs around the edges of the release, this will entrain more air into the mixture and more combustion will take place. The process accelerates until the mixture rising above the ground as a ball of fire. A fireball may also result from a boiling liquid expanding vapour explosion (BLEVE). This results from the bursting of a vessel (owing to a high internal pressure and a weakening of the vessel material, as a result of a fire for example). The vessel contents rapidly vaporise and are ignited.

3.2.1.3 If not ignited immediately, the gas will disperse and dilute. If ignition occurs when the gas concentration is between lower Flammable Limit (LFL) and Upper Flammable Limit (UFL), a flame front will propagate to produce a flash fire.

3.2.1.4 For small releases, immediate ignition will produce a long vigorous jet flame from the point of release. As for large releases, delayed ignition will generally produce a flash fire.

3.2.1.5 For all sizes of release the LPG will disperse harmlessly if there is no source of ignition.

3.3 Hazard Identification

3.3.1 Spontaneous Failures

<u>Failure of Storage Vessel</u>

3.3.1.1 A failure of a vessel can result from: (i) a cold catastrophic failure leading to instantaneous release of the full inventory; and (ii) a partial failure leading to continuous release of the full inventory via a 25mm hole. The causes of failure are summarised as follows:

(a) Spontaneous failure due to corrosion, fatigue, etc.

(b) Overfilling

(c) Earthquake

Failure of Road Tanker

3.3.1.2 The causes of failure of a road tanker are similar to those of a storage vessel. Furthermore, road tankers are vulnerable to collision with other road vehicles during delivery.

Guillotine Failure of Liquid Filling Line to Storage Vessel

3.3.1.3 Failure of the liquid line is possible as a result of corrosion or fatigue, vehicle impact and external events. Only guillotine failure of the LPG pipework was considered in this QRA as partial failure of the pipeworks is an insignificant contributor to the overall risk levels. The failure would result in LPG leaking from the full bore of the pipe. Moreover, part of the pipeworks will be installed aboveground. Failure of the aboveground portion of the liquid filling line can result from vehicle impact while failure of the underground portion of the liquid filling line can result from earthquakes.

Guillotine Failure of Liquid Line to Dispenser

3.3.1.4 The causes of failure of this line are similar to those of the liquid filling line to the storage vessel, namely mainly corrosion or fatigue. Moreover, the failure of the underground portion of the pipework can result from external events while the aboveground portion of the pipework can result from vehicle impact. Releases would result in leakage from the full bore of the pipe.

Guillotine Failure of Liquid Line from Tanker Pipe to Loading Hose

3.3.1.5 The causes of failure of this line are similar to those of the liquid filling line to the storage vessel, namely mainly corrosion or fatigue. Moreover, the failure can result from vehicle impact and other external events.

Failure of Dispenser

3.3.1.6 The causes of failure of the dispensers could be corrosion, fatigue, vehicle impact (vehicle visiting the filling station) and other external events, which would result in a release from the dispenser pipework.

Failure of Flexible Hose

3.3.1.7 The loading hose could fail due to the following causes:

(a) Fatigue

(b) Hose misconnection

(c) Hose disconnection during loading or unloading process

(d) Vehicle impact

(e) Operator / driver error

Failure of Vapour Return Line

3.3.1.8 Similar to the liquid line, failure of the vapour return line is credible which would result in vapour leak equivalent to the diameter of the line. Moreover, the failure of vapour return line can result from external events.

Release from Storage Vessel Pump Flange

3.3.1.9 A release from the submersible pump on the storage vessel is not credible as the LPG release would flow back into the storage vessel. The release however would take place from the flanges associated with the pump fitting.

Release from Storage Tank Drain Valve

3.3.1.10 The storage tank drain valve is open to drain out accumulated water several times per year. A release from the drain valve is possible as a result of human error, i.e. the operator fails to close it by accident.

Leak from Vehicle Vessel

3.3.1.11 Similar to the failure of the LPG storage vessel and road tanker, a leak from a vehicle vessel could be spontaneously caused by impact by other vehicles or refuelling error. However, the LPG inventory of a vehicle vessel is small compared to that of the storage vessel and road tanker, and therefore the effect is insignificant.

3.3.2 Loading / Unloading Failures

3.3.2.1 When LPG releases occur as a direct result of the road tanker unloading operation, the failure events can be regarded as loading failures.

3.3.2.2 The failure events could be categorised as loading failures are listed as follows:

(a) Hose misconnection and disconnection error

(b) Tanker drive-away error

(c) Road tanker collision

(d) Vehicle impact with road tanker during unloading

(e) Storage vessel overfilling

(f) Over-pressurisation of pipework.

Hose Misconnection and Disconnection Error

3.3.2.3 A significant release of LPG during its transfer from the road tanker to the storage vessel could occur as a result of the failure of the transfer hoses and coupling, human error, or vehicle impact.

Tanker Drive-away Error

3.3.2.4 This error could result from: (i) repositioning of the road tanker during delivery; and/or (ii) the driver driving the tanker away before the delivery is completed.

Road Tanker Collision

3.3.2.5 Road tanker collision refers to an event in which an LPG road tanker strikes the facilities of the filling station and causes damages to these facilities. Provision of a dedicated road tanker parking area and unloading area, implementation of speed control, control on the use of dispenser system and implementation of a rigorous training system are safety measures commonly adopted to avoid serious collision incidents. The likelihood of a road tanker collision leading to the failure of the road tanker itself is considered to be insignificant. Underground facilities such as LPG storage vessel and pipework would not be affected by this event since they are installed underground. Collision of an LPG road tanker with other road tankers is considered not possible as concurrent unloading of liquid fuels and LPG at the filling station is not allowed in Hong Kong.

Vehicle Impact with Road Tanker during Unloading

3.3.2.6 There is a possibility that a vehicle collides with the road tanker during unloading operation. When this happens, a release of LPG could occur.

Storage Vessel Overfilling

3.3.2.7 Failure of the LPG storage vessel could occur as a result of overfilling of LPG from the road tanker to the vessel.

Over-pressurisation of Pipework

3.3.2.8 Over-pressurisation could be caused by continuing unloading operation when a storage vessel is overfilled or the isolation valves at the receiving storage vessel are closed. It was considered that the probability of the pipework over-pressurisation would be negligible with all the safety system to be provided at the GFSs, and therefore not considered in this QRA.

3.3.3 External Events

3.3.3.1 A LPG release event could occur due to external events and the consequences could be catastrophic. The related external events are listed as follows:

(a) Earthquake

(b) Aircraft crash

(c) Landslide

(d) Severe environmental event such as typhoon or tsunami

(e) Subsidence

(f) External fire.

3.3.3.2 According to BDEIA [3], an earthquake of Modified Mercali Intensity (MMI) VII could provide enough intensity to result in damage to the storage vessel or pipework, and therefore earthquake was considered in this QRA.

3.3.3.3 Aircrafts crashing into the two GFSs during take-off and landing as well as arrival/departure flight paths were taken into account in this QRA. The method given in HSE (1997) [6] for the calculation of aircraft crash frequency was adopted.

3.3.3.4 Failure of LPG facilities due to landslide is considered possible if the station is located adjacent to natural slope. The two proposed GFSs are bounded by open spaces, roads and buildings with no slope in vicinity of them. Therefore, the probability of landslide is negligible, and this external event was not further considered in this QRA.

3.3.3.5 According to BDEIA [3], loss of LPG content owing to severe environmental event such as typhoon or tsunami (i.e. a tidal wave following an earthquake) was considered to be insignificant as the installation of LPG vessels is situated underground and away from the seashore. Subsidence is usually slow in movement and such movement can be observed and remedial action can be taken in time. Based on the above, the probabilities of severe environmental events and subsidence are very small or negligible, so these external events were not further considered in this QRA.

3.3.3.6 External fire refers to the occurrence of fire event that leads to failure of the road tanker / vessel or other facilities. The key concern is the LPG road tanker being affected by external fires. In Hong Kong, LPG road tankers are covered with Chartek coating. The Chartek coating serves to keep the tanker wall temperatures sufficiently low. Fire extinguishers will also be provided in the two GFSs. The LPG system will be shut down as a closed system once there is external fire threatening the station. Escalation due to fire outside of the GFSs is therefore considered not credible. Fire events, such as vehicle fire, within the GFSs may cause damage to the LPG facilities and these are further elaborated in the "Escalation" section below.

3.3.4 Safety Features

3.3.4.1 Safety features to be installed in the LPG facilities of the GFSs can act in different combination to mitigate LPG releases. Such features are highlighted in the following sections.

<u>Pressure Relief Valve</u>

3.3.4.2 A relief valve is employed to ensure the vessel is not subject to an excessive internal pressure which may cause failure due to overfilling. It also offers protection against excessive pressure build up within the vessel in case of fire situation.

<u>Non-return Valve</u>

3.3.4.3 A non-return valve on the liquid filling line can isolate release immediately. If it functions properly, there will be no significant consequence.

<u>Excess Flow Valve</u>

3.3.4.4 An excess flow valve installed on the road tanker and the storage vessel is expected to mitigate a release from guillotine failure of the pipework or the flexible filling hose.

<u>Emergency Shutdown System</u>

3.3.4.5 An Emergency Shutdown (ESD) system is installed on both the road tankers and the vessel. For a release from the road tanker, the emergency isolation system and the engine emergency stop system can be activated to isolate the release caused by equipment failure and human error. For a release from the vessel, the emergency isolation system can be triggered to enable quick remote closure of all actuated valves at the station and prevent a release at the road tanker unloading / filling point, the liquid supply line and the vapour return line of each dispenser, the liquid outlet / inlet and vapour return line on the vessel.

<u>Double-check Filler Valve</u>

3.3.4.6 A double-check filler valve is provided at the hose connection point on the liquid filling line to prevent a release to be fed back from the vessel. The design of this valve is essentially two non-return valves in series.

<u>Breakaway Coupling</u>

3.3.4.7 One problem identified with road tankers and refilling vehicles is the possibility of them being driven away whilst the hose is still connected, thereby causing damage to the facilities of the GFSs and resulting in the release of LPG. The breakaway coupling is installed to prevent undue spillage of LPG owing to the movement of road tankers and vehicles.

Manual Isolation System

3.3.4.8 A manual valve is installed for the operators/ drivers to shut off the delivery connection manually in case of failure.

3.3.5 Human Error

3.3.5.1 When a failure of equipment or loading process occurs, it is possible for the staff to rectify the problem before a hazard event occurs. Human error of this nature was regarded as a failure case.

3.3.6 Fire Protection / Fighting System

Water Spray System

3.3.6.1 The two proposed GFSs will be installed with a water spray system with their own storage of water supply. When a water spray system is activated, the fire associated with equipment in the filling station such as pipeworks, dispensers and LPG vehicles can be extinguished or prevented from spreading towards a parked road tanker.

Fire Services

3.3.6.2 The fire services will be available within a few minutes in case of a fire. The extinction of fire by fire fighters prevents BLEVE from occurring. Besides, a street fire hydrant is available nearby and fire service water inlet is installed at the perimeter of the GFSs to provide additional fire water supply.

Chartek Coating

3.3.6.3 Chartek coating is a safety feature of all road tankers. The coating has been reported to provide protection for at least 30 minutes in the case of a jet fire. The coating could prevent a hot spot from developing in a jet fire attack on the road tanker, which can cause thermal weakening of the road tanker wall leading to BLEVE.

3.3.7 Escalation

3.3.7.1 BLEVE of a LPG road tanker can happen if the road tanker is impinged by jet fire from the failure of aboveground LPG facilities listed below:

(a) Dispenser

(b) Inlet filling pipework

(c) Liquid supply line to dispenser

(d) Flexible hose during loading to underground vessel

(e) Liquid line from tanker to loading hose

(f) Flexible hose during loading to vehicle is not considered as the jet flame produced will not impinge on the road tanker; and

(g) While Chartek coating can provide 30 minutes protection to the storage tank, the release and jet fire duration is less than 10 min in leak failure of a LPG vehicle. Therefore, jet fire in leak failure of LPG vehicle does not lead to BLEVE of a LPG road tanker.

3.3.8 Summary

3.3.8.1 The possible hazard events for the day-to-day operations of the two proposed GFSs have been identified and reviewed in the previous sections. Among these hazard events, only the possible failure cases considered to have the potential to cause off-site fatality are summarised in **Table 3.1**.

3.3.8.2 The significance of each failure case and adoption of generic frequency are discussed in the next section.

Table 3.1 Identified Failure Cases for the GFSs

Failure Types	Failure Cases
Spontaneous Failure of Pressurised LPG Equipment	• Storage Vessel Failure • Road Tanker Failure • Pipework Failure • Dispenser Failure • Hose Failure • Vapour Return Line Failure • Release from Storage Vessel Pump Flange • Release from Storage Vessel Drain Valve
Loading / Unloading Failure	• Hose Misconnection Error • Hose Disconnection Error • Tanker Drive-away Error • Road Tanker Collision during Unloading • Vehicle Impact with Tanker during Unloading • Storage Vessel Overfilling
External Event	• Earthquake MMI VIII • Aircraft Crash
Safety System Failure	• Pressure Relief Valve Failure • Non-return Valve Failure • Excess Flow Valve Failure • Emergency Shutdown System Failure • Double-check Filler Valve Failure • Breakaway Coupling Failure • Manual Isolation Valve Failure
Human Error	Human Error
Fire Fighting System Failure	• Water Spray System Failure • Fire Services Failure • Chartek Coating Failure
Escalation	• LPG Road Tanker BLEVE Due to Fire in the Filling Facilities • LPG Road Tanker BLEVE Due to Jet Fire from Aboveground LPG Facilities

3.4 Hazard Analysis

3.4.1 Spontaneous Failure of Pressurised LPG Equipment

Storage Vessel Failure

3.4.1.1 A release of LPG could occur as a result of catastrophic failure or partial failure of the storage vessel and such a failure would lead to either a loss of entire contents of the vessel or a continuous release of LPG to atmosphere. A generic failure rate of 1.8×10^{-7} per vessel year [1] was adopted for cold catastrophic failure, and a generic failure rate of 5.0×10^{-6} per vessel year [1] was applied for partial failure. It was assumed that the storage vessels were nominally full for 30% of the time and at 60% of maximum inventory for the other 70% of time.

Road Tanker Failure

3.4.1.2 As discussed in Section 3.3.1.2, the definitions of catastrophic and partial failures of road tanker are similar to those of the storage vessel. It is generally considered that the catastrophic failure rate for LPG road tankers could be higher than that for a fixed storage vessel because of a) stresses experienced by the road tanker owing to vibration during transportation; and b) cyclic loading associated with filling/unloading the road tanker. A failure rate of 2.0×10^{-6} per tanker year [1] was adopted for catastrophic tanker failure, and a failure rate of 5.0×10^{-6} per tanker year [1] was applied for partial failure of road tanker. The road tanker was modelled at maximum content for 20% of the time and at 50% of maximum inventory for the other 80% of the time.

Pipework Failure

3.4.1.3 Reeves et al. (1997) [1] indicated that releases from pipework partial failures were insignificant contributors to the overall risk levels. Based on this, this QRA only considered guillotine failure of LPG pipework as the contribution of a release from the partial failure of pipework to the overall risk levels would be insignificant. A generic rate of 1.0×10^{-6} per meter per year for guillotine failure of the pipework was adopted.

Dispenser Failure

3.4.1.4 The dispenser is a metering device, a hose with a self-sealing connector, four ball valves (with two flanges for each valve) and a certain length of rigid pipework. The only way to estimate the failure frequency would be to account for each of these components and add together. Assuming the dispenser is equivalent to 1m of small bore piping (<100mm) with two flanges joints and four ball valves with eight flange joints, a failure rate of 5.0×10^{-5} per hour for a LPG disperser would be obtained with the following parameters:

(a) 1m piping * 1×10^{-10} per meter per hour [10]

(b) 10 flanges (8 from 4 ball valves, 2 from meter joints) * 3×10^{-7} per flange per hour [11]

(c) 4 ball valves * 0.5×10^{-6} per valve per hour [11]

3.4.1.5 Based on the above, the dispenser failure rate was estimated as $5.0\times10^{-6} \times 8{,}760$ (1 year = 8760 hours) = 4.38×10^{-2} per year.

Hose Failure

3.4.1.6 The effect of partial failure of the hose is neglected. A generic guillotine failure rate of flexible hose of 1.8×10^{-7} per transfer, for a 2-hour transfer, was assumed thus giving a guillotine failure rate of flexible hose of 9.0×10^{-8} per hour [1].

3.4.1.7 In addition, the vehicle loading process takes about 5 minutes (from the dispenser to the vehicle). Based on the above, the guillotine failure rate of flexible hose for LPG loading to a vehicle was taken to be 7.5×10^{-9} per transfer.

Vapour Return Line Failure

3.4.1.8 A generic failure rate of 1.0×10^{-6} per meter per year was adopted [1].

Release from Storage Vessel Pump Flange

3.4.1.9 A generic failure rate of 1.09×10^{-4} per flange per year[1] was adopted [8].

Release from Storage Vessel Drain Valve

3.4.1.10 For the operator failing to close the drain valve by accident, a failure rate of 2.0×10^{-5} per operation [4] was adopted.

3.4.2 Loading / Unloading Failures

Hose Misconnection Error

3.4.2.1 A significant release of LPG during its transfer from the road tanker to the storage vessel could occur as a result of the failure of the transfer hoses and coupling, human error, or vehicle impact. The likelihood of such an event was taken to be 3.0×10^{-5} per operation [1].

Hose Disconnection Error

3.4.2.2 A rate of 2.0×10^{-6} per operation [1] was adopted for this failure case.

Tanker Drive-away Error

3.4.2.3 Tanker drive-away error refers to an event in which the tanker moves away with the hose still connected. It could result from the tanker driver inadvertently driving the vehicle away before delivery is completed. It was considered that drive-away was unlikely. Even if such errors do occur, it is highly likely that the failure can be immediately rectified since the delivery process would not go unattended. A failure rate of 4×10^{-6} per operation [1] was adopted.

Tanker Collision during Unloading

3.4.2.4 A release of LPG cloud occurs as a result of an incident involving an LPG tanker and LPG equipment during delivery. It was assumed that the failure rate of tanker impact during unloading was 1.5×10^{-4} per delivery [1].

Vehicle Impact with Road Tanker during Unloading

3.4.2.5 A rate of 1.0×10^{-8} per operation [1] was adopted for the case that a vehicle impact into road tanker during unloading.

Storage Vessel Overfilling

3.4.2.6 The practice on-site in unloading LPG to the underground storage vessel is that the vessel will only be filled to 85% of its maximum capacity. It is considered that the probability of the driver overfilling a storage vessel is low. A rate of 2.0×10^{-2} per operation [1] was adopted for this failure case.

3.4.3 External Events

Earthquake MMI VIII

3.4.3.1 A probability of 1.0×10^{-5} per year was adopted for the occurrence of an MMI VIII earthquake. The rate of failure of pipework and partial failure of underground vessel owing to

[1] Referencing the SPC/TECH/OSD/24 - accident/incident data from Health and Safety Executive (HSE) reviewed in March 2007, it stated the failure rate of pump flange is between 4.11×10^{-5} and 1.09×10^{-4} /flange year. Thus, a conservative value of 1.09×10^{-4} /flange year was assumed in this study as this is an updated value in March 2007 to reflect the failure frequency of a pump flange.

earthquakes was assumed to be 0.01 [3], whereas the probability of failure of road tanker and the underground vessels was considered to be zero.

Aircraft Crash

3.4.3.2 The aircraft crash frequency of Station #2 was calculated to represent the frequency for both GFSs as conservative, with consideration that the area of Station #2 is larger than Station #1 and the calculated aircraft crash frequency will be larger. The distance between the nearest arrival/departure flight path for the Hong Kong International Airport (HKIA) and Station #2 is approximately 13.2km. The distance between the Stations #2 and HKIA is about 25.0km, which exceeds the criteria of 5 miles (8km) for the consideration of airfield accident. At such distances, the two proposed GFSs would not come into the flight paths of the critical take-off and landing phases, and therefore only the background crash rate and airway crash rate were taken into account. The frequency of aircraft crash was estimated using the methodology of the HSE (1997) [6]. The model took into account specific factors such as the target area of the station and the distance between the station and the runway threshold. The aircraft crash frequency per year was calculated as:

Frequency (per year) = Background Crash Rate + Airway Crash Rate

Frequency (per year) = (A x Bi)+ (A x Ni x Ri x afac/ alt)

where A is the area of the GFS, N is the number of runway movements per year and Ri is the aircraft in-flight reliability per year per km per aircraft movement. According to the statistics from *Civil International Air Transport* Movements *of Aircraft* [13], there were 429,446 movements per year from July 2018 to June 2019. The detailed calculation of aircraft crash is shown in **Annex B**.

3.4.3.3 The frequency of the event aircraft due to background and airway crash in the Station #2 was estimated to be 4.33×10^{-9} per year, and the same value was adopted in the fault tree analysis for Station #1.

3.4.4 Safety System Failure

3.4.4.1 If the safety system operates as designed, then releases will not present an off-site hazard. There is, however, a potential for failure of the safety system. A typical safety system involves pressure relief valve, non-return valve, excess flow valve, emergency shutdown system, breakaway coupling and double-check filler valve.

Pressure Relief Valve Failure

3.4.4.2 The pressure relief valve avoids the LPG pipework or underground storage vessel from getting overpressure. A generic failure of 1.0×10^{-4} [1] for the pressure relief valve per demand was adopted.

Non-return Valve Failure

3.4.4.3 The non-return valve is intended to avoid the back flow of LPG. A generic failure rate of 0.013 per demand [1] was adopted.

Excess Flow Valve Failure

3.4.4.4 The excess flow valve installed at the road tanker and the storage vessel is expected to be functional when guillotine failure of pipework or flexible hose occurs. Considering different testing interval for road tankers and storage vessels, generic failure rates of 0.013 and 0.13 per demand [1] were adopted for the road tanker and the vessel respectively.

Emergency Shutdown System Failure

3.4.4.5 A generic failure rate of 1.0×10^{-4} per demand [1] was assumed.

Breakaway Coupling Failure

3.4.4.6 Generic failure rates of 0.013 and 0.13 per demand [1] were adopted for the road tanker and the dispenser respectively.

Double-check Filler Valve Failure

3.4.4.7 A double-check filler valve prevents the LPG release to be fed back from the storage vessel. The design has two non-return valves in series. A generic failure rate of 2.6×10^{-3} per demand [1] for common mode failure was adopted.

Manual Isolation Valve Failure

3.4.4.8 A generic failure rate of 0.5 per demand [1] was assumed.

3.4.5 Human Error

3.4.5.1 According to Appendix III of Reactor Safety Study prepared by US Nuclear Regulatory Commission in 1975, an estimation of average error rate of 0.2 to 0.3 was assumed for nuclear power plant personnel in a high-stress situation [4]. In that study, it also stated that the range of 0.2 to 0.3 was to be considered conservative. In this QRA, a probability of 0.2 per demand[2] [3] was assumed to account for the human error in which the operators fail to rectify the problem before any hazard event occurs.

3.4.6 Fire Fighting System Failure

Water Spray System Failure

3.4.6.1 A generic failure rate of 1.5×10^{-2} per demand [1] was adopted to account for the common problems of the water spray system: blocked nozzles and malfunction of the fire detectors.

Failure of Fire Services

3.4.6.2 It was assumed that the fire services would always be available, and therefore zero probability was applied for the failure case of "fire services arrive late". A generic failure

[2] According to the EIA study "Proposed Headquarters and Bus Maintenance Depot in Chai Wan" (BDEIA), by Ling Chan + Partners Limited. (2001)", a probability of 0.2 is assumed for human error. Moreover, from Appendix III of Reactor Safety Study prepared by US Nuclear Regulatory Commission in 1975, an estimation of average error rate of 0.2 to 0.3 was assumed for nuclear power plant personnel in a high-stress situation. In that study, it also stated that the range of 0.2 to 0.3 was to be considered conservative. In this study, a probability of 0.2 (per demand) was assumed to account for the human error in which operators fail to rectify the problem before any hazard event occurs.

rate of 0.5 per demand [1] was assumed for the fire services to be ineffective against a fire attack.

Gas Detection System

3.4.6.3 The system is identified as an additional safety device for the operator to take emergency actions when LPG release occurs. Since the system would not induce additional likelihood of failure events, the system would not be included into the fault tree analysis.

Chartek Coating Failure

3.4.6.4 A generic failure rate of 0.1 per demand [1] was applied for the Chartek coating failing to prevent a hot spot from developing on the road tanker in a jet fire attack owing to poor maintenance.

3.4.6.5 The above initialising events could result in LPG release scenarios. **Table 3.2** summarises the identified failure cases and their corresponding failure rates adopted in this QRA.

Table 3.2 Summary of Identified Failure Cases and Their Corresponding Failure Rates for the GFSs

Failure Types	Failure Rates	Reference Source
Spontaneous Failure of Pressurised LPG Equipment		
Catastrophic Failure of Storage Vessel	1.8×10^{-7} per vessel year	Reference [1]
Partial Failure of Storage Vessel	5.0×10^{-6} per vessel year	Reference [1]
Catastrophic Failure of Road Tanker	2.0×10^{-6} per tanker year	Reference [1]
Partial Failure of Road Tanker	5.0×10^{-6} per tanker year	Reference [1]
Guillotine Failure of Pipework	1.0×10^{-6} per meter per year	Reference [1]
Hose Failure	9.0×10^{-8} per hour	Reference [1]
Dispenser Failure	4.38×10^{-2} per year	Section 3.4.1
Vapour Return Line Failure	1.0×10^{-6} per meter per year	Reference [1]
Release from Storage Vessel Pump Flange	1.09×10^{-4} per year	Reference [8]
Release from Storage Vessel Drain Valve	2.0×10^{-5} per operation	Reference [4]
External Event		
Earthquake (MMI VIII)	1.0×10^{-5} per year	Reference [3]
Aircraft Crash	4.33×10^{-9} per year	Annex B
LPG Loading Failure		
Hose Misconnection Failure	3.0×10^{-5} per operation	Reference [1]

Failure Types	Failure Rates	Reference Source
Hose Disconnection Failure	2.0×10^{-6} per operation	Reference [1]
Tanker Drive-away Error	4.0×10^{-6} per operation	Reference [1]
Road Tanker Collision	1.5×10^{-4} per operation	Reference [1]
Vehicle Impact into Tanker During Unloading	1.0×10^{-8} per operation	Reference [1]
Storage Vessel Overfilling	2.0×10^{-2} per operation	Reference [1]
Safety Features Failure		
Pressure Relief Valve Failure	1.0×10^{-4} per demand	Reference [1] based on ESD system
Non-return Valve Failure	0.013 per demand	Reference [1]
Excess Flow Valve Failure	0.013 per demand for tanker 0.13 per demand for vessel	Reference [1]
Emergency Shutdown System Failure	1.0×10^{-4} per demand	Reference [1]
Breakaway Coupling Failure	0.013 per demand for tanker, 0.13 per demand for dispenser	Reference [1]
Double-check Filler Valve Failure	2.6×10^{-3} per demand	Reference [1]
Human Error		
Human Error	0.2 per demand	Reference [3]
Fire Protection / Fighting System Failure		
Water Spray System Failure	1.5×10^{-2} per demand	Reference [1]
Failure of Fire Services	0.5 per demand	Reference [1]
Chartek Coating Failure	0.1	Reference [1]

3.4.7 Escalation

3.4.7.1 Escalation refers to the situation in which a relatively insignificant accident causing an event with much more significance to occur.

3.4.7.2 Typical hazards that could lead to escalation are:

(a) Shrapnel from LPG storage vessel impacting on an LPG road tanker;

(b) Ignited leak from above ground LPG facilities (jet fire) impinging an LPG road tanker and causing BLEVE; and

(c) Other fire incidents engulfing an LPG road tanker and causing BLEVE

3.4.7.3 As the storage vessel will be installed underground, the knock-on failure on this equipment from other accidents is unlikely to occur. Based on this, knock-on failures on the storage vessel were not further considered.

3.4.7.4 When an LPG road tanker is impacted by the shrapnel from the LPG storage vessel (i.e. catastrophic rupture of vessels occurs), this is already a severe event and no knock-on events significantly worse have been identified.

BLEVE of LPG Road Tanker Caused by Jet Fire from Aboveground LPG Facilities

3.4.7.5 For a jet fire leading to BLEVE of LPG road tanker, the following factors need to be considered:

(a) Frequency of LPG leak from above ground LPG facilities last for at least 30 minutes

(b) Immediate ignition probability of LPG leak from above ground LPG facilities which causes a jet fire

(c) The portion of jet fire impinging at road tanker

(d) The portion of time for road tanker present in the GFS

(e) Failure to prevent BLEVE from occurring

3.4.7.6 The calculation of probability of road tanker BLEVE is shown in **Annex C**. The elaboration of the first three factors is provided below.

Frequency of LPG Leak from Aboveground LPG Facilities Lasting for at Least 30 Minutes

3.4.7.7 It was conservatively assumed that the inventory in the storage vessel at maximum inventory or 60% of maximum inventory would be enough to support a 30-minute leakage. On this basis, the frequencies of aboveground LPG facilities failure shown in **Annex C** were applied to the frequencies of LPG leak lasting for at least 30 minutes.

Immediate Ignition Probability of LPG Leak from Aboveground LPG Facilities

3.4.7.8 Immediate ignition of LPG release from aboveground LPG facilities will cause a jet fire. A probability of 0.05 was adopted in **Annex D** for immediate ignition of LPG leak from aboveground LPG facilities.

The Portion of Jet Fire Impinging at Road Tanker On Site

3.4.7.9 Not all the ignited jet fire from aboveground LPG facilities will impinge into the LPG road tanker. Jet fire due to LPG release from aboveground LPG facilities may impinge into other objects or burn as a free jet. A probability of 0.25 was assumed for the jet fire from most of the aboveground LPG facilities impinge into LPG road tanker on site by considering the relative angular position of the LPG road tanker to LPG facilities such as dispensers. For jet fire caused by liquid supply line between from road tanker and loading hose, probability of 0.5 was assumed.

3.4.7.10 By considering the five factors mentioned above, the calculated frequency of a jet fire from aboveground LPG facilities causing BLEVE of LPG road tanker is 4.14×10^{-9} per year.

BLEVE of LPG Road Tanker Caused by Other Fire Incidents

3.4.7.11 For a fire leading to BLEVE of the LPG road tanker, the factors needed to be considered are as follows:

(a) Frequency of fire incidents occurring in GFS

(b) The proportion of fire incidents severe enough to endanger the road tanker

(c) The portion of time for tanker present in the GFS

(d) Failure to prevent BLEVE from occurring

Frequency of Fire Incidents Occurring in GFS

3.4.7.12 The frequency is estimated by the equation:

Number of fire incidents occurred / number of petrol filling station-year

3.4.7.13 Information on the number of fire incidents occurred was provided by the Hong Kong Fire Services Department (**Annex E**). According to the record, there were 32 fire incidents occurred in petrol filling stations / LPG filling stations from the year of 1995 to 2018. Until 2007, there were 189 commercial petrol filling stations in Hong Kong. In 2011, there were 187 commercial petrol filling stations. The latest record as of December 2019 shows that there were 174 commercial petrol filling stations and 65 LPG filling stations. Assuming that the number of petrol filling stations remained constant from 1995 to 2007 and from 2008 to 2011, and that the number of petrol filling stations and LPG filling stations also remained constant from 2012 to 2019, it was estimated that the frequency of fire incidents = 32 fire incidents / (189×13 + 187×4 + 239×7 petrol filling station-year) = 6.56×10^{-3} fire incident per petrol filling station-year.

3.4.7.14 It should be noted that it was a conservative estimate because all the recorded fire incidents were assumed to be vehicle fire occurred in LPG filling stations.

The Proportion of Fire Incidents Severe Enough to Endanger the Road Tanker

3.4.7.15 Not all the fire incidents recorded/occurred in LPG filling stations will endanger the road tanker. A portion of recorded fire incidents could be false alarms that lead to over-estimation of the fire incident frequency. Moreover, a fire leading to BLEVE of road tanker needs to be of a sufficiently long duration (i.e. 30 minutes). However, most of the fire incidents occurred is small in scale such as fire caused by smoking, small fire in the office of the filling stations, etc. Based on the above, a proportion of 1 in 100 was assumed for severe fire incidents.

3.4.7.16 By considering the four factors mentioned above, the calculated frequency of a fire incident in a GFS causing BLEVE of LPG road tanker is 5.81×10^{-9} per year.

4. HAZARD OCCURRENCE

4.1 Introduction

4.1.1.1 Subsequent to the hazard identification and analysis in the previous section, the next step is to estimate the likelihoods of the various LPG release cases. There are combinations of hazard initiating events, as identified in the previous section, which would lead to an LPG release.

4.1.1.2 Fault Tree Analysis (FTA) permits the hazardous incident ("Significant Failure Events") frequency to be estimated from a logical model of the failure mechanisms of a system. The model is based on the combinations of failures of more basic components, safety systems and human errors. Station-specific circumstances (e.g. number of LPG tanker visit) were taken into account in the FTA.

4.1.1.3 FTA is the use of a combination of simple logic gates, "AND" and "OR" gates, to synthesise a failure model of the hazardous installation. The "Significant Failure Events" frequency is calculated from failure data of more simple events.

4.1.1.4 A basic assumption in FTA is that all failures in a system are binary in nature, a component or operator either performs successfully or fails completely. In addition, the system is assumed to be functioning if all sub-components are operating properly.

4.1.1.5 The steps for an FTA are presented below:

- Hazard identification and selection of the "Significant Failure Events", where the "Significant Failure Events" are considered as significant LPG release cases;
- Construction of fault trees; and
- Quantitative evaluation of the fault trees

4.2 Frequency of Occurrence

4.2.1.1 The fault tree diagrams are provided in **Annex C**. The estimated likelihoods of various releases of LPG at the two proposed GFSs are summarised in **Table 4.1**.

Table 4.1 Estimated Occurrence Frequency of Significant LPG Releases

Release Case	Frequency of Occurrence / Year
Catastrophic Failure of a Storage Vessel (Full Inventory)	1.27E-07
Catastrophic Failure of a Storage Vessel (60% Inventory)	2.97E-07
Catastrophic Failure of Road Tanker (Full Inventory)	4.75E-08
Catastrophic Failure of Road Tanker (50% Inventory)	1.90E-07
Partial Failure of a Storage Vessel (Full Inventory)	3.02E-06
Partial Failure of a Storage Vessel (60% Inventory)	7.05E-06
Partial Failure of Road Tanker (Full Inventory)	1.19E-07
Partial Failure of Road Tanker (50% Inventory)	4.77E-07
Guillotine Failure of Liquid Filling Line to Storage Vessel – release from vessel (Full Inventory in Storage Vessel)	2.85E-11
Guillotine Failure of Liquid Filling Line to Storage Vessel – release from vessel (60% Inventory in Storage Vessel)	6.65E-11
Guillotine Failure of Liquid Filling Line to Storage Vessel – release from road tanker (Full Inventory in Road Tanker)	2.24E-12

Release Case	Frequency of Occurrence / Year
Guillotine Failure of Liquid Filling Line to Storage Vessel – release from road tanker (50% Inventory in Road Tanker)	8.97E-12
Guillotine Failure of Liquid Filling Line to Dispenser (Full Inventory in Storage Vessel)	1.58E-07
Guillotine Failure of Liquid Filling Line to Dispenser (60% Inventory in Storage Vessel)	3.70E-07
Failure of Dispenser (Full Inventory in Storage Vessel)	1.11E-03
Failure of Dispenser (60% Inventory in Storage Vessel)	2.58E-03
Guillotine Failure of Hose during Unloading from Road Tanker to Storage Vessel, LPG Released from Tanker (Full Inventory in tanker)	6.23E-07
Guillotine Failure of Hose during Unloading from Road Tanker to Storage Vessel, LPG Released from Tanker (50% Inventory in tanker)	2.49E-06
Guillotine Failure of Hose during Unloading from Road Tanker to Storage Vessel, LPG Released from Vessel (Full Inventory in vessel)	2.43E-09
Guillotine Failure of Hose during Unloading from Road Tanker to Storage Vessel, LPG Released from Vessel (60% Inventory in vessel)	5.67E-09
Failure of Flexible Hose during Loading to LPG vehicles, LPG Released from Dispenser (Full Inventory in Storage Vessel)	1.41E-01
Failure of Flexible Hose during Loading to LPG vehicles, LPG Released from Dispenser (60% Inventory in Storage Vessel)	3.29E-01
Failure of Flexible Hose during Loading to LPG vehicles, LPG Released from vehicle (Full Inventory in Vehicle)	9.40E-01
Release from Storage Vessel Pump Flange (Full Inventory in Storage Vessel)	1.31E-04
Release from Storage Vessel Pump Flange (60% Inventory in Storage Vessel)	3.05E-04
Release from Storage Vessel Drain Valve (Full Inventory in Storage Vessel)	1.44E-04
Release from Storage Vessel Drain Valve (60% Inventory in Storage Vessel)	3.36E-04
Failure of Vapour Return Line (Full Inventory in Storage Vessel)	2.26E-07
Failure of Vapour Return Line (60% Inventory in Storage Vessel)	5.28E-07
Guillotine Failure of Liquid Line from Tanker to Flexible Hose (full inventory in Road Tanker)	1.70E-09
Guillotine Failure of Liquid Line from Tanker to Flexible Hose (50% inventory in Road Tanker)	6.80E-09
BLEVE of Road Tanker (Full Inventory in Road Tanker)	1.99E-09
BLEVE of Road Tanker (50% Inventory in Road Tanker)	7.96E-09

5. CONSEQUENCE AND IMPACT ANALYSIS

5.1 Introduction

5.1.1.1 Consequence and impact analysis was conducted to provide a quantitative estimate of the likelihood and number of deaths associated with the range of possible outcomes (i.e. fireball, jet fire, flash fire etc.) which would result from the failure cases identified in the previous sections. In this QRA, PhastRisk 6.7 was used for such estimation.

5.2 Modelling Input

5.2.1.1 Failure events identified in the previous sections were considered and evaluated through consequence analysis. It was considered that the following failure events may have potential off-site impacts:

(a) Rupture of storage vessel

(b) Rupture of road tanker

(c) Partial failure of storage vessel

(d) Partial failure of road tanker

(e) Guillotine failure of liquid filling line to storage vessel

(f) Pump flange leak

(g) BLEVE of road tanker

5.2.1.2 There are two underground vessels with capacity of 25.4kL (water capacity) each at each GFS. The storage vessels were assumed to be filled to a maximum permissible level (85% of the maximum capacity) in this QRA. Replenishment of LPG was assumed to be 730 deliveries per year for each GFS, which can be arranged either daytime or night-time.

5.3 Ignition Source

5.3.1 General

5.3.1.1 To calculate the risk from flammable materials, information on ignition sources presented in the study area needs to be identified. Such data was included in the risk model for each type of ignition source (i.e. point sources, line sources and area sources). The risk calculation program (MPACT) in PhastRisk predicts the probability of a flammable cloud being ignited (delayed ignition) as the cloud moves downwind over ignition sources.

5.3.2 Point Source

5.3.2.1 According to HSE (1997) [5], compressors could be categorised as a strong ignition source with an ignition probability of greater than 0.5 but smaller than 1. Although a vehicle using the GFS is close to a release source, it is classified as a weak ignition source with ignition probability between 0.05 and 0.5. Based on the above, the following assumptions were applied to estimate the presence factor of the point source and the ignition probability.

(a) Probability of ignition for a compressor is taken as 0.75 in 60 seconds; and

(b) Presence factor of the ignition source is assumed to be 1.

5.3.3 Line Sources

5.3.3.1 Roads are defined as line sources in PhastRisk. The following assumptions were applied to estimate the presence factor of the line source and the ignition probability:

(a) The probability of ignition for a vehicle was taken to be 0.4 in 60 seconds [9]; and

(b) The traffic density was based on the projected traffic flow for roads shown in **Table 2.2**, and are summarized in **Error! Reference source not found.** and **Error! Reference source not found.**.

Table 5.1 Summary of Road Ignition Sources

ID	Traffic Speed (km/hr)	Traffic Density (veh/hr)			
		Year 2032		Year 2039	
		Daytime	Night-time	Daytime	Night-time
R1	50	186	69	425	145
R2	50	652	261	1419	570
R3	50	250	106	1071	462
R4	50	323	126	1212	520
R5	50	453	184	582	241
R6	100	7051	2758	9910	3923
R7	100	6524	2579	8011	3205
R8	100	7007	2776	9520	3884
R9	100	4872	1977	5485	2350
R10	100	6402	2713	7448	3312
R11	50	774	292	1443	545
R12	50	619	262	2410	1048
R13	50	222	94	721	256
R14	50	305	85	1179	462
R15	50	246	100	835	378
R16	50	238	97	674	301
R17	50	179	79	729	309
R18	50	286	83	540	192
R19	50	244	96	612	247
R20	50	213	85	607	240
R21	50	227	97	696	292
R22	50	516	208	925	357
R23	50	645	264	684	280
R24	50	519	226	567	246
R25	50	453	202	880	392
R26	50	61	27	901	381
R27	50	36	14	671	289
R28	50	0	0	913	366
R29	50	0	0	1011	430
R30	50	95	29	676	285
R31	50	519	187	826	299
R32	50	394	159	894	313
R33	50	1237	622	1825	894
R34	50	593	202	1127	371
R35	50	1082	534	1370	715

ID	Traffic Speed (km/hr)	Traffic Density (veh/hr)			
		Year 2032		Year 2039	
		Daytime	Night-time	Daytime	Night-time
R36	50	362	153	422	181
R37	50	21	9	21	9
R38	50	388	166	282	115
R39	50	1281	556	1958	860
R40	50	0	0	206	85
R41	50	44	114	44	115
R42	50	968	968	1274	1274
R43	50	1015	1015	1364	1364
R44	50	442	442	708	708
R45	50	395	395	583	583
R46	50	594	594	748	748

5.3.4 Area Sources

5.3.4.1 PhastRisk considers a residential population as an ignition source (as a result of activities such as cooking, smoking, heating appliances etc.). The ignition probability was derived from the population densities in the concerned area by PhastRisk.

5.4 Ignition Probability

5.4.1.1 Immediate ignition probabilities of 0.9 and 0.05 [1] were adopted for instantaneous release and continuous release of LPG, respectively. These ignition probabilities were applied to event trees and were adopted in PhastRisk as shown in **Annex D**.

5.5 Protection Factors

5.5.1 Protection afforded to persons indoors in a building

5.5.1.1 It was generally assumed that the respective outdoor/ indoor population are 5% and 95% at the time of an accident [1].

5.5.1.2 For flash fire consequence, the fatality rate for indoor persons was assumed to be one tenth of the outdoor fatality rate.

5.5.1.3 For fireball, it was assumed that 50% of indoor persons would be killed.

5.5.2 Protection afforded to persons by being on the upper floors of building

5.5.2.1 Cloud height decreases further away from the source. Most dispersed clouds for LPG will have a cloud height lower than 10m [1]. To be conservative, no height protection factor was applied in this QRA.

5.5.3 Protection afforded to persons by being on the upper floors of building

5.5.3.1 Shielding protection factors for fireball events were applied to the population surrounding the GFSs [1].

5.5.3.2 For building wholly within the fireball diameter, population at the back of the building were considered protected.

5.5.3.3 For building wholly outside the fireball diameter, population without direct line of sight of the LPG facilities were considered protected.

5.5.3.4 While for building partly inside and partly outside of the fireball diameter, population outside the fireball diameter were considered shielded by the rest of the building.

5.5.3.5 The actual population affected by fireball events were also detailed in **Annex A**.

6. RISK EVALUATION

6.1 Introduction

6.1.1.1 In this section, the risks arising from the LPG supply facilities are evaluated in terms of both individual and societal risks.

6.1.1.2 Individual risk is a measure of the risk to a chosen individual at a particular location. As such, this is evaluated by summing the contributions to that risk across a spectrum of incidents that could occur at a particular location.

6.1.1.3 Societal risk is a measure of the overall impact of an activity upon the surrounding community. As such, the likelihoods and consequences of the range of incidents postulated for that particular activity are combined to create a cumulative picture of the spectrum of the possible consequences and their frequencies. This is usually presented as an FN curve and the acceptability of the results can be judged against the societal risk criterion under the HKRG.

6.2 Individual Risk

6.2.1 Risk Level

6.2.1.1 The predicted individual risk (IR) levels associated with operation of the two GFSs are shown in **Plate 6.1** and **Plate 6.2**. The risk levels were estimated based on 100% occupancy with no allowance made for shelter or escape, which can be referred from the user manual of *PhastRisk*.

6.2.1.2 The 1×10^{-5} per year risk contour was not found for both stations; while the 1×10^{-6}, 1×10^{-7}, 1×10^{-8} and 1×10^{-9} per year risk contours extend 30m, 60m, 110m and 140m from the center of the stations respectively. Based on the operational details for the two proposed GFSs, the predicted results show that no off-site individual would be exposed to risk levels greater than 1×10^{-5} per year.

6.2.2 Acceptability

6.2.2.1 Based on the results above, the level of individual risk posed by operation of the two proposed GFSs on the surrounding population is considered acceptable as it meets the HKRG.

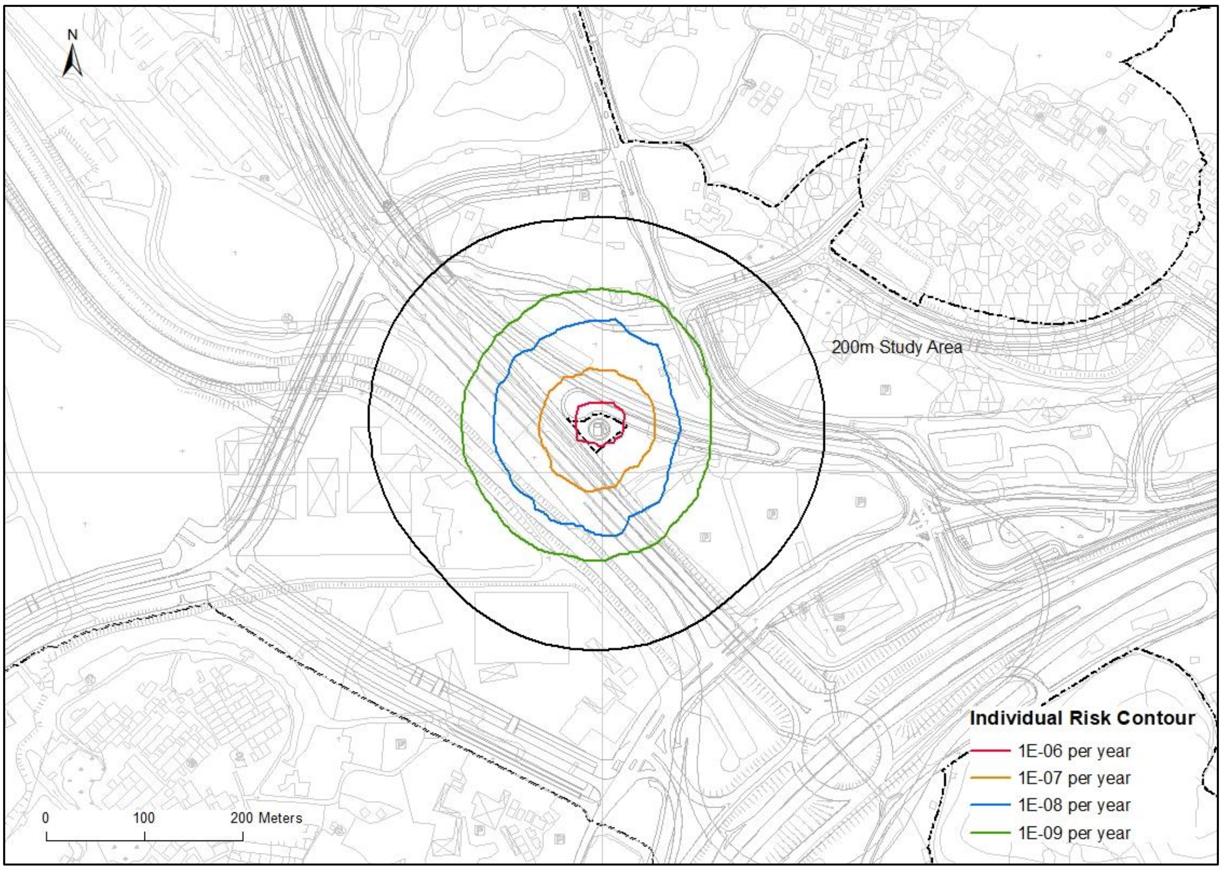

Plate 6.1 **Individual Risk Contours for the Proposed Station #1**

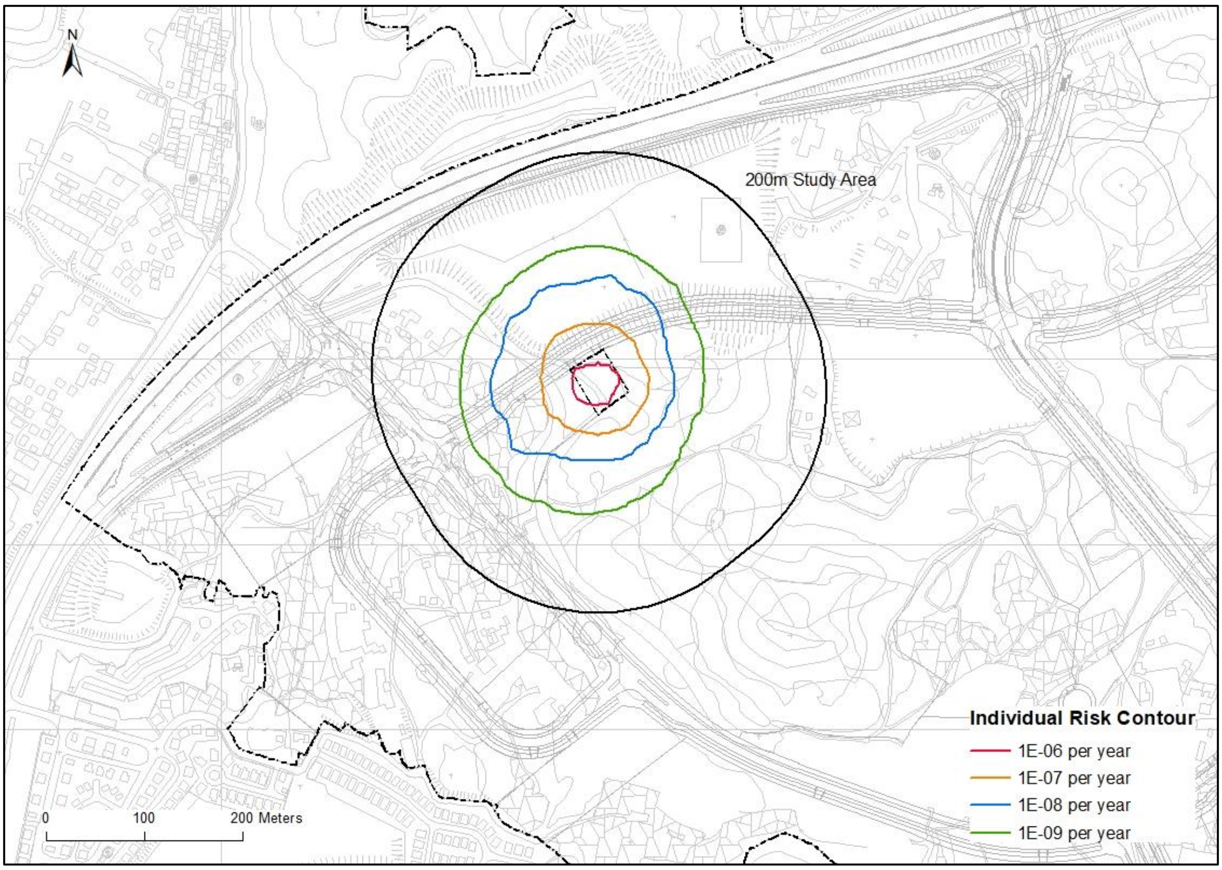

Plate 6.2 **Individual Risk Contours for the Proposed Station #2**

6.3 Societal Risk

6.3.1 Risk Level

6.3.1.1 The societal risks were evaluated for the range of incidents with the potential for fatalities in the vicinity of the two proposed GFSs and are shown in **Plate 6.3** and **Plate 6.4**, in form of F-N curves for comparison with the HKRG.

6.3.1.2 The societal risk is more complex than that for individual risk but, in essence, comprises three regions:

(a) Unacceptable – a region within which the risks may be regarded as unacceptable

(b) Acceptable – a region within which the risks may be regarded as acceptable

(c) ALARP – a region between the two in which measures should be taken to demonstrate the risks as “as low as reasonably practicable” (ALARP). In other words, consideration is given not only to the level of risk but also the cost and practicality of reducing it

6.3.1.3 Numerically, the upper bound of the ALARP region (and hence the borderline of “unacceptability”) can be summarised as:

(a) 1 chance in 1,000 per year of an incident resulting in 1 or more fatalities;

(b) 1 chance in 10,000 per year of an incident resulting in 10 or more fatalities;

(c) 1 chance in 100,000 per year of an incident resulting in 100 or more fatalities; and

(d) not more than 1,000 fatalities at a frequency of greater than 1 chance in a billion (1,000,000,000) per year.

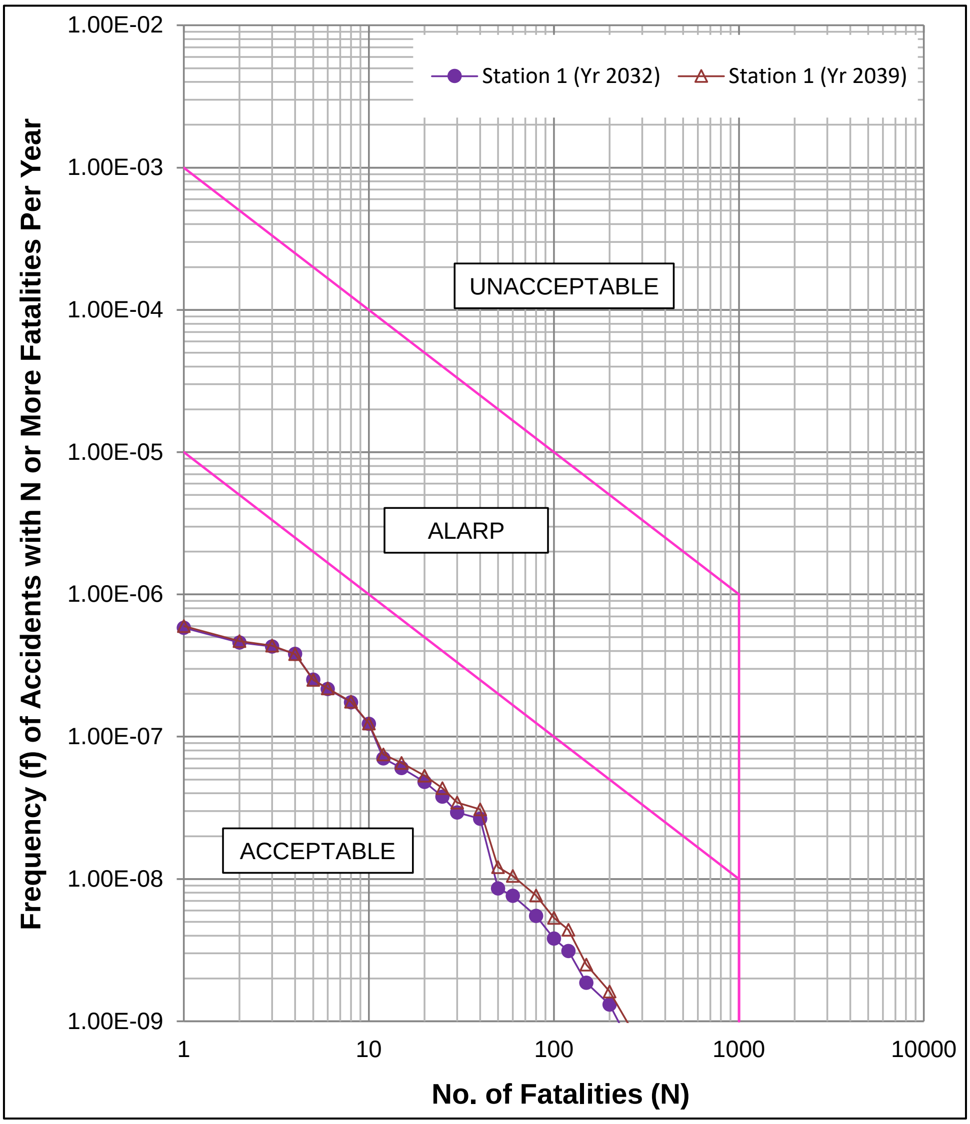

Plate 6.3 Societal Risk Curves for the Proposed Station #1

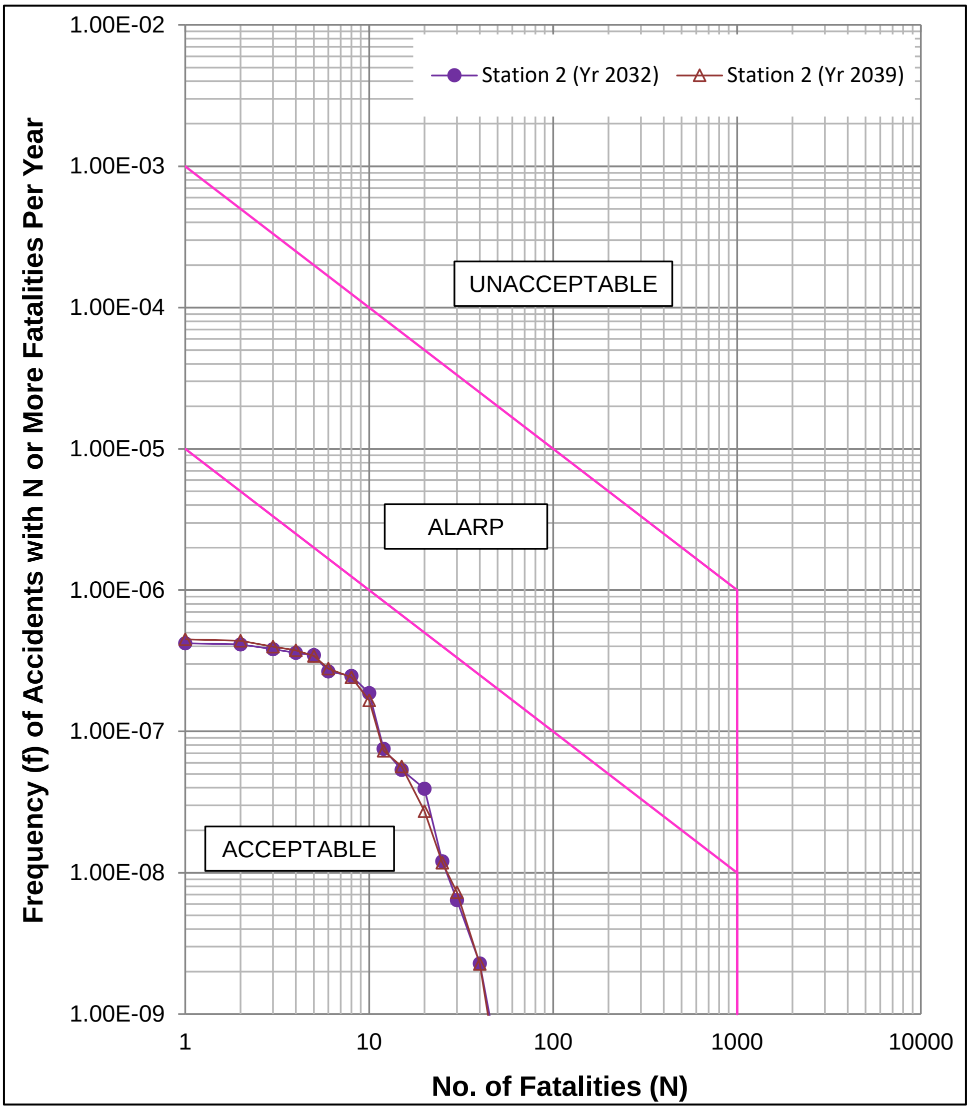

Plate 6.4 **Societal Risk Curves for the Proposed Station #2**

6.3.2 Acceptability

6.3.2.1 As shown in **Plate 6.3** and **Plate 6.4**, the societal risk associated with operation of both stations falls in the "Acceptable" region during both construction and operation phases, and therefore the associated societal risk is considered acceptable.

6.3.3 Potential Loss of Life (PLL)

6.3.3.1 The total PLLs and top five most significant risk contributing events for the assessed scenario for Station #1 and Station #2 are tabulated in Error! Reference source not found. a nd Error! Reference source not found., respectively. The total PLLs for the Station #1 are 5.16×10^{-6} per year and 5.62×10^{-6} per year in 2032 and 2039 respectively; while the total PLLs for the Station #2 are 3.83×10^{-6} per year and 3.89×10^{-6} per year in 2032 and 2039 respectively. The most significant event was the cold catastrophic failure of road tanker for all cases.

Table 6.1 Breakdown of PLL for Station #1

Event Description	Year 2032		Year 2039	
	Potential Loss of Life (PLL) per year	**% of Total PLL**	**Potential Loss of Life (PLL) per year**	**% of Total PLL**
Road Tanker Rupture (100% of inventory)	1.24E-06	24.0	1.28E-06	22.7
Road Tanker Rupture (50% of inventory)	1.22E-06	23.7	1.24E-06	22.0
Road Tanker Leak (50% of inventory)	1.08E-06	20.9	1.07E-06	19.1
Storage Vessels Rupture (100% Inventory)	5.45E-07	10.6	8.48E-07	15.1
Storage Vessels Rupture (60% Inventory)	5.10E-07	9.9	6.26E-07	11.1
Others	5.68E-07	11.0	5.64E-07	10.0
Total	**5.16E-06**	**100**	**5.62E-06**	**100**

Table 6.2 Breakdown of PLL for Station #2

Event Description	Year 2032		Year 2039	
	Potential Loss of Life (PLL) per year	**% of Total PLL**	**Potential Loss of Life (PLL) per year**	**% of Total PLL**
Road Tanker Rupture (50% of inventory)	1.38E-06	36.1	1.36E-06	35.0
Road Tanker Leak (50% of inventory)	9.45E-07	24.7	9.54E-07	24.5
Road Tanker Rupture (100% of inventory)	6.84E-07	17.9	6.72E-07	17.3
Road Tanker Leak (100% of inventory)	2.70E-07	7.1	2.59E-07	6.7
Storage Vessels Rupture (60% Inventory)	2.49E-07	6.5	3.17E-07	8.1
Others	2.98E-07	7.8	3.29E-07	8.5
Total	**3.83E-06**	**100**	**3.89E-06**	**100**

7. CONCLUSIONS AND RECOMMENDATION

7.1 Conclusions

7.1.1.1 A full QRA was carried out for the 2 green fuel stations, which are proposed to provide LPG filling services, within the project site. The assessment was conducted based on LPG throughput estimates by the Consultant, and also information collected from Census and Statistics Department, Hong Kong Observatory, Planning Department and Transport Department.

7.1.1.2 The predicted individual risks for both stations comply with the HKRG as stipulated in HKPSG with no off-site population subject to individual risk levels exceeding the criterion of 1×10^{-5} per year. The predicted societal risks for both stations also fall into the "Acceptable" region.

7.1.1.3 Based on the above results, the assessment finds that the operation of the 2 green fuel stations would not result in unacceptable risks to the overall population around the stations.

7.2 Recommendations

7.2.1.1 As shown in the previous sections, the level of individual and societal risks for the 2 proposed green fuel stations would be acceptable on risk grounds based on the information and data available at the time of preparing this report.

7.2.1.2 The future land uses, in particular those associated with significant population increase when compared with those assumed in this QRA, in the vicinity of the two proposed GFSs should be carefully assessed using QRA to ensure that the risk levels to any new population are acceptable. In addition, the QRA should be reviewed and updated when the LPG delivery frequency and throughput exceeds those specified in the assessment as a significant increase in the throughput of the GFSs and/or the number of LPG road tanker deliveries would also increase the risk outcomes. Should usage of the GFS other than LPG filling services is proposed in the future, the QRA should be reviewed.

8. REFERENCES

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Annex A

Population Data

Popu_ID	Land_ID	Description	Maximum Population in 2032	Maximum Population in 2039	Indoor Ratio in 2032	**% Occupancy in 2032**				Population in 2032				Shielding Factor [FB]	Shielded Population in 2032				Indoor Ratio in 2039	**% Occupancy in 2039**				Population in 2039				Shielding Factor [FB]	Shielded Population in 2039			
						Weekday		Weekend		Weekday		Weekend			Weekday		Weekend			Weekday		Weekend		Weekday		Weekend			Weekday		Weekend	
						Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	Day	Night		Day	Night	Day	Night	Day	Night	Day	Night		Day	Night	Day	Night
P03	G.5.3	Existing Mai Po ESS	125	84	0	1	0.1	0.5	0.1	125	13	63	13	0	125	13	63	13	0.95	1	0.1	0.5	0.1	84	8	42	8	0.5	42	4	21	4
P04	G.5.1	Sport Centre	125	1018	0	1	0.1	0.5	0.1	125	13	63	13	0	125	13	63	13	0.95	1	0.1	0.5	0.1	1018	102	509	102	0.5	509	51	255	51
P06	RSc.2.2	Public Housing	7603	7603	0.95	0.5	1	0.7	1	3802	7603	5322	7603	0.5	1901	3802	2661	3802	0.95	0.5	1	0.7	1	3802	7603	5322	7603	0.5	1901	3802	2661	3802
P07a	OU(EPP).5.3	Food Waste Pretreatment Facilities	100	100	0.95	1	0.1	0.5	0.1	100	10	50	10	0.5	50	5	25	5	0.95	1	0.1	0.5	0.1	100	10	50	10	0.5	50	5	25	5
P07b	OU(EPP).5.3	Effluent Polishing Plant	200	200	0.95	1	0.1	0.5	0.1	200	20	100	20	0.5	100	10	50	10	0.95	1	0.1	0.5	0.1	200	20	100	20	0.5	100	10	50	10
P09	G.5.2	Reserve	0	0	0.95	1	0.1	0.5	0.1	0	0	0	0	0.5	0	0	0	0	0.95	1	0.1	0.5	0.1	0	0	0	0	0.5	0	0	0	0
P41	OU(I&T)3.1.7	Information and Technology - Zone 3	3536	3536	0.95	1	0.1	0.5	0.1	3536	354	1768	354	0.5	1768	177	884	177	0.95	1	0.1	0.5	0.1	3536	354	1768	354	0.5	1768	177	884	177
P45	OU(I&T)2.1.1	Information and Technology - Zone 2	2788	2788	0.95	1	0.1	0.5	0.1	2788	279	1394	279	0.5	1394	140	697	140	0.95	1	0.1	0.5	0.1	2788	279	1394	279	0.5	1394	140	697	140
P46	OU(ESS).1.4	132kV ESS	0	0	0.95	1	0.1	0.5	0.1	0	0	0	0	0.5	0	0	0	0	0.95	1	0.1	0.5	0.1	0	0	0	0	0.5	0	0	0	0
P47	A.1.4	Amenity	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
P48	OU(MU)2.1.1	Mixed use (Chau Tau Station)	80	17826	0	1	0.1	0.5	0.1	80	8	40	8	0	80	8	40	8	0.95	1	1	1	1	17826	17826	17826	17826	0.5	8913	8913	8913	8913
P57	OU(WRP).5.2	Water Reclamation Plant	100	100	0.95	1	0.1	0.5	0.1	100	10	50	10	0.5	50	5	25	5	0.95	1	0.1	0.5	0.1	100	10	50	10	0.5	50	5	25	5
P60	GB.5.1	Green Belt	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
P66	A.1.5	Amenity	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
P67	OU(I&T)3.1.5	Information and Technology - Zone 3	1135	1135	0.95	1	0.1	0.5	0.1	1135	114	568	114	0.5	568	57	284	57	0.95	1	0.1	0.5	0.1	1135	114	568	114	0.5	568	57	284	57
P68	OU(I&T)3.1.4	Information and Technology - Zone 3	1580	1580	0.95	1	0.1	0.5	0.1	1580	158	790	158	0.5	790	79	395	79	0.95	1	0.1	0.5	0.1	1580	158	790	158	0.5	790	79	395	79
P69	A.1.3	Amenity	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0
P70	OU(I&T)3.1.6	Information and Technology - Zone 3 (Government Data Centre)	240	240	0.95	1	0.1	0.5	0.1	240	24	120	24	0.5	120	12	60	12	0.95	1	0.1	0.5	0.1	240	24	120	24	0.5	120	12	60	12

Road Population

	Road Length (km)	Designed Speed (km/h)	Traffic Flow (veh/hr) at Daytime (Year 2032)										
			Motorcycle	Private Car	Taxi	Private Light Bus	Public Light Bus	Light Goods Vehicle	Medium/ Heavy Goods Vehicles	Non-franchised Bus	Franchised Bus (Single Deck)	Franchised Bus (Double Deck)	Total
Road R1													
Total Vehicle per hour	0.7	50	2	73	12	1	26	34	30	4	0	3	186
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	6	1	1	2	0	3	18
Road R2													
Total Vehicle per hour	0.16	50	9	299	50	5	49	115	100	16	0	7	652
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	3	1	1	2	0	2	14
Road R3													
Total Vehicle per hour	0.34	50	5	160	27	3	0	25	21	9	0	0	250
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	2	0	0	9
Road R4													
Total Vehicle per hour	0.69	50	6	183	30	3	3	45	39	11	0	4	323
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	1	1	1	3	0	3	16
Road R5													
Total Vehicle per hour	0.7	50	7	232	39	4	21	73	63	13	0	0	453
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	5	2	1	5	2	2	4	0	0	22
Road R6													
Total Vehicle per hour	0.58	100	106	3416	568	62	134	1266	1081	189	6	224	7051
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	28	7	2	13	10	8	23	0	66	158
Road R7													
Total Vehicle per hour	0.64	100	99	3197	532	58	131	1166	996	176	4	164	6524
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	29	7	2	14	10	8	23	0	54	148
Road R8													
Total Vehicle per hour	0.83	100	106	3440	572	62	131	1244	1064	189	5	192	7007
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	40	10	3	18	14	11	32	0	81	210
Road R9													
Total Vehicle per hour	0.68	100	77	2474	412	45	108	816	698	136	3	105	4872
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	24	6	2	12	8	6	19	0	37	115
Road R10													
Total Vehicle per hour	1.18	100	109	3518	586	64	108	903	772	192	4	147	6402
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		2	59	14	4	21	14	11	46	0	89	260
Road R11													
Total Vehicle per hour	0.19	50	7	238	39	4	3	142	121	14	5	201	774
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	1	1	1	2	0	39	49
Road R12													
Total Vehicle per hour	0.37	50	7	217	36	4	0	34	29	12	7	273	619
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	103	113
Road R13													
Total Vehicle per hour	0.32	50	3	101	17	2	0	29	25	5	1	38	222
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	13	20
Road R14													
Total Vehicle per hour	0.27	50	4	115	18	2	3	70	59	7	1	26	305
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	1	1	1	1	0	8	16
Road R15													
Total Vehicle per hour	0.45	50	4	133	22	2	0	37	32	7	0	7	246
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	2	0	4	13

Road R16													
Total Vehicle per hour	0.39	50	3	110	18	2	0	41	36	6	1	20	238
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	1	0	9	17

Road R17													
Total Vehicle per hour	0.13	50	2	74	12	1	0	11	10	4	2	62	179
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	9	16

Road R18													
Total Vehicle per hour	0.15	50	3	103	17	2	3	83	70	6	0	0	286
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	1	1	1	1	0	0	8

Road R19													
Total Vehicle per hour	0.37	50	2	56	9	1	52	36	30	3	1	53	244
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	7	1	1	1	0	21	35

Road R20													
Total Vehicle per hour	0.54	50	1	43	7	1	52	28	24	3	1	53	213
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	9	1	1	1	0	30	46

Road R21													
Total Vehicle per hour	0.44	50	2	65	11	1	67	13	11	4	1	51	227
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	10	1	1	1	0	23	40

Road R22													
Total Vehicle per hour	0.2	50	3	110	18	2	89	78	66	6	4	139	516
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	6	1	1	1	0	29	42

Road R23													
Total Vehicle per hour	0.45	50	9	281	47	5	17	86	73	16	3	109	645
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	3	2	1	3	0	50	66

Road R24													
Total Vehicle per hour	1.11	50	7	226	38	4	17	55	47	12	3	109	519
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	8	2	1	7	2	2	6	0	124	153

Road R25													
Total Vehicle per hour	0.86	50	5	161	27	3	0	31	27	9	5	185	453
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	4	0	163	176

Road R26													
Total Vehicle per hour	0.67	50	1	27	4	0	0	4	3	2	1	21	61
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	15	22

Road R27													
Total Vehicle per hour	0.63	50	0	7	1	0	0	4	3	0	1	21	36
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	14	21

Road R28													
Total Vehicle per hour	0.2	50	0	0	0	0	0	0	0	0	0	0	0
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		0	0	0	0	0	0	0	0	0	0	0

Road R29													
Total Vehicle per hour	0.15	50	0	0	0	0	0	0	0	0	0	0	0
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		0	0	0	0	0	0	0	0	0	0	0

Road R30													
Total Vehicle per hour	0.67	50	1	22	4	0	0	8	6	1	1	52	95
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	36	43

Road R31													
Total Vehicle per hour	1.62	50	7	219	36	4	5	125	107	12	0	4	519
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	10	3	1	3	6	5	9	0	7	45

Road R32													
Total Vehicle per hour	0.21	50	4	130	21	2	0	56	49	7	3	121	394
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	26	33

Road R33													
Total Vehicle per hour	0.6	50	28	918	154	17	0	38	32	49	0	0	1237
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	16	4	1	0	1	1	12	0	0	36
Road R34													
Total Vehicle per hour	0.42	50	7	238	39	4	12	127	108	14	1	42	593
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	2	2	2	3	0	19	34
Road R35													
Total Vehicle per hour	0.31	50	23	730	123	13	0	73	63	38	0	19	1082
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	7	2	1	0	1	1	5	0	6	24
Road R36													
Total Vehicle per hour	0.59	50	4	125	21	2	0	37	32	7	3	131	362
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	79	89
Road R37													
Total Vehicle per hour	0.25	50	0	12	2	0	0	3	3	1	0	0	21
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7
Road R38													
Total Vehicle per hour	0.38	50	4	139	23	3	0	41	35	8	3	131	388
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	2	0	51	60
Road R39													
Total Vehicle per hour	0.6	50	19	603	101	11	45	182	155	32	3	130	1281
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	11	3	1	9	3	3	8	0	80	119
Road R40													
Total Vehicle per hour	0.2	50	0	0	0	0	0	0	0	0	0	0	0
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7
Road R41													
Total Vehicle per hour	0.23	50	0	14	2	0	0	14	12	1	0	0	44
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7
Road R42													
Total Vehicle per hour	0.16	50	16	516	85	9	0	168	143	30	0	0	968
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	0	10
Road 43													
Total Vehicle per hour	0.24	50	16	531	88	10	0	170	145	30	1	25	1015
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	2	1	3	0	7	20
Road 44													
Total Vehicle per hour	0.32	50	8	259	43	5	0	61	52	14	0	0	442
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	0	10
Road 45													
Total Vehicle per hour	0.23	50	7	210	34	4	0	69	58	13	0	0	395
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	2	0	0	9
Road 46													
Total Vehicle per hour	0.25	50	11	358	60	6	0	75	64	20	0	0	594
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	0	10

[1] Person per vehicle is based on the average occupancy at core stations 5016 in Year 2019 from Transport Department - The Annual Traffic Census 2019

Road Population

	Road Length (km)	Designed Speed (km/h)	Traffic Flow (veh/hr) at Night-time (Year 2032)										
			Motorcycle	Private Car	Taxi	Private Light Bus	Public Light Bus	Light Goods Vehicle	Medium/ Heavy Goods Vehicles	Non-franchised Bus	Franchised Bus (Single Deck)	Franchised Bus (Double Deck)	Total
Road R1													
Total Vehicle per hour	0.7	50	1	32	6	0	13	7	6	2	0	1	69
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	3	1	1	1	0	2	12
Road R2													
Total Vehicle per hour	0.16	50	5	149	29	1	24	23	21	6	0	3	261
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	2	1	1	1	0	1	10
Road R3													
Total Vehicle per hour	0.34	50	2	76	15	0	0	5	4	3	0	0	106
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7
Road R4													
Total Vehicle per hour	0.69	50	3	83	16	1	1	9	8	4	0	2	126
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	1	1	1	2	0	2	12
Road R5													
Total Vehicle per hour	0.7	50	4	115	22	1	10	14	13	5	0	0	184
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	3	1	1	2	0	0	13
Road R6													
Total Vehicle per hour	0.58	100	52	1673	322	8	66	242	216	73	4	102	2758
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	14	4	1	7	2	2	9	0	31	71
Road R7													
Total Vehicle per hour	0.64	100	49	1583	304	7	64	224	200	69	3	75	2579
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	15	4	1	7	2	2	9	0	25	66
Road R8													
Total Vehicle per hour	0.83	100	53	1704	328	8	64	239	214	74	3	88	2776
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	20	6	1	9	3	3	13	0	37	93
Road R9													
Total Vehicle per hour	0.68	100	38	1239	238	5	53	158	142	54	2	48	1977
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	12	4	1	6	2	2	8	0	17	53
Road R10													
Total Vehicle per hour	1.18	100	55	1778	341	8	53	175	157	77	3	67	2713
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	30	8	1	10	3	3	19	0	41	116
Road R11													
Total Vehicle per hour	0.19	50	4	112	22	1	1	27	24	5	4	93	292
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	1	1	1	1	0	18	26
Road R12													
Total Vehicle per hour	0.37	50	3	98	19	1	0	6	5	4	5	121	262
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	1	0	46	54
Road R13													
Total Vehicle per hour	0.32	50	2	52	10	0	0	5	5	2	1	17	94
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	6	13
Road R14													
Total Vehicle per hour	0.27	50	2	38	8	0	1	13	10	2	0	10	85
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	1	1	1	1	0	3	11
Road R15													
Total Vehicle per hour	0.45	50	2	65	12	0	0	7	7	3	0	3	100
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	2	9

Road R16													
Total Vehicle per hour	0.39	50	2	56	11	0	0	8	8	2	0	10	97
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	4	11
Road R17													
Total Vehicle per hour	0.13	50	1	38	7	0	0	2	2	2	1	26	79
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	4	11
Road R18													
Total Vehicle per hour	0.15	50	2	41	8	0	1	16	13	2	0	0	83
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	1	1	1	1	0	0	8
Road R19													
Total Vehicle per hour	0.37	50	1	25	5	0	26	7	6	1	1	25	96
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	4	1	1	1	0	10	21
Road R20													
Total Vehicle per hour	0.54	50	1	19	4	0	26	5	5	1	1	25	85
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	5	1	1	1	0	14	26
Road R21													
Total Vehicle per hour	0.44	50	1	27	5	0	33	3	2	1	1	24	97
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	5	1	1	1	0	11	23
Road R22													
Total Vehicle per hour	0.2	50	2	54	10	0	44	15	13	2	3	64	208
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	3	1	1	1	0	14	24
Road R23													
Total Vehicle per hour	0.45	50	4	134	26	1	9	17	15	6	2	51	264
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	2	1	1	2	0	24	35
Road R24													
Total Vehicle per hour	1.11	50	4	113	22	0	9	11	10	5	2	51	226
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	4	1	1	3	0	58	74
Road R25													
Total Vehicle per hour	0.86	50	2	80	15	0	0	6	5	3	3	86	202
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	2	0	76	85
Road R26													
Total Vehicle per hour	0.67	50	0	12	2	0	0	1	1	1	0	10	27
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	7	14
Road R27													
Total Vehicle per hour	0.63	50	0	3	1	0	0	1	1	0	0	10	14
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	7	14
Road R28													
Total Vehicle per hour	0.2	50	0	0	0	0	0	0	0	0	0	0	0
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		0	0	0	0	0	0	0	0	0	0	0
Road R29													
Total Vehicle per hour	0.15	50	0	0	0	0	0	0	0	0	0	0	0
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		0	0	0	0	0	0	0	0	0	0	0
Road R30													
Total Vehicle per hour	0.67	50	0	8	2	0	0	1	1	0	1	17	29
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	12	19
Road R31													
Total Vehicle per hour	1.62	50	3	108	21	1	3	24	21	5	0	2	187
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	5	2	1	2	2	1	4	0	3	21
Road R32													
Total Vehicle per hour	0.21	50	2	62	12	0	0	11	10	3	2	56	159
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	13	20

Road R33													
Total Vehicle per hour	0.6	50	14	480	92	2	0	7	6	20	0	0	622
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	9	3	1	0	1	1	5	0	0	21

Road R34													
Total Vehicle per hour	0.42	50	4	102	20	1	6	24	21	5	1	19	202
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	1	1	1	1	0	9	18

Road R35													
Total Vehicle per hour	0.31	50	12	394	75	1	0	14	13	16	0	9	534
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	3	0	3	15

Road R36													
Total Vehicle per hour	0.59	50	2	60	12	0	0	7	6	3	2	61	153
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	37	44

Road R37													
Total Vehicle per hour	0.25	50	0	6	1	0	0	1	1	0	0	0	9
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7

Road R38													
Total Vehicle per hour	0.38	50	2	69	13	0	0	8	7	3	2	61	166
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	24	31

Road R39													
Total Vehicle per hour	0.6	50	9	320	61	1	22	35	31	13	2	60	556
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	6	2	1	5	1	1	4	0	37	58

Road R40													
Total Vehicle per hour	0.2	50	0	0	0	0	0	0	0	0	0	0	0
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7

Road R41													
Total Vehicle per hour	0.23	50	1	43	7	1	0	32	28	2	0	0	114
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7

Road R42													
Total Vehicle per hour	0.16	50	16	516	85	9	0	168	143	30	0	0	968
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	0	10

Road 43													
Total Vehicle per hour	0.24	50	16	531	88	10	0	170	145	30	1	25	1015
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	2	1	3	0	7	20

Road 44													
Total Vehicle per hour	0.32	50	8	259	43	5	0	61	52	14	0	0	442
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	0	10

Road 45													
Total Vehicle per hour	0.23	50	7	210	34	4	0	69	58	13	0	0	395
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	2	0	0	9

Road 46													
Total Vehicle per hour	0.25	50	11	358	60	6	0	75	64	20	0	0	594
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	0	10

Note:
[1] Person per vehicle is based on the average occupancy at core stations 5016 in Year 2019 from Transport Department - The Annual Traffic Census 2019

Road Population

	Road Length (km)	Designed Speed (km/h)	Traffic Flow (veh/hr) at Daytime (Year 2039)										
			Motorcycle	Private Car	Taxi	Private Light Bus	Public Light Bus	Light Goods Vehicle	Medium/ Heavy Goods Vehicles	Non-franchised Bus	Franchised Bus (Single Deck)	Franchised Bus (Double Deck)	Total
Road R1													
Total Vehicle per hour	0.7	50	6	185	30	3	26	86	74	11	0	3	425
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	6	2	2	4	0	3	24
Road R2													
Total Vehicle per hour	0.16	50	22	725	120	13	49	238	203	40	0	7	1419
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	3	1	1	3	0	2	17
Road R3													
Total Vehicle per hour	0.34	50	20	661	110	12	0	124	107	37	0	0	1071
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	7	2	1	0	2	1	6	0	0	20
Road R4													
Total Vehicle per hour	0.69	50	23	733	122	13	3	148	126	40	0	4	1212
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	15	4	1	1	3	3	12	0	3	43
Road R5													
Total Vehicle per hour	0.7	50	9	287	48	5	21	106	91	15	0	0	582
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	6	2	1	5	2	2	5	0	0	24
Road R6													
Total Vehicle per hour	0.58	100	152	4909	816	89	133	1785	1522	270	6	228	9910
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	40	9	3	13	14	11	32	0	68	191
Road R7													
Total Vehicle per hour	0.64	100	124	4007	667	73	131	1416	1210	220	4	159	8011
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	36	9	3	14	12	10	29	0	52	166
Road R8													
Total Vehicle per hour	0.83	100	154	4969	827	90	131	1557	1330	272	5	185	9520
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		2	58	14	4	18	17	14	46	0	79	252
Road R9													
Total Vehicle per hour	0.68	100	94	3046	508	55	108	748	640	166	3	116	5485
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	30	7	2	12	7	6	23	0	41	129
Road R10													
Total Vehicle per hour	1.18	100	136	4409	736	80	108	853	730	238	4	153	7448
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		2	73	17	5	21	14	11	58	0	92	293
Road R11													
Total Vehicle per hour	0.19	50	17	560	93	10	3	269	229	32	6	225	1443
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	1	2	2	3	0	44	58
Road R12													
Total Vehicle per hour	0.37	50	43	1389	231	25	0	262	223	77	4	157	2410
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	15	4	1	0	3	2	12	0	60	98
Road R13													
Total Vehicle per hour	0.32	50	10	336	55	6	0	136	116	20	1	41	721
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	2	1	3	0	14	27
Road R14													
Total Vehicle per hour	0.27	50	18	566	94	10	3	232	197	31	1	28	1179
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	5	1	1	1	2	2	4	0	8	25
Road R15													
Total Vehicle per hour	0.45	50	17	561	93	10	0	66	56	31	0	0	835
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	8	2	1	0	1	1	6	0	0	20

Road R16													
Total Vehicle per hour	0.39	50	12	401	67	7	0	75	64	22	1	25	674
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	5	1	1	0	1	1	4	0	11	25

Road R17													
Total Vehicle per hour	0.13	50	13	424	70	8	0	88	75	24	1	26	729
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	2	0	4	13

Road R18													
Total Vehicle per hour	0.15	50	6	204	34	4	3	136	115	11	1	28	540
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	1	1	1	1	0	5	13

Road R19													
Total Vehicle per hour	0.37	50	9	275	45	5	52	84	71	16	1	53	612
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	7	1	1	3	0	21	39

Road R20													
Total Vehicle per hour	0.54	50	8	266	44	5	52	87	74	15	1	53	607
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	5	1	1	9	2	1	4	0	30	54

Road R21													
Total Vehicle per hour	0.44	50	10	315	52	6	67	95	82	17	1	51	696
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	10	2	1	4	0	23	47

Road R22													
Total Vehicle per hour	0.2	50	10	329	54	6	89	149	127	19	4	139	925
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	6	1	1	2	0	29	44

Road R23													
Total Vehicle per hour	0.45	50	9	295	49	5	17	97	83	16	3	109	684
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	3	2	1	4	0	50	67

Road R24													
Total Vehicle per hour	1.11	50	8	244	41	4	17	62	53	13	3	121	567
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	8	2	1	7	2	2	7	0	138	168

Road R25													
Total Vehicle per hour	0.86	50	14	459	76	8	0	72	62	25	4	159	880
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	12	3	1	0	2	2	9	0	140	170

Road R26													
Total Vehicle per hour	0.67	50	15	478	80	9	0	121	103	26	2	68	901
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	9	3	1	0	3	2	8	0	47	74

Road R27													
Total Vehicle per hour	0.63	50	11	346	58	6	0	75	64	19	2	89	671
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	7	2	1	0	2	1	5	0	58	77

Road R28													
Total Vehicle per hour	0.2	50	15	491	81	9	0	127	108	28	1	52	913
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	3	0	11	22

Road R29													
Total Vehicle per hour	0.15	50	17	542	90	10	0	136	116	30	2	68	1011
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	11	21

Road R30													
Total Vehicle per hour	0.67	50	11	340	56	6	0	78	66	19	3	98	676
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	7	2	1	0	2	2	6	0	67	88

Road R31													
Total Vehicle per hour	1.62	50	12	376	62	7	5	182	156	21	0	4	826
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	18	4	1	3	8	7	15	0	7	64

Road R32													
Total Vehicle per hour	0.21	50	9	297	49	5	0	211	181	17	3	121	894
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	2	1	2	0	26	36

Road R33													
Total Vehicle per hour	0.6	50	39	1265	212	23	0	118	100	67	0	0	1825
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	22	5	2	0	2	2	17	0	0	51

Road R34													
Total Vehicle per hour	0.42	50	15	481	78	9	12	251	215	29	1	36	1127
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	6	2	1	2	3	3	5	0	16	39

Road R35													
Total Vehicle per hour	0.31	50	30	965	163	17	0	71	61	49	0	13	1370
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	9	2	1	0	1	1	7	0	5	27

Road R36													
Total Vehicle per hour	0.59	50	5	164	27	3	0	50	42	9	3	118	422
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	3	0	72	83

Road R37													
Total Vehicle per hour	0.25	50	0	12	2	0	0	3	3	1	0	0	21
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7

Road R38													
Total Vehicle per hour	0.38	50	2	69	11	1	0	33	28	4	3	131	282
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	51	58

Road R39													
Total Vehicle per hour	0.6	50	31	991	166	18	45	268	229	52	4	154	1958
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	17	4	1	9	5	4	13	0	95	149

Road R40													
Total Vehicle per hour	0.2	50	4	129	21	2	0	23	19	7	0	0	206
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7

Road R41													
Total Vehicle per hour	0.23	50	0	14	2	0	0	14	12	1	0	0	44
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7

Road R42													
Total Vehicle per hour	0.16	50	21	674	111	12	0	225	192	38	0	0	1274
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	3	0	0	12

Road 43													
Total Vehicle per hour	0.24	50	22	722	120	13	0	227	194	41	1	25	1364
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	5	2	1	0	2	2	4	0	7	24

Road 44													
Total Vehicle per hour	0.32	50	14	442	73	8	0	79	67	25	0	0	708
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	4	0	0	13

Road 45													
Total Vehicle per hour	0.23	50	10	330	54	6	0	89	75	19	0	0	583
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	0	10

Road 46													
Total Vehicle per hour	0.25	50	14	452	75	8	0	94	80	25	0	0	748
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	3	0	0	12

[1] Person per vehicle is based on the average occupancy at core stations 5016 in Year 2019 from Transport Department - The Annual Traffic Census 2019

Road Population

	Road Length (km)	Designed Speed (km/h)	Traffic Flow (veh/hr) at Night-time (Year 2039)										
			Motorcycle	Private Car	Taxi	Private Light Bus	Public Light Bus	Light Goods Vehicle	Medium/ Heavy Goods Vehicles	Non-franchised Bus	Franchised Bus (Single Deck)	Franchised Bus (Double Deck)	Total
Road R1													
Total Vehicle per hour	0.7	50	3	76	15	1	13	17	16	4	0	1	145
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	3	1	1	2	0	2	14
Road R2													
Total Vehicle per hour	0.16	50	11	358	69	2	24	46	41	16	0	3	570
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	2	1	1	2	0	1	12
Road R3													
Total Vehicle per hour	0.34	50	10	327	63	2	0	24	22	14	0	0	462
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	2	0	0	11
Road R4													
Total Vehicle per hour	0.69	50	11	364	70	2	1	28	25	16	0	2	520
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	8	2	1	1	1	1	5	0	2	22
Road R5													
Total Vehicle per hour	0.7	50	5	151	29	1	10	21	19	6	0	0	241
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	3	1	1	2	0	0	13
Road R6													
Total Vehicle per hour	0.58	100	76	2439	469	11	66	343	304	107	4	105	3923
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	20	6	1	7	3	3	13	0	31	85
Road R7													
Total Vehicle per hour	0.64	100	62	2005	385	9	64	273	243	87	3	73	3205
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	18	5	1	7	3	2	12	0	24	73
Road R8													
Total Vehicle per hour	0.83	100	77	2489	478	11	64	300	268	108	3	85	3884
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	29	8	1	9	4	3	19	0	36	110
Road R9													
Total Vehicle per hour	0.68	100	47	1548	297	6	53	145	131	67	2	53	2350
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	15	4	1	6	2	2	10	0	19	60
Road R10													
Total Vehicle per hour	1.18	100	69	2263	434	9	53	165	149	97	3	70	3312
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	38	10	1	10	3	3	24	0	43	133
Road R11													
Total Vehicle per hour	0.19	50	9	265	51	1	1	51	45	12	4	104	545
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	1	1	1	1	0	21	30
Road R12													
Total Vehicle per hour	0.37	50	21	690	133	3	0	50	44	30	3	73	1048
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	8	2	1	0	1	1	5	0	28	47
Road R13													
Total Vehicle per hour	0.32	50	5	146	28	1	0	26	23	7	1	19	256
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	1	0	7	15
Road R14													
Total Vehicle per hour	0.27	50	9	288	55	1	1	44	38	12	1	13	462
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	1	1	1	2	0	4	15
Road R15													
Total Vehicle per hour	0.45	50	9	278	54	1	0	13	12	12	0	0	378
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	3	0	0	12

Road R16													
Total Vehicle per hour	0.39	50	6	206	39	1	0	15	13	9	0	12	301
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	5	15

Road R17													
Total Vehicle per hour	0.13	50	7	208	40	1	0	17	15	9	1	13	309
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	2	9

Road R18													
Total Vehicle per hour	0.15	50	3	102	20	0	1	26	22	4	1	13	192
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	1	1	1	1	0	2	10

Road R19													
Total Vehicle per hour	0.37	50	4	130	25	1	26	16	14	6	1	25	247
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	4	1	1	1	0	10	22

Road R20													
Total Vehicle per hour	0.54	50	4	123	24	1	26	17	15	6	1	25	240
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	5	1	1	2	0	14	28

Road R21													
Total Vehicle per hour	0.44	50	5	157	30	1	33	18	17	7	1	24	292
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	5	1	1	2	0	11	25

Road R22													
Total Vehicle per hour	0.2	50	5	150	29	1	44	29	26	7	3	64	357
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	3	1	1	1	0	14	24

Road R23													
Total Vehicle per hour	0.45	50	5	144	28	1	9	19	17	6	2	51	280
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	2	1	1	2	0	24	35

Road R24													
Total Vehicle per hour	1.11	50	4	123	24	1	9	12	11	5	2	56	246
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	4	1	1	3	0	64	80

Road R25													
Total Vehicle per hour	0.86	50	7	226	44	1	0	14	13	10	3	74	392
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	6	2	1	0	1	1	4	0	65	81

Road R26													
Total Vehicle per hour	0.67	50	7	239	46	1	0	23	21	10	1	31	381
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	5	2	1	0	1	1	3	0	22	36

Road R27													
Total Vehicle per hour	0.63	50	5	171	33	1	0	15	13	8	2	41	289
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	2	0	27	38

Road R28													
Total Vehicle per hour	0.2	50	8	231	45	1	0	24	22	11	1	24	366
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	1	0	5	13

Road R29													
Total Vehicle per hour	0.15	50	8	274	53	1	0	26	23	12	1	31	430
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	1	0	5	13

Road R30													
Total Vehicle per hour	0.67	50	5	164	32	1	0	15	13	7	2	45	285
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	2	0	31	42

Road R31													
Total Vehicle per hour	1.62	50	6	178	34	1	3	35	32	8	0	2	299
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	9	3	1	2	2	2	6	0	3	29

Road R32													
Total Vehicle per hour	0.21	50	5	139	27	1	0	41	37	6	2	56	313
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	13	20

Road R33													
Total Vehicle per hour	0.6	50	20	673	129	2	0	23	20	28	0	0	894
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	12	3	1	0	1	1	7	0	0	26

Road R34													
Total Vehicle per hour	0.42	50	7	198	39	2	6	49	44	10	1	17	371
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	1	1	1	2	0	8	19

Road R35													
Total Vehicle per hour	0.31	50	15	540	103	1	0	14	13	22	0	6	715
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	5	2	1	0	1	1	3	0	2	16

Road R36													
Total Vehicle per hour	0.59	50	3	84	16	0	0	10	8	4	2	55	181
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	2	1	1	0	1	1	1	0	33	41

Road R37													
Total Vehicle per hour	0.25	50	0	6	1	0	0	1	1	0	0	0	9
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7

Road R38													
Total Vehicle per hour	0.38	50	1	32	6	0	0	6	6	1	2	61	115
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	24	31

Road R39													
Total Vehicle per hour	0.6	50	16	526	101	2	22	52	46	22	3	71	860
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	9	3	1	5	1	1	6	0	44	71

Road R40													
Total Vehicle per hour	0.2	50	2	61	12	0	0	4	4	3	0	0	85
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7

Road R41													
Total Vehicle per hour	0.23	50	1	43	7	1	0	33	28	2	0	0	115
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	1	1	1	0	1	1	1	0	0	7

Road R42													
Total Vehicle per hour	0.16	50	21	674	111	12	0	225	192	38	0	0	1274
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	3	0	0	12

Road 43													
Total Vehicle per hour	0.24	50	22	722	120	13	0	227	194	41	1	25	1364
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	5	2	1	0	2	2	4	0	7	24

Road 44													
Total Vehicle per hour	0.32	50	14	442	73	8	0	79	67	25	0	0	708
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	4	0	0	13

Road 45													
Total Vehicle per hour	0.23	50	10	330	54	6	0	89	75	19	0	0	583
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	3	1	1	0	1	1	2	0	0	10

Road 46													
Total Vehicle per hour	0.25	50	14	452	75	8	0	94	80	25	0	0	748
Person per vehicle [1]	-		1.0	1.4	1.9	4.5	15.9	1.3	1.2	20.3	0.0	50.9	-
No. of Person	-		1	4	1	1	0	1	1	3	0	0	12

Note:
[1] Person per vehicle is based on the average occupancy at core stations 5016 in Year 2019 from Transport Department - The Annual Traffic Census 2019

Annex B

Aircraft Crash Frequency Calculation

ANNEX B AIRCRAFT CRASH FREQUENCY CALCULATION

Introduction

The distance between the nearest arrival/departure flight path and the proposed Station #2 is about 13.2 km. The distance between the proposed Station #2 and Chek Lap Kok International Airport is 25 km, the separation distance is over 8 km, which fulfills the criteria of not considering the airfield accident. At such distances, the GFS is not covered by critical takeoff and landing phases. The frequency of aircraft crash is estimated using the methodology of the HSE (1997). Civil aircraft is the main type using the airport. According to the statistic of Civil International Air Transport Movements of Aircraft, there are 429,446 movements between July 2018 and June 2019 inclusively.

Frequency Calculation

The frequency of aircraft crash of a particular aircraft type is calculated with reference to *Health and Safety Executives - The Calculation of Aircraft Crash Risk in the UK* prepared by J P Byrue in 1997, given by the following equation:

Frequency (per year) = Background Crash Rate + Airway Crash Rate

Frequency (per year) = $(A \times B_i) + (A \times N_i \times R_i \times afac/ alt)$*, where*

- A = area of the GFS (in km^2)
- N_i = number of aircraft movement (for aircraft type i)
- B_i = background crash rate for aircraft (for aircraft type i, in per year per km^2)
- R_i = aircraft in-flight reliability (for aircraft type i, crashes per year per km per aircraft movement)
- alt = altitudes of airways (in km)
- afac = area factor used in airway calculation

The parameters of the above equation are listed as follows:

- Area of the Station #2 (A): 2.1×10^{-3} km^2 = $2{,}100 m^2$
- Number of aircraft movement (N):
  - There is 429,446 aircraft movement annually.
- Background aircraft crash rate (B_i):
  - The background crash rate for airliners is 2×10^{-6} per year per km^2
- Aircraft in-flight crash rate (R_i):
  - It is taken as 4.7×10^{-11} per year per km per movement
- Altitudes of airways (alt):
  - altitudes of airways is taken as 5 km
- Area factor (afac):
  - area factor (afac) is taken as 0.015 from Table 9 of Byrne (1997) with corresponding x1 = 2.64
    (x1 = x/alt where x = the minimum horizontal distance from airway/ flight path to the site which is taken as 13.2 km)

By substituting the parameters into the equation listed above, the annual aircraft crash rate can be estimated and listed as follows:

- Crash rate for airliners = 4.33×10^{-9} per year

Therefore, the frequency of aircraft crash at Station #2
= 4.33×10^{-9} per year.

Probability of LPG equipment failure due to aircraft crash

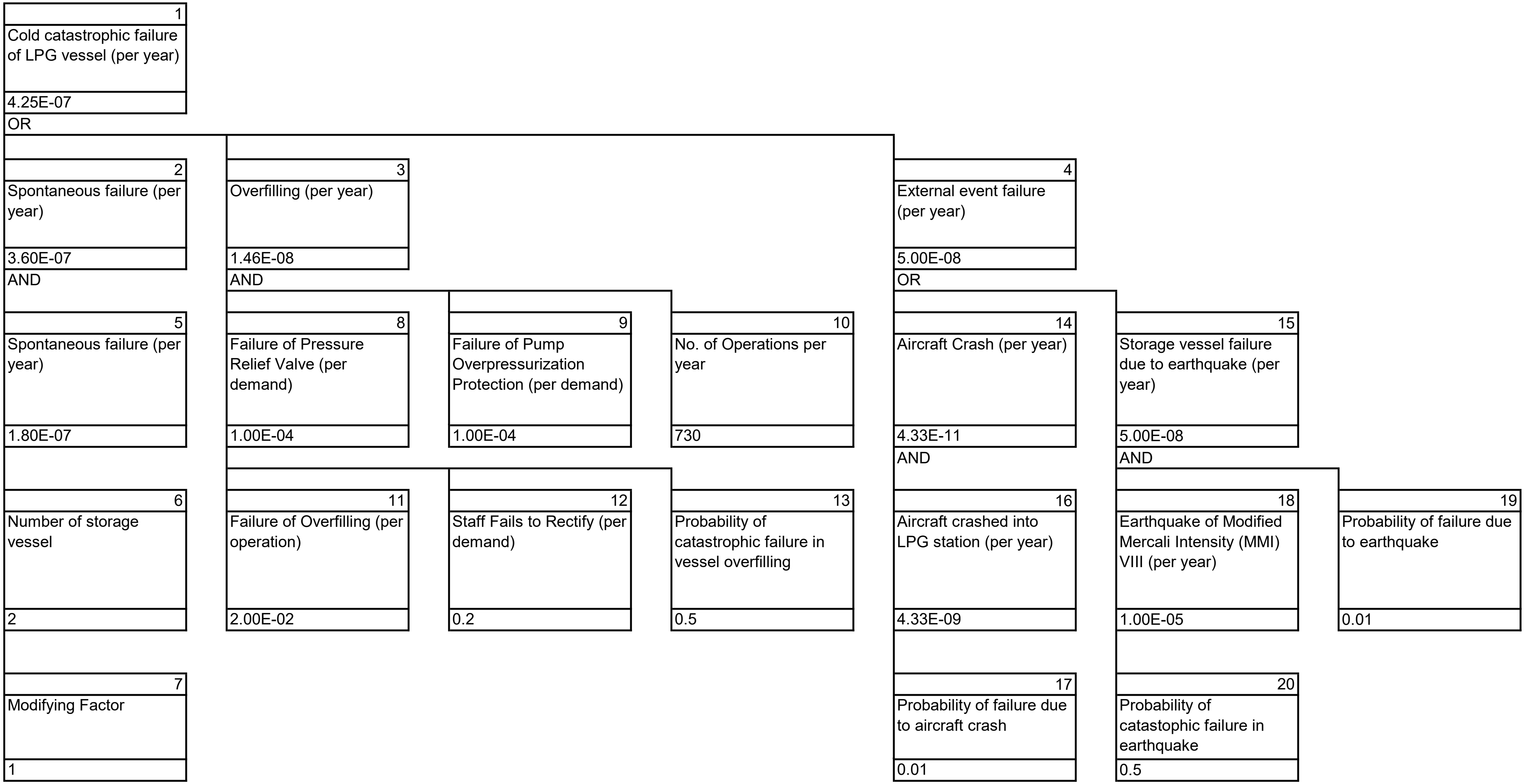
It is assumed that when there is an aircraft crash, the LPG liquid-line pipework (i.e. 'liquid inlet pipeline to storage vessel' and 'liquid line to dispenser') and dispenser will definitely fail (i.e. probability = 1). For 'vapour return line', it is assumed that the probability is 10 times lower than that of liquid-line pipework because the vapour return line is installed underground. The 'liquid line from tanker to flexible hose' is not considered because aircraft crash to tanker will lead to 'road tanker failure', which has a greater consequence.

For failure of road tanker, it is assumed that the probability of 'road tanker rupture' and 'road tanker partial failure' given that there is an aircraft crash are 0.1 and 0.9 respectively. For failure of storage vessel, it is assumed that the probability of failure is 10 times lower than that of road tanker because the LPG storage vessel is installed underground. Therefore, it is assumed that the probability of 'storage vessel rupture' and 'storage vessel partial failure' given that there is an aircraft crash are 0.01 and 0.09 respectively.

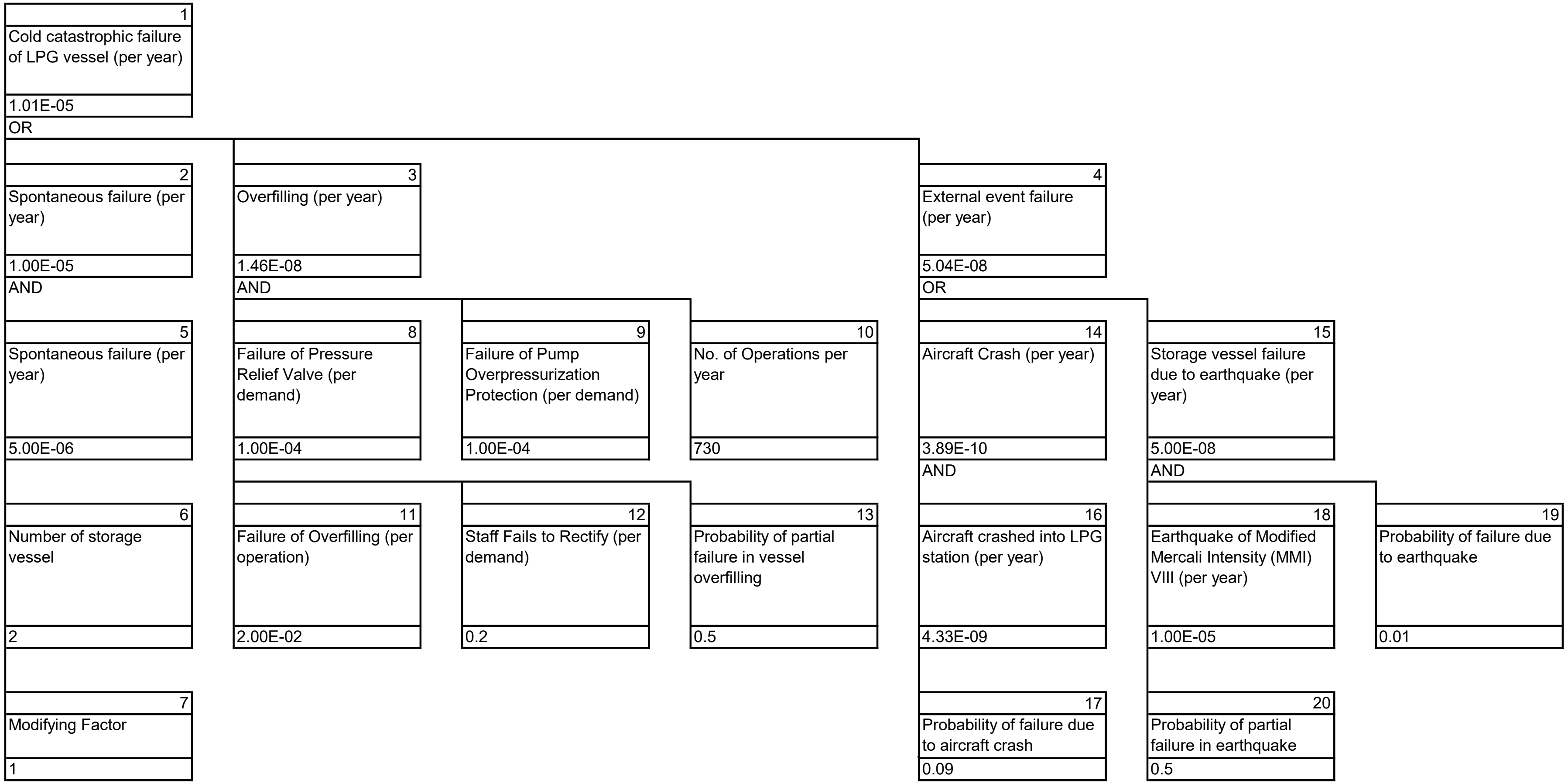
Annex C

Fault Tree Analysis

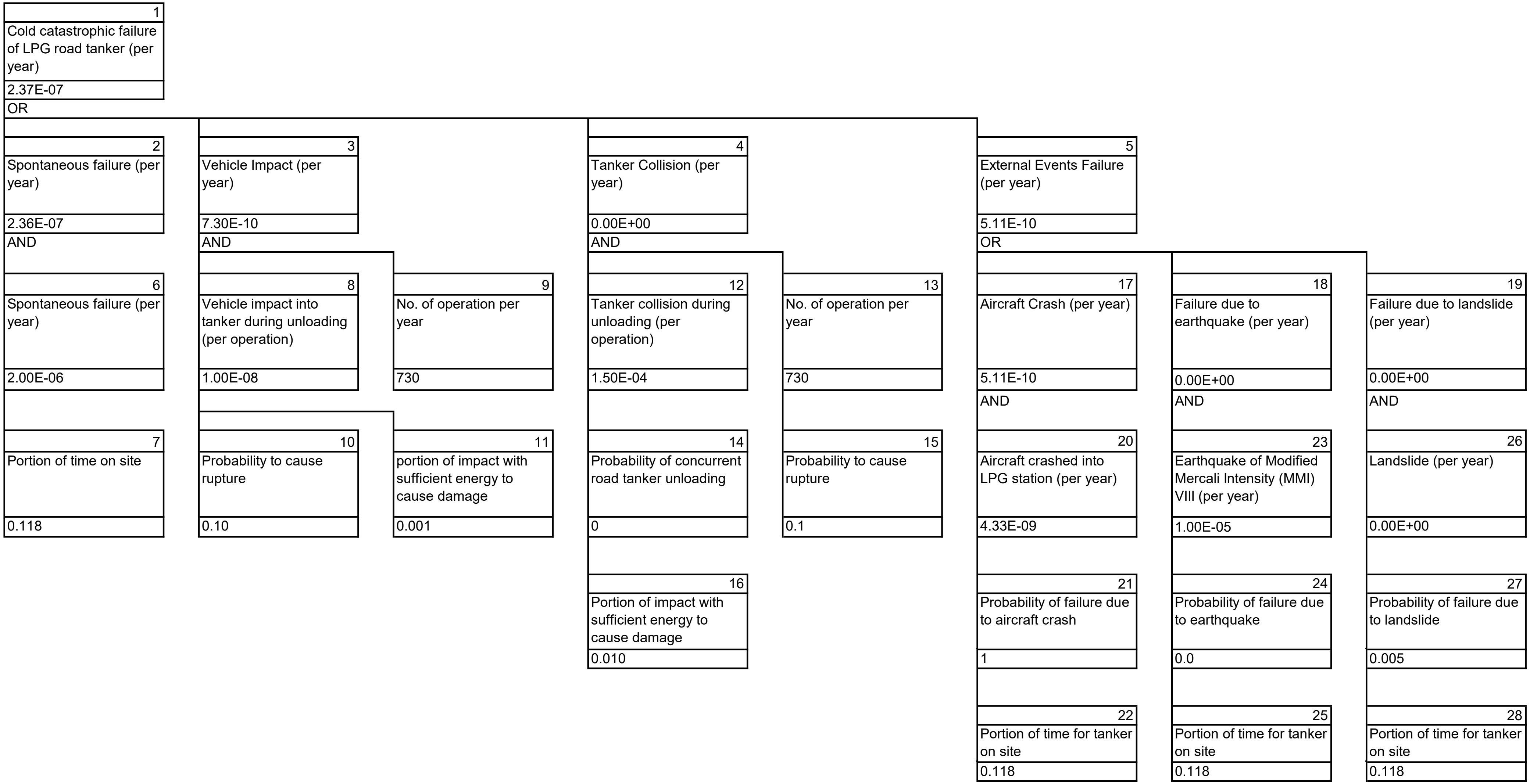
A-1 *Cold Catastrophic Failure of an LPG Vessel*



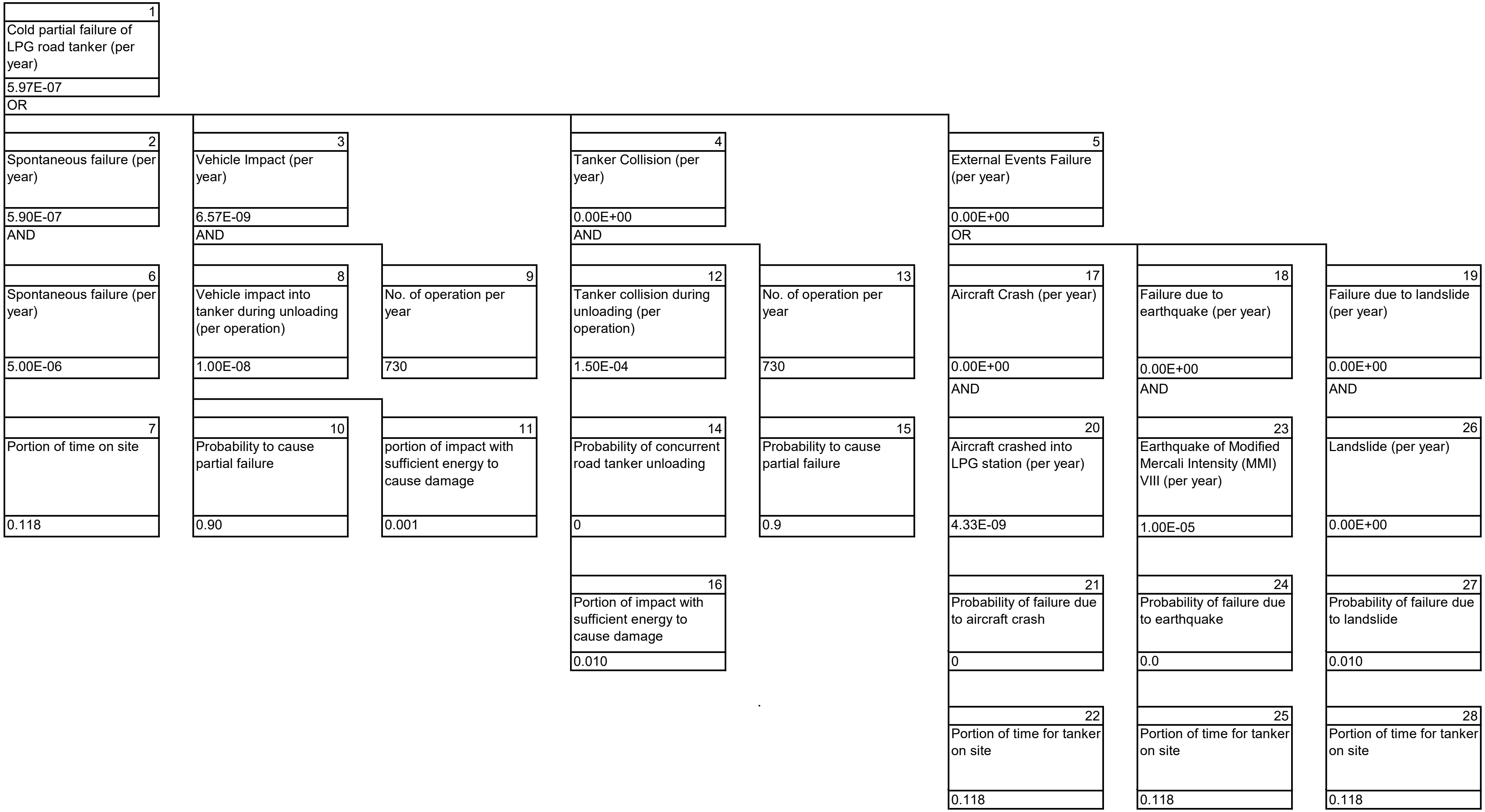
A-2 ***Cold Partial Failure of an LPG Vessel***



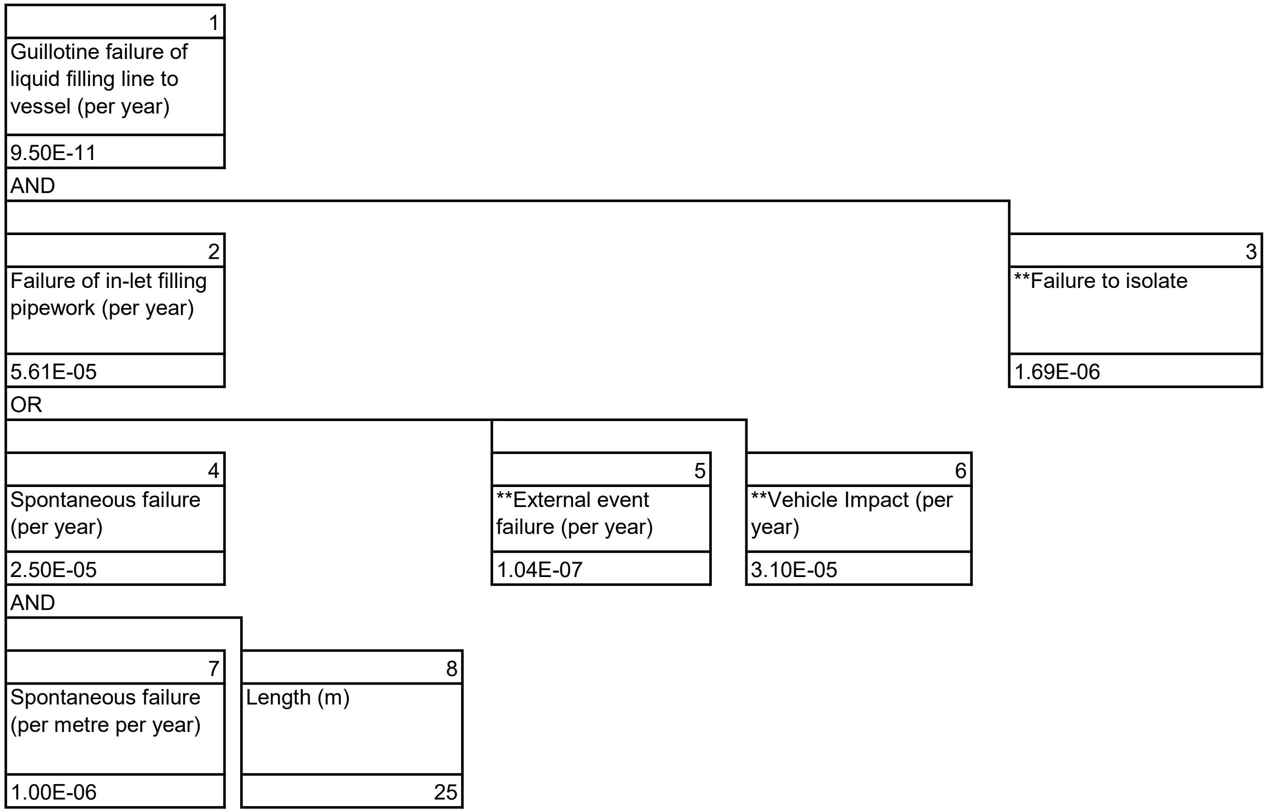
A-3 ***Cold Catastrophic Failure of Road Tanker***



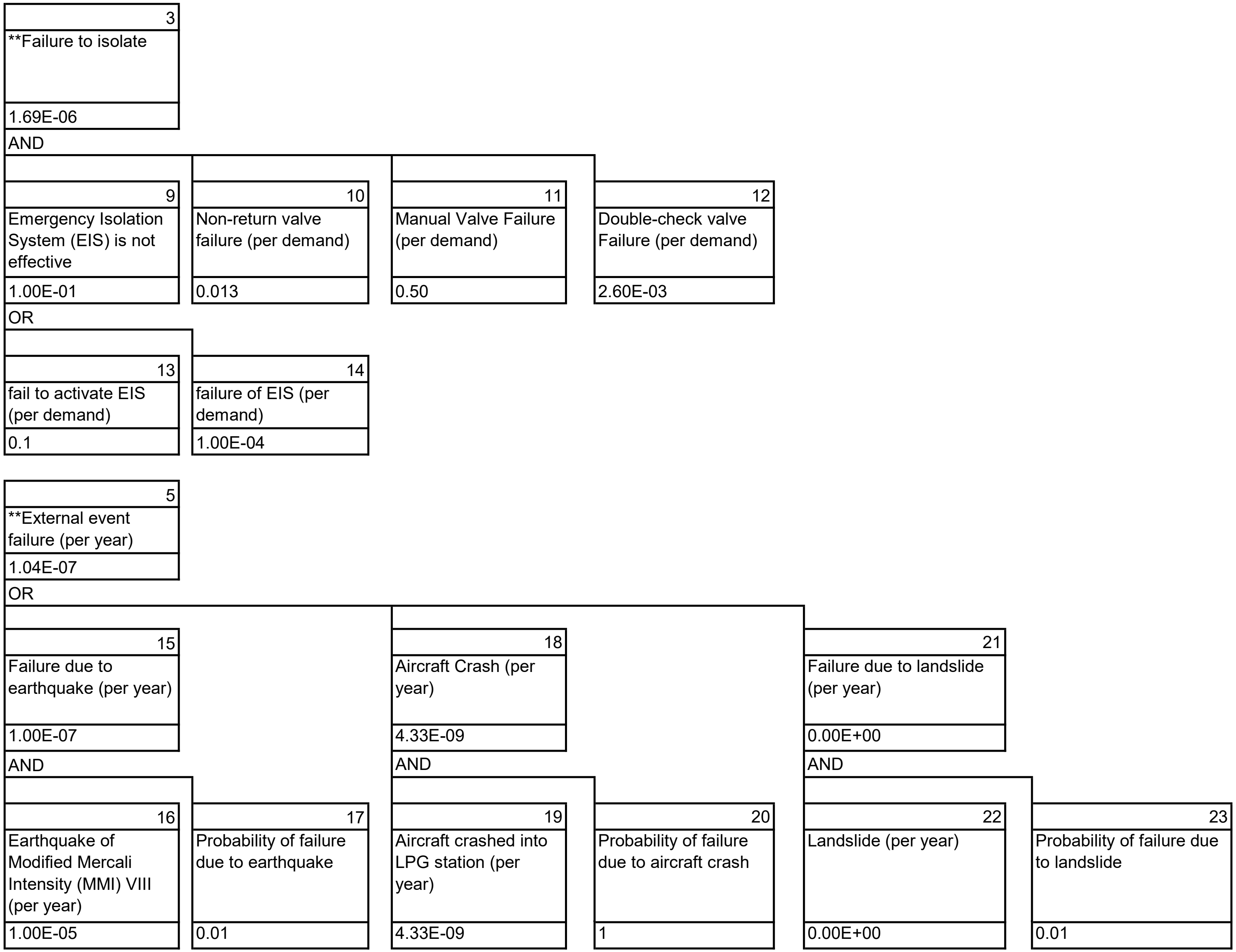
A-4 ***Cold Partial Failure of Road Tanker***



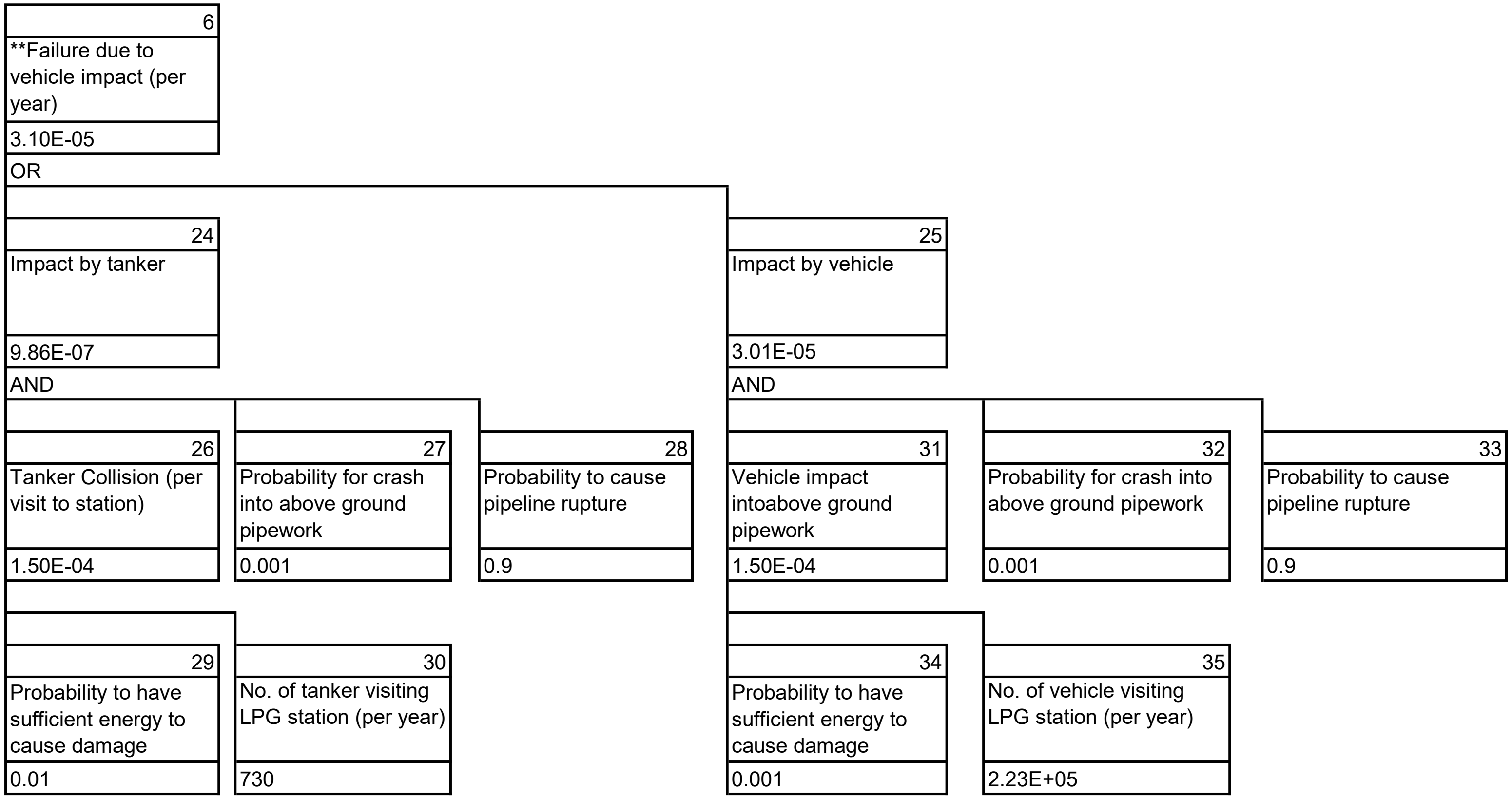
A-5a ***Guillotine Failure of In-let Filling Pipework (release from the vessel)***



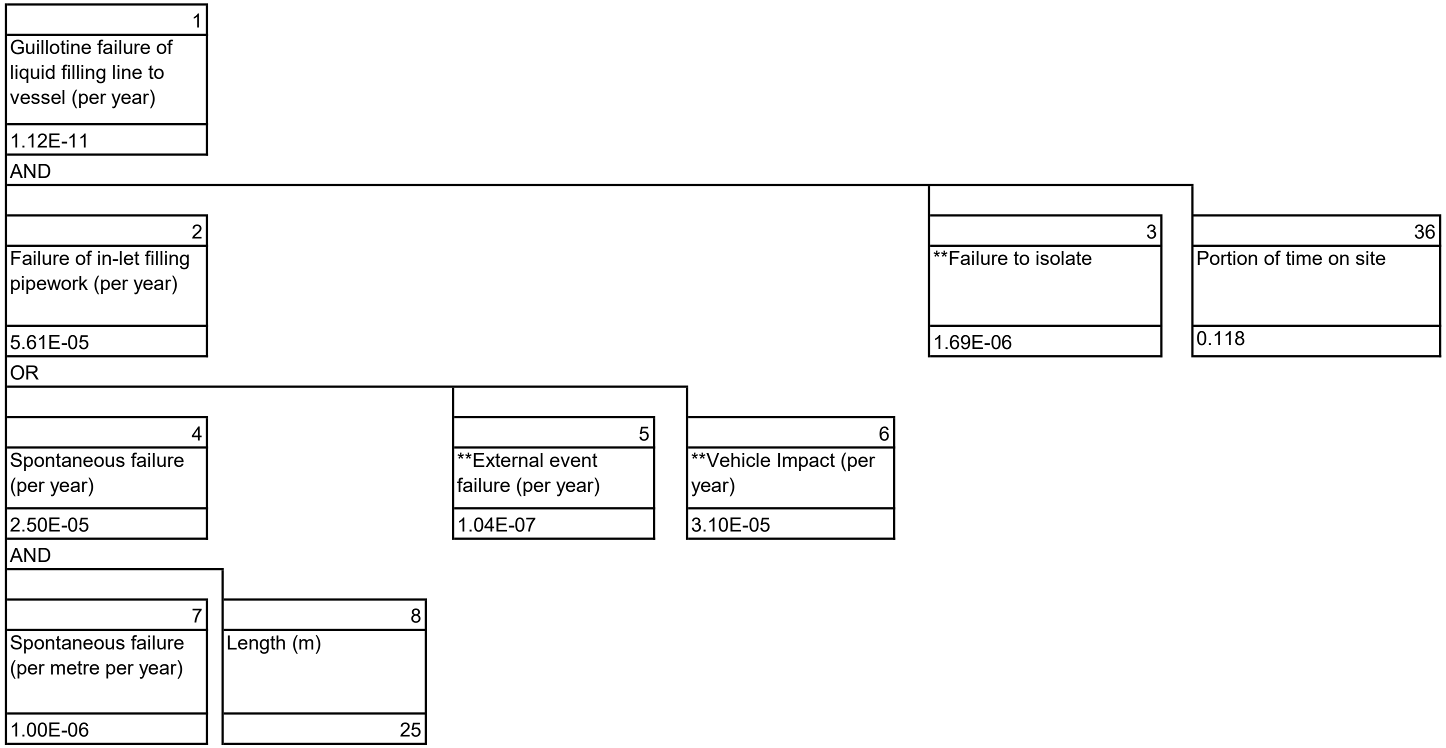
A-5a ***Guillotine Failure of In-let Filling Pipework (release from the vessel) (Con't)***



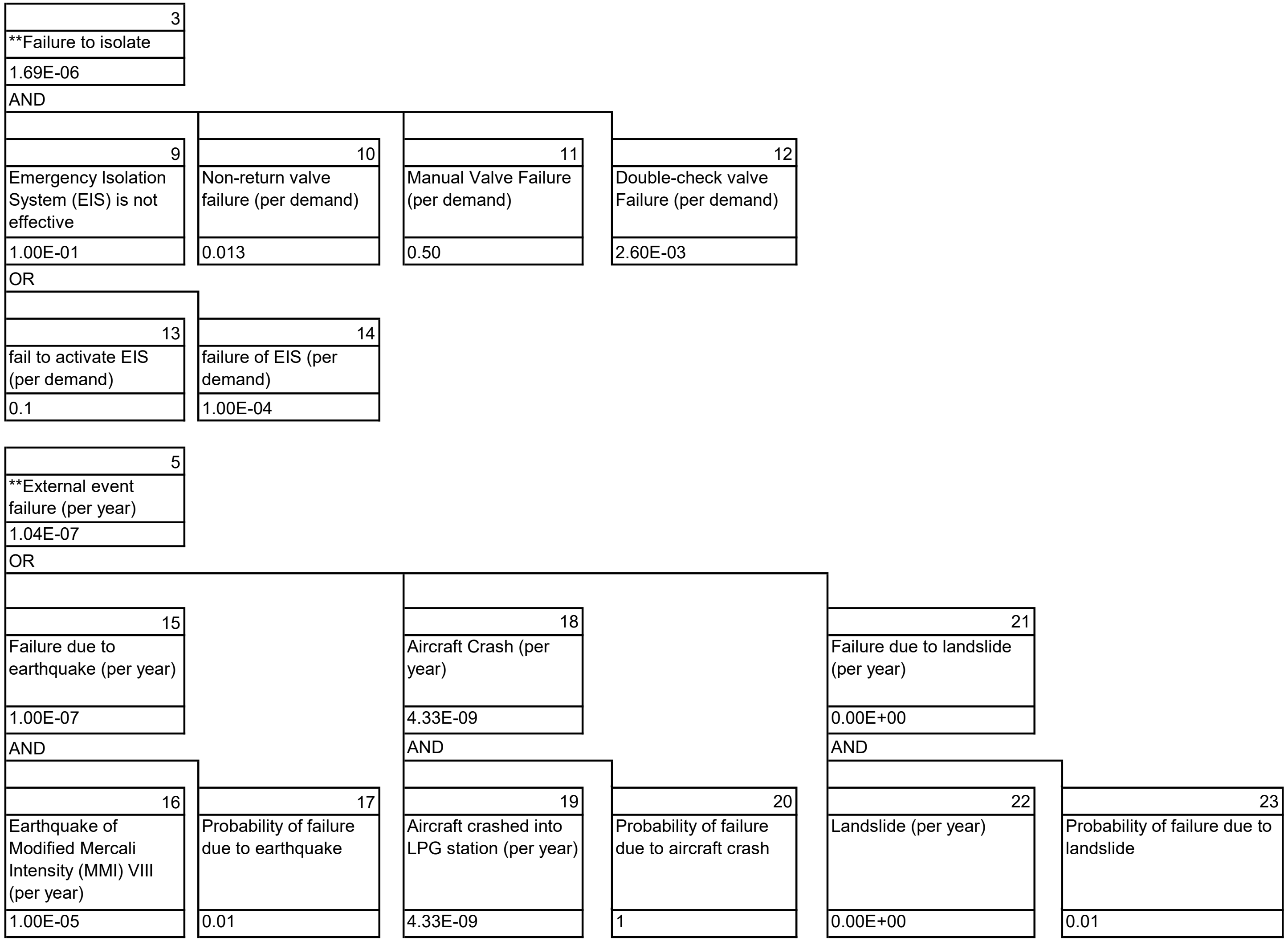
A-5a ***Guillotine Failure of In-let Filling Pipework (release from the vessel) (Con't)***



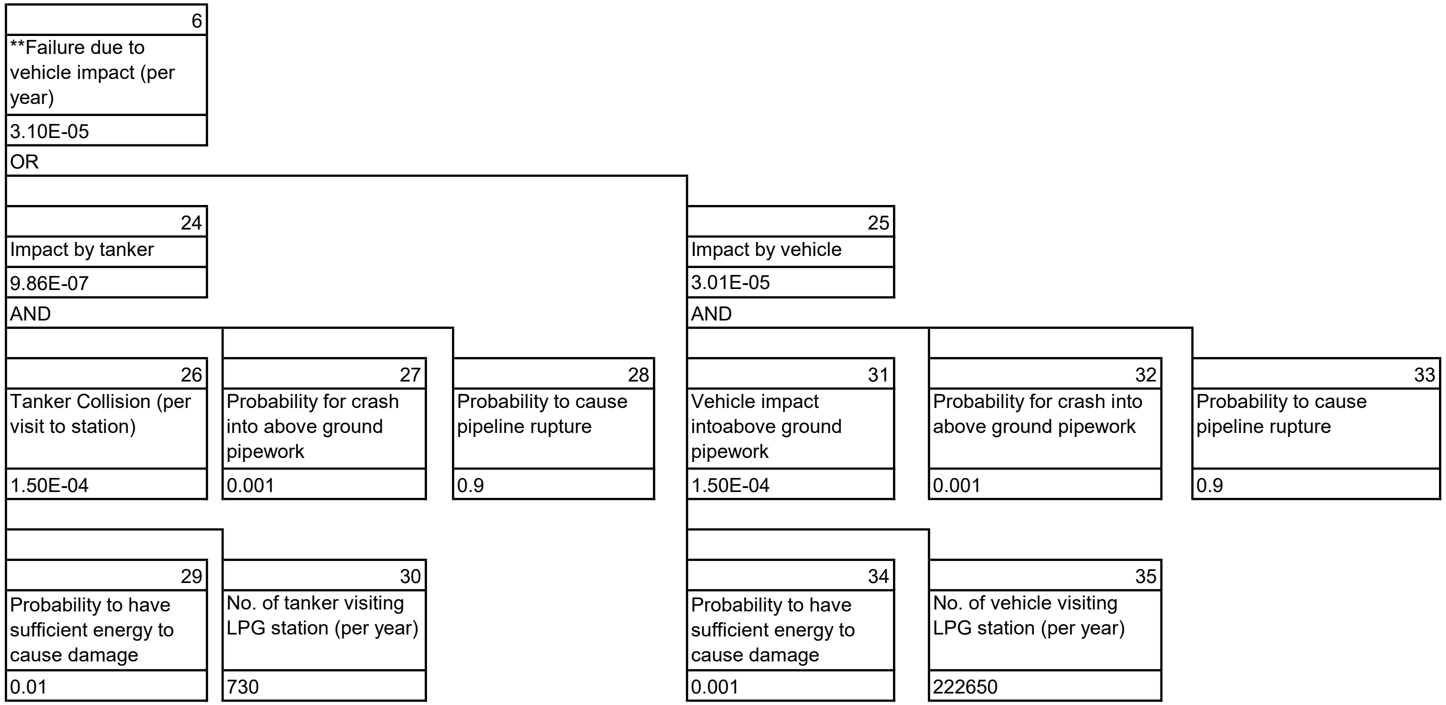
A-5b ***Guillotine Failure of In-let Filling Pipework (release from road tanker)***



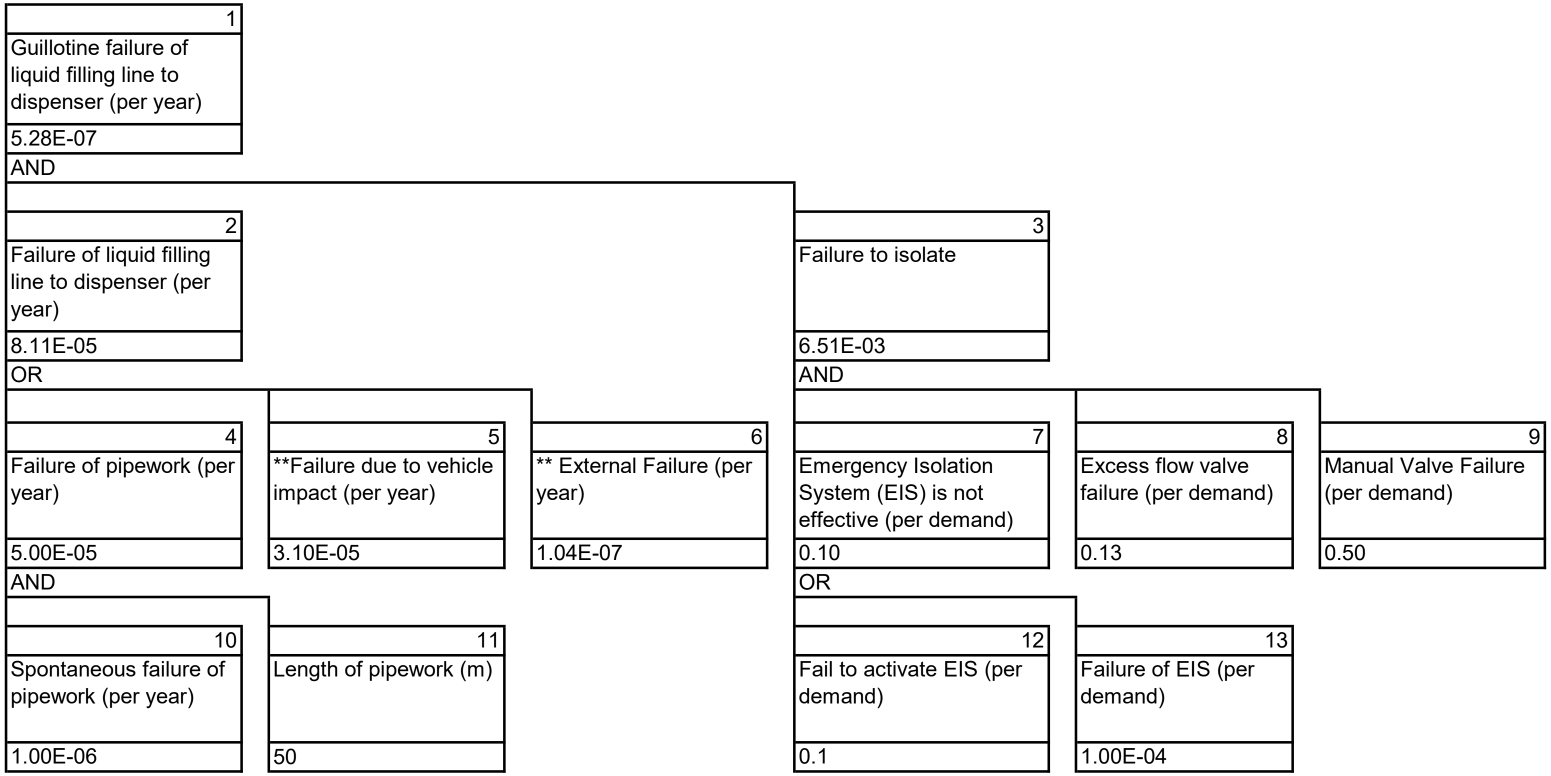
A-5b ***Guillotine Failure of In-let Filling Pipework (release from road tanker) (Con't)***



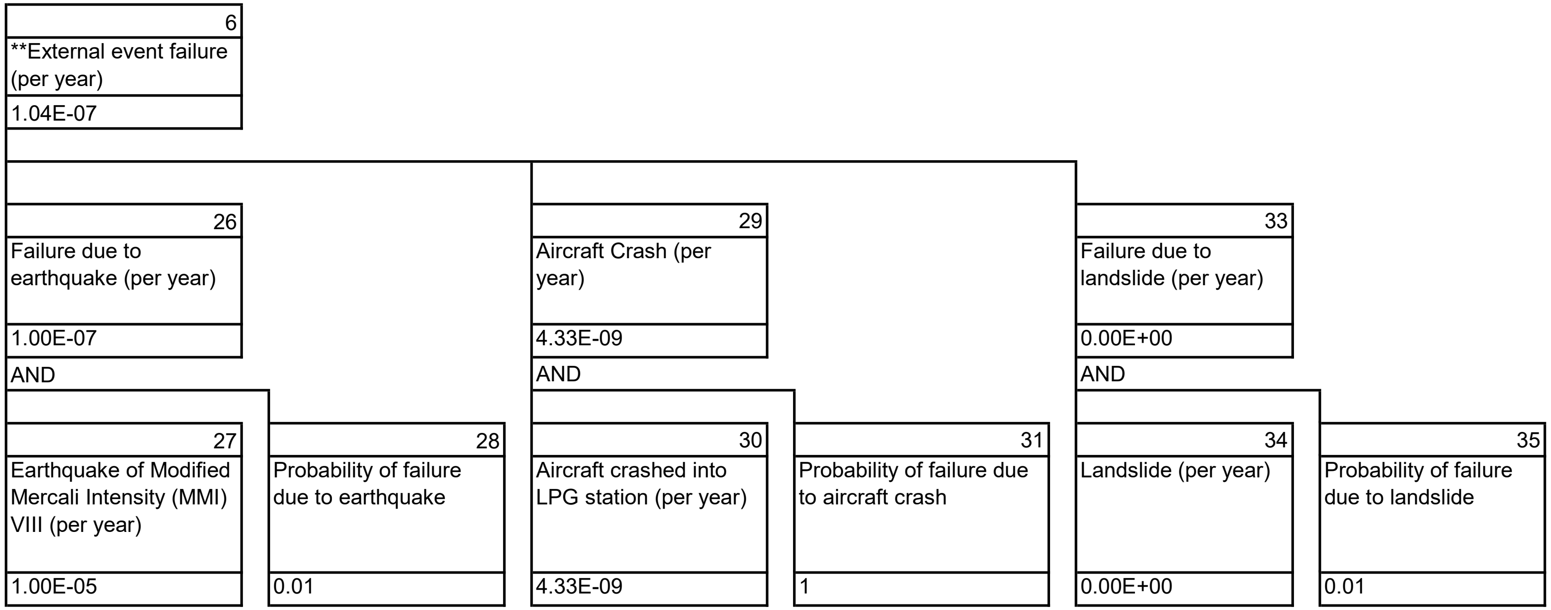
A-5b ***Guillotine Failure of In-let Filling Pipework (release from road tanker) (Con't)***



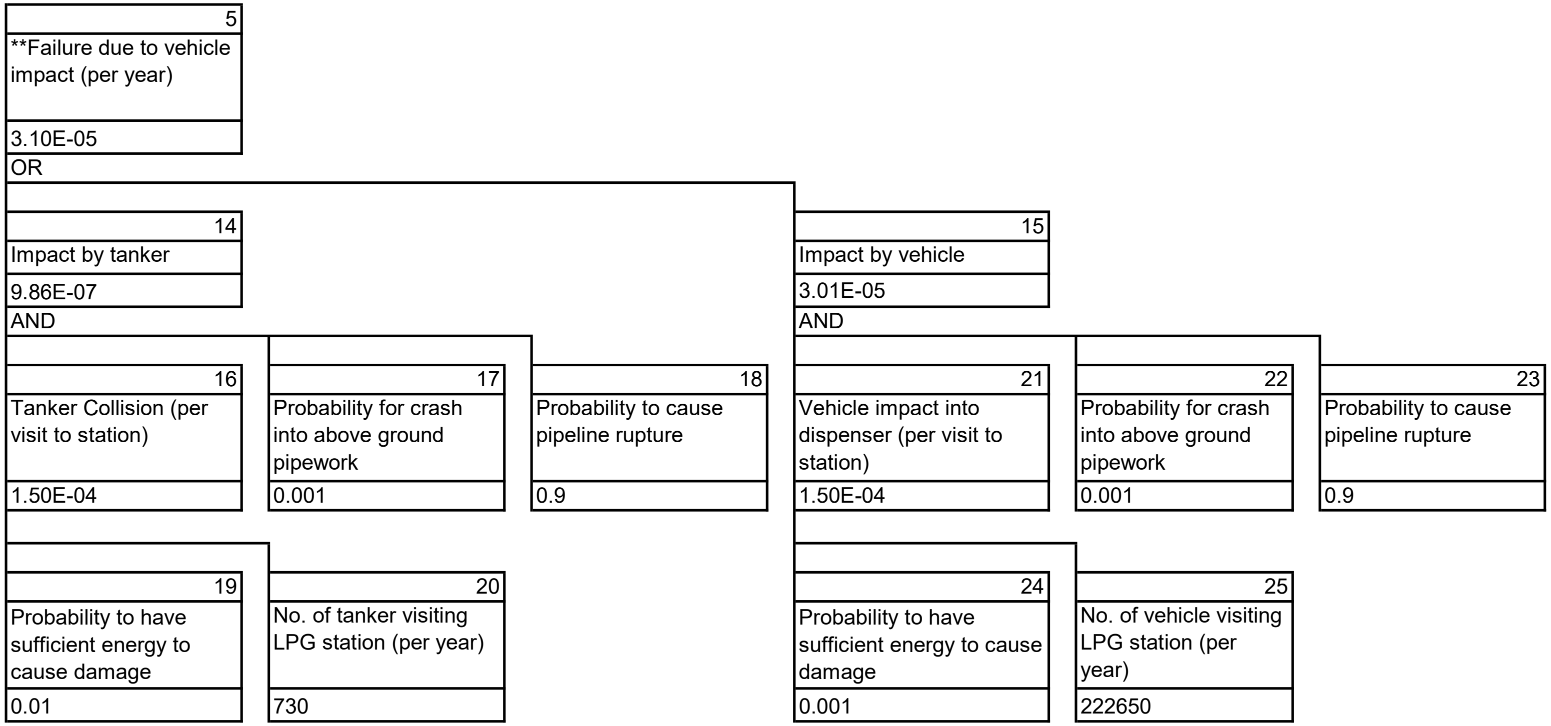
A-6 ***Guillotine Failure of Liquid Supply Line to Dispenser***



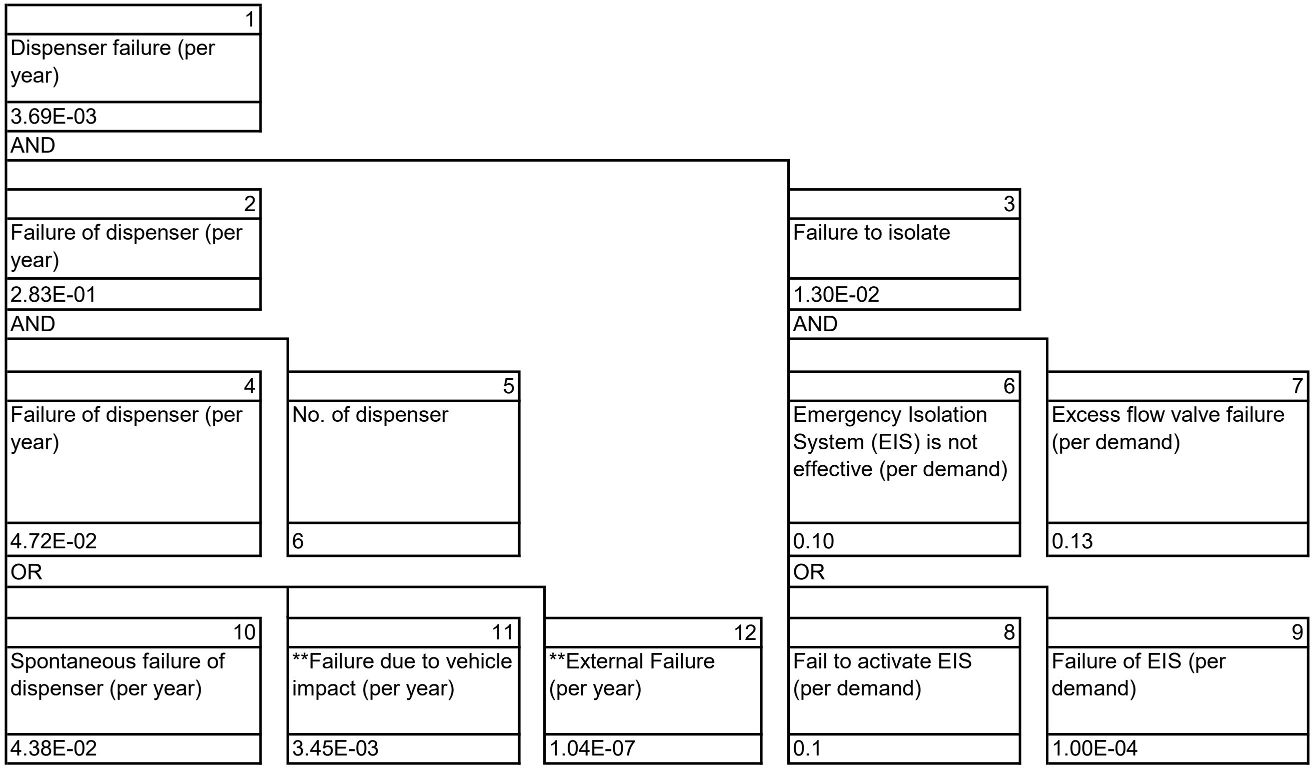
A-6 ***Guillotine Failure of Liquid Supply Line to Dispenser (Con't)***



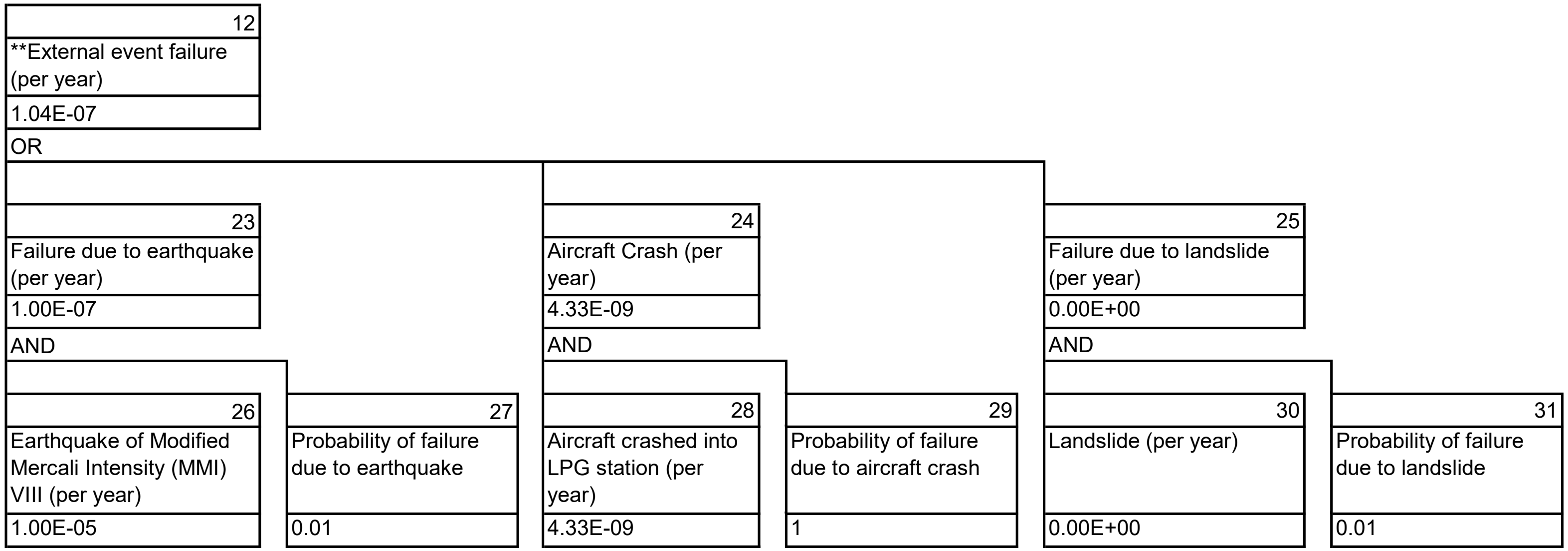
A-6 ***Guillotine Failure of Liquid Supply Line to Dispenser (Con't)***



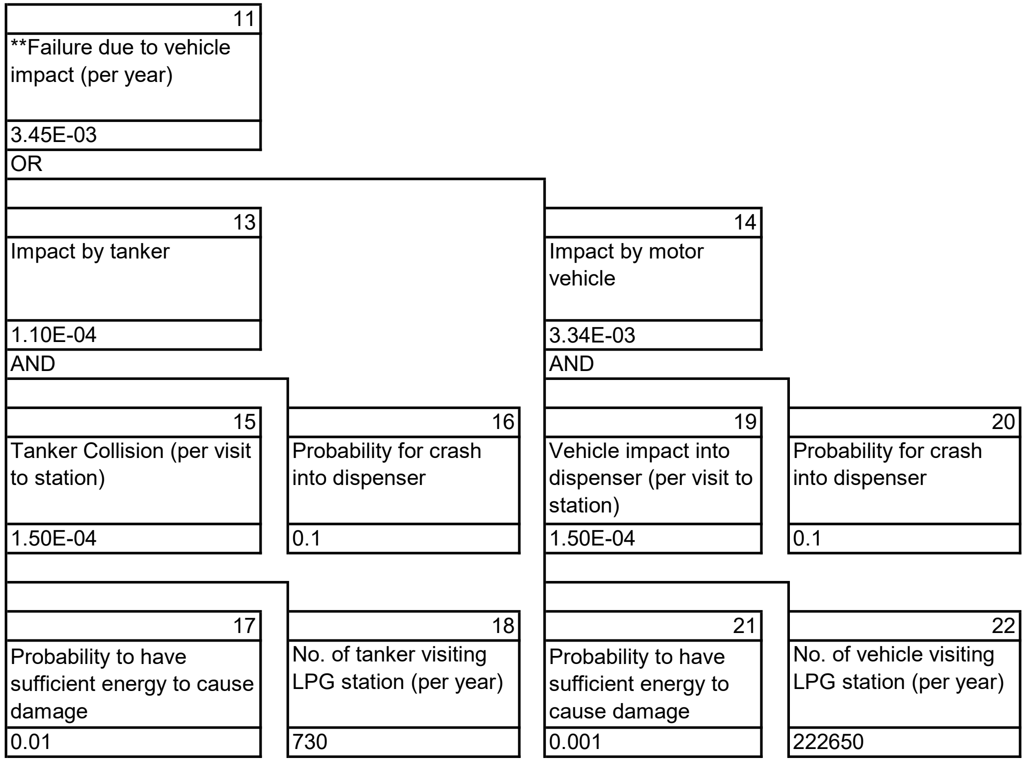
A-7 ***Failure of Dispenser***



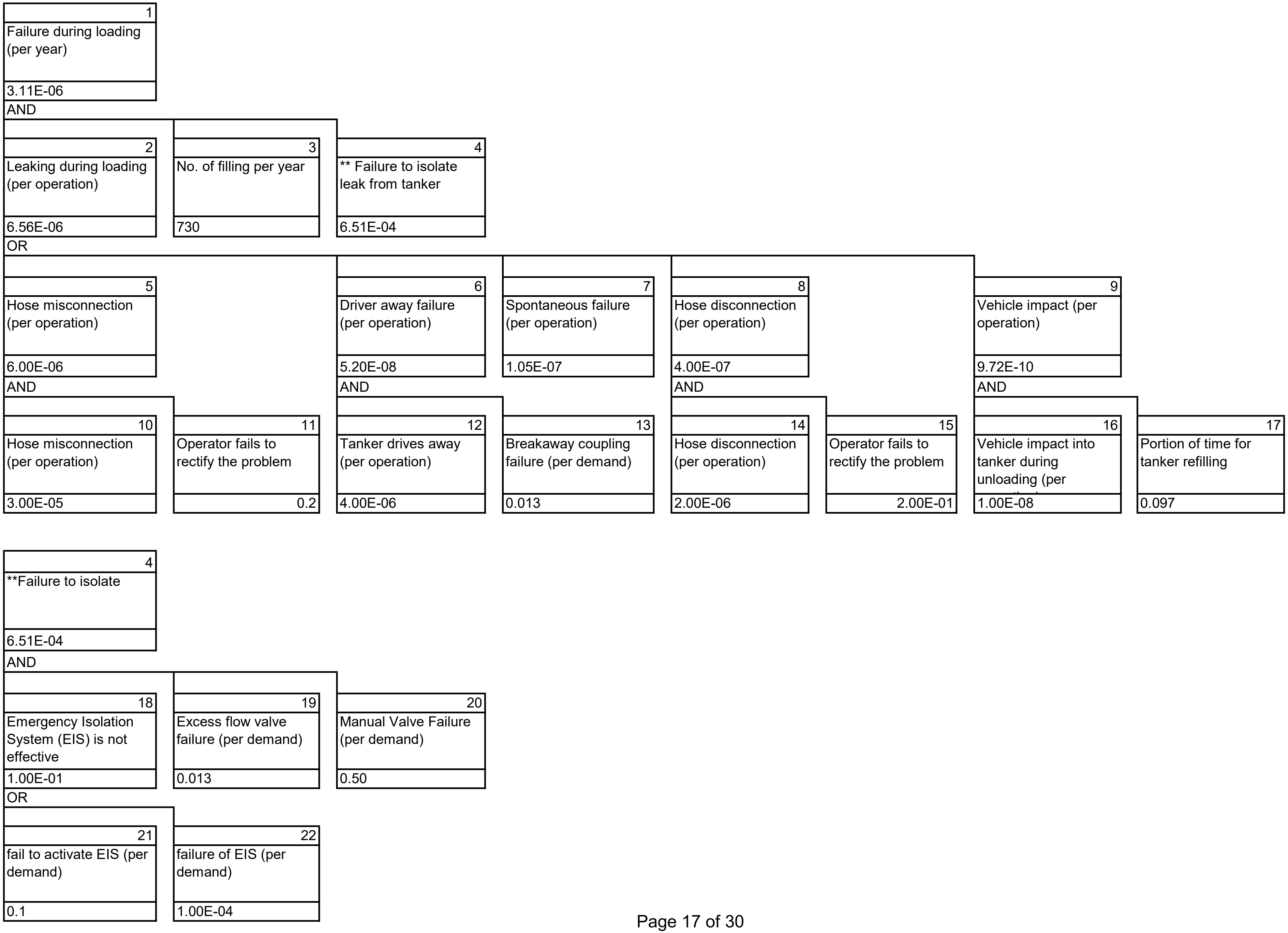
A-7 ***Failure of Dispenser (con't)***



A-7 ***Failure of Dispenser (con't)***



Failure of Flexible Hose during Loading to Storage Vessel (LPG released from the Hose Connecting to Road Tanker)

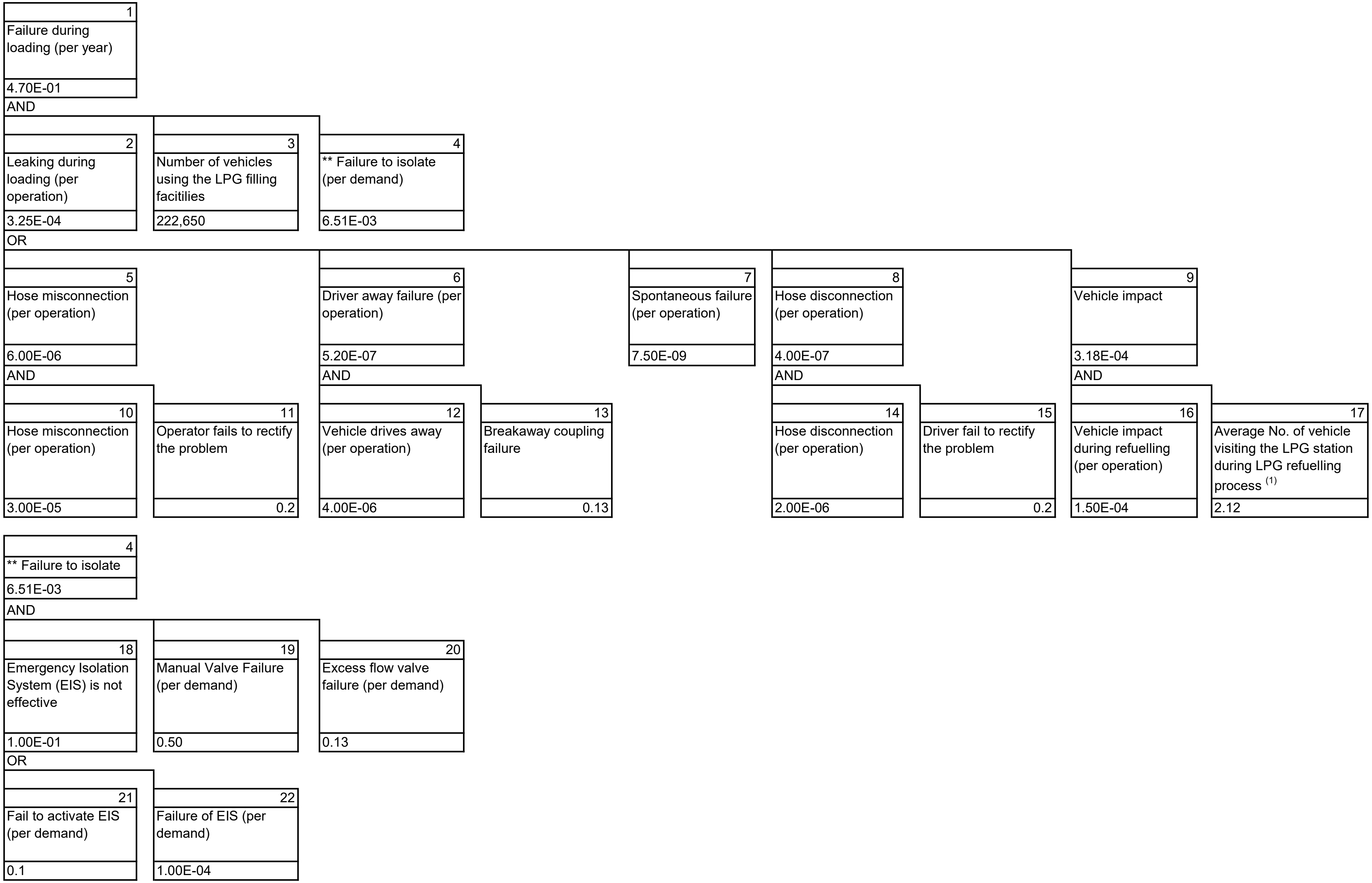


A-8b ***Failure of Flexible Hose during Loading to Storage Vessel (LPG released from the Hose Connecting to vessel)***

- 1 Failure during loading (per year) — 8.10E-09 — AND
  - 2 Leaking during loading (per operation) — 6.56E-06 — OR
    - 5 Hose misconnection (per operation) — 6.00E-06 — AND
      - 10 Hose misconnection (per operation) — 3.00E-05
      - 11 Operator fails to rectify the problem — 0.2
    - 6 Driver away failure (per operation) — 5.20E-08 — AND
      - 12 Tanker drives away (per operation) — 4.00E-06
      - 13 Breakaway coupling failure (per demand) — 0.013
    - 7 Spontaneous failure (per operation) — 1.05E-07
    - 8 Hose disconnection (per operation) — 4.00E-07 — AND
      - 14 Hose disconnection (per operation) — 2.00E-06
      - 15 Operator fails to rectify the problem — 0.2
    - 9 Vehicle impact (per operation) — 9.72E-10 — AND
      - 16 Vehicle impact into tanker during unloading (per operation) — 1.00E-08
      - 17 Portion of time for tanker refilling — 0.097
  - 3 No. of filling per year — 730
  - 4 ** Failure to isolate leak from tanker — 1.69E-06

- 4 **Failure to isolate — 1.69E-06 — AND
  - 18 Emergency Isolation System (EIS) is not effective — 1.00E-01 — OR
    - 22 Fail to activate EIS (per demand) — 0.1
    - 23 Failure of EIS (per demand) — 1.00E-04
  - 19 Non-return valve failure (per demand) — 0.013
  - 20 Manual Valve Failure (per demand) — 0.50
  - 21 Double Check Valve Failure (per demand) — 2.60E-03

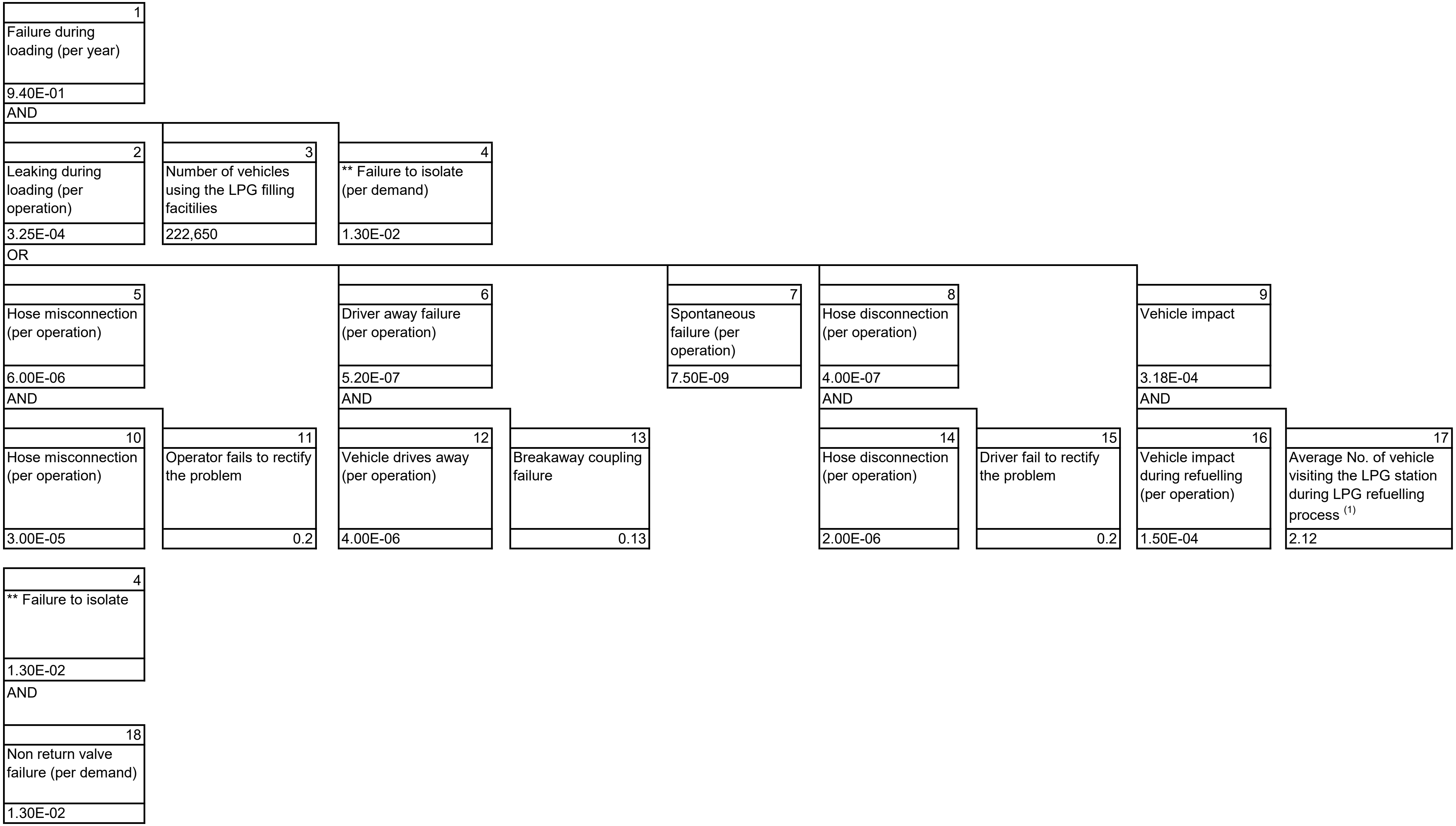
A-9a ***Failure of Flexible Hose during Loading to Vehicle (LPG released from the Hose Connecting to Dispenser)***



Remarks:

(1) = (daily no. of vehicle visit/24 hours)/(60 mins) * average time of filling

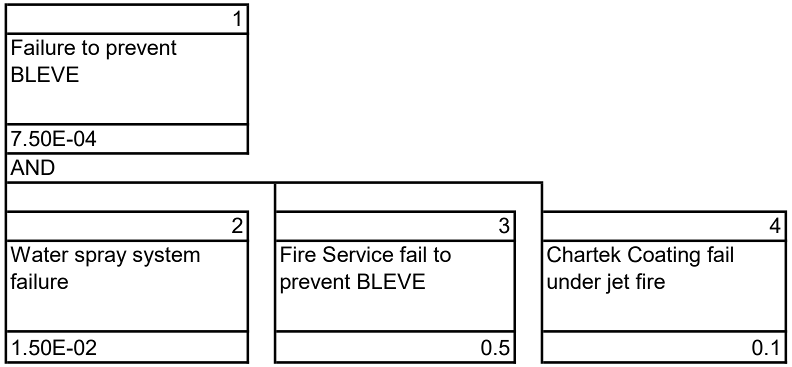
A-9b **_Failure of Flexible Hose during Loading to Vehicle (LPG released from the Hose Connecting to Vehicle)_**



Remarks:

(1) = (daily no. of vehicle visit/24 hours)/(60 mins) * average time of refilling

A-10 ***Failure to Prevent BLEVE***



A-11 ***Leak From Pump Flange***

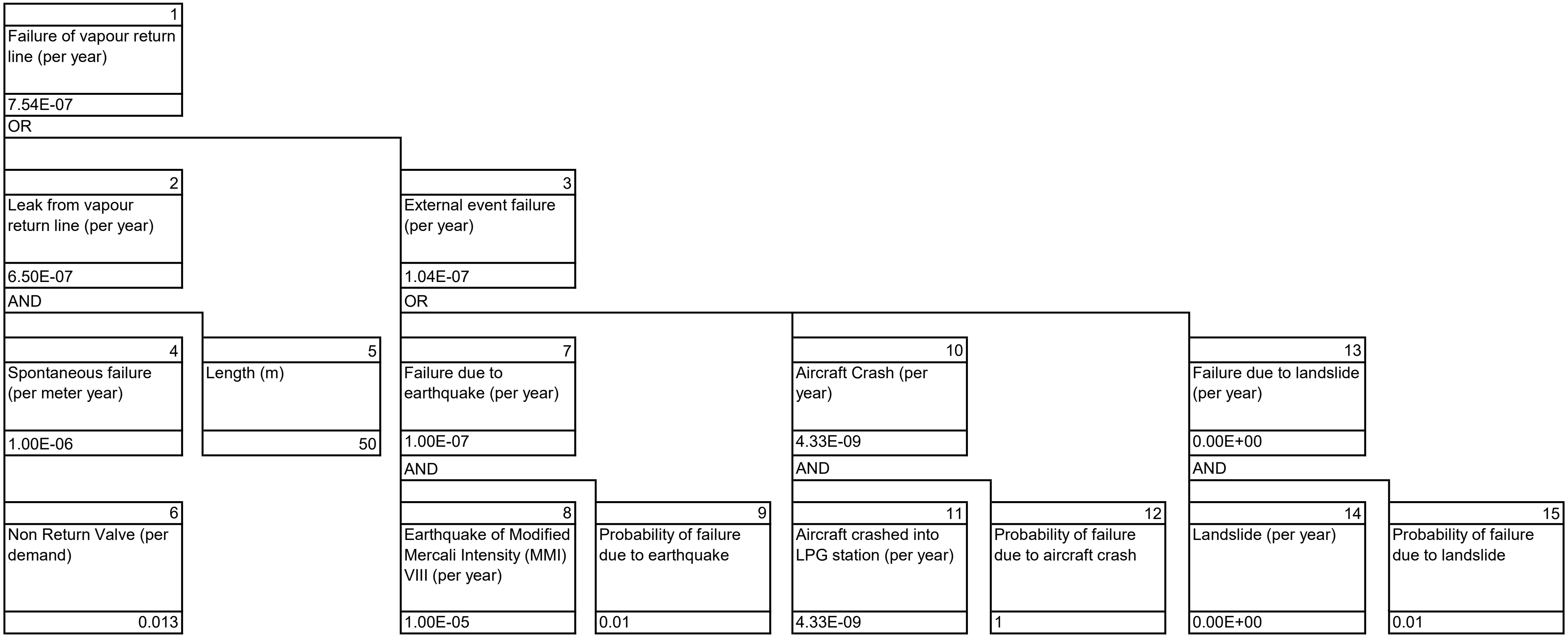
1		
Leak from Pump Flange (per year)		
4.36E-04		
AND		
2		3
Flange Faliure (per year)		No. of Flange
1.09E-04		4

A-12 ***Leak From Drain Valve***

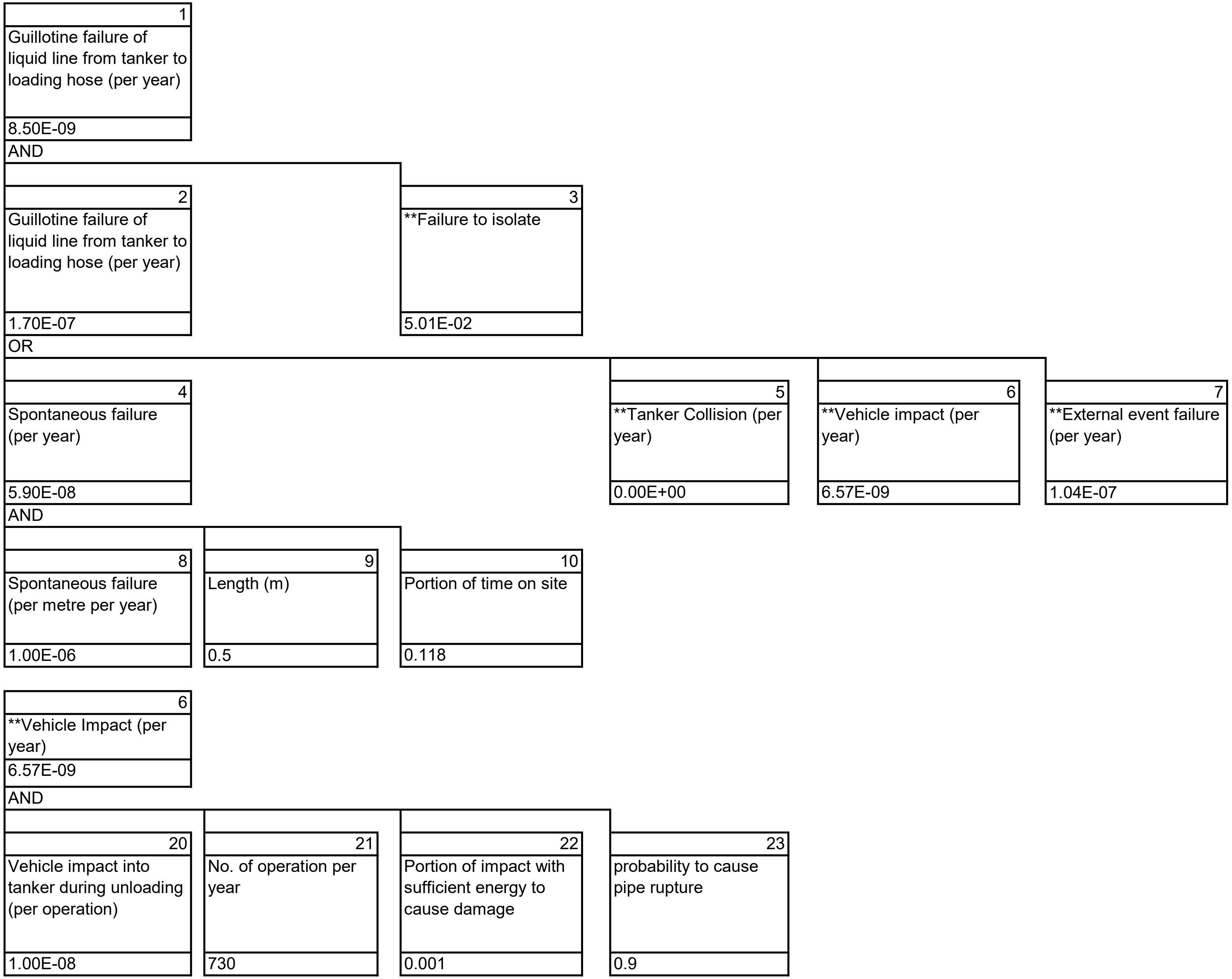
1	Leak from drain valve (per year)
	4.80E-04
	AND

2	3
Valve fails to close (per operation)	No. of operation per year
2.00E-05	24

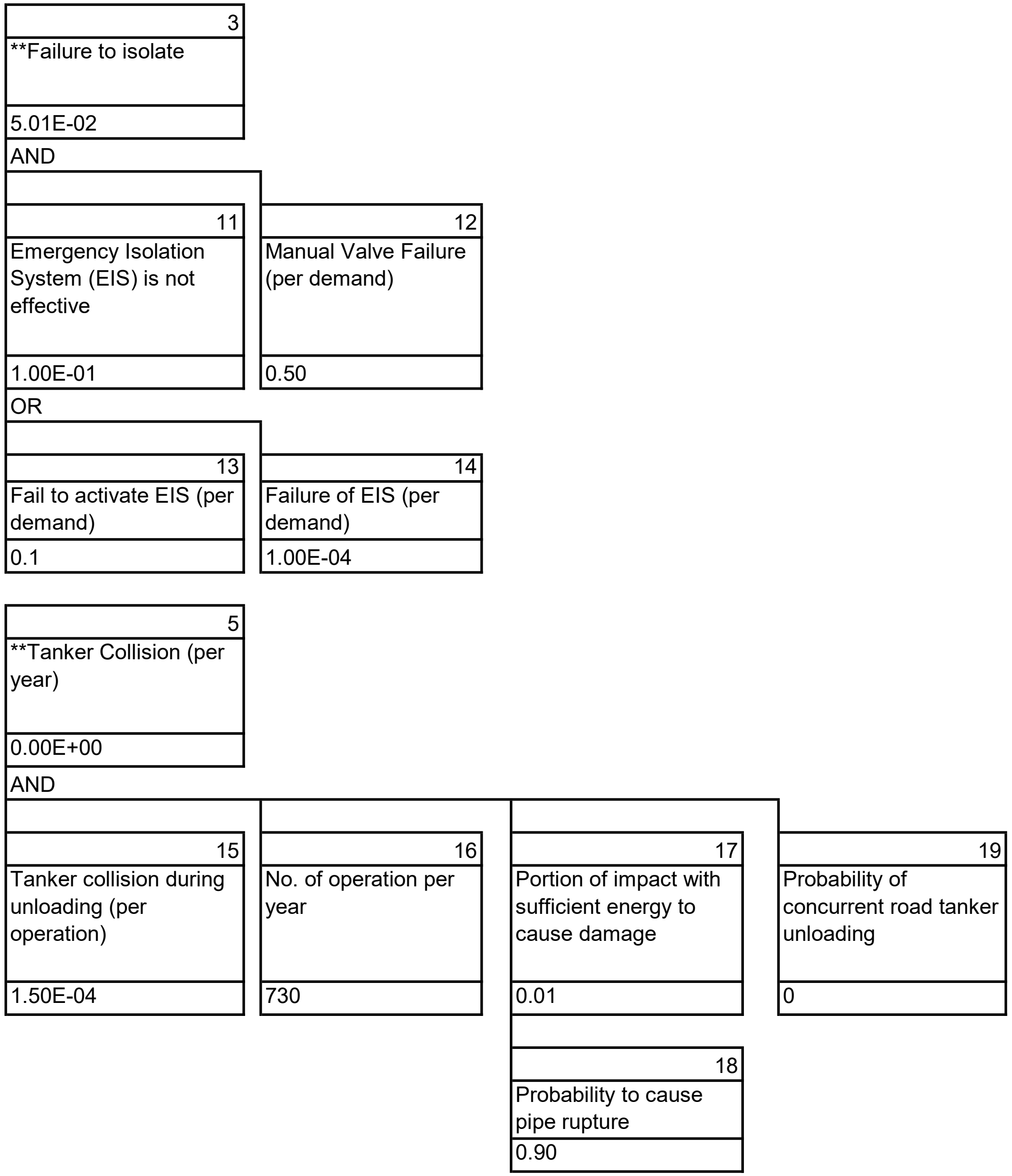
A-13 ***Failure of Vapour Return Line***



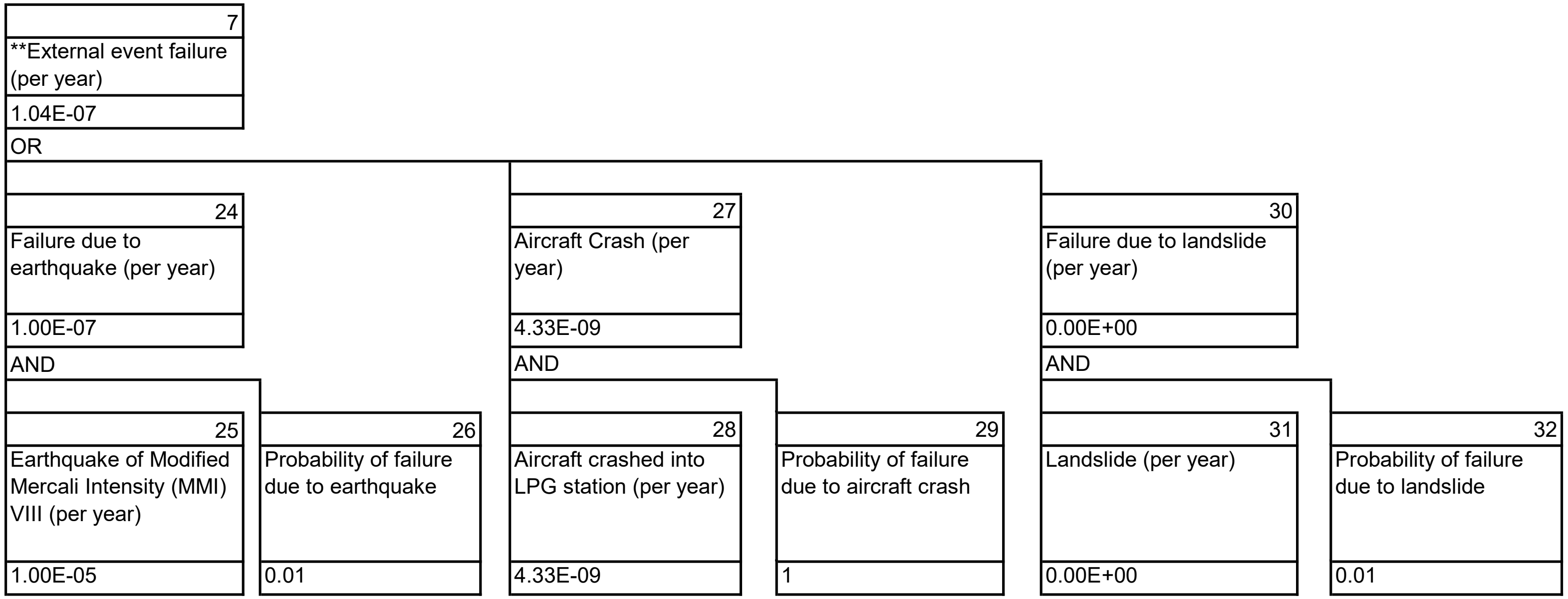
A-14 ***Guillotine Failure of liquid line from Road Tanker to loading hose***



Guillotine Failure of liquid line from Road Tanker to loading hose (Con't)



Guillotine Failure of liquid line from Road Tanker to loading hose (Con't)



A-15a **BLEVE of LPG road tanker due to fire from LPG dispenser**

1 BLEVE of road tanker (per year): 4.08E-09

AND

2	LPG dispenser failure (per year)	3.69E-03
3	Portion of release become jet fire	0.05
4	Portion of jet fire impinge on road tanker *	0.25
5	Portion of time for tanker on site	0.118
6	Failure to prevent BLEVE	7.50E-04

6 Failure to prevent BLEVE: AND

7	Water spray system failure	1.50E-02
8	Fire Service fail to prevent BLEVE	0.5
9	Chartek Coating fail under jet fire	0.1

* considering the road tanker unloading bay is within a quadant of a dispenser

A-15b **BLEVE of LPG road tanker due to fire from In-let Filling Pipework**

1 BLEVE of road tanker (per year): 2.35E-16

AND

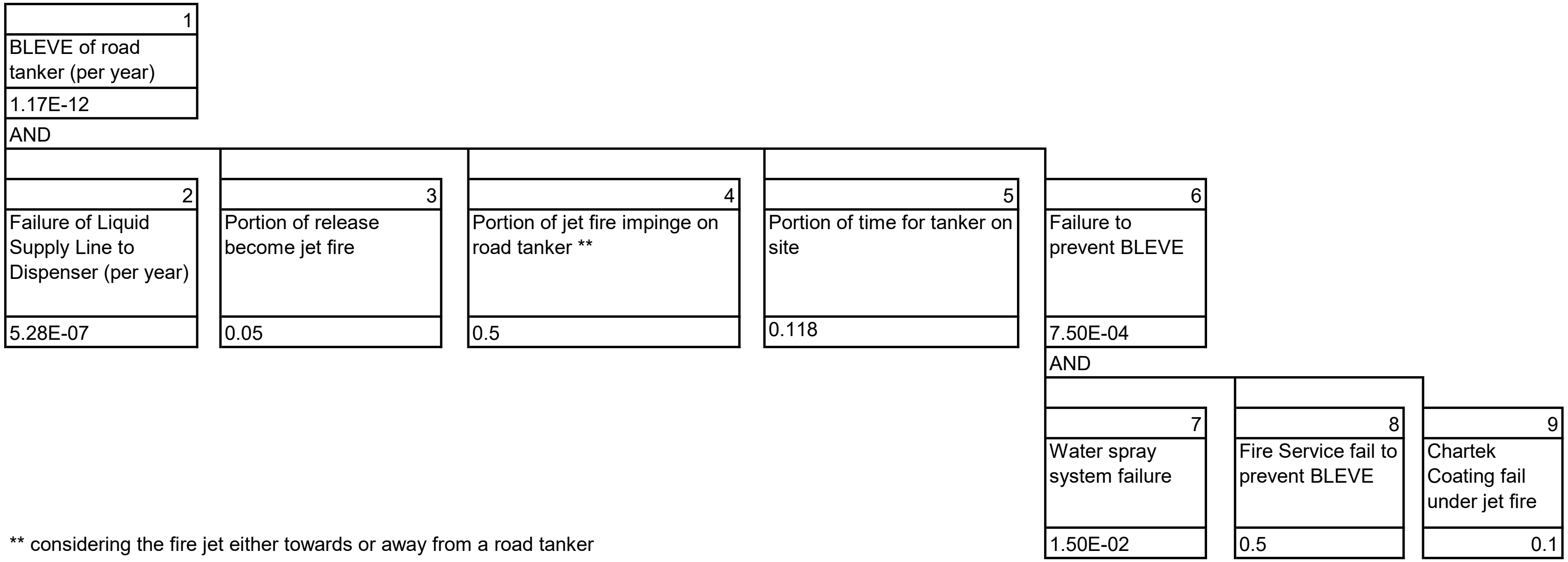
2	Failure of In-let filling pipework (per year)	1.06E-10
3	Portion of release become jet fire	0.05
4	Portion of jet fire impinge on road tanker **	0.5
5	Portion of time for tanker on site	0.118
6	Failure to prevent BLEVE	7.50E-04

6 Failure to prevent BLEVE: AND

7	Water spray system failure	1.50E-02
8	Fire Service fail to prevent BLEVE	0.5
9	Chartek Coating fail under jet fire	0.1

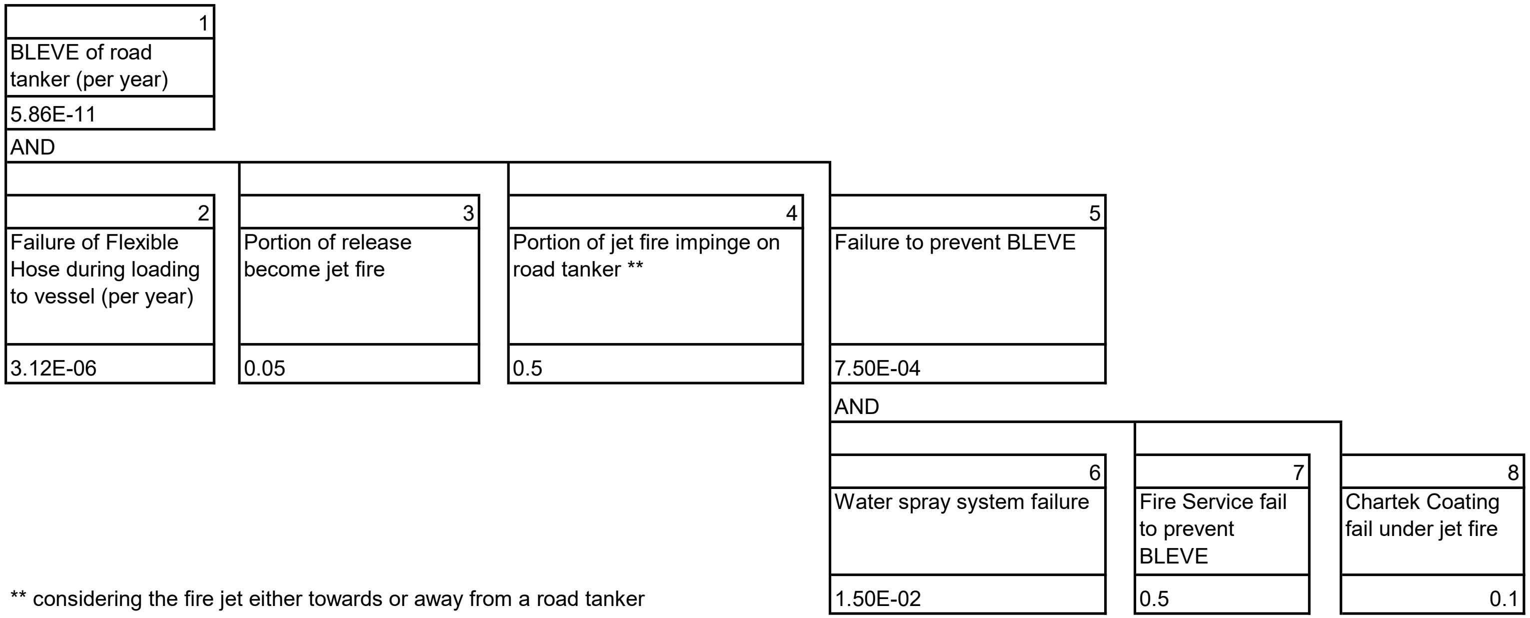
** considering the fire jet either towards or away from a road tanker

A-15c **BLEVE of LPG road tanker due to fire from Liquid Supply Line to Dispenser**



** considering the fire jet either towards or away from a road tanker

A-15d **BLEVE of LPG road tanker due to fire from Flexible Hose during loading to underground vessel**



** considering the fire jet either towards or away from a road tanker

A-15e BLEVE of LPG road tanker due to fire from Liquid Line (from tanker to loading hose)

- 1 BLEVE of road tanker (per year) — 1.59E-13
  - AND
    - 2 Failure of Liquid Line from tanker to loading hose (per year) — 8.50E-09
    - 3 Portion of release become jet fire — 0.05
    - 4 Portion of jet fire impinge on road tanker ** — 0.5
    - 5 Failure to prevent BLEVE — 7.50E-04
      - AND
        - 6 Water spray system failure — 1.50E-02
        - 7 Fire Service fail to prevent BLEVE — 0.5
        - 8 Chartek Coating fail under jet fire — 0.1

** considering the fire jet either towards or away from a road tanker

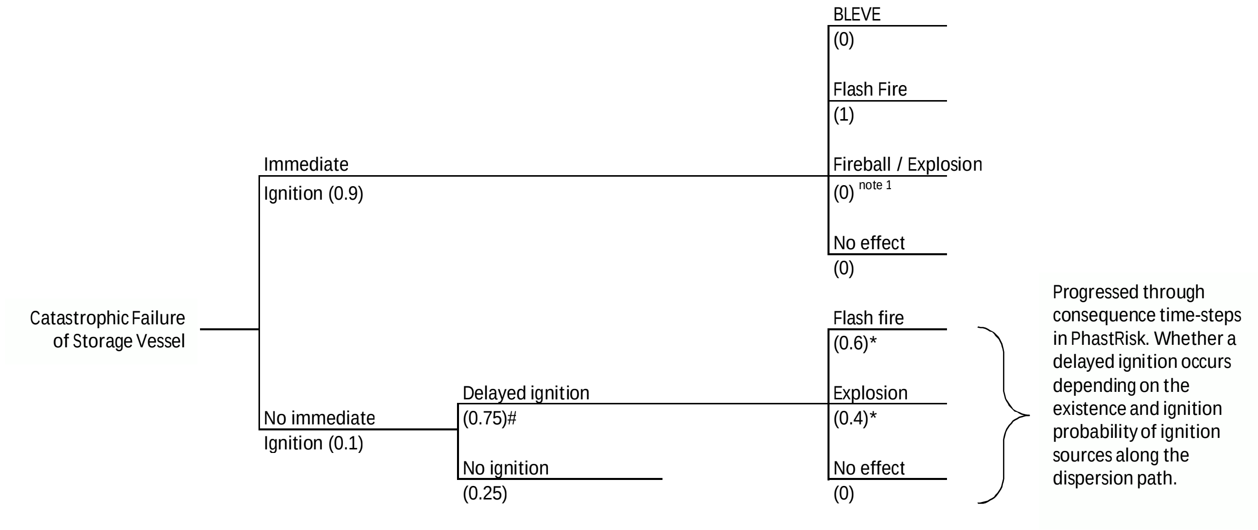
A-15f BLEVE of LPG road tanker due to other fire incidents

- 1 BLEVE of road tanker (per year) — 5.81E-09
  - AND
    - 2 Fire incident from petrol filling facilities (per year) — 6.56E-03
    - 3 Portion of fire incident which is serious enough to endanager road tanker — 0.01
    - 4 Portion of time for tanker on site — 0.118
    - 5 Failure to prevent BLEVE — 7.50E-04
      - AND
        - 6 Water spray system failure — 1.50E-02
        - 7 Fire Service fail to prevent BLEVE — 0.5
        - 8 Chartek Coating fail under jet fire — 0.1

Annex D

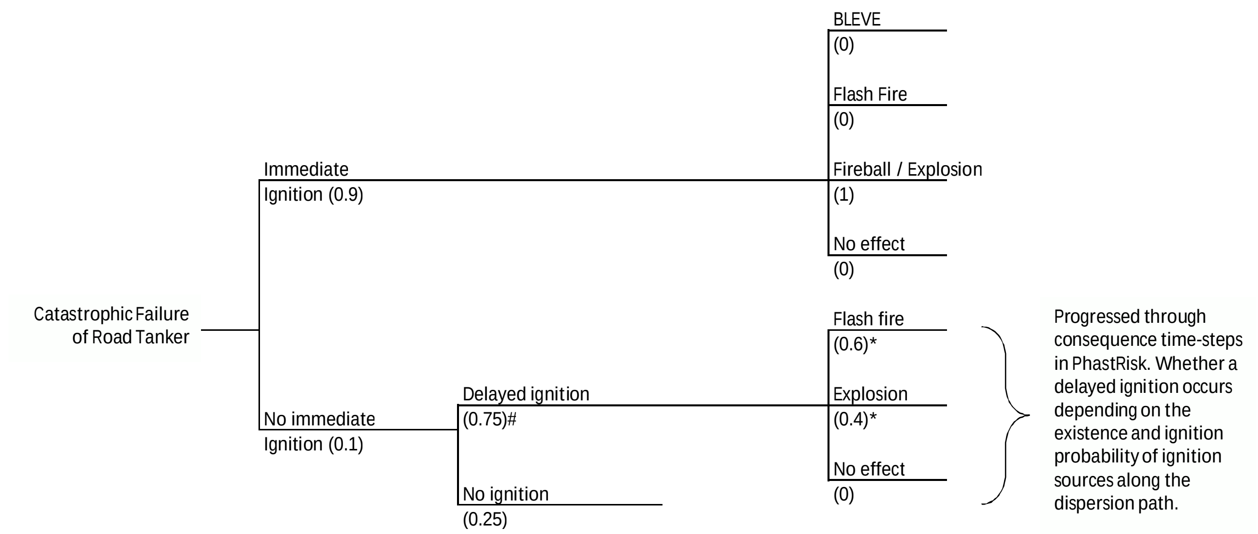
Event Tree Analysis

Catastrophic Failure of Storage Vessel (Instantaneous release without rainout)



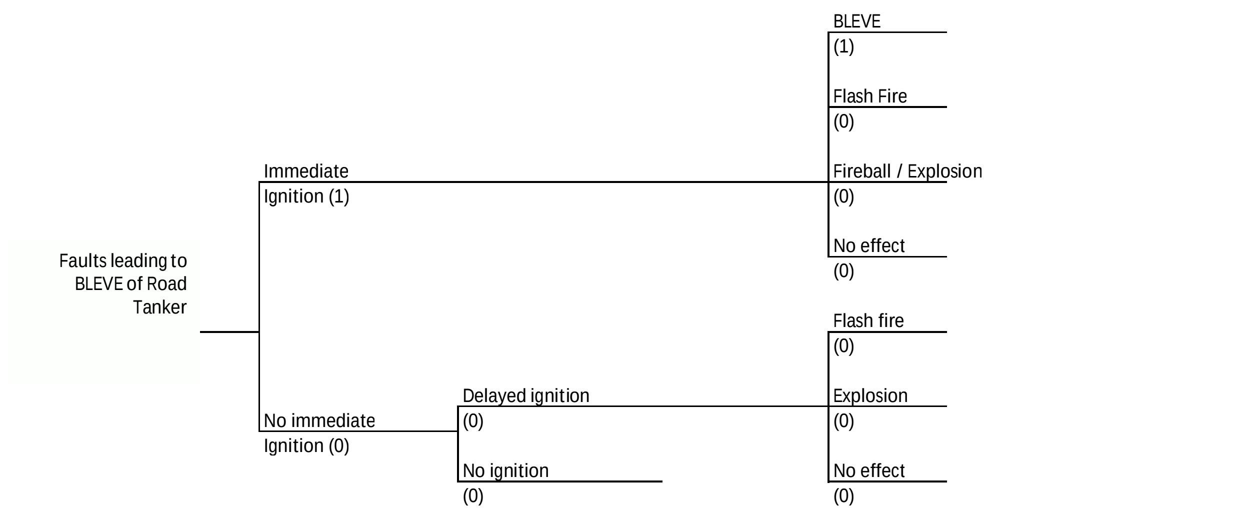
Note 1: applicable to mounded or underground tank only
* default in PhastRisk - based on TNO Purple Book
# delayed ignition probability varies from 0.4 to 0.75 for specified ignition sources and together with ignition due to population

Catastrophic Failure of Road Tanker (Instantaneous release without rainout)

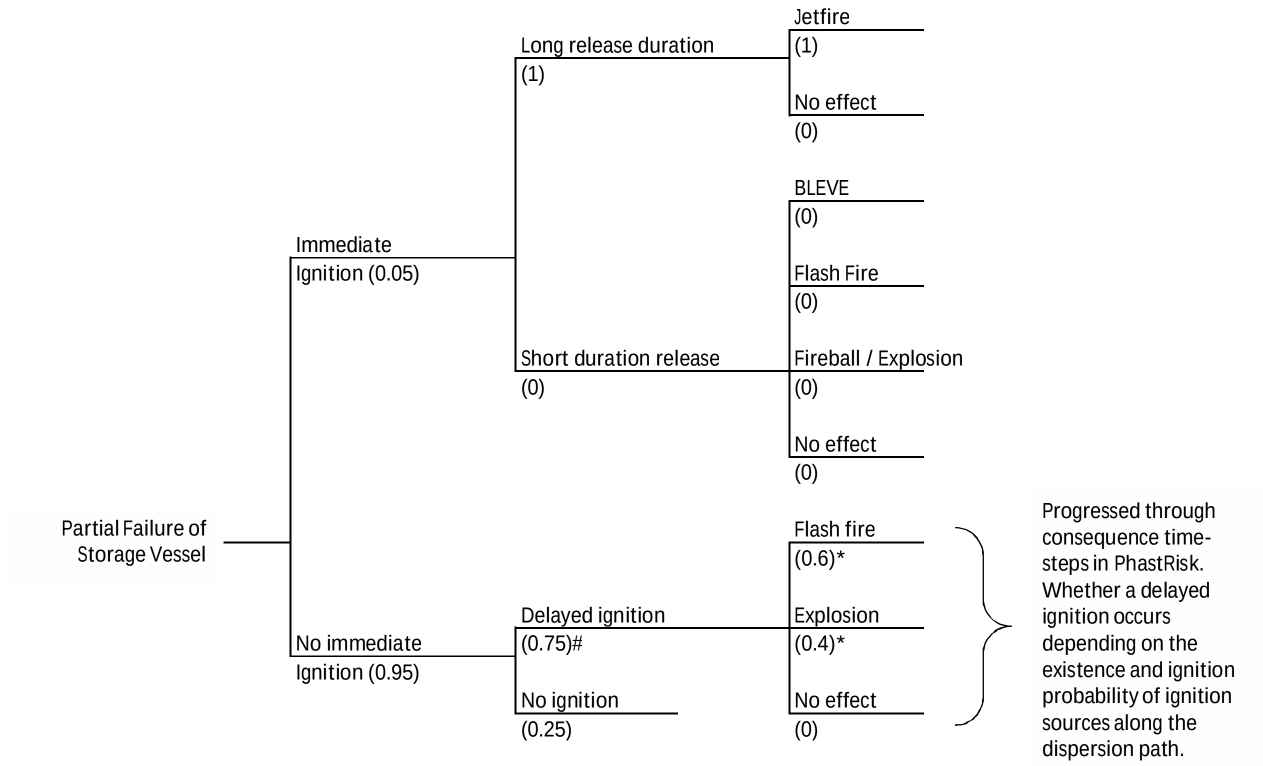


* default in PhastRisk - based on TNO Purple Book
# delayed ignition probability varies from 0.4 to 0.75 for specified ignition sources and together with ignition due to population

Faults leading to BLEVE of Road Tanker (Instantaneous release without rainout)

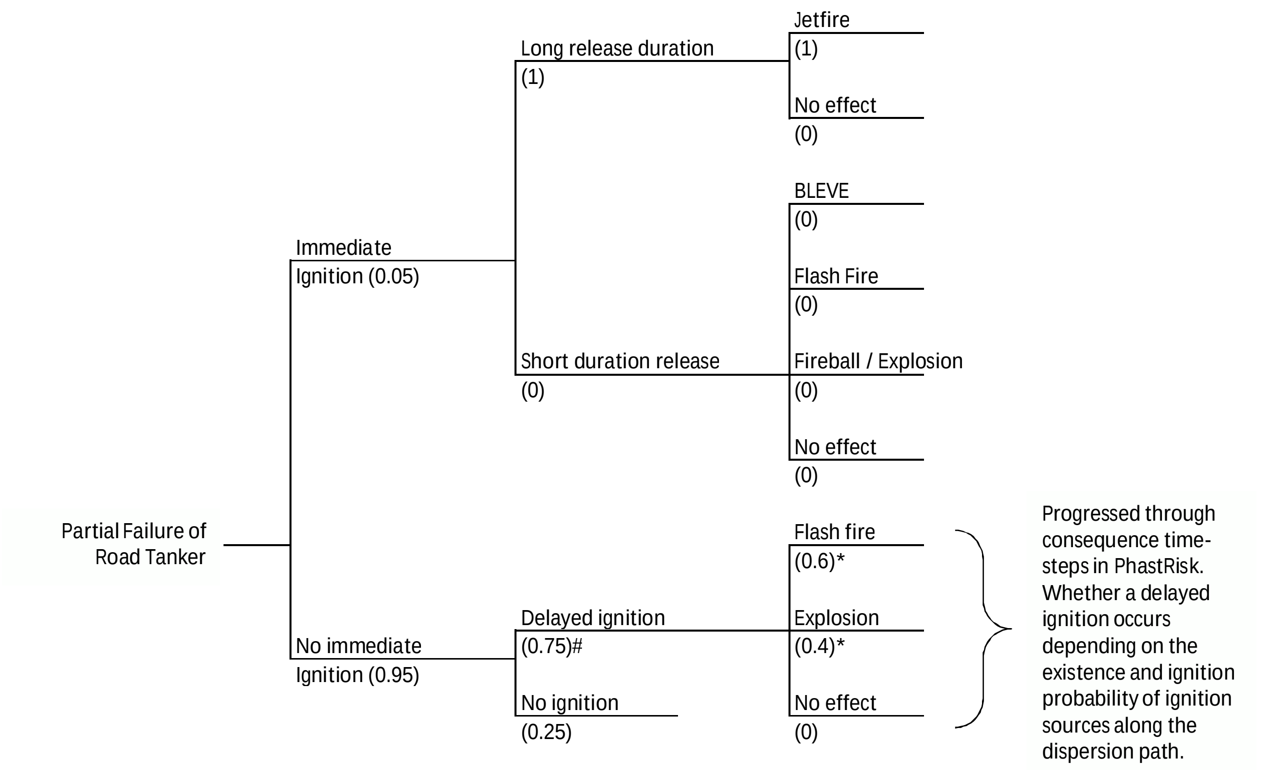


Partial Failure of Storage Vessel (Continuous release without rainout)



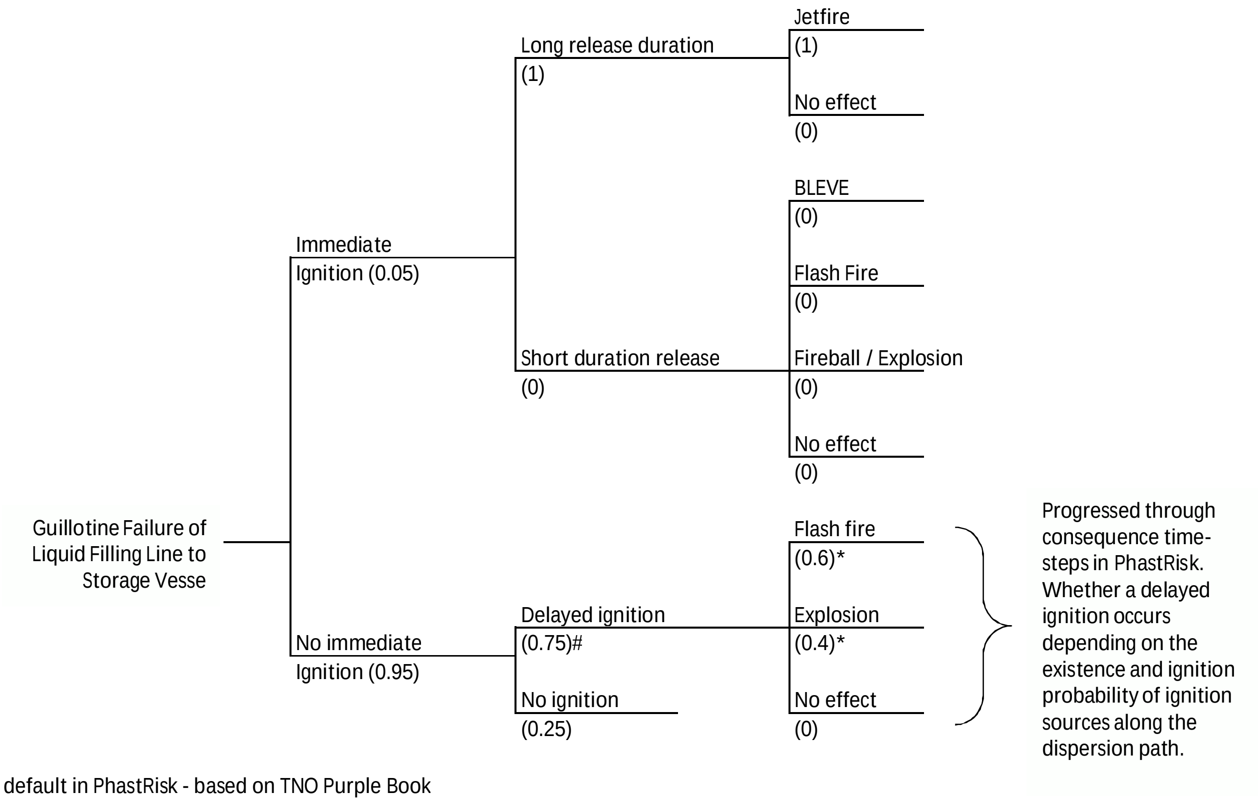
* default in PhastRisk - based on TNO Purple Book
# delayed ignition probability varies from 0.4 to 0.75 for specified ignition sources and together with ignition due to population

Partial Failure of Road Tanker (Continuous release without rainout)



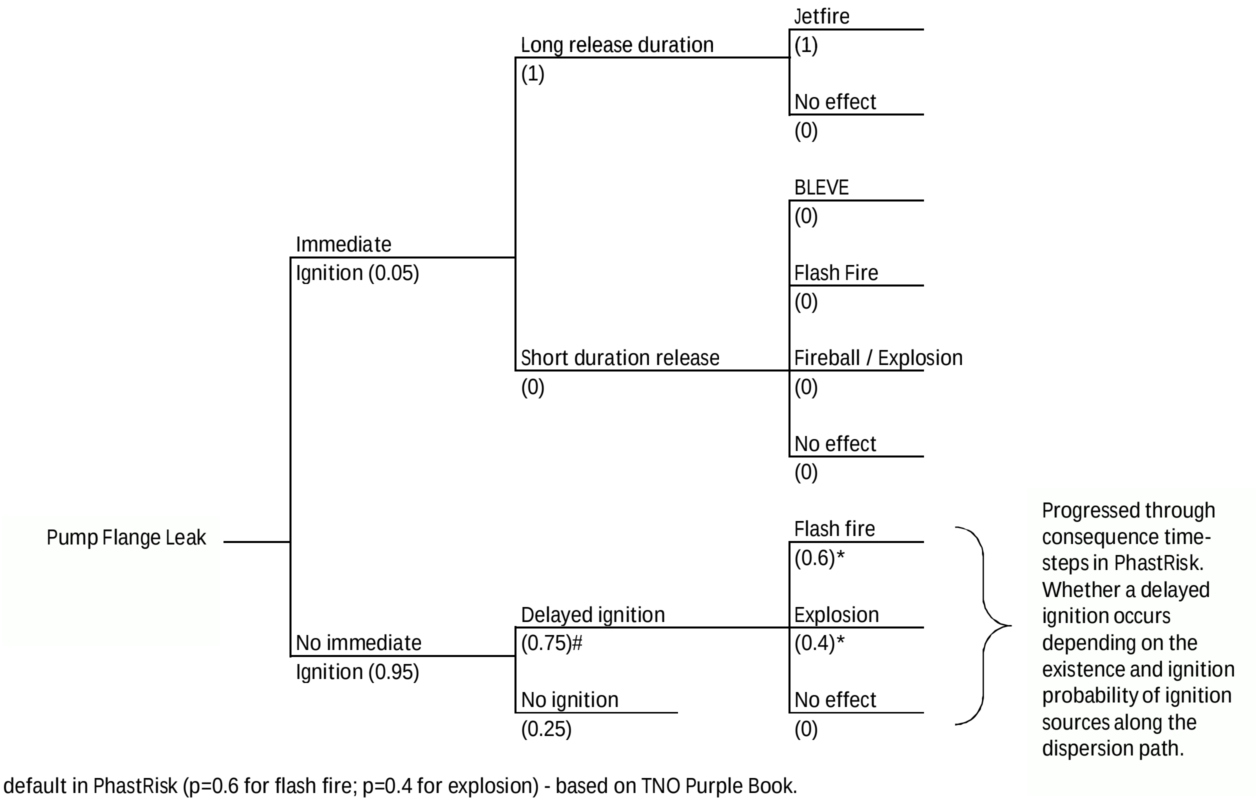
* default in PhastRisk - based on TNO Purple Book
# delayed ignition probability varies from 0.4 to 0.75 for specified ignition sources and together with ignition due to population

Guillotine Failure of Liquid Filling Line to Storage Vessel (Continuous release without rainout)



* default in PhastRisk - based on TNO Purple Book
# delayed ignition probability varies from 0.4 to 0.75 for specified ignition sources and together with ignition due to population

Pump Flange Leak (Continuous release without rainout)



* default in PhastRisk (p=0.6 for flash fire; p=0.4 for explosion) - based on TNO Purple Book.
# delayed ignition probability varies from 0.4 to 0.75 for specified ignition sources and together with ignition due to population

Annex E

Information from Fire Services Department

消防處
香港九龍尖沙咀東部康莊道1號
消防總部大廈

FIRE SERVICES DEPARTMENT
FIRE SERVICES HEADQUARTERS BUILDING,
No.1 Hong Chong Road,
Tsim Sha Tsui, Kowloon,
Hong Kong.

本處檔號 OUR REF. : (2) in FSD/GR AI 22/03
來函檔號 YOUR REF. : R01501/c/wwck/3
電訊掛號 Telex : 39607 HKFSD HX (24 小時 Hours FAX)
圖文傳真 FAX: : 852-2739 5879
電話 TEL NO. : 852-2733 7818

6 June 2003

Maunsell Environment Management Consultants Ltd.
Room 1213-1219, Grand Central Plaza, Tower 2,
138 Shatin Rural Committee Road,
Shatin, New Territories,
Hong Kong.
(Attn.: Mr. Arthur Lee)

By fax only : 2891 0305

Dear Mr. Lee,

Quantitative Risk Assessment (QRA) of a LPG Compound at Repulse Bay

I refer to your letter of 28 May 2003.

I wish to inform you that we do not have any record of fire incidents under petrol filling station category before 1995, as such, I can only provide you below with the number of incidents in Petrol Filling Stations after 1995:-

Year	Number of Incidents in Petrol Filling Station
1995	4
1996	2
1997	2
1998	4
1999	1
2000	2
2001	0
2002	1
2003 (Up to March)	0

Yours faithfully,

(TSANG Wan-hing)
for Director of Fire Services

消 防 處
香港九龍尖沙咀東康莊道1號
消防總部大廈

FIRE SERVICES DEPARTMENT
FIRE SERVICES HEADQUARTERS BUILDING
No.1 Hong Chong Road
Tsim Sha Tsui East Kowloon
Hong Kong

本處檔號 Our Ref.: (2) in FSD/GR AI 9/08
來函檔號 Your Ref.:
電子郵件 E-mail: hkfsdenq@hkfsd.gov.hk
圖文傳真 Fax: 852-2739 5879
電 話 Tel No.: 852-2733 7818

26 June 2008

ENSR Asia(HK) Ltd
11/F Grand Central Plaza, Tower 2,
138 Shatin Rural Committee, Shatin,
Hong Kong

By fax only : 2891 0305

Dear Mr. Hung,

Code on Access to Information
Fire Incidents Records under
Fuel Filling Station
From 2003 to present

I refer to your email dated 20 June 2008.

2. Please be advised that the number of incidents in Fuel Filling Station as follows:-

Year	Number of Incidents in Fuel (Petrol/LPG/Petrol cum LPG) Filling Station
2003	1
2004	0
2005	2
2006	0
2007	0
2008 (up to Feb)	0

Yours faithfully,

(CHUI Man-leung)
for Director of Fire Services

REF. NUMBER AND DATE SHOULD BE QUOTED IN REFERENCE TO THIS LETTER
凡 提 及 本 信 時 請 引 述 編 號 及 日 期

消 防 處
香港九龍尖沙咀東康莊道 1 號
消防總部大廈

FIRE SERVICES DEPARTMENT
FIRE SERVICES HEADQUARTERS BUILDING
No.1 Hong Chong Road
Tsim Sha Tsui East Kowloon
Hong Kong

本處檔號 Our Ref. : (139) in FSD GR 6-5/5 R
來函檔號 Your Ref. : 60268214/C/atym12100812
電子郵件 E-mail : hkfsdenq@hkfsd.gov.hk
圖文傳真 Fax : 852-2739 5879
電　　話 Tel No. : 852-2733 7818

18 October 2012

AECOM
8/F, Grand Central Plaza, Tower 2,
138 Shatin Rurai Committee Road, Shatin,
Hong Kong
(Attn: Ms. Angie TAI, Assistant Environmental Consultant)

Dear Ms. TAI,

Request for Fire Incidents Records under
Fuel Filling Station Category from Year 2008 to Present

Reference is made to your letter dated 8 October 2012.

Please be advised that the statistical information pertaining to the captioned subject is as follows:-

Year	Number of Incidents in Fuel (Petrol/LPG/Petrol cum LPG) Filling Station
2008	0
2009	3
2010	1
2011	0
2012 (Jan to Jun)	0

Should you have any queries, please feel free to contact Miss CHAN at 2733 7532.

Yours sincerely,

(YEUNG Ping-kwai)
for Director of Fire Services

REF. NUMBER AND DATE SHOULD BE QUOTED IN REFERENCE TO THIS LETTER
凡提及本信時請引述編號及日期

FS 107A (Rev.10/95)

消 防 處
香港九龍尖沙咀東部康莊道 1 號
消防總部大廈

FIRE SERVICES DEPARTMENT
FIRE SERVICES HEADQUARTERS BUILDING,
No.1 Hong Chong Road,
Tsim Sha Tsui East, Kowloon,
Hong Kong.

本處檔號 OUR REF. : (143) in FSD GR 6-5/4 R Pt. 15
來函檔號 YOUR REF. : 60544159/C/LCWW1705242
電子郵件 E-mail : hkfsdenq@hkfsd.gov.hk
圖文傳真 FAX NO. : 2739 5879
電 話 TEL NO. : 2733 7741

15 June 2017

AECOM Asia Co. Ltd.
8/F, Grand Central Plaza, Tower 2,
138 Shatin Rural Committee Road,
Shatin, Hong Kong.
(Attn: Ms. Benita KUNG, Associate Environment)

Dear Ms. KUNG,

Request for Fire Incidents Records
under Fuel Filing Station Category from Year 2012 to Present

Reference is made to your letter dated 24.5.2017.

Please be advised that the statistical information pertaining to the captioned subject is as follows:-

Year	Number of Incidents in Fuel (Petrol/LPG/Petrol cum LPG) Filing Station
2012	1
2013	1
2014	2
2015	0
2016	0
2017 (Jan to May)	1

If you have further questions, please feel free to contact the undersigned.

Yours sincerely,

(CHEU Yu-kok)
for Director of Fire Services

消 防 處
香港九龍尖沙咀東部康莊道1號
消防總部大廈

FIRE SERVICES DEPARTMENT
FIRE SERVICES HEADQUARTERS BUILDING,
No.1 Hong Chong Road,
Tsim Sha Tsui East, Kowloon,
Hong Kong.

本處檔號 OUR REF. : (54) in FSD GR 6-5/4 R Pt. 25
來函檔號 YOUR REF. : 60611423/C/TWYC1912021
電子郵件 E-mail : hkfsdenq@hkfsd.gov.hk
圖文傳真 FAX NO. : 2739 5879
電 話 TEL NO. : 2733 7741

19 December 2019

AECOM Asia Co. Ltd.
8/F, Grand Central Plaza, Tower 2,
138 Shatin Rural Committee Road,
Shatin, Hong Kong.
(Attn: Ms. Connie TSAI, Senior Environmental Consultant)

Dear Ms. TSAI,

Request for Fire Incidents Records
<u>under Fuel Filling Station Category from Year 2017 to Present</u>

Reference is made to your letter dated 2.12.2019.

Please be advised that the statistical information pertaining to the captioned subject is as follows:-

Year	Number of Incidents in Fuel (Petrol/LPG/Petrol cum LPG) Filling Station
2017	3
2018	2
2019 (Jan to Nov)	0

If you have further questions, please feel free to contact the undersigned.

Yours sincerely,

(TANG Long-kiu)
for Director of Fire Services