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PHA Supplemental

Planning Plus Pty Ltd

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Prepared For

Planning Plus Pty Ltd

Wendy Todd, Principal

Email: wendy@planningplus.net.au, Mobile: 0418 616 443

7 Rosemont Street, West Wollongong NSW 2500

PO Box 113 Keiraville NSW 2500

Prepared By

Advitech Pty Limited

ABN: 29 003 433 458

Colin Barker, Senior Consultant

Email: colin.barker@advitech.com.au, Telephone: 02 4924 5400, Mobile: 0412 043 439

Facsimile: 02 4967 3772, Web: www.advitech.com.au, General Email: mail@advitech.com.au

7 Riverside Drive Mayfield West NSW 2304 PO Box 207 Mayfield NSW 2304

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Endorsements

Function	Signature	Name and Title	Date
Prepared By		Colin Barker Senior Consultant Process Engineering and Sustainability	21-09-2021
Checked By		Patrick McGaw Process Engineer Process Engineering and Sustainability	21-09-2021
Authorised for Release By		Carl Fung Lead Consultant Process Engineering and Sustainability PhD, BE(Env), MIEAust, CPEng, NER, RPEQ, CAQP (Casanz)	21-09-2021

TABLE OF CONTENTS

1. INTRODUCTION

In mid-2021, Planning Plus Pty Ltd (Planning Plus) submitted a comprehensive EIS on behalf of the DGL Group in relation to the Unanderra Liquid Waste Treatment Plant/Facility (LWTP) (SSD-8304). Appendix W of the EIS was a preliminary hazard analysis (PHA) prepared by Advitech Pty Ltd (Advitech).

In a letter dated 16 August 2021, the NSW DPIE requested DGL Group to address several matters arising from the public exhibition of the EIS document. Among the matters, was a request to obtain further information and insights into the modelling of potential toxic gas release scenarios identified as:

- Scenario #2a – Cl_2 release due to incorrect road tanker transfer; and
- Scenario #2c – SO_2 release due to incorrect road tanker transfer.

Subsequent discussions between the parties led to a request by NSW DPIE for the remodelling of Scenario #2a and Scenario #2c to improve its alignment with all methodologies outlined within HIPAP No. 4 (Refer **Section 2, Reference 4** of Appendix W within the original EIS document). In particular, it was agreed the treatment of toxic gas release consequence be more cognisant of the meteorological data already published within the EIS Air Quality Assessment.

This supplemental report is published to address the specific requests from the NSW DPIE. This supplemental report should be read in conjunction with Appendix W within the original EIS document. The subsequent section numbering within this supplement reflects the numbering of the relevant sections of Appendix W as they relate to Scenario #2a and Scenario #2c. Additionally, the analysis following supersedes the analysis previously published.

It should be noted that this report was prepared by Advitech Pty Limited for Planning Plus Pty Ltd ("the customer") in accordance with the scope of work and specific requirements agreed between Advitech and the customer. This report was prepared with background information, terms of reference and assumptions agreed with the customer. The report is not intended for use by any other individual or organisation and as such, Advitech will not accept liability for use of the information contained in this report, other than that which was intended at the time of writing.

7. CONSEQUENCE ANALYSIS

7.2 Toxic Gas Release Scenarios

7.2.1 LWTP – Process Description

Caustic wastes, acid wastes (including SPL and waste acid from the BRP) and wash water/first flush water wastes, etc are stored at the designated locations in Store B (see **Figure 5** of Appendix W within the original EIS document). These 'raw materials' will be individually pumped to the Neutralisation Reactors within Building E according in specific amounts (depending upon the relative strength of the wastes) and a specific sequence. The generic composition of the proposed 75 kL neutralisation batches is shown in **Table 11** below.

Table 11: Generic Charge Composition and Sequence for 75 kL LWTP Neutralisation Batches

Charging Sequence Step	Additive/Raw Material	Total Quantity	Transfer Rate From Store B
1	Wastewater ex BRP	40 – 45 kL	8 kL/hr max
2	Battery Acid	5 - 10 kL	2 kL/hr max
3	SPL	4 - 7 kL	1 kL/hr max
4	Waste Caustic	1 - 3 kL	0.5 kL/hr max
5	Lime Slurry	7 - 10 kL	2 kL/hr max

The purpose of the LWTP is to neutralise industrial processing liquids; primarily pickling liquors from the metal and metal product finishing industries. Given the LWTP neutralisation process will be focused primarily upon pickling liquors, there will typically only be a narrow range of acid/base neutralisation reactions experienced.

Despite the narrow focus of the liquid waste streams to be neutralised within the LWTP facility, in certain circumstances/conditions, potential exist for the generation and release of toxic and/or nuisance vapours/gases during processing. These vapours/gases may either result from:

- Evolution/release of species likely to be present at very low levels within some pickle liquors (eg ammonia). This scenario constitutes the more likely scenario but will be of very low consequence given the low maximum concentrations to be encountered and the lower toxicity of the species; or
- Evolution/release of species that have been inadvertently introduced into the plant through gross contamination during tanker unloading operations (eg contamination of waste caustic with hypochlorites or bisulphites capable of releasing chlorine Cl_2 and SO_2 respectively) at the point of consignment origin. This scenario is far less likely given the proposed personnel training and analytical regime to be in place for consignments of liquids for treatment in the LWTP. The regime includes:
  - Specification of liquid to be treated including composition and signed declaration by the generator as to the liquid's origin;
  - A tanker washout certificate (prior to loading) is to be presented with each consignment;
  - Almost exclusive utilisation of single compartment (baffled) tankers for the transport of incoming consignments. (This means any inadvertent contamination of a waste acid consignment will manifest at the source site and not at DGL Environmental.);
  - Sampling from each tanker (a single composite sample) upon arrival at the DGL Group Unanderra site;

– Suitable testing of the composite sample to detect any potential for gas/vapour evolution prior to unloading into the LWTP storage tank farm;
– Establishment of a specific training regime to apply to all personnel able to receive and authorise consignments; and
– Recording of the storage location of each LWTP consignment.

Given the protocols to be implemented prior to the treatment of liquids (pickle liquors and waste caustic solutions) within the LWTP, any fume or gas generated during the neutralisation process(es) will be of a minor quantity. Nonetheless, fume and/or gas generated within LWTP neutralisation reactors will be positively ventilated to a two stage wet gas scrubbing system designed to sequentially remove any low concentration acid or alkali gases that may be present.

7.2.1.1 Gas Scrubber Operations and Chemistry

DGL Group proposes to install a two-stage wet scrubbing system for the removal of acid and/or alkali gases that may arise during neutralisation operations. The two-stage ventilated gas scrubbing system will include:

- An alkali gas scrubber primarily for the removal of traces of ammonia. This scrubber will utilise dilute sulphuric acid as the recirculating absorbing medium.; and
- An acid gas scrubber primarily for the removal of traces of Cl_2, SO_2 and oxides of nitrogen (NO_X). This scrubber will utilise dilute sodium hydroxide as the recirculating absorbing medium.

Procedures will be developed and implemented to ensure the recirculating scrubber absorbent mediums are maintained within specified concentration (activity) ranges and are themselves appropriately treated/neutralised prior to disposal.

At the time of preparing this PHA no detailed design information is available. Advitech's view is that an acid/alkali gas removal efficiency afforded by the respective gas scrubbers would be greater than 95%. A higher stripping efficiency may be achievable but will be dependent upon good design and maintenance systems.

7.2.2 LWTP Neutralisation Process Failure

Despite the implementation of the protocols described in **Section 7.2.1**, were significant contamination of feed streams to occur, or inadvertent admission to the process of certain industrial reagents, the emission of toxic gas species such as Cl_2, SO_2 and NO_X is conceivable. **Section 7.2.2.1** and **Section 7.2.2.2** (following) explain the mechanisms by which Cl_2 and SO_2 could be generated.

Consultation between DGL Group and Advitech process engineering personnel suggests the formation of SO_2 presents the greater potential health concern given it has the greater toxicity among the species potentially emitted. (Compare **Section 7.2.2.3 Table 12** with **Section 7.2.2.4 Table 13**)

7.2.2.1 *Chlorine Generation Mechanism*

Were it to occur, the generation of Cl_2 is most likely from the contact of sodium hypochlorite (e.g. NaOCl alkali solutions of bleach) in contact with strong acids. Commercial grade sodium hypochlorite solutions typically have a pH of around 12 to 13. The release of Cl_2 would likely occur during the mixing of acidic pickle liquor with an alkaline solution laden with hypochlorite within a neutralisation reactor. A number of factors would influence the rate of formation of Cl_2 and these include:

- The concentration of acid being introduced into the neutralisation reactor.
- The amount/concentration of hypochlorous acid (sodium hypochlorite in equilibrium in water) being introduced into the neutralisation reactor.
- The neutralisation reactor acid buffering capacity and absolute pH (a low pH drives the reaction chemistry toward Cl_2 formation).

7.2.2.2 *Sulphur Dioxide Generation Mechanism*

Were it to occur, the generation of SO_2 is most likely from either:

- The contact of alkaline sodium sulphite or sodium bisulphite solutions with any strong mineral acid such as sulphuric acid. The release of SO_2 would likely occur during the mixing of acidic pickle liquor with an alkaline solution laden with a sulphites/bisulphites within the neutralisation reactors.

The factors influencing the rate of formation of SO_2 would be similar to those influencing Cl_2 generation as described in **Section 7.2.2.1**.

7.2.2.3 *Chlorine Exposure Guideline Level*

The PHA has applied the United States Acute Exposure Guideline Levels (AEGLs) (as presented in **Table 12:**) to determine human fatality risk.

Table 12: Chlorine Acute Exposure Guideline Levels (AEGLs)[1]

Identifier	Ten Minute Averaging Time (ppm)	End Point Reference
AEGL-1 (non-disabling)	0.5	The airborne concentration which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
AEGL-2 (disabling)	2.8	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
AEGL-3 (lethality)	50	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

[1] - Acute Exposure Guideline Levels for Selected Airborne Chemicals- Committee on Toxicology Board on Environmental Studies and Toxicology, National Research Council USA - Volume 4.

7.2.2.4 *Sulphur Dioxide Exposure Guideline Level*

The PHA has applied the following AEGLs to determine human fatality risk.

Table 13: Sulphur Dioxide Acute Exposure Guideline Levels (AEGLs)[1]

Identifier	Ten Minute Averaging Time (ppm)	End Point Reference
AEGL-1 (non-disabling)	0.2	The airborne concentration which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
AEGL-2 (disabling)	0.75	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
AEGL-3 (lethality)	30	The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

[1] - Acute Exposure Guideline Levels for Selected Airborne Chemicals- Committee on Toxicology Board on Environmental Studies and Toxicology, National Research Council USA - Volume 8.

7.2.2.5 *Potential Extent of Emissions - Various Sub-Scenarios*

The four toxic gas release sub-scenarios utilised for the modelling of potential toxic gas cloud consequences include the following:

2 a. Incorrect road tanker consignment transfer of contaminated caustic waste (with sodium hypochlorite) results in release of toxic Cl_2 gas from the target waste acid storage tank within Store B.

2 b. Contaminated caustic waste (with sodium hypochlorite) results in release of toxic Cl_2 gas from the LWTP Neutralisation Reactor during batching within Building E. It is additionally assumed the waste gas scrubber is inoperative at the time.

2 c. Incorrect road tanker consignment transfer of contaminated caustic waste (with sodium bisulphite) results in release of toxic SO_2 gas from the target waste acid storage tank within Store B.

2 d. Contaminated caustic waste (with sodium bisulphite) results in release of toxic SO_2 gas from the LWTP Neutralisation Reactor during batching within Building E. It is additionally assumed the waste gas scrubber is inoperative at the time.

Table 14 reproduces the distances to the AEGL 1, AEGL 2 and AEGL 3 contours in the four scenarios modelled (as described above). All scenarios modelled assume Class D (neutral) atmospheric stability conditions prevail at the time of release. This assumption is considered conservative for reasons including:

- Class D stability conditions prevail for approximately 64% of the time on an annual basis;
- Class E and Class F stability conditions (prevalent for approximately 10% and 4% respectively) don't exist between the hours of 8.00 am and 5.00 pm when tanker unloading operations will occur; and
- Corresponding scenarios under Class A, Class B and Class C stability conditions will all yield reduced distances to the corresponding impact contours.

More detail regarding the individual SLAB model scenario reports, the wind roses utilised and the various impact distances derived, are reproduced within **Appendix V** of Appendix W within the original EIS document.

Table 14: Distance to AEGL Contours In Modelled Emission Scenarios

Scenario	Wind Speed	Distance to AEGL 1 Contour	Distance to AEGL 2 Contour	Distance to AEGL 3 Contour
Scenario #2 a - Cl_2 Release (Incorrect road tanker consignment transfer results in release of toxic gas from target storage tank)	0.75 m/sec	1,227 metres	498 metres	74 metres
	2.25 m/sec	894 metres	373 metres	73 metres
	3.75 m/sec	732 metres	268 metres	0.0 metres
	5.25 m/sec	606 metres	199 metres	0.0 metres
	6.75 m/sec	519 metres	148 metres	0.0 metres
	7.50 m/sec	489 metres	0.0 metres	0.0 metres
Scenario #2 b - Cl_2 Release (Contaminated waste in storage is pumped to the Neutralisation reactor while scrubber is inoperative resulting in release of toxic gas)	0.75 m/sec	122 metres	49 metres	9 metres
	2.25 m/sec	0.0 metres	0.0 metres	0.0 metres
	3.75 m/sec	0.0 metres	0.0 metres	0.0 metres
	5.25 m/sec	0.0 metres	0.0 metres	0.0 metres
	6.75 m/sec	0.0 metres	0.0 metres	0.0 metres
	7.50 m/sec	0.0 metres	0.0 metres	0.0 metres
Scenario #2 c - SO_2 Release (Incorrect road tanker consignment transfer results in release of toxic gas from target storage tank)	0.75 m/sec	2,920 metres	1,594 metres	192 metres
	2.25 m/sec	2,406 metres	1,199 metres	162 metres
	3.75 m/sec	1,938 metres	965 metres	0.0 metres
	5.25 m/sec	1,666 metres	807 metres	0.0 metres
	6.75 m/sec	1,489 metres	694 metres	0.0 metres
	7.50 m/sec	1,416 metres	0.0 metres	0.0 metres
Scenario #2 d - SO_2 Release (Contaminated waste in storage is pumped to the Neutralisation reactor while scrubber is inoperative resulting in release of toxic gas)	0.75 m/sec	320 metres	155 metres	17 metres
	2.25 m/sec	175 metres	0.0 metres	0.0 metres
	3.75 m/sec	0.0 metres	0.0 metres	0.0 metres
	5.25 m/sec	0.0 metres	0.0 metres	0.0 metres
	6.75 m/sec	0.0 metres	0.0 metres	0.0 metres
	7.50 m/sec	0.0 metres	0.0 metres	0.0 metres

Comparison of the impact radii for Scenario #2 a. vs Scenario #2 c. and Scenario #2 b. vs Scenario #2 d. as presented in **Section 7.2.2.5** shows the SO_2 gas emission scenarios (Scenarios #2 c. and Scenario #2 d.) represent the worst case toxicity impacts of a gas release from the operations at the LWTP.

It is evident the toxic gas emission impact of incorrectly transferring a badly contaminated consignment to the wrong waste tank results in a far larger impact than if contaminated waste is stored in a compatible waste tank prior to being processed in the Neutralisation Reactors. The difference in toxic gas emission rate are around 100 times greater, even if the waste gas scrubber is assumed to be inoperative during the batching process (compare Scenario #2 a. vs Scenario #2 b. and Scenario #2 c. vs Scenario #2 d.).

It is concluded that in order for a process failure to result in serious off-site consequences, the following scenario would be required to unfold:

1. The waste caustic/alkali consignment composition advice would be either knowingly or inadvertently incorrect. The inadvertent error would presumably be based upon an inadvertent (from the perspective of the liquid waste generator) contamination event.
2. If contamination were to have occurred, the pre-loading tanker washout certificate would either be forged or non-existent.
3. The contamination involves substantial quantities of a narrow range of substances where acid/base neutralisation results in the evolution of toxic fumes/gases.
4. The requisite sampling and testing of the consignment is either not done, or the testing regime fails to identify the presence of the dangerous contaminant prior to the consignment being discharged into the LWTP storage tanks.
5. The LWTP operator fails to correctly direct the consignment waste to the acid waste tanks or the caustic waste tanks as appropriate. The incorrectly directed waste results in significant reaction, and subsequent gas generation occurring in the incorrectly targeted waste storage tank.

The anticipated maximum rate of toxic emission in the modelled scenarios is based upon the following assumptions:

- A maximum of 10% by weight of the liquid waste consignment being the unwanted contaminant species. This species is evenly distributed through the load and is not confined to a single tanker compartment.
- All consequences arising from incoming waste caustic loads will be modelled based upon the more severe consequences associated with tanker contamination by 40% sodium bisulphite solution (Scenario #2 c.).
- The maximum annual quantity of waste caustic solutions treated at the LWTP is 2,000 kL/annum. This equates to around waste caustic 100 tanker movements per annum.
- The transfer rate from the tanker to the incorrectly targeted storage tank is 25 kL/hour.
- The fatality distance will be taken as the distance to the AEGL 3 envelope for that scenario.
- The injury distance will be taken as the distance to the AEGL 2 envelope for that scenario.

7.2.2.6 Sulphur Dioxide Gas Emission Resulting In Off-Site Consequences

Table 15 shows the direction and approximate distances from Building E to various neighbouring businesses and residences. **Table 15** also includes the threshold wind speed, below which, the nominated impact concentration will be realised.

Table 15: Neighbours and Maximum Threshold Wind Speeds for Various Consequences

Neighbour(s)	Distance (metres)	Direction	Threshold Wind Speeds (metres/second)					
			Cl_2 AEGL 1	Cl_2 AEGL 2	Cl_2 AEGL 3	SO_2 AEGL 1	SO_2 AEGL 2	SO_2 AEGL 3
Residential								
Figtree	560	N & NNW	**6.2**	NA	NA	All	**6.8**	NA
Unanderra	730	WNW	**3.7**	NA	NA	All	**6.1**	NA
Nan Tien Temple	1,780	SSW	NA	NA	NA	**4.6**	NA	NA
Cringilla	1,890	SE	NA	NA	NA	**4.1**	NA	NA
Industrial								
BlueScope Stainless Products	80	N	All	**7.2**	**2.2**	All	**7.4**	**3.1**
Premium Tyres	100	NE	All	**7.1**	NA	All	**7.4**	**2.9**
BlueScope Steel Welded Products	100	W	All	**7.1**	NA	All	**7.4**	**2.9**
Bisalloy	120	SW	All	**6.9**	NA	All	**7.3**	**2.6**
McKeons Swim Centre	140	E	All	**6.8**	NA	All	**7.3**	**2.4**

Table 16 shows the maximum percentage of the total time that wind speeds from the critical direction would be below the threshold speed resulting in the **Table 15** impacts being realised at the neighbouring properties.

Table 16: Neighbours and Probabilities Associated With Table 15 Thresholds

Neighbour(s)	Distance (metres)	Direction	Maximum Percentage of Time Threshold Wind Speed & Direction Applies					
			Cl_2 AEGL 1	Cl_2 AEGL 2	Cl_2 AEGL 3	SO_2 AEGL 1	SO_2 AEGL 2	SO_2 AEGL 3
Residential								
Figtree	560	N & NNW	**8%**	0%	0%	**9%**	**8%**	0%
Unanderra	730	WNW	**< 2%**	0%	0%	**2%**	**2%**	0%
Nan Tien Temple	1,780	SSW	0%	0%	0%	**6%**	0%	0%
Cringilla	1,890	SE	0%	0%	0%	**2%**	0%	0%
Industrial								
BlueScope Stainless Products	80	N	**4%**	**4%**	**2%**	**4%**	**4%**	**2%**
Premium Tyres	100	NE	**11%**	**10%**	0%	**11%**	**10%**	**5%**
BlueScope Steel Welded Products	100	W	**< 2%**	**< 2%**	0%	**< 2%**	**< 2%**	**1%**
Bisalloy	120	SW	**12%**	**11%**	0%	**12%**	**11%**	**4%**
McKeons Swim Centre	140	E	**11%**	**10%**	0%	**11%**	**10%**	**3%**

The conclusions to be drawn from **Table 15** and **Table 16** include:

Industrial Neighbours

- AEGL 1 consequences (non-disabling) would occur at any surrounding industrial site downwind of the event, irrespective of prevailing wind speed.
- AEGL 2 consequences (disabling) would occur at any surrounding industrial site downwind of the event, where prevailing wind speeds fell below around 7.4 m/sec. Given the directionality of surrounding businesses, this consequence would be expected to be realised with a probability of 37%.
- AEGL 3 consequences (fatality) would occur at any surrounding industrial site downwind of the event, where prevailing wind speeds fell below around 3.0 m/sec. Given the directionality of surrounding businesses, this consequence would be expected to be realised with a probability of 15%.

Nearest Residential Areas

- AEGL 1 consequences (non-disabling) could occur at surrounding residential neighbourhoods downwind of the event. Given the directionality of the various surrounding neighbourhoods, this consequence would be expected to be realised with a probability of up to 19%.

- AEGL 2 consequences (disabling) could occur at the Figtree and Unanderra residential neighbourhoods downwind of the event where wind speeds were below around 7.0 m/sec. Given the directionality of these neighbourhoods, this consequence would be expected to be realised with a probability of up to 10%.
- AEGL 3 consequences (fatality) would not be expected to occur at any surrounding residential area irrespective of wind speed. Therefore, this consequence would be expected to be realised with a probability of zero.

The extent and persistence of toxic gas cloud generation event could vary widely. Depending upon the extent of the undetected contamination and the governing meteorological conditions, the event could range from being:

- Highly localised with the toxic gas generation based upon minor undetected contamination within the LWTP coincident with favourable meteorological conditions; through to
- A persistent cloud with the AEGL 3 contour at up to 200 metres and the AEGL 2 contour at up to 1.6 kilometres. Such an improbable scenario could only arise where the contamination was characterised as a full strength bisulphite reagent and wind speeds of less than 0.75 m/sec prevailed.

The potential consequence for a toxic gas cloud generation event involving SO_2, is multiple off-site fatalities. The bases/pre-requisites for this assumed outcome include:

- Wind speeds below 3.0 m/sec coming from the South East right around to the North West. Given these wind speeds and directions at the time of the event, the distance to the AEGL 2 contour is likely to engulf vehicular traffic on the Princes Motorway and/or Five Islands Road. The potential to temporarily disable motorists on such main thoroughfares is considered likely to result in one or more fatalities with a meteorological probability of up to 40%.
- Given the resultant toxic cloud is potentially to be up to 1.6 kilometres in extent, the probability of avoiding any encounter with the AEGL 2 (disabling) injury contour for passing motorists, passing pedestrians and industrial neighbours is considered low.

It is noted the toxic release scenario with off-site impacts can only occur where three requisite sequential checks all fail. The sequential failures are:

1. Failure of the consignment to conform to specification through load mix-up, incorrect or overlooked tanker washout, etc;
2. Failure of the standard consignment delivery checks by suitably (trained, accredited and authorised) personnel to detect the contaminant within the consignment; and
3. Failure of the LWTP operator to deliver the tanker consignment to the correct waste storage tanks. That is a contaminated caustic waste is incorrectly diverted to acid waste storage tanks or vice versa.

The potentially critical nature of each of the above sequential checks is recognised by the DGL Group and a comprehensive inward goods consignment regime (including testing and authorisation by trained personnel) is to be implemented as a consequence.

Once delivered to the correct set of waste storage tanks, the potential for a contaminated consignment to create a serious toxic gas emission is greatly diminished. The seriousness of this type of scenario is diminished due to the following factors:

- The contaminated waste has been diluted by the other contents within the waste storage tank;
- The rate of transfer from the waste storage tank (Store B) to the neutralisation reactor within Building E is capped at 0.5 kL/hour. This represents approximately 2% of the transfer rate that would apply in transferring a consignment from a road tanker into storage.
- The neutralisation reactor fumes are drawn through a two-stage scrubber system in order to remove toxic gas contaminants prior to discharge to the environment.

7.2.2.7 Sulphur Dioxide Gas Emission Resulting In On-Site Consequences

In order for the process failure to occur with on-site consequences, the following developing scenario would include all of the first 5 scenario steps as described in **Section 7.2.2.5**. Conservatively, it will be assumed the on-site fatality scenario is equally likely to occur, irrespective of the prevailing meteorological conditions at the time of the release.

The assumed resultant consequence for a toxic gas cloud generation event involving SO_2, is an on-site fatality. The bases/pre-requisites for this assumed outcome include:

- Meteorological conditions are largely irrelevant to this scenario which would partly unfold in an indoor environment.
- Given the resultant toxic cloud is not accumulating too rapidly, operational personnel are considered likely to be able to be able to escape the building. Once outside the building it is likely meteorological conditions will not be such that personnel may be able to position themselves upwind.

8. LIKELIHOOD ANALYSIS

In estimating the initiating event frequencies and probabilities, no account was taken of any of the electrical safety-related systems (e.g. thermal cut-off switch, programmable logic controller function) or other risk reduction measures that might be present or possible with the equipment. **Table 17** shows the frequencies of initiating events and probabilities involved in the adverse scenarios outlined in **Section 6** of Appendix W within the original EIS document.

Table 17: Data/Assumptions for Off-Site Fatality Analysis

Assumption/Basis	Assigned Value	Unit	Source	Comments
Toxic Release				
Operator Error of Omission in Lab testing	0.01	probability per event	HIPAP #6 Hazard Analysis - 2011 NSW Department of Planning	
Probability of Inadvertent Tanker Contamination with bleach, bisulphites, etc up to 10% level	0.001	probability per event	HIPAP #6 Hazard Analysis - 2011 NSW Department of Planning	
Probability of Wilful Tanker Contamination	0.00001	probability per event		Assumed value. Probability of sabotage act with sufficient knowledge understanding to overcome lab checks is remote.
Human Error of Omission	0.01	probability per event	HIPAP #6 Hazard Analysis - 2011 NSW Department of Planning	
Annual number of waste caustic consignments as goods inwards	100	per annum	DGL Environmental DA parameters	The LWTP is expected to treat up to 2,000 kL per annum of waste caustic solutions with each consignment assumed to be of 20 kL.
Probability contamination is not detected	0.0001	probability per event	HIPAP #6 Hazard Analysis - 2011 NSW Department of Planning	
Operator Error of Incorrectly pumping caustic waste to a waste acid tank	0.01	probability per event	HIPAP #6 Hazard Analysis - 2011 NSW Department of Planning	
LWTP Neutralisation Operator fails to respond quickly to a release.	0.5	probability per event		Conservatively estimated
Probability of passer-by or industrial neighbour being present.	1			Conservatively estimated

Assumption/Basis	Assigned Value	Unit	Source	Comments
Probability of failure of on-site personnel to escape plume	0.2			Conservatively estimated given on-site personnel will be readily able egress the building to safety. This scenario is independent of meteorological conditions prevailing.
Probability of an off-site person being within an AEGL 3 envelope	0.55		Wind rose data and SLAB model outputs at various wind speeds	There is calculated to be a 15% chance of an industrial neighbour fatality and 40% chance of passers-by being overcome.
Probability of failure of off-site persons to escape plume	0.9			Conservatively estimated given off-site personnel will be likely in vehicles and quickly overcome by a cloud of this concentration.
<u>Lead Poisoning</u>				
Guest/visitor on-site	0.2			Conservative estimate based on examination of DGL Group Visitor and Contractor registers.
Probability guest/visitor is left alone	0.1	probability per year		This is considered a highly unusual event. An un-inducted visitor would not be left alone.
Probability of accessing lead paste or concentrated lead materials	0.01			Conservative estimate for visitors and contractors.
Probability of significant ingestion	0.001			Considered extremely unlikely that a visitor would ingest materials.
Probability ingestion would ultimately be fatal	0.1			Estimate regarding the fatality risk if materials were ingested.
<u>Off-site Lead Release</u>				
Tank Failure - lead slurry tank	0.000003	probability per year	From OGP Risk Assessment Data Directory International Association of Oil and Gas Producers Storage Incident Frequencies Report 434-3 March 2010 Atmospheric Storage Tanks - Table 2.1 Fixed Roof tank rupture = 3.0 x 10-6 per year	
Bund is compromised	0.01	probability		Conservative estimate that established bunds may be compromised for specific reasons on average 3 or 4 days per year.
Extent/duration of power failures	0.0057	proportion of time		Assume 10 hours of power failure on average with site

Assumption/Basis	Assigned Value	Unit	Source	Comments
				operating 1,760 hours per annum on average.
First flush system full	0.1	proportion of time		The system is normally in the empty state. Conservative estimate applied.
Sealed area of site significantly compromised	0.025	proportion of time		Assume the seal is significantly compromised approx 1 working week in every year.
Probability of rain prevailing	0.1	proportion of time	Australian Government BOM records. Wollongong has an average of 33.3 days per year where greater than 10mm of rainfall occurs.	
<u>Fire/Explosion Involving Natural Gas</u>				
Major NG Leak	0.0023	events per annum	Cox Chapter 11 Table 11.1 **Pipework** 0.050m diameter pipework Piping length = 200 m (est) Mean major leak frequency = 1.0E-5 leaks/m/a **Valves - All Sizes** Number = 3 Mean major leak frequency = 1.0E-4 leaks/a **Total** =200*1.0E-5 + 3*1.0E-4	
Within Flammability Limits	0.1	probability per event		Conservative estimate
Ignition Source Present	0.01	probability per event		Conservative estimate
Gas Can Accumulate	1	probability per event		Conservative estimate
People Present in Building	0.1	proportion of time		Conservative estimate. People are not normally in locations high in building roofs.
System Pressure Is Sufficient Indoors	0	proportion of time		
System Pressure Is Sufficient Outdoors	1	proportion of time	See Table 6.	Outdoor pressure is taken to be 1,000 kPa.
People Present In Line of Fire	0.01	proportion of time		Conservative estimate based on likely size and location of a jet fire.
Unable to Escape Radiation	0.9	proportion of time		Conservative estimate
Probability of jetfire at internal plant gas pressure of 1 bar	0			

On the basis of the probabilities and frequencies reported in **Table 17:**, fault tree diagrams were produced for the following off-site and on-site fatality impacts:

- Off-site fatality from toxic gas/fume emission/release (**Figure 7**);
- Off-site fatality from natural gas jet-fire (**Figure 8**);
- Combined off-site fatality risk (all causes) (**Figure 9**);
- On-site fatality from toxic gas/fume emission/release (**Figure 11**);
- On-site fatality from natural gas explosion (**Figure 12**);
- On-site fatality from ingestion of lead (Pb) (**Figure 13**); and
- Combined off-site fatality risk (all causes) (**Figure 14**).

Figure 9 summarises the calculation of the frequency of an off-site fatality as a result of all causes. The off-site fatality frequency was calculated to be 5.07 x 10^{-6}/year. This is consistent with the NSW government industrial fatality risk criteria of 50 x 10^{-6}/yr.

Figure 14 summarises the calculation of the frequency of an on-site fatality as a result of all causes. The on-site fatality frequency was calculated to be 4.33 x 10^{-6}/year. This is consistent with the NSW government industrial fatality risk criteria of 50 x 10^{-6}/yr.

The probability of fatality at a local residential area is calculated to be 0.0.

The probability of injury at a local residential area is calculated to be 1.02 x 10^{-6}/year.
This is calculated as the product of:

- The probability of a serious off-site release event occurring = 1.02 x 10^{-5}/year (**Figure 7**); and
- The probability of unfavourable wind speed and direction = 1.00 x 10^{-1} (**Section 7.2.2.6**).

The probability of fatality at any neighbouring industrial site is calculated to be 1.38 x 10^{-6}/year.
This is calculated as the product of:

- The probability of a serious off-site release event occurring = 1.02 x 10^{-5}/year (**Figure 7**);
- The probability of unfavourable wind speed and direction = 1.50 x 10^{-1} (**Section 7.2.2.6**); and
- The probability of the receptor's inability to escape = 9.00 x 10^{-1} (**Table 17**).

The probability of fatality to a motorist or passer-by is calculated to be 3.67 x 10^{-6}/year.
This is calculated as the product of:

- The probability of a serious off-site release event occurring = 1.02 x 10^{-5}/year (**Figure 7**);
- The probability of unfavourable wind speed and direction = 4.00 x 10^{-1} (**Section 7.2.2.6**); and
- The probability of the receptor's inability to escape = 9.00 x 10^{-1} (**Table 17**).

The probability of fatality at the neighbouring commercial swim centre is calculated to be 2.75 x 10^{-7}/year.
This is consistent with the NSW government commercial fatality risk criteria of 5.0 x 10^{-6}/yr.
The fatality probability at the swim centre was calculated as the product of:

- The probability of a serious off-site release event occurring = 1.02 x 10^{-5}/year (**Figure 7**);
- The probability of unfavourable wind speed and direction = 3.00 x 10^{-2} (**Table 16**); and
- The probability of the receptor's inability to escape = 9.00 x 10^{-1} (**Table 17**).

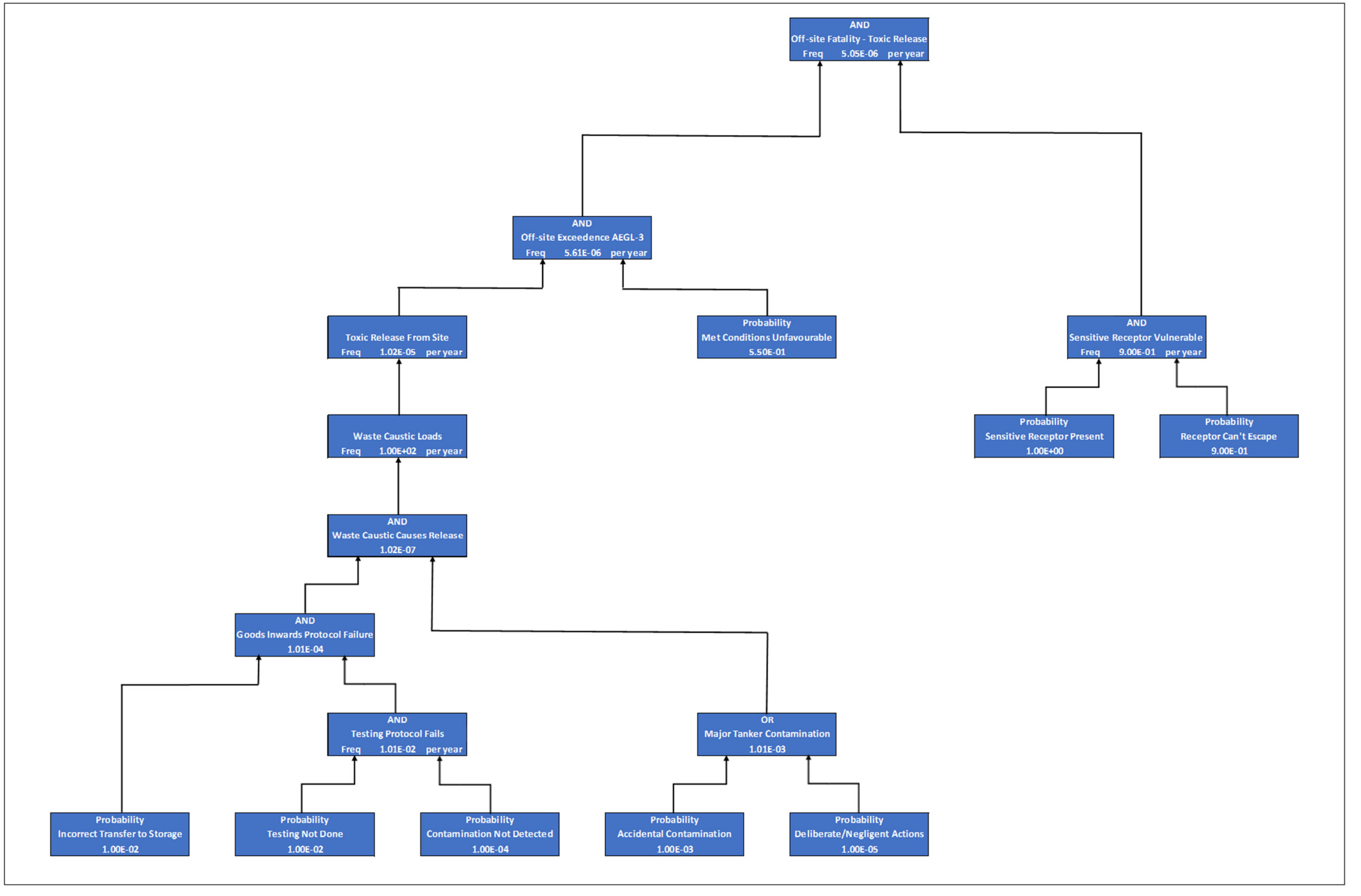

Figure 7: Fault Tree for Toxic Gas/Fume Emission Leading to Off-site Fatality

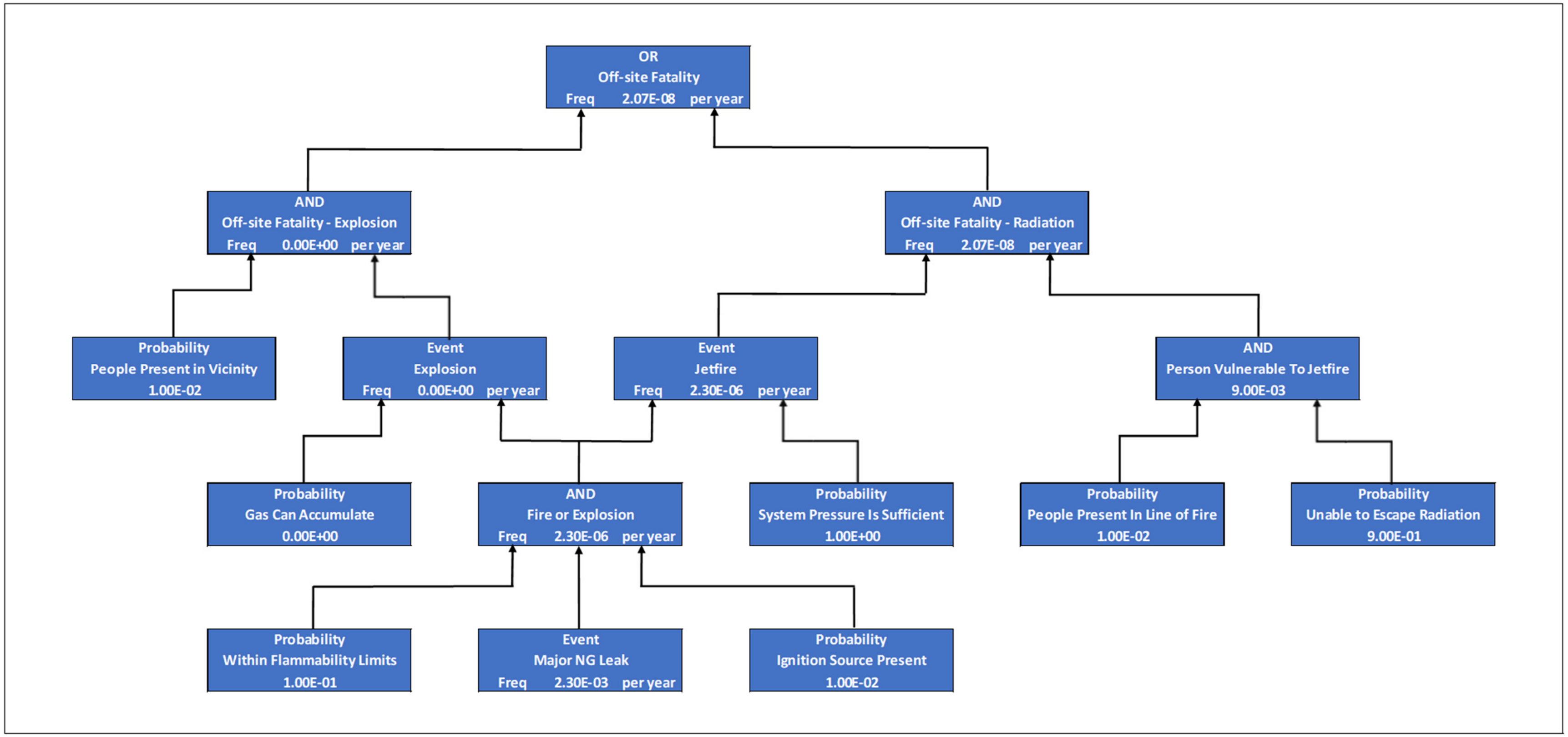

Figure 8: Fault Tree for Fire/Explosion Leading to Off-site Fatality

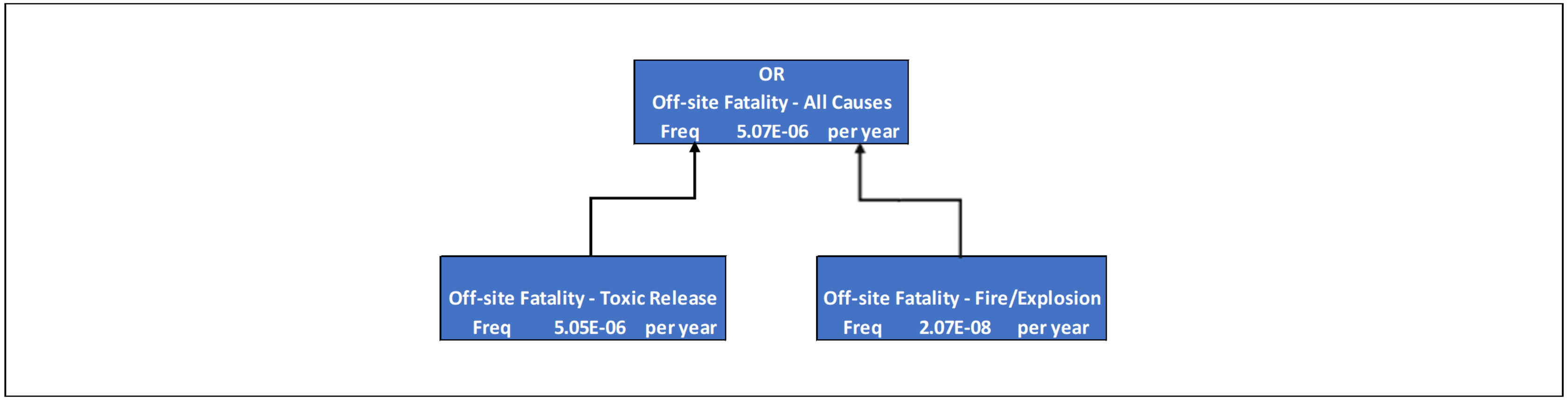

Figure 9: Fault Tree for an Off-site Fatality - All Causes

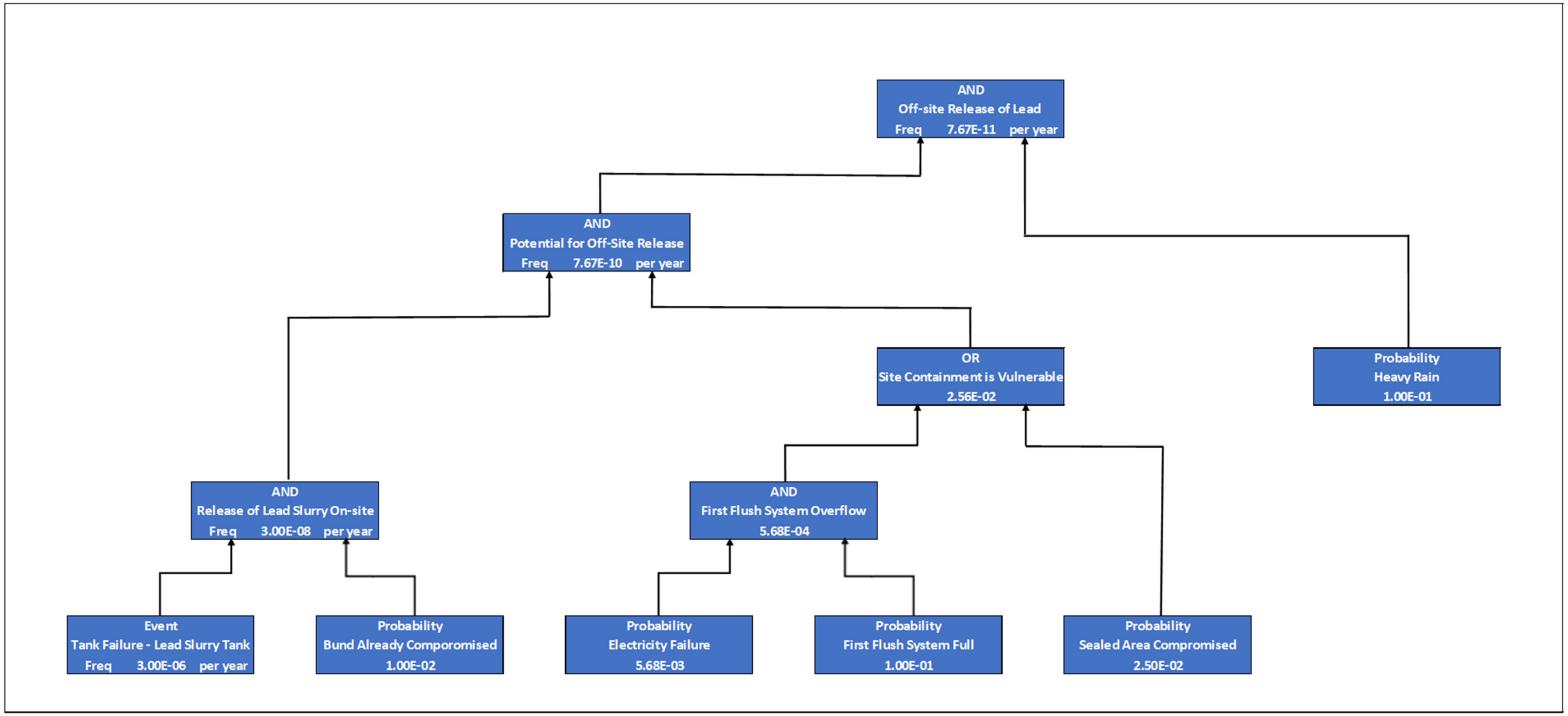

Figure 10: Fault Tree for an Off-site Release of Lead (Pb)

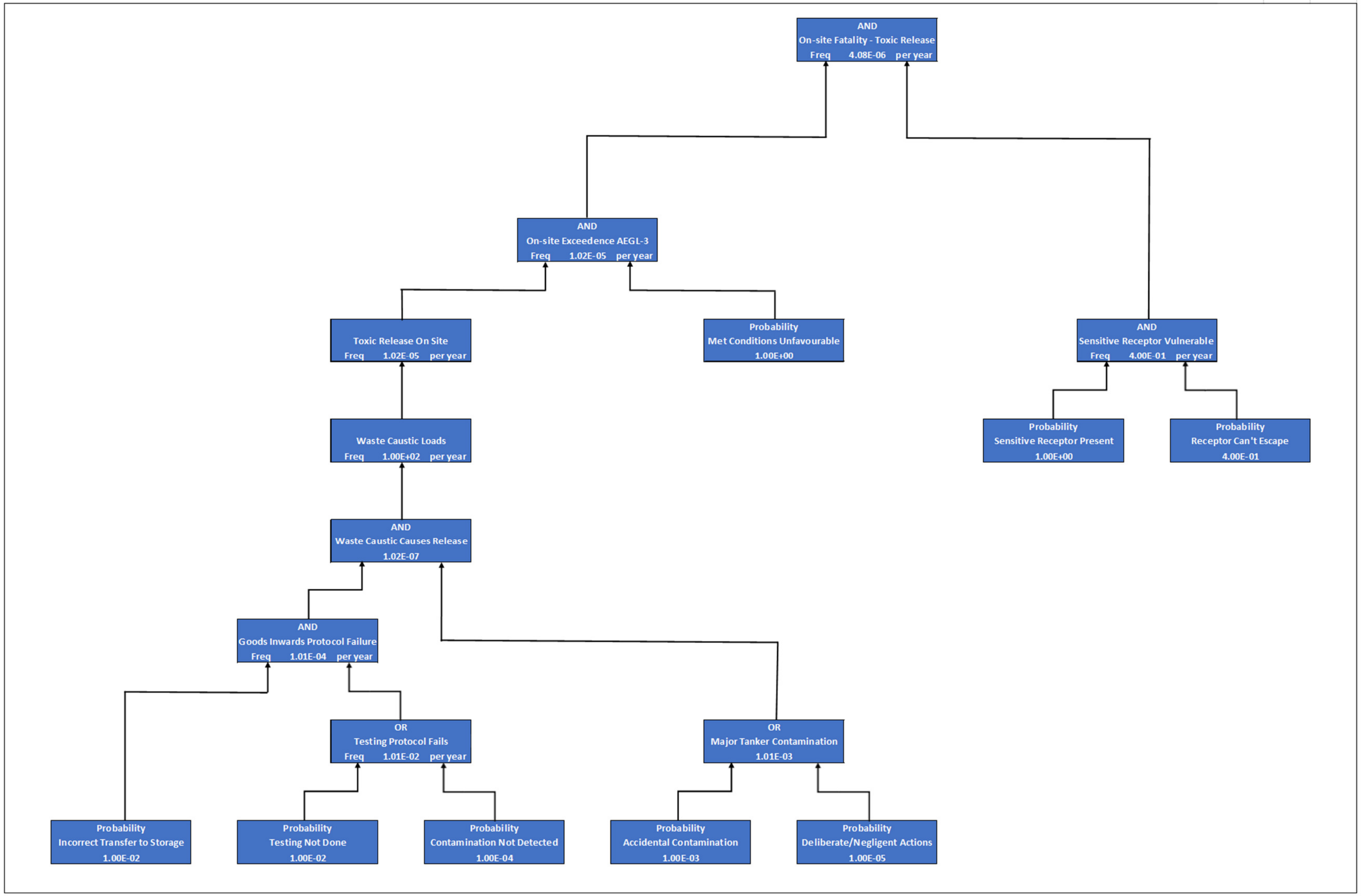

Figure 11: Fault Tree for Toxic Gas/Fume Emission Leading to On-site Fatality

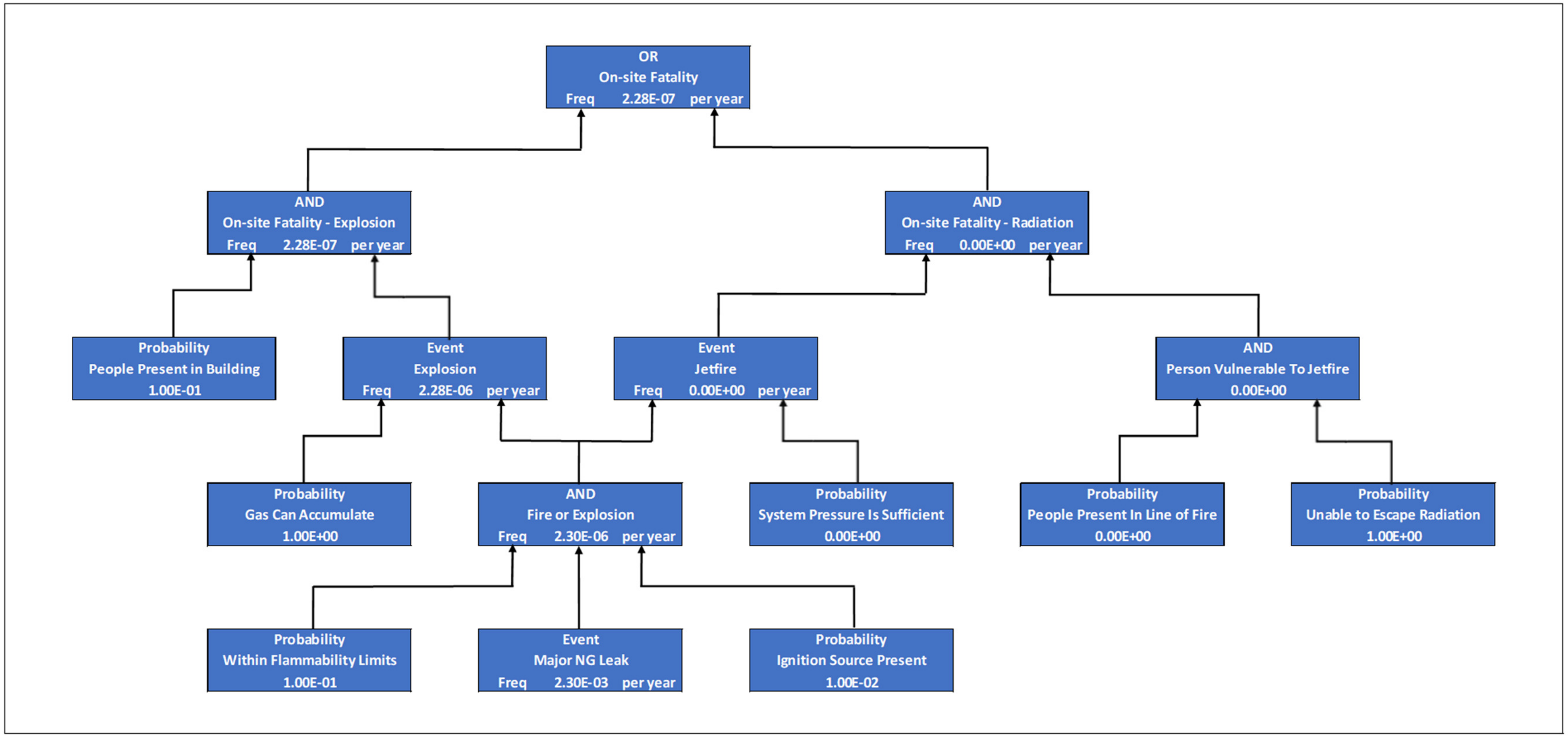

Figure 12: Fault Tree for Fire/Explosion Leading to On-site Fatality

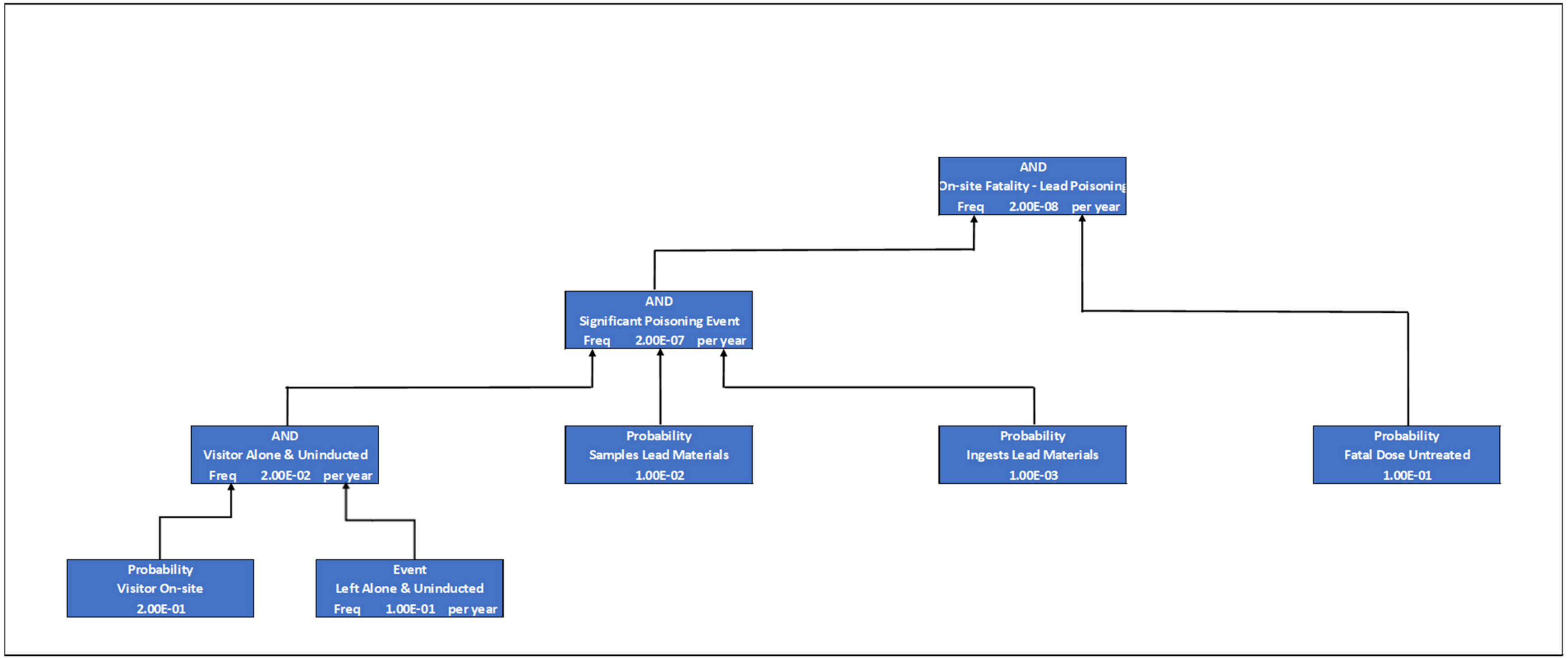

Figure 13: Fault Tree for Lead (Pb) Poisoning Leading to On-site Fatality

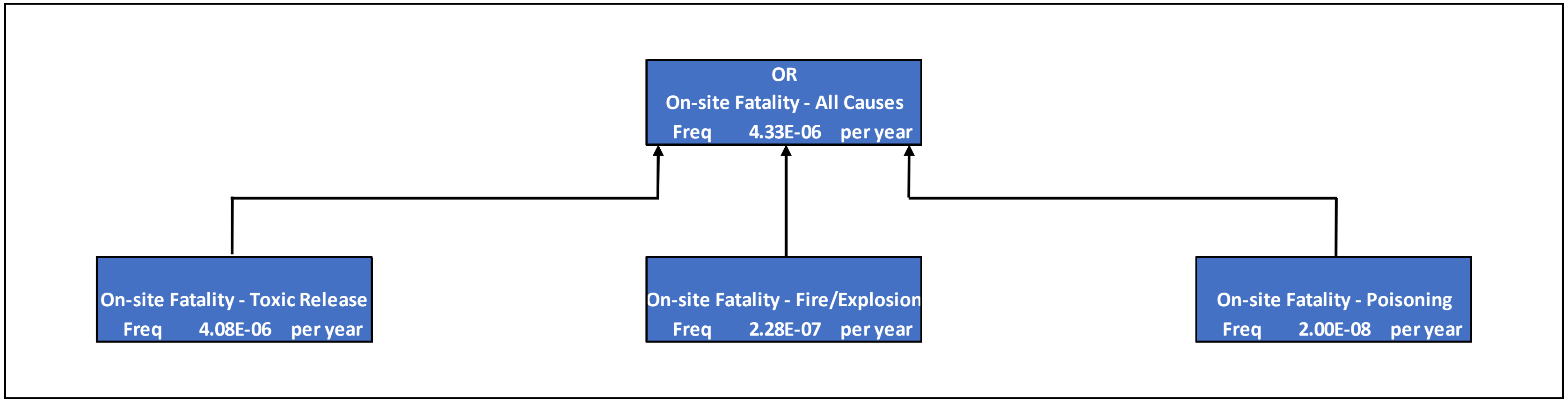

Figure 14: Fault Tree for an On-site Fatality - All Causes

9. ASSESSMENT OF RISK

9.1 Criteria For Off-Site Scenario Impacts

HIPAP No. 4 (Refer **Section 2, Reference 4** of original PHA document (EIS Appendix W)) articulates threshold fatality risk criteria to be applied in a quantitative assessment. In considering the potential for both off-site and on-site human fatality, it is necessary to understand the likelihood and frequency of adverse events arising from DGL Group's operations and the probabilities associated with relevant human movements and meteorological conditions. This section examines the individual fatality risk for the key scenarios listed in **Section 6** of the original EIS document. By definition 'individual fatality risk' is the risk of death to a person at a particular point.

Fatality Risk Criteria for Various Land Uses[1]

Land Use	Suggested Criteria (risk in a million per year)
Hospitals, schools, child-care facilities, old age housing	0.5
Residential, hotels, motels, tourist resorts	1
Commercial developments including retail centres, offices and entertainment centres	5
Sporting complexes and active open space	10
Industrial	50

[1] - NSW Department of Planning *Risk Criteria for Land Use Safety Planning* (2011, Section 2.4.2)

The individual fatality risk for industrial developments, should not be greater than 50 x 10^{-6} fatalities per year. Given the traffic and public utilisation of the SP2 corridor, a lower threshold may be considered more appropriate by NSW DPE. It should be noted that, irrespective of numerical risk criteria proposed, the broad aim should be to avert avoidable risk.

9.2 Potential For Domino Effects

The risk assessment workshop (summarised in **Section 6** of Appendix W within the original EIS document) determined the hazard scenarios with the greatest potential for off-site and on-site impacts are:

1. An explosion or jet fire resulting from a major natural gas leak on site;
2. Toxic gas release (eg SO_2) resulting from treatment of liquids containing high concentrations of dissolved gases;
3. Lead poisoning of personnel or a member of the public through exposure to lead bearing products; and
4. A release of lead bearing dust or slurry into the surrounding environment.

Each of these scenarios has been subsequently assessed for their individual potential consequence (**Section 7**) and likelihood (**Section 8**).

The incidence of any of scenarios 1, 2, 3 and 4 cannot create any plausible causal relationship with any other scenarios. These scenarios are consequently considered to be genuinely independent events without the potential for significant additional domino effects to result from their occurrence.

It is considered the independence of the scenarios 2, 3 and 4 is likely to be easily understood. The independence of a Scenario 1 event relates to the limitations around the available gas system pressure within the site and the relative remoteness of the higher-pressure upstream pipework located in the north east corner of the site.

9.3 ALARP Analysis – Societal Risk Assessment

HIPAP No. 4 also provides guidance with respect to societal risk criteria. The guidance or indicative societal risk criteria is reflected in three societal risk bands as presented on a frequency (F) vs number of fatalities (N) chart: negligible, As Low As Reasonably Practicable (ALARP) and intolerable. These three regions are indicated in **Figure 15**. It should be noted, *HIPAP No. 4* emphasises the criteria are indicative only. *HIPAP No. 4* indicates that "below the negligible line, provided other individual criteria are met, societal risk is not considered significant. Above the intolerable level, an activity is considered undesirable, even if individual risk criteria are met. Within the ALARP region, the emphasis is on reducing risks as far as possible toward the negligible line. Provided other quantitative and qualitative criteria of *HIPAP 4* are met, the risks from the activity would be considered tolerable in the ALARP region."

The distribution and density of surrounding populations and guidance threshold data published by NSW DPE forms the basis of the examination of the societal risk impacts.

The overall societal risk based on the methodology described in *HIPAP No. 4* is presented in **Figure 15**. The risk F vs N function is within the "Negligible" region when all of the risk scenarios are aggregated. The commitments and undertakings forwarded by DGL Group and the further actions outlined/discussed in the Hazard Assessment Workshops (See minutes in Appendix I of Appendix W within the original EIS document) are considered to reduce the risks to a minimum. It is considered the societal risk function, in combination with the actions and commitments already presented, constitute risk mitigation to the lowest level practicable for this development.

The dominant societal risk presented by operations at the site involves the release of toxic acid gases during periods of low prevailing wind speed. Given the analysis in **Section 7.2.2.5** and **Section 7.2.2.6**, the anticipated distance to the AEGL 3 contour (and potential fatality) will be restricted to a radius of 192 metres. The distance to the nearest residences in Unanderra and Figtree exceeds 500 metres.

The potential for fatalities to occur involves the presence of significant populations being present within the AEGL 3 contour and a failure for the population to escape. The most likely scenario involves traffic on Five Islands Road. Based upon probable population densities, it is estimated there is a:

- 10% chance that 10 individuals would be fatally overcome within the AEGL 3 contour; and
- 0.5% chance that 100 individuals would be fatally overcome within the AEGL 3 contour.

Figure 15 shows the F vs N function is within the negligible region given the probability and frequency associated with the scenario.

It is considered the description "Negligible Risk" applies to societal risks associated with the DGL Group Unanderra facility, provided the following factors are maintained at a high standard:

- The level of supervision of operations and testing of consignments involving hazardous chemicals at the site; and
- The management practices associated with identifying and properly segregating the various classes of hazardous chemicals.

Significant changes to these practices/factors would be considered likely to introduce greater risk than those accounted for in this analysis.

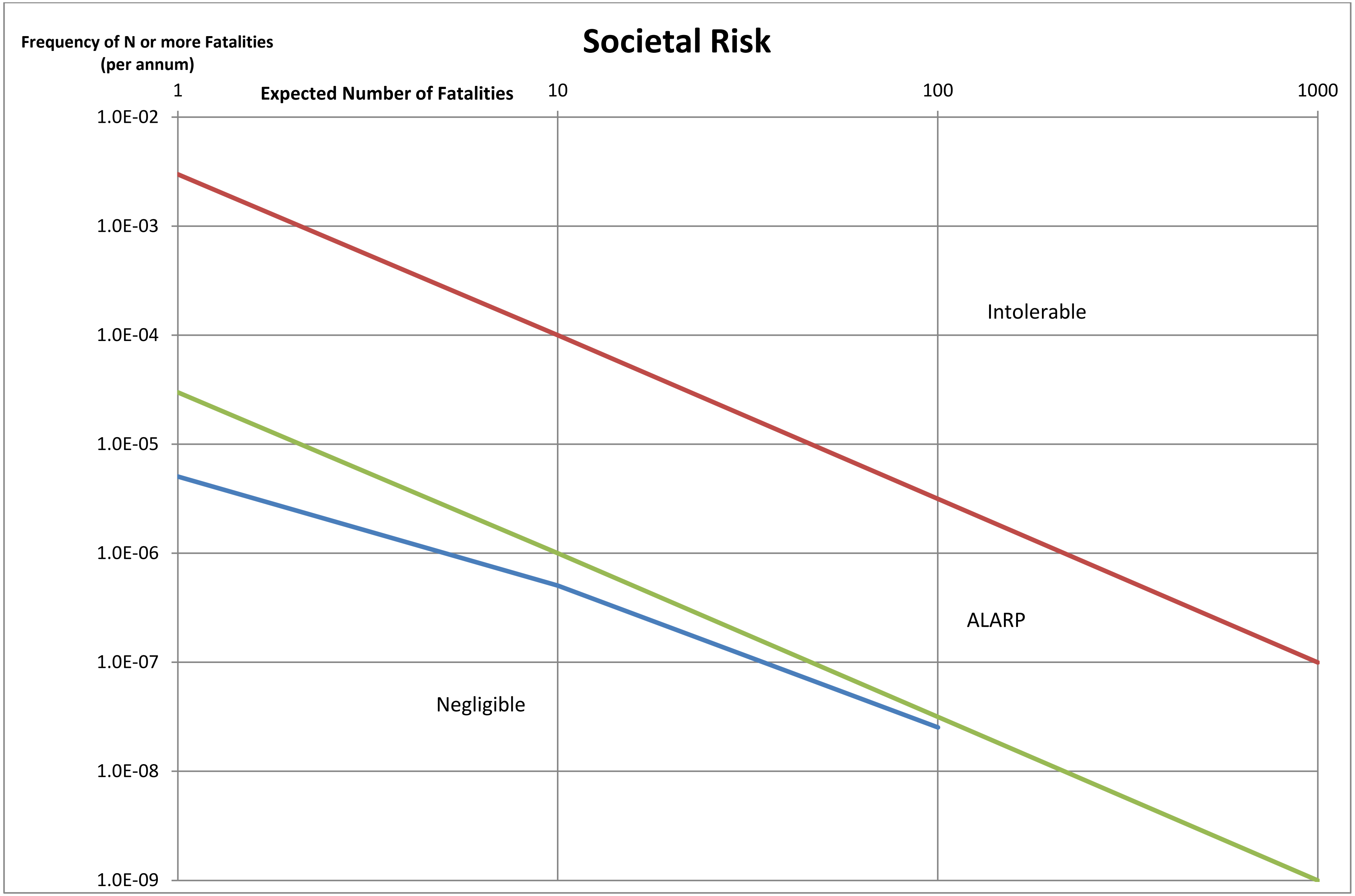

Figure 15: ALARP/Societal Risk Chart For DGL Group Unanderra

10. CONCLUSION

All risks identified during the facilitated risk assessments as having potential for off-site impacts have been qualitatively assessed.

Two (2) hazard scenarios identified have the potential to cause off-site impacts.

This report has determined that on-site and off-site risk is within (i.e. less than) the maximum risk acceptability criteria (i.e. 50 x 10-6 fatalities per year) as outlined by the NSW hazard planning guidelines.

Under the scope of this assessment, the proposed development for the site will not increase the overall risks to levels exceeding the recommended guideline thresholds published within *NSW Department of Planning - Hazardous Industry Planning Advisory Paper No.4 – Risk Criteria for Land Use Planning:2011* (Refer **Section 2**, **Reference 4** of original PHA document (EIS Appendix W))).

The existing (background) off-site fatality risk profile attributable to the BRP plant is negligible based upon the nature and scale of the unit processes undertaken. It should be recognised the LWTP development will increase the on-site and off-site fatality and injury risk profile of the DGL Group Unanderra facility at 210 Five Islands Road, Unanderra; but off a negligible base. Given the only conceivable off-site fatality consequences associated with the DGL Group Unanderra site (post the LWTP development) involve aspects of the LWTP development, the LWTP development does contribute significantly to what will remain, a low off-site fatality risk

The post-LWTP development societal risk associated with the site is considered acceptable and within the negligible region of the societal risk chart. (See **Figure 15**, **Section 9**)