Port Kembla Bulk Liquids Terminal
(SSD 7264 - MOD1)

APPENDIX A

REVISED SITE LAYOUT

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00.04	DATE: 18/11/2016	CHANGE APPROVAL No: -
DRAWING STATUS: PRELIMINARY - NOT FOR CONSTRUCTION		
MINOR UPDATES TO ANNOTATION - - -		
DRAWN: J. KOLOSKI	CHECKED: -	
O/No, CONT. NAME & REF No: -		
CONT. APPR: -		
TQ RE: -	TQ RA: -	

00.03	DATE: 26/10/2016	CHANGE APPROVAL No: -
DRAWING STATUS: PRELIMINARY - NOT FOR CONSTRUCTION		
MINOR UPDATES TO LAYOUT - - -		
DRAWN: J. KOLOSKI	CHECKED: -	
O/No, CONT. NAME & REF No: -		
CONT. APPR: -		
TQ RE: -	TQ RA: -	

00.02	DATE: 25/10/2016	CHANGE APPROVAL No: -
DRAWING STATUS: PRELIMINARY - NOT FOR CONSTRUCTION		
UPDATED LAYOUT - - -		
DRAWN: J. KOLOSKI	CHECKED: -	
O/No, CONT. NAME & REF No: -		
CONT. APPR: -		
TQ RE: -	TQ RA: -	

DRAWING REVISIONS

	RESPONSIBLE ENGINEER: -	CONTRACTOR IDENTIFICATION	DRAWN (COMPANY): J.KOLOSKI	DATE DRN: 15/09/16
	APPROVAL: -		CHECKED (POSITION): -	DATE CHK: -
CONTRACTOR/COMPANY NAME: -	CONTRACTOR REF No: -		RESPONSIBLE ENGINEER (POSITION): -	DATE ENG: -
FBS CODES: - - - - -	REFERENCE DRAWINGS: - - - - - -		REGISTRATION APPROVAL (POSITION): -	DATE APP: -
			TQ REF No: -	

PORT KEMBLA BULK LIQUIDS TERMINAL
SITE WIDE
DA MODIFICATION LAYOUT COMPARISON
-
-

FILE NAME: SK90012-017.DWG	SCALE: 1:1250	A1	DRAWING No: **SK90012-017**	
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AUTOCAD

Port Kembla Bulk Liquids Terminal
(SSD 7264 - MOD1)

APPENDIX

B

PRELIMINARY HAZARD ANALYSIS

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PORT KEMBLA BULK LIQUIDS TERMINAL

STAGE 1 AND 2 DEVELOPMENT

PRELIMINARY HAZARD ANALYSIS

TQ HOLDINGS AUSTRALIA PTY LTD

PREPARED FOR:	**Alex Larance** **Cardno Project Co-ordinator**
TQ DOCUMENT NO:	**PJ-PK-0001-REPT-022**
SHERPA DOCUMENT NO:	**21089-RP-001 Rev 1**
REVISION:	**1**
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Sherpa Consulting Pty Ltd (ABN 40 110 961 898)
Phone: 61 2 9412 4555
Web: www.sherpaconsulting.com

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Preliminary Hazard Analysis Port Kembla Bulk Liquids Terminal Stage 1 and 2 development	H de Vries
	Date: 21-Nov-2016

CONTENTS

TABLES

FIGURES

ABBREVIATIONS

AAT	Australian Amalgamated Terminal
ADG	Australian Dangerous Good
API	American Petroleum Institute
AS	Australian Standard
AWS	Automatic Weather Station
BoM	Bureau of Meteorology
DA	Development Application
DG	Dangerous Goods
DPE	Department of Planning & Environment
EIS	Environmental Impact Statement
ESD	Emergency Shutdown
FRNSW	Fire and Rescue New South Wales
FSS	Fire Safety Study
HAZID	Hazard Identification
HIPAP	NSW Hazardous Industry Planning Advisory Paper
IBC	Intermediate Bulk Container
IFR	Internal Floating Roof
LFL	Lower Flammability Limit
MHF	Major Hazard Facility
ML	Mega Litres
MLA	Marine Loading Arm
MOC	Management of Change
NSW	New South Wales
OGP	Oil and Gas Producers
NFPA	National Fire Protection Association
PHA	Preliminary Hazard Analysis
PG	Packaging Group
PKBLT	Port Kembla Bulk Liquids Terminal
PKCT	Port Kembla Coal Terminal
QRA	Quantitative Risk Assessment
RTS	Response To Submission
SCADA	Supervisory Control and Data Acquisition
SEARs	Secretary's Environment Assessment Requirements
SEPP	State Environmental Planning Policy
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SRS	Safety Requirement Specification

SSD	State Significant Development
UK HSE	United Kingdom Health and Safety Executive
VCA	Vapour Cloud Assessment
VCE	Vapour Cloud Explosion
VRU	Vapour Recovery Unit
WHS	Work Health Safety

1. SUMMARY

1.1. Background

TQ Holdings Australia Pty Ltd (TQ Holdings) is planning to develop a bulk liquids terminal within the New South Wales (NSW) Ports precinct at Port Kembla, Australia. TQ Holdings has identified 3 sites (Figure 3.1) and plans to develop the terminal on the sites in a number of stages. The proposed development will be located in the vicinity of the Port Kembla Coal Terminal (PKCT), GrainCorp Grain Terminal, Quattro Grain Terminal and Australian Amalgamated Terminal (AAT).

In 2015, Cardno Limited (Cardno) prepared an Environmental Impact Statement (EIS) for the development of the Port Kembla Bulk Liquids Terminal (PKBLT) at the end of Stage 3 (all three sites developed). As part of the EIS, Cardno engaged Sherpa Consulting Pty Ltd (Sherpa) to undertake a Preliminary Hazard Analysis (PHA) to assess the risks associated with the Stage 3 development (Ref.1). The Development Application (DA) has since been approved by Department of Planning and Environment (DPE). The approved DA is supported by the original EIS (Ref. 2) and the Response To Submission (RTS) report (Ref. 3) (Approval Number 15_7264).

TQ is seeking to submit a modification to the approved DA for PKBLT. The proposed modifications include:

- Consolidation of development staging into two stages consisting of:
  - Stage 1 – Immediate capacity terminal located at Sites 2 and 3. At completion of this stage, the terminal will have a storage capacity of 144 ML of combustible and flammable liquids.
  - Stage 2 – Addition of combustible and flammable bulk liquids storage and pump bay located at Site 1. Site 1 will not be developed during the proposed Stage 1 and development for Site 1 would occur as approved during Stage 2. At completion of this stage, the terminal would have a total storage capacity of 275 ML of combustible and flammable liquids.
- Minor alterations to the design and layout of Site 2.

All other project details remain as approved in the EIS and RTS documents.

TQ has engaged Sherpa, via Cardno, to prepare this PHA to support the modification to the DA.

This PHA covers the steps and findings of the risk analysis for Stage 1. The report also contains the risk contours for the Stage 2 development (refer to Section 10.4) to allow for comparison with the risk contours presented in the PHA for the approved DA (Ref. 1).

1.2. Objective

The primary objective of this report is to address the 'hazard and risk' component of the Secretary's Environment Assessment Requirements (SEARs) for the Stage 1 development as follows:

- Conduct a preliminary risk screening in accordance with State Environmental Planning Policy (SEPP) 33 analysis.
- Conduct a PHA in accordance with *Hazardous Industry Planning Advisory Paper 6* (HIPAP 6) '*Guidelines for Hazard Analysis'* and Multi-Level Risk Assessment.
- Identify the hazards associated with the existing site and proposed development, as well as any external hazards (i.e. natural hazards).
- Address all relevant recommendations arising from the Buncefield accident.
- Demonstrate that the proposed development complies with the criteria set out in *HIPAP No 4 – Risk Criteria for Land Use Safety Planning.*
- Estimate the cumulative impacts from the overall site and the surrounding potentially hazardous developments in the area (if any) and demonstrate that the proposed development does not increase the cumulative risk of the area to unacceptable levels.

The secondary objective of this report is to compare the fatality and escalation risk contours for the Stage 2 development (associated with the modification) and the risk contours from the approved DA (Ref. 1).

1.3. Scope

This PHA covers development of risk contours for the Stage 1 development.

Stage 2 risk contours were also developed based on:

- Risk contours determined from this PHA ie site 2 (storage and handling) and site 3 (utilities and logistics support)
- Site 1 risk contours in the PHA for the approved DA (Ref. 1).

An evaluation of the impacts of the transport of Dangerous Goods (DG) to and from the site was covered in the Traffic Impact Assessment section of the EIS and is not covered in this report.

1.4. Study methodology

The 'Hazards and Risk' requirements of the SEARs were met using the following methodology:

- A SEPP 33 analysis was completed for Stage 1. The analysis involved obtaining the list and quantities of dangerous goods that are proposed to be stored onsite and transported by road tankers and comparing with the threshold quantities to determine whether a PHA and transport risk assessment are required. The SEPP 33 analysis involved assessing the proposed site as a '*potentially hazardous'* installation only. Assessment as '*potentially offensive'* is covered in another section of the EIS. Stage 2 development includes additional storage of dangerous goods. The SEPP 33 analysis was conducted for the Stage 2 development as part of the original EIS submission (Ref. 1) and does not change the assessment.

- Based on the screening, a PHA was conducted in accordance with HIPAP 6 'Guidelines for Hazard Analysis' (Ref.4). PHA is a land use planning tool. The steps in the PHA are:
  - Hazard Identification (HAZID) study – To identify the hazards, causes, consequences and safeguards. The findings allowed identification of hazards associated with the proposed development and hazardous scenarios that have the potential for offsite impact.
  - Consequence Analysis – To determine the impact area of the hazardous scenarios and the resulting extent of injury or fatality effects.
  - Frequency Analysis – To determine the likelihood of each loss of containment and ignition scenario using historical leak frequency data.
  - Risk Analysis and Evaluation – To establish whether the offsite risk levels comply with the risk criteria in the NSW DPE HIPAP 4 'Risk Criteria for Land Use Safety Planning' (Ref.5), which covers:
    - Injury, irritation and fatality risks to offsite land uses, expressed as individual risk
    - Risk of property damage and accident propagation to neighbouring hazardous installations.
- The impact of external hazards on the site was captured in the HAZID and has been considered in the site design through the use of relevant standards.
- The approach adopted to address the recommendations from the Buncefield accident which are relevant to the site are provided in APPENDIX G.
- Cumulative impacts from the overall site and the surrounding potentially hazardous developments in the area were assessed qualitatively.

1.5. Findings

1.5.1. SEPP 33 analysis

The SEPP 33 analysis found that the quantities of Class 3 Packaging Group (PG) II materials, ie gasoline, stored onsite exceeded the threshold quantities stated in the SEPP 33 guideline (Ref.13). The proposed development is '*potentially hazardous'* and a PHA study is required.

The SEPP 33 analysis also found that a transport route evaluation study is required as weekly vehicle movements of Class 3 PG II materials are above the SEPP 33 transport screening threshold levels. This requirement is addressed in the Traffic Impact Assessment by Cardno in accordance with HIPAP No. 11 guideline.

1.5.2. Preliminary Hazard Analysis

1.5.3. Stage 1 development

A quantitative PHA was completed for the preliminary design of the Stage 1 development. The PHA included external hazards.

The results of the PHA are compared with the HIPAP 4 criteria in Table 1.1.

Table 1.1: Summary of compliance of HIPAP 4 risk criteria

Description and land use	HIPAP 4 Criteria (per year)	Criterion Met
Individual fatality risk		
Hospitals, child-care facilities and old age housing (sensitive land use).	5×10^{-7}	Yes
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1×10^{-6}	Yes
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres (commercial land use).	5×10^{-6}	Yes
Sporting complexes and active open space areas (recreational land use).	1×10^{-5}	Yes
For industrial sites, individual fatality risk level should, **as a target**, be contained within the boundaries of the site where applicable.	5×10^{-5}	No Note 1
Injury risk – heat radiation exceeding 4.7 kW/m²		
Residential and sensitive use.	5×10^{-5}	Yes
Injury risk – explosion overpressure exceeding 7 kPa		
Residential and sensitive use.	5×10^{-5}	Yes
Risk of property damage and accident propagation – 23 kW/m² heat flux		
Neighbouring potentially hazardous installations or at land zoned to accommodate such installations.	5×10^{-5}	No Note 1
Risk of property damage and accident propagation – 14 kPa explosion overpressure		
Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings.	5×10^{-5}	Yes
Note. 1. See discussion on the following page under 'Damage and propagation (escalation) risk' heading.		

Injury risk

Injury heat radiation and explosion overpressure contours, conservatively approximated to be within the Lower Flammability Limit (LFL) cloud, do not extend into the nearest residential and sensitive land use areas. Therefore, the PKBLT site meets the HIPAP 4 injury risk criteria.

Individual fatality risk

Figure 1.1 shows the individual fatality risk contours for the PKBLT site Stage 1 development.

The 5 x 10^{-5} per year individual fatality risk contour extends into the Gurungaty waterway east of Site 2 (up to 10 m from site boundary). The main risk contributor is a jet fire from the road tanker loading gantry area.

This does not meet the **target** of retaining the risk contour within the site boundary where applicable.

The following points are noted:

- Fire detection is provided in the road tanker loading bay area. A terminal ESD will be activated on fire detection stopping the gantry loading pumps and closing tank actuated valves. The jet fire will rapidly reduce in size limiting the duration of any offsite impact.
- The affected area is a shallow waterway, which precludes ship or boat access, and is within the port area, which restricts public access.
- The site is elevated approximately 3 m above the waterway providing additional protection from an incident. Hence it is considered unlikely people will be present in this area and exposed to the risk.

Property damage and accident propagation (escalation) risk

Figure 1.2 shows the escalation risk contours for heat radiation for the PKBLT site Stage 1 development. The 5 x 10^{-5} per year heat flux escalation risk contour extends into the Gurungaty waterway east of Site 2 (up to 10 m from site boundary). The main risk contributor is a jet fire from the road tanker loading gantry area. The criteria applies to neighbouring potentially hazardous installations or land zoned to accommodate such installations. The land does not currently contain a potentially hazardous facility and given its nature (shallow, narrow, water way) it is not considered credible that a potentially hazardous facility will be constructed on the boundary.

Figure 1.3 shows the 5 x 10^{-5} per year contour associated with the LFL cloud to represent the maximum extent of the explosion overpressure and the risk of damage and propagation to neighbouring potentially hazardous installations. The risk contour associated with LFL cloud is retained within the Site 2 boundary and meets the HIPAP 4 risk criteria.

All 30 kL, 50 kL and 1.5 ML tanks were modelled in flammable service. This shows that the fatality and escalation risk contours comply with HIPAP 4 criteria if these tanks are in flammable liquid service.

1.5.4. Stage 2 development

Individual fatality and property damage and propagation risk contours were constructed for the Stage 2 development based on the risk contours associated with the Stage 1 development (ie Site 2 layout modification) and Site 1 risk contours from the PHA for the approved DA (Ref. 1). The Stage 2 development fatality and propagation risk contours are presented in Figure 1.4 and Figure 1.5 respectively. This shows that the HIPAP 4 criteria compliance conclusions are the same as that reported in Table 1.1 for Stage 1.

As identified in the PHA (Ref. 1) for the approved DA (Approval SSD 15_7264), the 5×10^{-5} per year risk escalation contour extends into the land north of Site 1 (up to 5 m from site boundary). The area is zoned to accommodate potentially hazardous installations. It is noted that there is currently no equipment, structures or dangerous goods in the area the risk contour extends into, and the PHA is based on a preliminary design of the site.

As the detailed design progresses, particularly for the Site 1 pump bay area, further refinements to the design to minimise risks associated with this section of the plant would be incorporated in accordance with the current consent conditions.

1.5.5. Comparison with risk contours in approved DA

The fatality and propagation risk contours associated with the approved DA are presented in Figure 1.6 and Figure 1.7 respectively.

The comparison of fatality risk contours associated with the Stage 2 development (Figure 1.4) and the approved DA (Figure 1.6) shows that the contours around Site 2 have been reduced and do not extend as far into the waterway and into the Graincorp site. This is due to the redesign of Site 2 for this modification ie relocation of shoreline and separation into north and south bunds. The risk contours around the berth and Site 1 have not changed from the approved DA.

The comparison of escalation risk contours associated with the Stage 2 development (Figure 1.5) and the approved DA (Figure 1.7) shows that the contour around Site 2 have increased around the loading gantry and new pump bay area due to the higher pump online time. However, this still meets HIPAP 4 criteria.

1.5.6. Buncefield recommendations

Sherpa has provided a table of Buncefield recommendations in APPENDIX G. For each recommendation, the corresponding status for the PKBLT site is provided. TQ Holdings should ensure that the recommendations are addressed as the detailed site design is finalised.

1.5.7. Cumulative risk

There is currently no integrated risk model publicly available for the port area. Therefore, the risk that PKBLT site adds to the cumulative risk profile for the area was assessed qualitatively in relation to the adjacent coal stockpiles and grain silos. As coal stockpile fires, and coal and grain dust explosion consequences typically remain onsite, there is low cumulative risk in the area. Risk contours from PKBLT are unlikely to increase the risk of the area.

Figure 1.1: Individual fatality risk contours – Stage 1

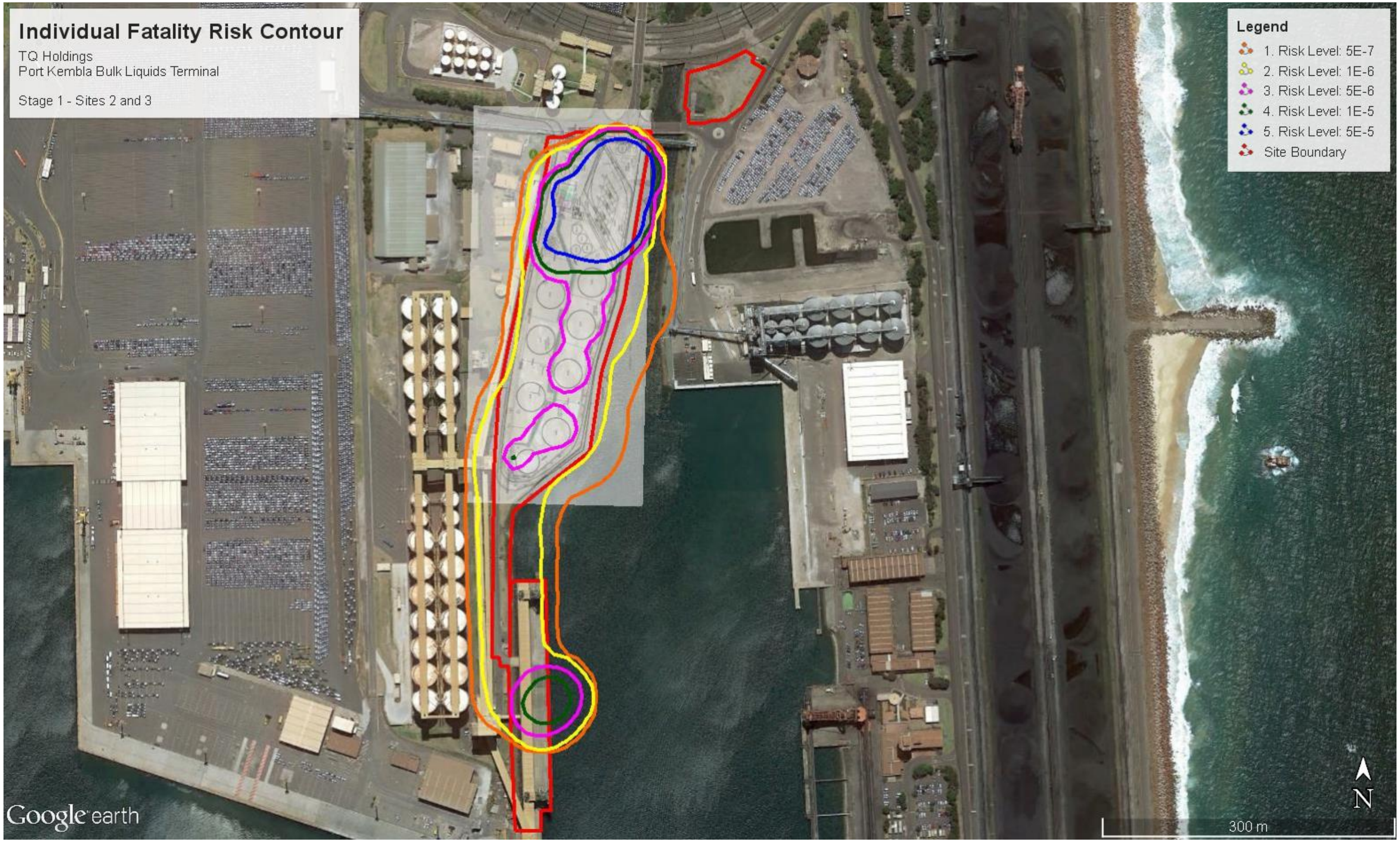


Figure 1.2: Escalation heat radiation damage and propagation risk contour – Stage 1

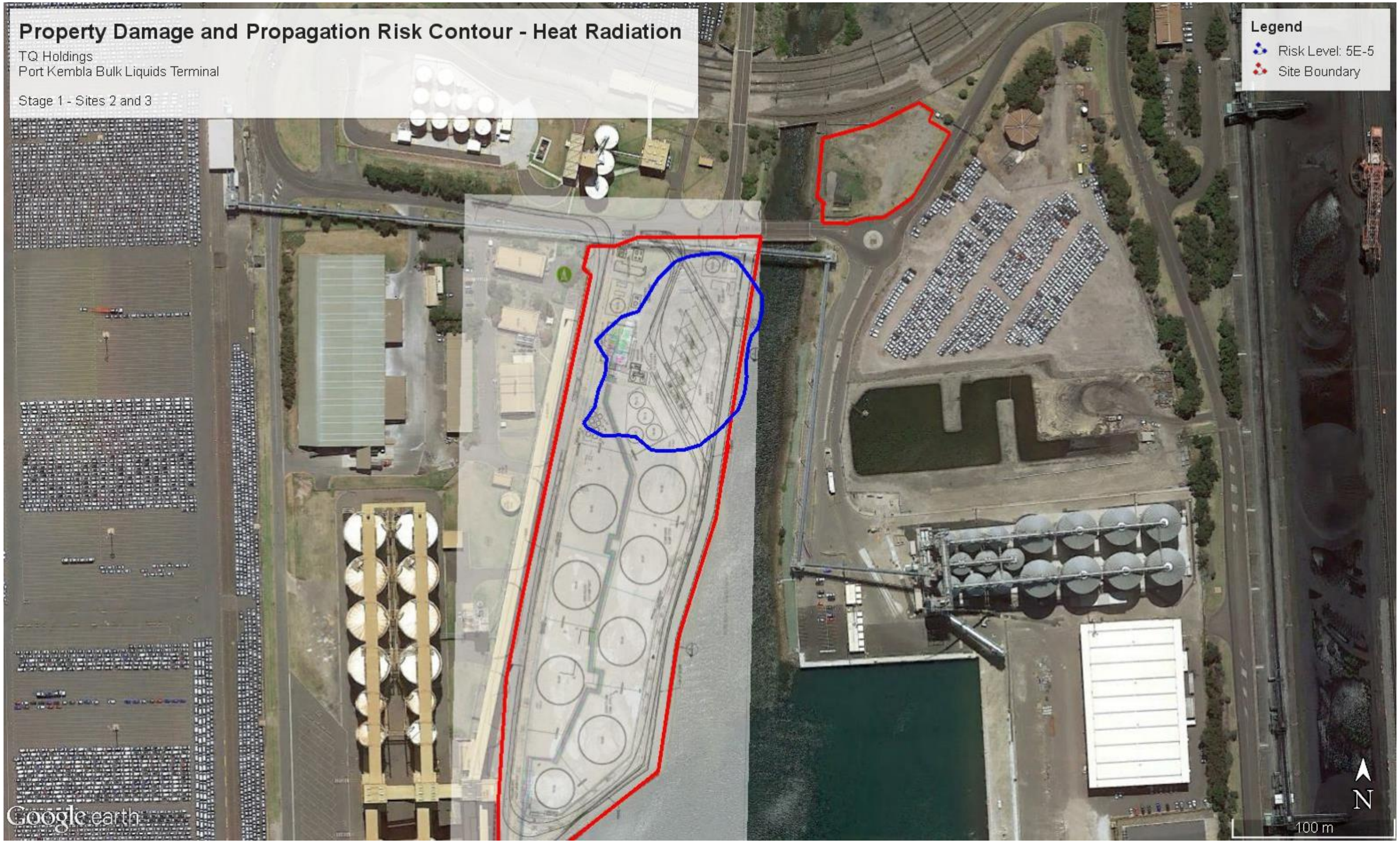


Figure 1.3: LFL cloud damage and propagation risk contour – Stage 1

Figure 1.4: Individual fatality risk contours – Stage 2

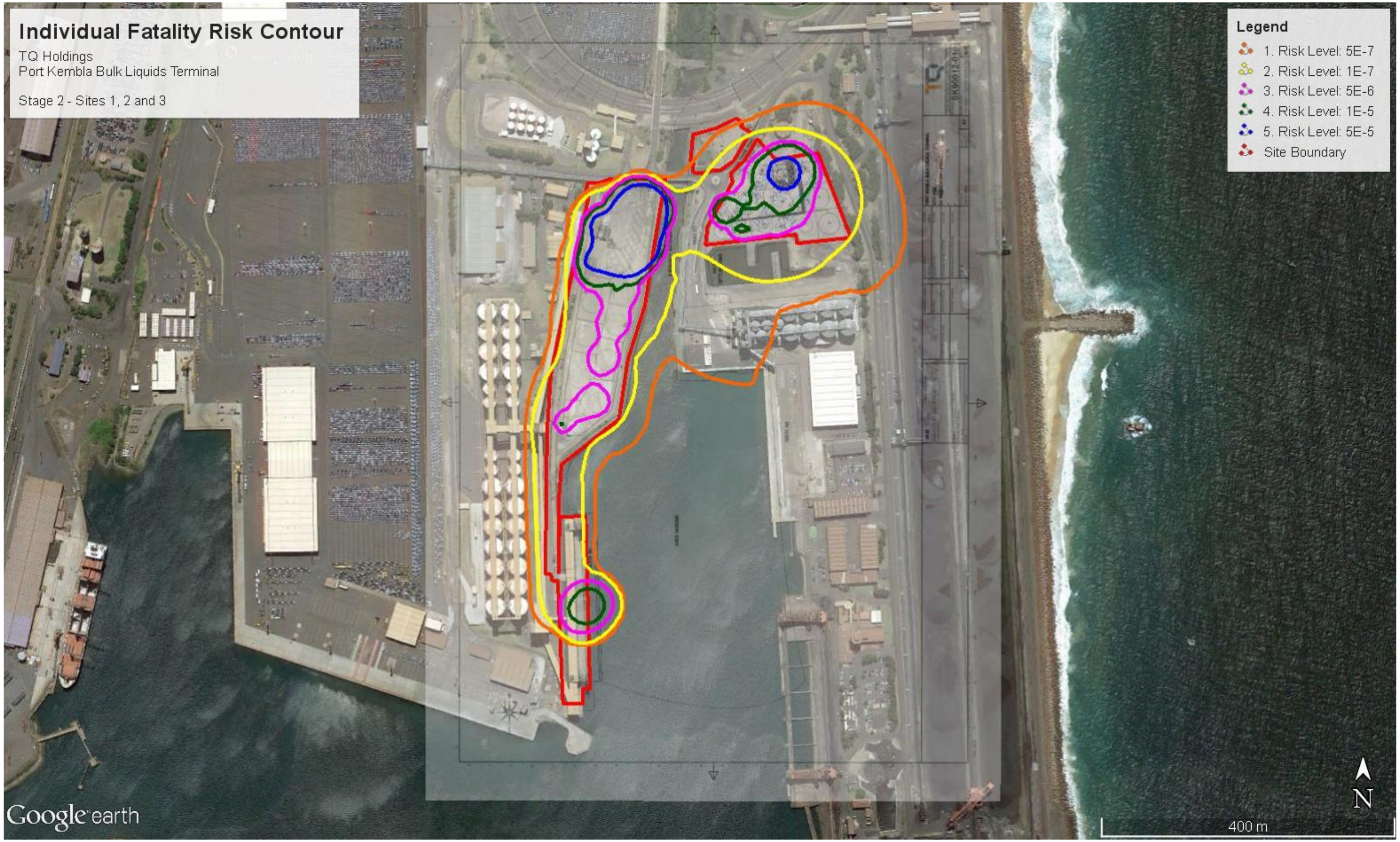


Figure 1.5: Escalation heat radiation damage and propagation risk contour – Stage 2

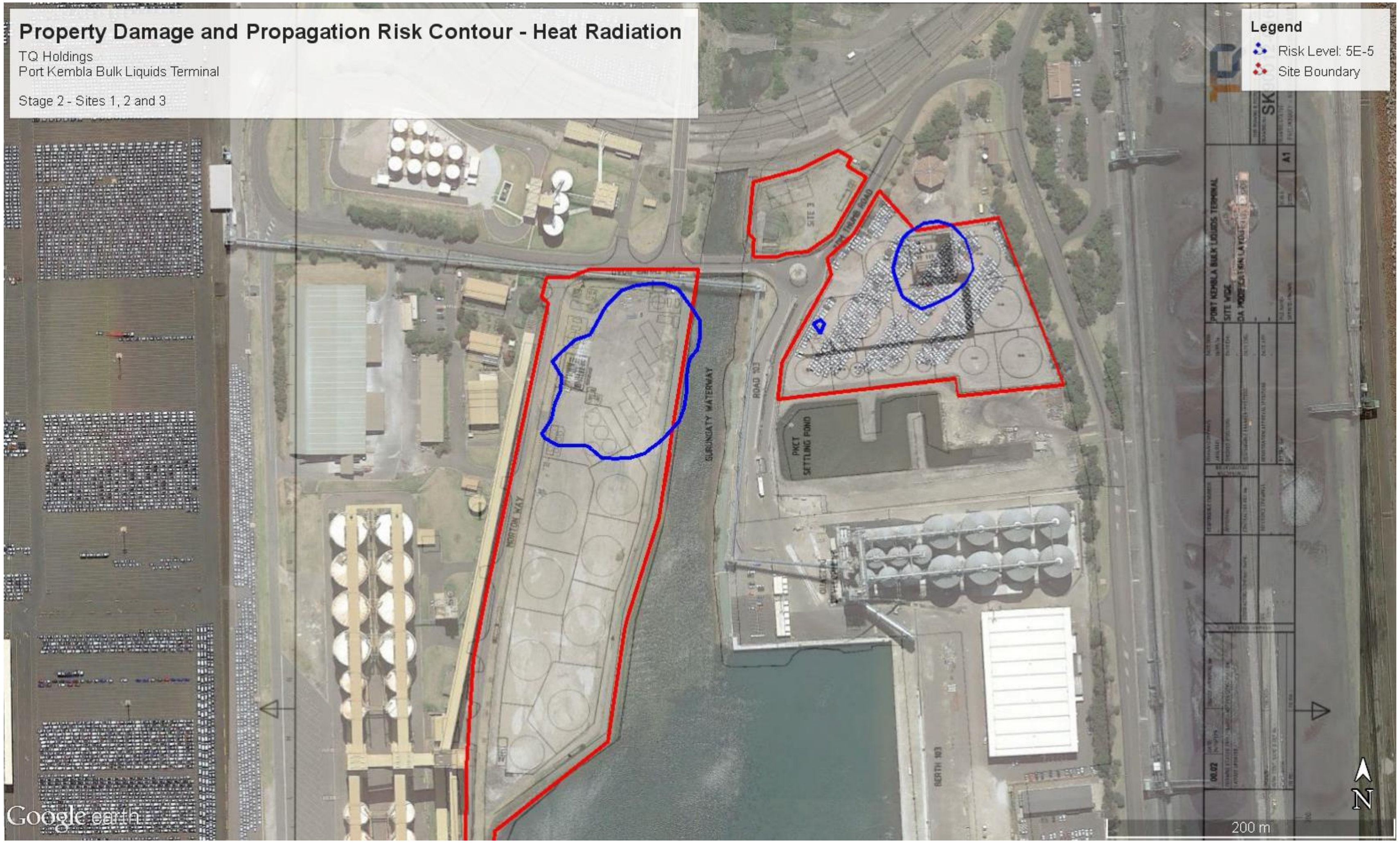


Figure 1.6: Individual fatality risk contours – Approved DA

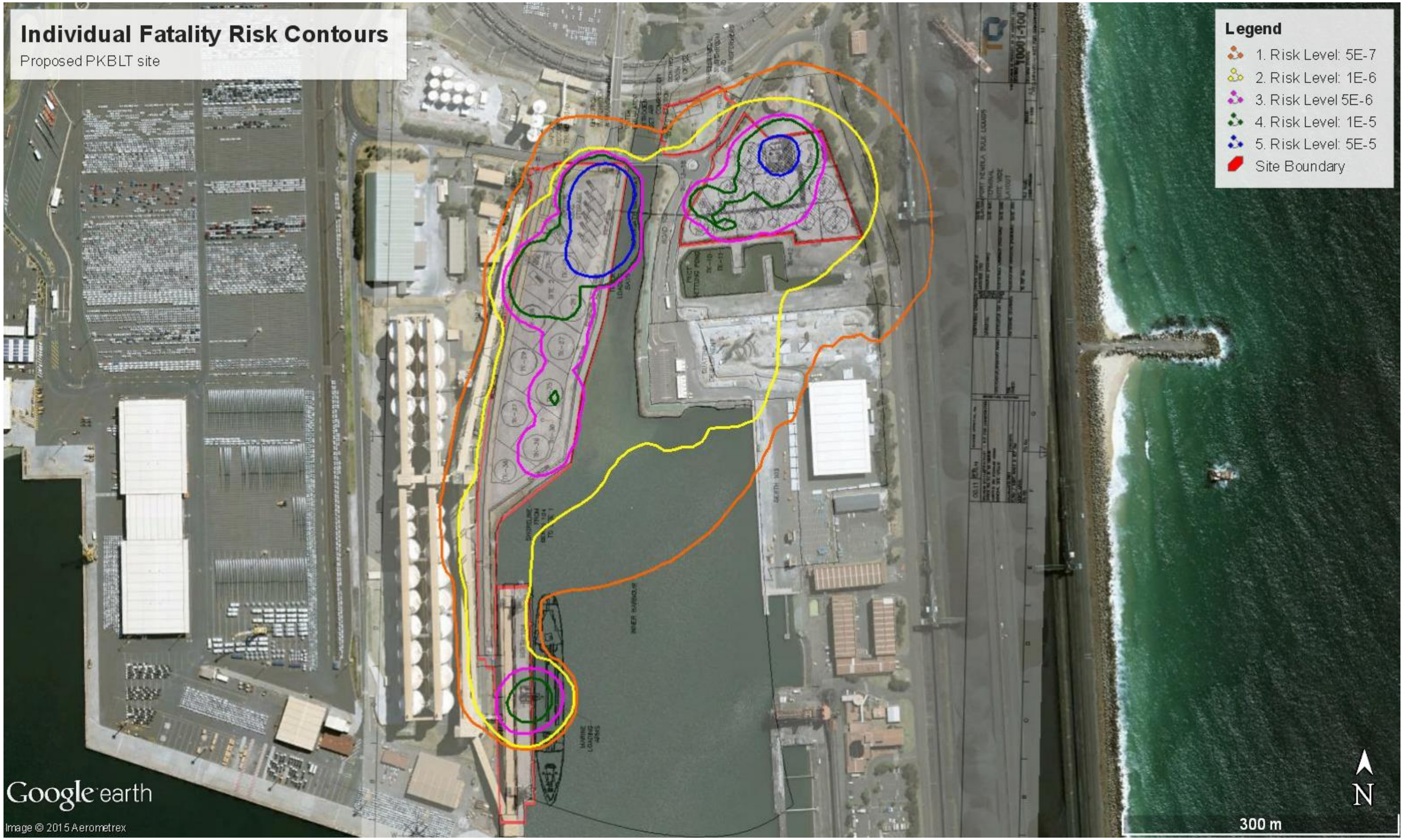


Figure 1.7: Escalation heat radiation damage and propagation risk contour – Approved DA

2. INTRODUCTION

2.1. Background

TQ Holdings Australia Pty Ltd (TQ Holdings) is planning to develop a bulk liquids terminal within the NSW Ports precinct at Port Kembla, New South Wales, Australia. The proposed development will be located in the vicinity of the Port Kembla Coal Terminal (PKCT), GrainCorp Grain Terminal, Quattro Grain Terminal and Australian Amalgamated Terminal (AAT).

In 2015, Cardno prepared an Environmental Impact Statement (EIS) for the development of the Port Kembla Bulk Liquids Terminal (PKBLT) at the end of Stage 3 (all three sites developed). As part of the EIS, Cardno engaged Sherpa to undertake a Preliminary Hazard Analysis (PHA) to assess the risks associated with the Stage 3 development (Ref. 1). The Development Application (DA) has since been approved by Department of Planning and Environment (DPE). The approved DA is supported by the original EIS (Ref. 2) and the Response To Submission (RTS) report (Ref. 3) (Approval SSD 15_7264).

TQ is seeking to submit a modification to the approved DA for PKBLT. The proposed modifications include:

- Consolidation of development staging into two stages consisting of:
  - Stage 1 – Immediate capacity terminal located at Sites 2 and 3 (subject to this modification). At completion of this stage, the terminal will have a storage capacity of 144 ML of combustible and flammable liquids.
  - Stage 2 – Combustible and flammable bulk liquids storage and pump bay located at Site 1. Site 1 will not be developed during the proposed Stage 1 and development for Site 1 would occur as approved during Stage 2. At completion of this stage, the terminal will have a total storage capacity of 275 ML of combustible and flammable liquids.
- Minor alterations to the design and layout of Site 2.

All other project details remain as approved in the EIS and RTS documents.

TQ Holdings has retained Sherpa, via Cardno, to develop a PHA for the immediate capacity terminal (referred to as Stage 1 in this document). This study presents:

- The SEPP 33 analysis, PHA methodology, consequence and frequency results for the Stage 1 development only.
- The risk contours for the Stage 1 development (Sites 2 and 3 only)
- The risk contours for the Stage 2 development (Sites 1, 2 and 3), based on the Stage 1 risk contours from this PHA, and Site 1 risk contours presented in the PHA for the approved DA (Ref. 1).

The infrastructure and equipment to be constructed under Stage 1 is summarised in Table 2.2. The infrastructure, equipment and risk contours associated with Stage 2 is summarised in Section 10.4. References to the proposed development in this PHA is to the Stage 1 development unless otherwise specified.

2.2. Requirement for study

TQ Holdings has requested Sherpa prepare a PHA for stage 1 and present risk contours for Stage 2. The PHA may be used to support the ongoing planning process for the site.

This PHA has been prepared in the context of the draft and final SEARs.

The draft SEARs was issued by DPE in January 2015. An excerpt from the draft SEARs is provided below.

> **Hazards and Risk –** including a preliminary risk screening completed in accordance with *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development and Applying SEPP 33* (DoP, 2011), with a clear indication of class, quantity and location of all dangerous goods and hazardous materials associated with the project. Should preliminary screening indicate that the project is "potentially hazardous," a Preliminary Hazard Analysis (PHA) must be prepared in accordance with *Hazardous Industry Planning Advisory Paper No. 6 - Guidelines for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011).

The final SEARs were issued in October 2015 which outlined key issues that needed to be covered in the EIS. The key issues relating to the 'Hazards and Risk' section and the references to the relevant sections in this report are outlined in Table 2.1.

Table 2.1: Final SEARs issues and references to PHA report

Final SEARs Issue	PHA Report Reference
A summary of the results of the PHA undertaken for the proposed development with consideration of the existing site. The PHA should be prepared in accordance with *HIPAP No. 6 – Guidelines for Hazard Analysis*. The PHA should: - identify the hazards associated with the existing site and proposed development, as well as any external hazards (ie natural hazards) to determine the potential for off-site impacts;	The hazards associated with the proposed development (all sites), including external hazards, are covered in the HAZID study in APPENDIX C. The basis of design for the site has taken into consideration the impact of external hazards on the site. This is further described in Section 3.4. A summary of the results of the PHA is included in Section 1.5.
- address all relevant recommendations arising from the Buncefield accident;	This is covered in APPENDIX G.
- demonstrate that the proposed development complies with the criteria set out in *Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning*	The proposed development compliance with HIPAP No 4 criteria is described in Section 10 and summarised in Section 1.5.2.

Final SEARs Issue	PHA Report Reference
- estimate the cumulative impacts from the overall site and the surrounding potentially hazardous developments in the area (if any) and demonstrate that the proposed development does not increase the cumulative risk of the area to unacceptable levels	The impact of the proposed development to the cumulative risk in the area is qualitatively assessed in Section 10.5.
- an evaluation of the impacts of the transport of Dangerous Goods to and from the site in the immediate vicinity	This is covered in the Traffic Impact Assessment in another section of the EIS and is not covered in this PHA Report.

2.3. Study objectives

The primary objective of this report is to address the 'Hazard and Risk' requirements of the final SEARs for the Stage 1 development.

The secondary objective of this report is to compare the fatality and escalation risk contours for the Stage 2 development (associated with the modification) and the risk contours presented in the PHA for the approved DA (Ref. 1).

2.4. Study scope

TQ Holdings proposes to develop the PKBLT in two stages. The major infrastructure included in Stage 1 is summarised in Table 2.2. The infrastructure and equipment associated with Stage 2 is summarised in Section 10.4.

Table 2.2: Proposed terminal infrastructure Stage 1

Location	Infrastructures
Berth 104	• Marine Loading Arms (MLAs) and associated wharf infrastructure • Shorelines to Site 2
Site 2	• Product tanks (all volumes are Maximum Safe Fill) - 3 x Combustible liquid 18,400 m^3 - 1 x Combustible liquid 12,200 m^3 - 2 x Flammable liquid 18,400 m^3 - 2 x Flammable liquid 18,400 m^3 - 2 x Flammable liquid 1,500 m^3 - 1 x Combustible liquid 1,500 m^3 - 1 x Ethanol 1,500 m^3 - 1 x Truck Slops 30 m^3 - 1 x Combustible Slops 50 m^3 - 1 x Flammable Slops 50 m^3 - 1 x Oily water 30 m^3 - 2 x Additive 30 m^3 • Bund walls • Pump bay and product piping to truck loading bays

Location	Infrastructures
	• Truck loading bays • Vapour Recovery Units • Compressed Air • Nitrogen
Site 3	• Workshop and control room/office facilities • Fire system, utilities

2.5. Study exclusions and limitations

The exclusions and limitations of this study are summarised in Table 2.3.

Table 2.3: Study exclusions and limitations

No.	Exclusions and Limitations	Remarks
1.	Only offsite risk was assessed	Onsite risk to employees and contractors was not assessed as this is not relevant for land use planning purposes.
2.	Context of assessment	This assessment does not address the requirements under the Work Health and Safety (WHS) Regulations 2011 in relation to Major Hazard Facilities (MHF). Assessment of the site was in the context of the HIPAP 4 guidelines.
3.	Ship tanker	This assessment covers potential loss of containment scenarios from the ship to wharf connection including the shoreline. It does not include incidents on the ships. Ships are not under the control of the terminal.
4.	Construction risks	In line with HIPAP 6 guidelines, risks were assessed for the proposed development during its operating phase only.
5.	Tanks and bunds	Tanks and bunds are assumed to be designed and constructed to the relevant standards including AS1940-2004.
6.	Additive tanks and IBCs	The additive tanks and Intermediate Bulk Containers (IBC) are assumed to contain flammable liquid but the exact material has not been finalised. This was modelled as gasoline in the consequence analysis. Note that these scenarios did not contribute to the offsite risk contours.
7.	Standards compliance	Statements in this report relating to compliance to codes and standards are based on advice received from TQ Holdings (including Point No. 5 in this table). Sherpa has not verified compliance with codes and standards.

3. FACILITY DESCRIPTION

3.1. Location and surrounding area

The proposed TQ Holdings' PKBLT is to be located in the inner harbour of Port Kembla, which is located 3 km south of Wollongong in NSW. TQ Holdings has identified three sites for the facility bounded by Tom Thumb Road to its north, Morton Way to its west, Berth 104 to its south and the Gurungaty Waterway (commonly referred to as the Western Drain) runs through the centre of the proposed facility between Site 1 and 2. The facility is to be located on separate land allotments leased on a long term arrangement from NSW Ports and also includes non-exclusive access and use of Berth 104.

This PHA covers development of Site 2 for bulk storage and handling of flammable material, Site 3 for office and support functions, the berth and shorelines. There is no proposed storage of dangerous goods at Site 3. Site 1 may be developed at a later date.

An aerial photo showing the location of the proposed PKBLT site (marked to indicate Sites 1, 2 and 3) and the surrounding facilities is provided in Figure 3.1.

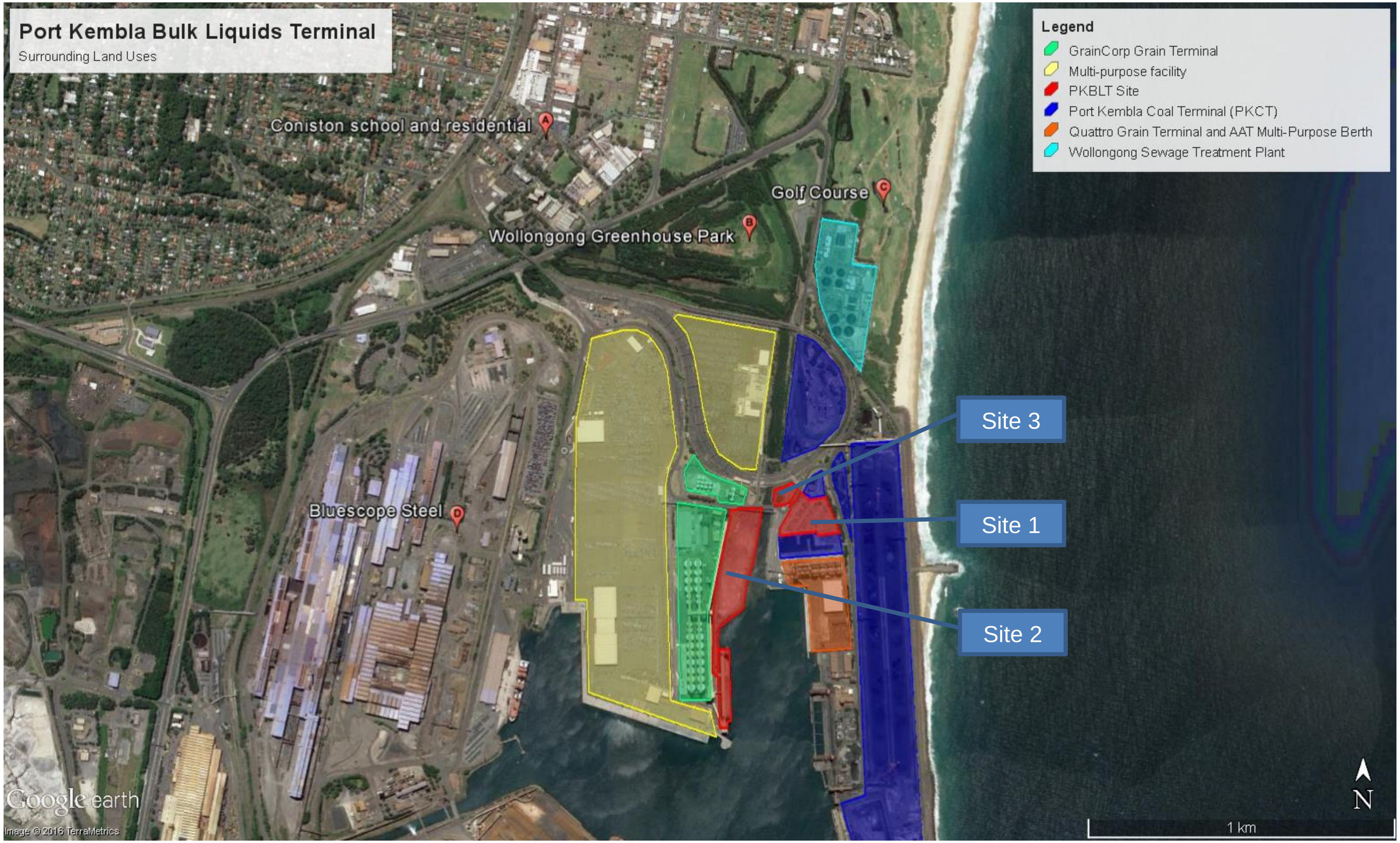
The surrounding land use is primarily categorised as industrial. There are no significant commercial spaces, warehouses open to the public, or similar developments that routinely have a large number of people occupying them (e.g. commercial office space, retail centres). Table 3.1 summarises the land uses near the proposed development.

Table 3.1: Industrial land uses near to terminal

Location	Neighbouring Facility
North	Multi-purpose facility (storage of motor vehicles, general cargo and containers) Wollongong Sewage Treatment Plant Wollongong Greenhouse Park Port Kembla Coal Terminal (PKCT)
East	PKCT
South	PKCT settling pond Australian Amalgamated Terminals (AAT) General Purpose Terminal Quattro Grain Terminal Port Kembla Inner Harbour
West	GrainCorp Grain Terminal Multi-purpose Facility (storage of motor vehicles and general cargo)

The nearest residential area is located at Coniston, which is located approximately 1200 m north-west of the proposed PKBLT facility. The nearest park is approximately 750 m north of the site.

Figure 3.1: Surrounding land uses



3.2. Proposed terminal infrastructure

TQ Holdings has a long-term lease for separate land allotments from NSW Ports and includes non-exclusive access and use of Berth 104. The land allotments are shown in Figure 3.2.

The typical proposed land uses for the sites are as follows:

- Site 1 – Combustible and flammable bulk liquids storage and pump bay
- Site 2 – Combustible and flammable bulk liquids storage, pumps and truck loading facilities
- Site 3 – Site control room and office block, maintenance workshop and utilities
- Berth 104 – Bulk liquids unloading facilities.

The proposed site comprises a number of storage tanks including 12 product tanks, 3 slops tanks, 2 additive tanks and 1 oily water tank to be developed in Stage 1 on Site 2. Stage 2 will involve developing Site 1 including an additional 12 product tanks, 5 slops tanks and 1 oily water tank.

Hazardous materials stored onsite comprises bulk petroleum fuel products (gasoline and diesel), ethanol and additives. The total storage capacity of the site in Stage 1 will be up to 144 ML of fuel products. The total storage capacity of the site in Stage 2 will be up to 275 ML of fuel products.

The proposed site will be operational 24 hours, 7 days per week. All terminal activities (controlling tank movements, product transfers, road tanker loading, Vapour Recovery Unit (VRU) monitoring, fire system control and alarms) will be coordinated by the Control Room Operator. Ship import and tank-to-tank transfer operations will only be undertaken when Operations personnel are onsite.

Sites 1 and 2 will have a perimeter fence, security monitoring and access protocols. All sites will be equipped with fire fighting provisions as required by the relevant standards.

Figure 3.3 shows the proposed PKBLT site layout for the Stage 2 development associated with the DA modification. Figure 3.4 shows the overall site layout for the approved and proposed modified site layout for Stage 2 development.

Figure 3.5 shows the proposed site layout for Site 2 only and is the basis for this PHA.

Figure 3.2: TQ Holdings' lease areas

Figure 3.3: Site layout – Stage 2 development (for DA modification)

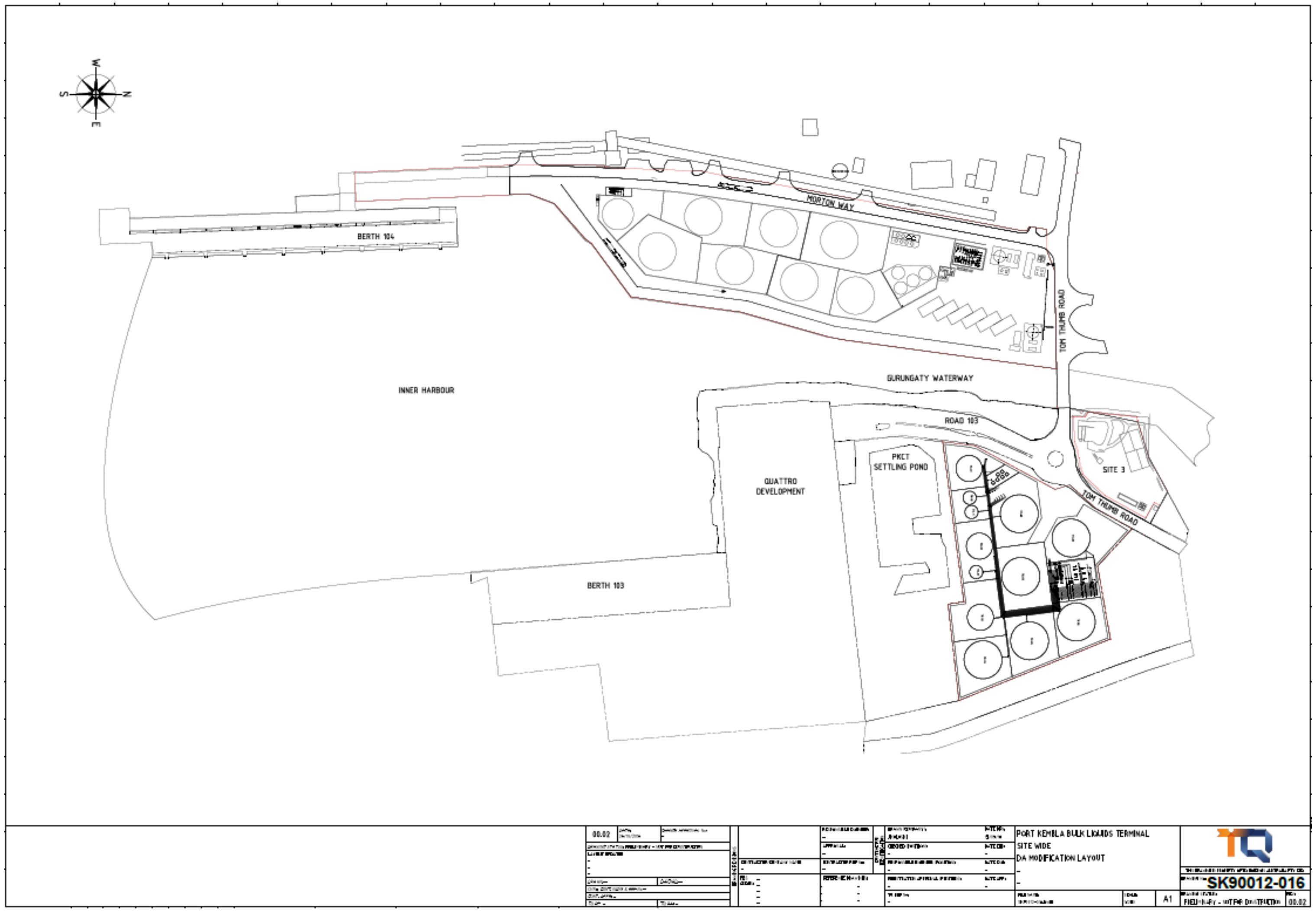


Figure 3.4: Overall site layout showing changes associated with the DA modification

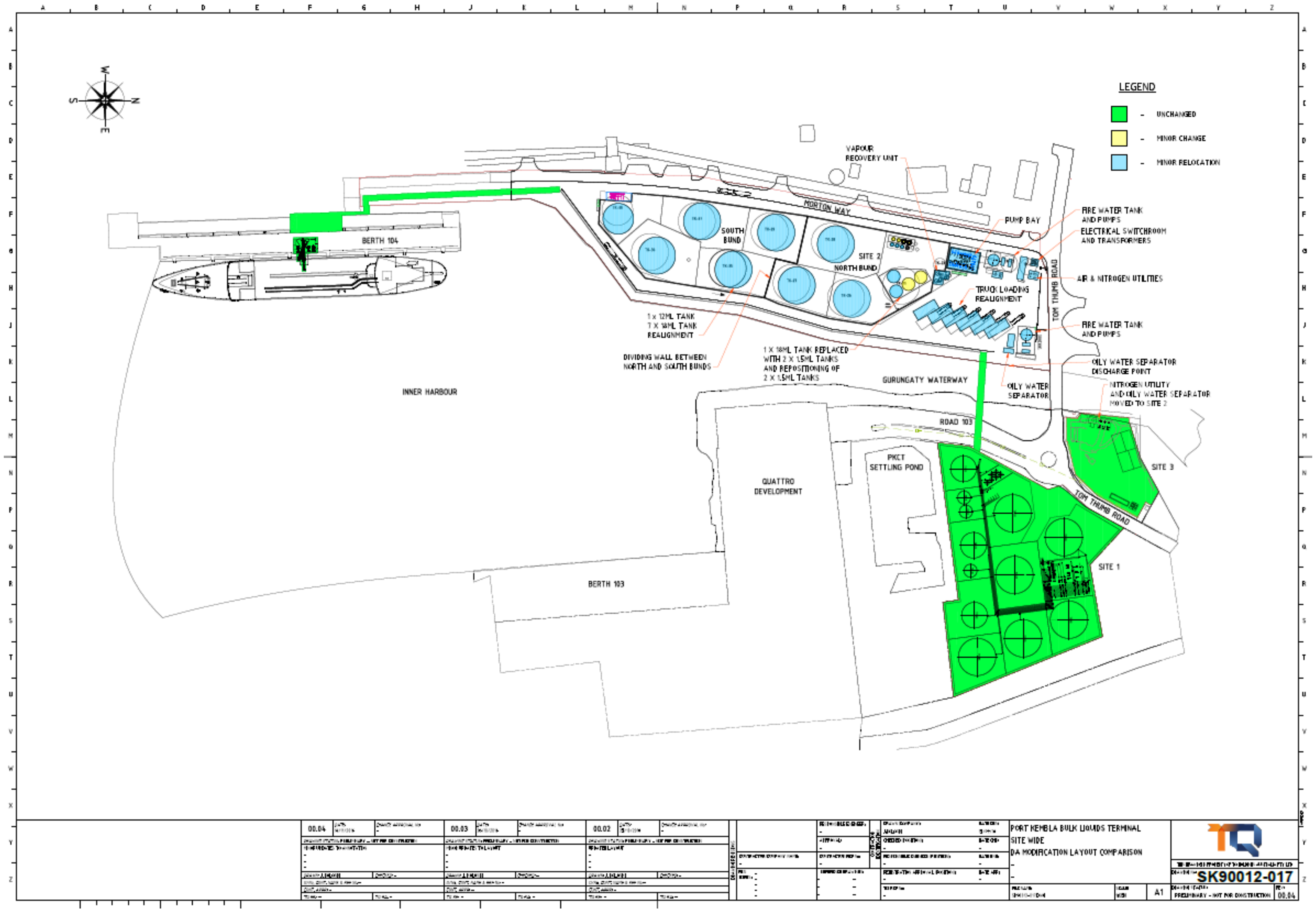
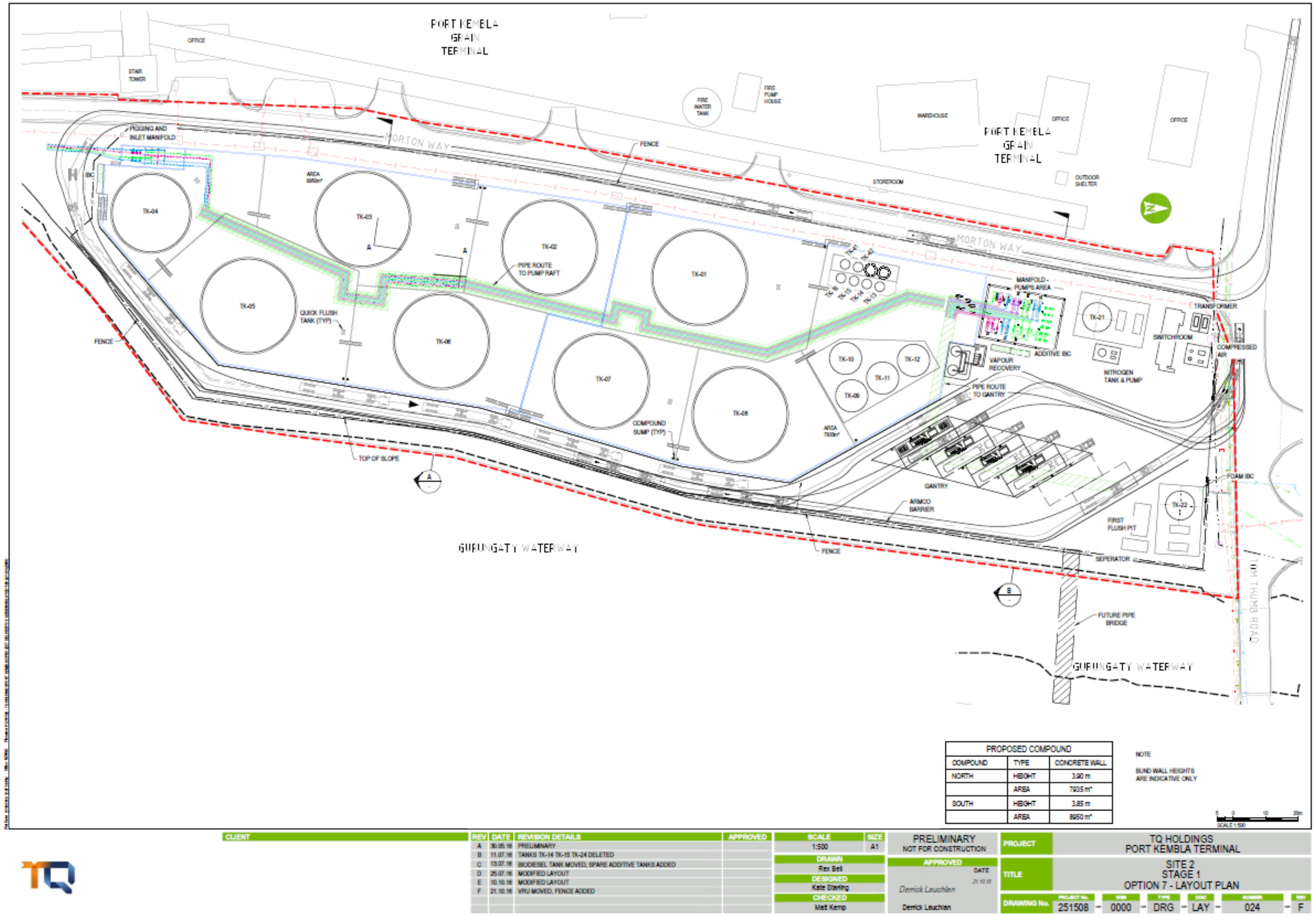


Figure 3.5: Site 2 layout



3.3. Proposed terminal operations

The proposed site will receive, store and export a variety of liquid petroleum products to customers in the region.

3.3.1. Product receipt and storage

Gasoline grades will be received by ship at Berth 104 using four Marine Loading Arms (MLAs) and dedicated shore lines. Product is transferred to the Site 2 manifold and then piped directly into the designated tanks split by interconnections made at the transfer manifold.

Ethanol, biodiesel and additives will be received by road tanker. These vehicles will enter Site 2 via the access gates and proceed to the road tanker gantry. Dedicated unloading pumps will be used to transfer product to the appropriate tanks.

Pigging operation

Each shore line is equipped with a pig launcher and receiver at Berth 104 and Site 2 in order to clear product into the tank and leave the line clean for the next product. This is done at the end of each ship import operation. Pig propulsion will be by nitrogen pressure using a reticulation system from the terminal nitrogen tank.

Tank-to-tank transfer/tank recirculation

Product can be transferred between any tank via the transfer pumps. The transfer pumps can also be used for recirculating the contents of any of the tanks as required for product quality purposes.

3.3.2. Storage tanks and bunds

The Project have designed storage tanks and bunds and intend to construct them in compliance to API 650 and AS 1940 *The storage and handling of flammable and combustible liquids* (Ref. 6). They are constructed from carbon steel and are fixed roof tanks if in combustible liquid service or internal floating roof with fixed cone roof if in flammable liquid service.

All bulk storage tanks will be provided with ducted overflows which direct the flow to the same bund sump in which the tank is located. Flow detection would be provided within the duct, triggering terminal ESD on flow detection. Hydrocarbon detection in the bund sump would activate an alarm in the control room.

Site 2 will be divided into a North and a South compound each with perimeter walls a nominal 3.9 m high. Intermediate bunds will be provided as required by code.

The main pipe rack will run North/South through the centre line of Site 2.

The storage tank capacities in Stage 1 development are shown in APPENDIX A.

3.3.3. Product export

Product distribution will be via single, rigid and B-double road tankers. Road tankers will enter Site 2 from the access gate, approach the main road gantry, park and commence bottom filling via dedicated loading arms. Trucks will be filled with a variety of gasoline blends and diesel/biodiesel percentage blends using either in-line blending immediately prior to road tanker export or in-tank blending.

There are a total of six road tanker loading bays proposed. Each loading bay will have six loading arms. The gantry area will have kerbing around the perimeter and be drained to the slops system.

A Vapour Recovery Unit (VRU) will recover vapours from road tankers.

3.3.4. Injection of additives

Provision will be made for additive injection:

- Into the shoreline as it is unloaded from the vessel
- During tank-to-tank transfers
- At the gantry into the product stream as it is loaded into road tankers.

Additives will be sourced from Intermediate Bulk Containers (IBCs) and two small tanks using dosing pumps. Additive dosing can also be made to each tank during recirculation by using a mobile dosing trolley and pump connected to a port on the tank inlet piping.

3.3.5. Fire protection system

The site will be protected by a fire protection system. The system will comprise the following:

- Mobile fire monitors at the berth
- Fire water ring main
- Foam system
- Cooling water deluge system to the tanks.

The ring main, hydrants, foam system and cooling water deluge systems will be designed and installed in accordance with AS 2419.1-2005, AS 3846-2005, NFPA16 and AS 1940-2004 respectively. A manual fire call point system complying with AS 1670.1-2004 will be provided along the wharf and escape routes to summon Fire and Rescue New South Wales (FRNSW) (Ref. 6).

3.3.6. Fire and hydrocarbon detection monitoring and alarms

Fire monitoring equipment will be installed at the gantry and hydrocarbon monitoring systems will be installed in the tank bund sump. Upon indication from either of these systems, an alarm will be initiated and the Emergency Shut Down (ESD) procedure will commence.

ESD will occur during operations through (Ref. 6):

- Supervisory Control And Data Acquisition (SCADA) – by operator activation
- ESD System – activated at either the berth or terminal control room
- Tank high level – in any tank (in case of line-up error or passing valve allowing filling of wrong tank)
- Tank overflow – in any tank (in case of line-up error or passing valve allowing filling of wrong tank)
- Flame detectors (on the berth, pump bays and road gantry bays).

3.4. Site design basis

Table 3.2 summarises how the PKBLT site design has taken into account environmental hazards that may occur in the area. The information in Table 3.2 was provided by TQ Holdings (Ref. 7).

Table 3.2: Environmental hazards consideration in PKBLT site design

Environmental Hazard	PKBLT site design consideration
Earthquake	The site structures, including the tanks, have been designed in accordance with AS 1170.4 *Structural design actions - Earthquake actions in Australia.*
Tsunami (high waves)	The site is located within the inner harbour area and is shielded from ocean waves by the Port Kembla Coal Terminal, and the Port Kembla Harbour breakwater and outer harbour.
Flooding	The project site is not impacted by flooding from Gurungaty Waterway as the site levels are a minimum of 1.7 m above the Probable Maximum Flood (PMF) levels in the watercourse. The bunded areas on Site 2 would provide capacity to temporarily store the 24 hour 100 year Average Recurrence Interval (ARI) rainfall plus a simultaneous major product spill. This is in excess of minimum design requirements.
Heavy winds	The site structures, including the tanks, have been designed in accordance with: - AS 1170.2 *Structural design actions - Wind actions* - API 650 (2013) *Welded Steel Tanks for Oil Storage*, as referred by AS 1692 (2006)
Storm surge	The NSW State Government released a Sea Level Rise Policy Statement in October 2009 that included sea level rise planning benchmarks of +0.4 m and +0.9 m by 2050 and 2100, respectively, which were adopted into the catchment wide flood study (WCFS 2013). The projected sea level rise would not, however, pose a risk to PKBLT due to site elevations.

4. METHODOLOGY

4.1. Study overview

An overview of the SEPP 33 and PHA process, including the steps and inputs for this study is shown in Figure 4.1. The PHA study approach is consistent with HIPAP 6 Hazard Analysis Guidelines (Ref.4). The subsequent sections provide further information.

4.2. SEPP 33 analysis

To determine whether the development is '*potentially hazardous*' and the requirement for a PHA, a SEPP 33 analysis was conducted.

A description of the methodology of the SEPP 33 analysis is provided in APPENDIX A.

4.3. Preliminary Hazard Analysis (PHA)

The following sections provide a description of the PHA methodology.

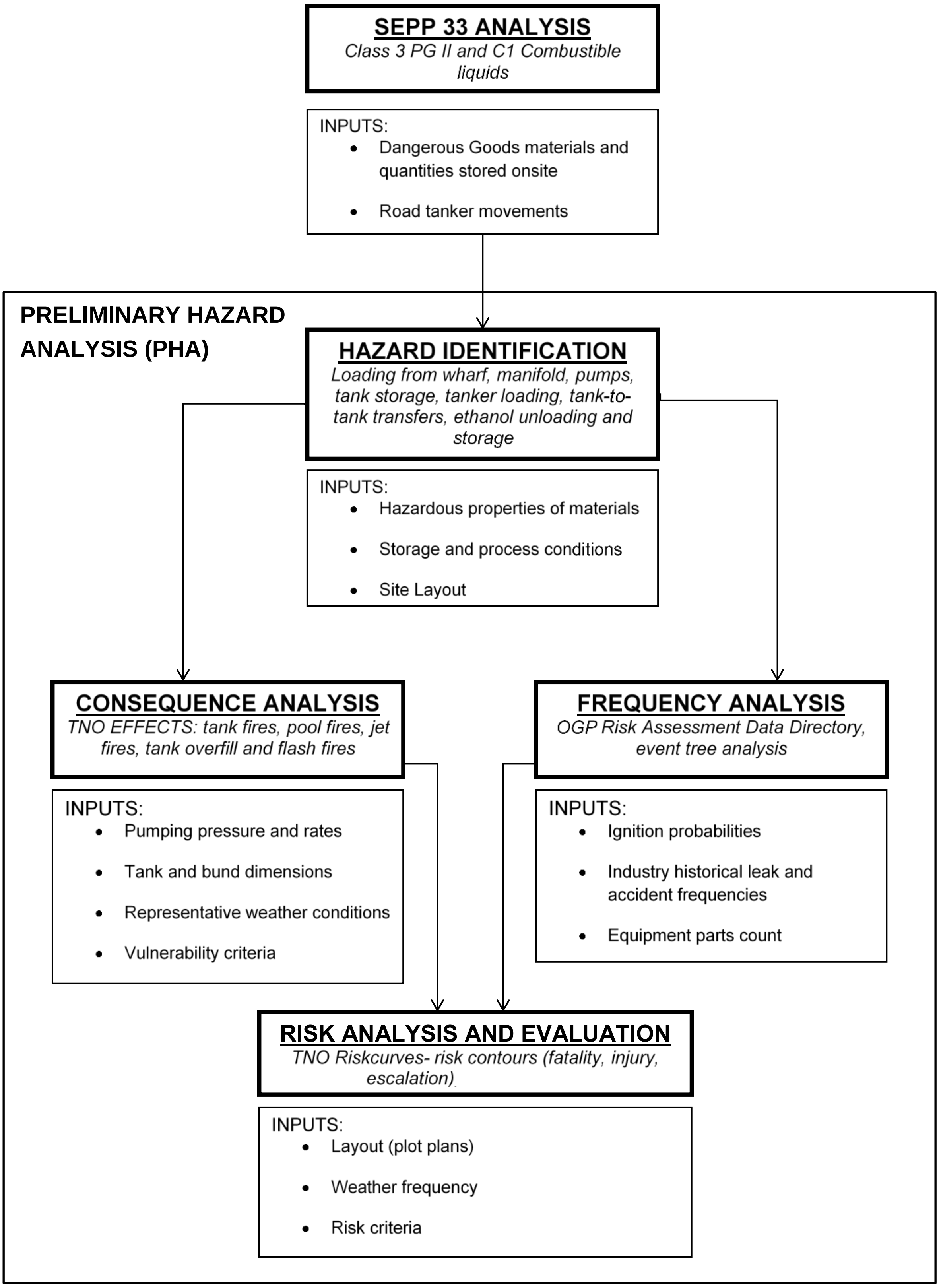
4.3.1. Hazard Identification (HAZID)

Hazard identification is the process of identifying material and situations with the potential to cause harm and establish credible scenarios that could result in an adverse impact, together with their causes, consequences and existing safeguards. The main aims are to:

- Show an understanding of the hazards at the facilities and the mechanisms by which the hazard's potential can be realised
- Show an understanding of the underlying causes of the hazardous scenarios
- Identify the safeguards that are in place to prevent the hazardous scenarios and/or consequence
- Identify hazardous scenarios for quantitative assessment to determine the potential for offsite impact.

A hazard identification table was conducted in a workshop setting with TQ Holdings' personnel (3 June 2015) to develop a list of all potentially hazardous scenarios requiring risk quantification to determine if there are any offsite impacts. The full HAZID for the Stage 2 development is included.

Figure 4.1: Overview of PHA process



4.3.2. Consequence analysis

Consequence modelling of identified scenarios was undertaken to determine the impact area (as heat radiation or within a flammable cloud) and the resulting extent of injury or fatality effects.

Software and models

Consequence modelling of identified hazardous events was undertaken using TNO EFFECTS v9.0. TNO EFFECTS is a commercial software package that uses the models in TNO's Yellow and Green Books (Ref.8 and Ref.9) for calculating the physical effects and consequences of the loss of containment of hazardous materials. PHAST v7.11 was used to model scenarios relating to ethanol releases.

Releases

Loss of containment from equipment was modelled for the representative range of hole sizes in Table 4.1.

The hole size selected for the ranges in Table 4.1 are the geometric means, which give a weighting towards the lower band, since smaller sized leaks tend to occur more frequently.

Table 4.1: Representative hole sizes for modelling loss of containment

Hole size (mm)	Range (mm)
2	1 to 3
6	3 to 10
22	10 to 50
85	50 to 150
Full bore	> 150

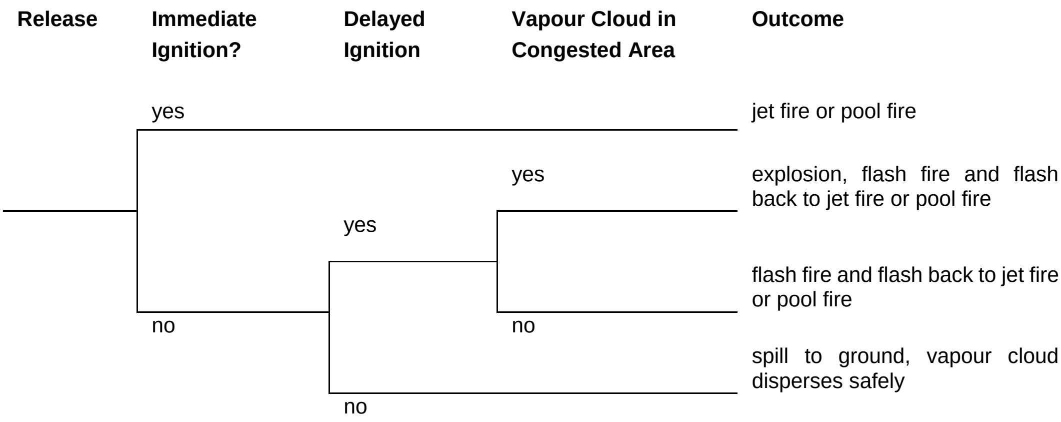
For loss of containment downstream of a pump, the maximum release rate was limited to the normal pumping rate or the process flow rate.

During tank filling, the pump rate is slowed when the high level is approaching. In a worst case scenario for overfill, the fill rate would not be slowed and pumping to a tank would continue at the maximum filling/ship import rate.

Scenarios

Figure 4.2 shows the general event tree showing the possible outcomes following loss of containment of a flammable or combustible liquid.

Figure 4.2: Event tree for loss of containment



When released at pressure, a liquid may form an airborne aerosol and/or fall to the ground. The pressure, hole size and fluid properties including vapour pressure all are factors in whether an aerosol, pool or combination of the two will form. The light components from gasoline such as C4s and C5s will tend to form a vapour cloud from evaporation or an aerosol release. The formation of a vapour cloud depends on the release characteristics and weather.

The rule set used for the outcome given ignition is shown in Table 4.2.

Table 4.2: Scenario rule set for pressurised liquid releases

Fluid	Ignition Timing	Hole Size	Outcome
Gasoline	Immediate	≤ 22 mm	Jet fire
		> 22 mm	Pool fire
	Delayed	≤ 22 mm	Rainout and evaporating pool Flash fire
		> 22 mm	Rainout and evaporating pool Flash fire
Diesel	Immediate	≤ 22 mm	Jet fire
		> 22 mm	Pool fire
	Delayed	≤ 22 mm	Pool fire
		> 22 mm	Pool fire
Ethanol	Immediate	≤ 22 mm	Jet fire
		> 22 mm	Pool fire
	Delayed	≤ 22 mm	Pool fire
		> 22 mm	Pool fire

For loss of containment within a bund, the size of the pool (whether a pool fire or evaporating pool) was limited to the bund size. For a tank rupture scenario, loss of containment is limited to the north or south compound bund. This is described further in APPENDIX D.

Tank overfill

A tank overfill scenario leading to flammable vapour cloud formation and consequences resembling the 'Buncefield' scenario was not considered to be credible due to installation of ducted overflow piping directing flow to the bund for flammable tanks.

However, overfilling the tank would still lead to flammable liquid accumulating in the bund. For this study, immediate ignition of the pool would result in an intermediate bund fire. If the pool is not immediately ignited, a flammable vapour cloud would form via neutral dispersion and ignition would result in a flash fire.

As an approximation the extent of the area where damaging overpressure could be experienced is assumed to be the extent of the gas cloud above the lower flammability limit. This is considered a conservative assumption as areas of congestion within a terminal are generally limited and overpressures decay rapidly beyond the boundary of the flammable gas cloud.

Weather conditions

Historical meteorological weather data for the proposed terminal was obtained from the Bureau of Meteorology (BoM). The acquired data sets were based on readings from the Automatic Weather Station (AWS) at Port Kembla NTC (AWS 068253) which is located approximately 3 km away.

From the acquired data sets, representative weather conditions were consolidated for consequence modelling, as outlined in in Table 4.3. Since evaporation and dispersion are significantly dependent on prevailing weather conditions, a wide range of conditions with significant likelihood of occurrence was selected. The analysis of the data, which is an input to the risk model is included in APPENDIX F.

Spray and pool fires were only modelled under a high wind speed case, D5, since they are less influenced by the prevailing wind and weather conditions and higher wind speeds are more conservative as they result in larger effect distances.

Table 4.3: Weather conditions for consequence modelling

Name	Pasquill Stability Class	Wind speed (m/s)	Description
B3	B	3	Day time, moderate wind condition
D5	D	5	Cloudy or high wind condition
F2	F	2	Night time/early morning, low wind speed

4.3.3. Vulnerability criteria

The assessment criteria for exposure to hazardous scenarios (eg fires) are given by vulnerability relationships. These are summarised in Table 4.4.

These criteria are based on the probit equation for fires, consistent with the HIPAP 4 guidance. The table includes the exposure levels for injury and property damage from fires given in HIPAP 4 (Ref.5).

Table 4.4: Vulnerability criteria for fire scenarios

Event	Level	Probability of fatality assumed in PHA	Other effects
Jet fire Pool fire	4.7 kW/m^2	-	Injury
	10 kW/m^2	1%	Fatality
	14 kW/m^2	10%	Fatality
	20 kW/m^2	50%	Fatality
	23 kW/m^2	70%	Escalation due to heat radiation
	Within fire envelope	100%	Escalation due to direct impingement
Flash fire/ Explosion	Within LFL (assumed to be flash fire envelope)	100%	Escalation due to damaging overpressure.

4.3.4. Frequency analysis

Hazardous scenarios involve loss of containment of hydrocarbon fuels and subsequent ignition. The likelihood of these scenarios was estimated using historical data for each loss of containment and for ignition. Loss of containment frequencies were determined by estimating the number of equipment items ('parts count') and combining with historical leak frequency data for each equipment type. The main source of historical leak frequencies was the Oil and Gas Producer (OGP) Risk Assessment Data Directory *Process release frequencies* (Ref.10) and TNO Purple Book (Ref.11). The full set of data and sources is included in APPENDIX E.

Full surface tank roof fire frequencies were estimated from LASTFIRE Project Update 2012 (Ref.16) based on the storage tank type.

The frequency of tank overfill leading to intermediate bund fire or flash fire was estimated using event tree analysis. The frequency of catastrophic tank rupture leading to full bund fire or flash fire was estimated using event tree analysis. The derivation and full set of data and sources is included in APPENDIX E.

4.3.5. Probability of ignition

The ignition probability values used in this study were based on the assessment done by Cox, Lees and Ang (Ref.12). The probabilities are based on the release rate and the phase of the fluid assessed. The ignition probability values used in the QRA are provided in APPENDIX E.

In this study, diesel is stored in common bunds with flammable liquids. Releases for combustible liquids such as diesel are more difficult to ignite due to their high flash point.

The ignition probability for diesel was assumed to be one-tenth that of flammable liquids such as gasoline.

4.3.6. Risk analysis

Risk analysis was performed using TNO Riskcurves v9.0, which combines the consequences and frequencies to produce contours of equal risk values.

The following risk contours were developed:

- Individual fatality risk
- Risk of property damage and accident - heat radiation of 23 kW/m^2.

4.3.7. Risk criteria and evaluation

Table 4.5 summarises the risk criteria against which the hazards from the facility were assessed. These criteria are consistent with the HIPAP 4 *Risk Criteria for Land Use Planning* (Ref.5).

Table 4.5: Risk assessment criteria

Description and land use	Criteria (per year) Note 1
Individual fatality risk	
Hospitals, child-care facilities and old age housing (sensitive land uses).	5×10^{-7}
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1×10^{-6}
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres (commercial land use).	5×10^{-6}
Sporting complexes and active open space areas (recreational land use).	1×10^{-5}
For industrial sites, individual fatality risk level should, as a target, be contained within the boundaries of the site where applicable.	5×10^{-5}
Injury risk – heat radiation exceeding 4.7 kW/m^2	
Residential and sensitive use.	5×10^{-5}
Injury risk – explosion overpressure exceeding 7 kPa	
Residential and sensitive use.	5×10^{-5}
Risk of property damage and accident propagation – 23 kW/m^2 heat flux	
Neighbouring potentially hazardous installations or at land zoned to accommodate such installations.	5×10^{-5}
Risk of property damage and accident propagation – 14 kPa explosion overpressure	
Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings.	5×10^{-5}
Note 1. Criteria specific to toxic injury and irritation are also provided in HIPAP4. These are not included as there are no significant acute toxicity impacts from PKBLT operations.	

5. SEPP 33 ANALYSIS

The SEPP 33 analysis found that the quantities of Class 3 Packaging Group (PG) II, ie gasoline, stored onsite exceeded the threshold quantities stated in the SEPP 33 guideline (Ref. 13). PKBLT is considered '*potentially hazardous*' and a PHA study was required.

The SEPP 33 analysis involved assessing the proposed site as a '*potentially hazardous'* installation only. Assessment of the site as '*potentially offensive'* is covered in another part of the EIS.

Another finding of the SEPP 33 analysis was that as the operational weekly vehicle movements are above the SEPP 33 transport screening threshold levels, the development is '*potentially hazardous'* with respect to transportation and a route evaluation study is required. This requirement is addressed in the Traffic Impact Assessment by Cardno in accordance with HIPAP No. 11 guideline.

The results of the SEPP 33 analysis are reported in APPENDIX A.

6. HAZARD IDENTIFICATION

6.1. Fuel properties

Materials handled at the PKBLT site are all petroleum based hydrocarbons and small quantities of additives with similar properties to fuels. These have a range of properties with regards to flammability. Representative hazardous materials are summarised in Table 6.1.

Gasoline is the only material with a significant fraction of 'light' components hence the only material where a loss of containment has potential to generate a large vapour cloud. For the purposes of considering the potential for formation of large flammable vapour clouds, the fraction of C4/C5s is of interest.

Gasoline additives are classified as Class 3 flammable liquids. These and other chemicals onsite are not included in Table 6.1 and were modelled as gasoline in the PHA.

For the Stage 1 development, all four slops tanks, the oily water tank and 1.5 ML biodiesel tank were considered to be in gasoline service for this PHA to allow for operational flexibility.

Table 6.1: Hazardous material properties

Characteristic	Gasoline	Diesel/Biodiesel	Ethanol
Initial Boiling Point (atm.) (ºC)	30-230	260	78
Density (kg/m^3 at 15-20ºC)	740	830	789
Autoignition temperature (ºC)	>350	340	363
Flash Point (ºC)	<-40	>60	13
Vapour Pressure (kPag)	30 to 99.7	<0.1	8
Lower Flammability Limit (LFL) (%)	1.4	N/A	3.3
Upper Flammability Limit (UFL) (%)	7.6	N/A	19.05
Pool burn rates (kg/m^2.s)	0.055	0.039	0.015
Dangerous Goods Class	3 PGII Flammable	C1 Combustible	3 PGII Flammable

Note:
1. Pool burn rates obtained from Lees (Ref.14).

6.2. Hazard identification table

The hazard identification table for the site is included in APPENDIX C. The table contains the following information:

- Scenario
- Cause
- Possible consequences

- Safeguards
- Whether the scenario was carried forward for risk quantification.

6.3. Summary of QRA scenarios

From the hazard identification table in APPENDIX C, Table 6.2 lists the scenarios which were carried forward for quantification and inclusion in the QRA.

Table 6.2: Scenarios carried forward for quantitative assessment

No.	Initial event	Potential consequences	Comment
1.	Berth 104	Jet fire Pool fire Flash fire	Pressurised release from marine loading arm (MLA) and piping. Applicable to both gasoline and diesel fuels. Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release. Liquid pool growth resulting from release/rainout is limited to width of Berth 104. Different ignition probabilities used depending on flash point.
2.	Pipeline – Ship Import	Jet fire Pool fire Flash fire	Pressurised release from the ship import pipeline. Applicable to both gasoline and diesel fuels. Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release. Different ignition probabilities used depending on flash point.
3.	Manifold and Pipework to tanks	Jet fire Pool fire Flash fire	Pressurised release from the manifold and pipework to/from tanks. Applicable to all fuels. Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release. Liquid pool growth resulting from release/rainout is limited to physical restriction (e.g. bunding around the manifold). Different ignition probabilities used depending on flash point.
4.	Storage Tank	Tank full surface fire	Applicable to all tanks and fuels (including bulk fuel tanks, slops tanks, additive tanks and excluding oily water tanks).

No.	Initial event	Potential consequences	Comment
5.	Storage Tank Spill to tank compound bund	Tank bund fire Flash fire	Applicable to all tanks and fuels (including bulk fuel tanks, slops tanks, additive tanks and excluding oily water tanks). This scenario represents the ignited event of liquid spill to tank compound bund. Intermediate and full bund fires were assessed depending on tank size. Different ignition probabilities used depending on flash point. Intermediate bund fires are defined as fires that are contained by the intermediate bund walls (600 mm height). Full bund fires are defined as fires that contained by the external bund walls (3850 to 3900 mm height) around the site perimeter. Pool evaporation of gasoline in bund may produce a flammable cloud. No such effect is expected for ethanol and diesel.
6.	Tank overfill	Intermediate bund fire Flash fire	Immediate ignition of a pool resulting from tank overfill is applicable to all fuels. Delayed ignition of a flammable cloud resulting from tank overfill is applicable to gasoline fuel only. Refer to Section 4.3.2 for a more detailed explanation.
7.	Pump Manifold (including Pumps)	Jet fire Pool fire Flash fire	Pressurised release from pump and discharge piping. Applicable to all fuels. Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release. Liquid pool growth resulting from release/rainout is limited to physical restriction (eg bunding around the pump manifold). Different ignition probabilities used depending on flash point.
8.	Road tanker loading release	Jet fire Pool fire Flash fire	Pressurised release from loading line or arm, limited to the load-out pumping rate. Applicable to both gasoline and diesel fuels. Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release. Different ignition probabilities used depending on flash point.

No.	Initial event	Potential consequences	Comment
9.	Ethanol unloading release	Jet fire Pool fire	Pressurised release from loading line or arm, limited to the import rate. Jet or pool fire depending on mist and rainout release. Flash fires envelope are usually small, will instantaneously flash back to the pool, resulting in a pool fire.
10.	Biodiesel unloading release	Jet fire Pool fire	Pressurised release from loading line or arm, limited to the import rate. Jet or pool fire depending on mist and rainout release.
11.	Additive IBCs	Pool fire	Flammable liquid pool (modelled as gasoline) involving IBCs stored in the curbed area.

7. QRA OPERATIONAL BASIS

A number of assumptions for Stage 1 were made to undertake the QRA. The QRA results are dependent on the assumptions made in defining the input scenarios. It is therefore important to understand any limiting assumptions in conjunction with the QRA results.

The QRA has utilised information including the proposed terminal operational data, throughput information and typical products (that will be handled) to arrive at a product allocation basis and throughput.

The QRA basis, including the proposed terminal operational data and throughputs used in this assessment, is provided in APPENDIX B. The basis for Stage 1 was provided by TQ Holdings.

The basis for Site 1, associated with the Stage 2 development, is as reported in the PHA for the approved DA (Ref. 1).

8. CONSEQUENCE ANALYSIS

Consequence analysis involves qualitative and/or quantitative review of the identified hazardous incidents to estimate the potential to cause injury, fatalities or damage to property. In this study, the materials are flammable or combustible with minimal acute toxicity issues. Hence, only fire scenarios, including dispersion of flammable vapours were modelled.

The following consequences were evaluated to determine the characteristics of unignited and ignited scenarios of hydrocarbon releases on the proposed terminal (as per Table 6.2):

- Jet fires
- Pool fires
- Flash fires due to pool evaporation
- Tank full surface roof fires
- Tank bund fires.

For scenarios where the calculated release rate exceeds the process flow rate, the consequences were modelled using the process flow rate (e.g. pump discharge rate).

All scenarios were included in the frequency assessment, i.e. even if the consequence assessment showed that there was no significant impact outside the site boundary (for example small leak sizes).

The assumptions used to undertake consequence analysis are listed in Table 8.1.

Consequence modelling results are provided in APPENDIX D with respect to the specified vulnerability criteria described in Section 4.3.3.

Table 8.1: Assumptions used for consequence analysis

No.	Consequence Scenario Type	Assumptions
1.	General	• All pipework around the site was assumed to be DN300, except at the road tanker gantry which was assumed to be DN200 due to lower flowrates.
2.	Jet Fires	• Leak sizes less than or equal to 25 mm were modelled as jet fires for all fuels.
3.	Pool Fires	• Pool fire scenarios for diesel/biodiesel were modelled. However, it is a combustible liquid and requires significant ignition energy to ignite. Ignition probability for diesel was assumed to be one-tenth that of flammable liquids such as gasoline. • Equilibrium pool size was estimated using pool burn rates and where required, pool growth size is limited by the physical constraint within the design (eg site dimension, bund size). • Releases from the MLAs are assumed to be limited to the width of the Berth 104 (18 m). • Leaks from the pumps and manifold are assumed to be contained within the bund provided. • Releases from the gantry (loading/unloading) are confined within 150 mm high kerbing, which has been approximated to be 5 x 25 m around each loading bay. Releases were not expected to spill over due to drainage provisions. • Pipework from and to manifold is not restricted by any constraint that limits the pool growth size.
4.	Flash Fires	• Pool evaporation leading to flash fires were modelled for gasoline only. • Refer to Section 4.3.2 for explanation of tank overfill scenarios considered.
5.	Tank Roof Fires	• For IFR tanks, this scenario represents a rim seal fire escalating to a full surface tank fire and subsequent collapse of the external roof. • For combustible tanks, this scenario represents escalation from a flammable tank.
6.	Tank Bund Fires	• Intermediate bund fires (or fires contained within intermediate bund walls of 600 mm height) were associated with tank overfill scenarios. This is based on 15 minutes overfill during ship import operations (worst case scenario). • Full bund fires (or fires contained within the external bund walls of 3850 to 3900 mm height) were associated with large mechanical leaks from bulk storage tanks, except for the smaller tanks (ie slops, additives). • Delayed ignition of bund contents was modelled as flash fires.

No.	Consequence Scenario Type	Assumptions
7.	Jet fires at the pump manifold bay (boundary shielding)	• TQ will construct a barrier on the site boundary to the west of the pump manifold bay. The barrier will mitigate the offsite effect of jet fires originating in the pump manifold.

9. FREQUENCY ANALYSIS

9.1. Overview

The frequency of an event is defined as the number of occurrences of the event over a specified time period; with the period in risk analysis generally taken as one year. Frequency analysis involves estimating the likelihood of occurrence of each of the identified hazardous scenarios considered in this study, using historical equipment failure frequencies and populating the Event Trees developed to characterise the accident pathways.

The overview methodology to estimate scenario frequencies is described in Section 4.3.4.

The following supporting data is included in APPENDIX E:

- Historical equipment leak frequencies
- Parts count
- Online time probability
- Probability of ignition
- Event tree analysis
- Outcome frequencies
- Storage tank fire frequencies (including tank overfill).

9.2. Effect of safeguards

There are a number of safeguards that have been accounted for in the risk model as they reduce the frequency of a scenario. The safeguards accounted for in the analysis are:

- Rim seal fire detection and automatic foam suppression system
- For bulk storage tanks, slops tanks and additive tanks, to prevent tank overfill leading to a release covering the intermediate bund:
  - Radar tank level gauging system
  - Second radar level instrument and operator action, assuming sufficient time to respond and stop inlet flow
  - Safety Integrity Level 2 (SIL 2) rated independent level gauging system with high level set point that will initiate terminal ESD
  - Flow detection would be provided within the duct, triggering terminal ESD
  - Hydrocarbon detection in the intermediate bund sump and operator response.

- Spray water cooling on combustible tanks
- Operator initiated ESD for loss of containment has been assumed to occur at:
  - Berth 104 (maximum event contained within wharf bunded area)
  - Road tanker gantries (maximum event contained within loading bay kerbing)
  - Tank overfill during ship import (maximum 15 mins overfill event).

APPENDIX E describes how safeguards have been accounted for in the QRA.

10. RISK ANALYSIS

The results of the consequence and frequency analysis were integrated into a quantitative risk model for the site. The quantitative risk analysis was completed for the preliminary Stage 1 design of the site. A discussion of the results in the context of HIPAP 4 criteria and risk contours for individual fatality, injury and property damage/propagation are presented in the following sections. Table 10.1 summarises the compliance against the fatality and escalation risk criteria for the preliminary Stage 1 design.

Table 10.1: Summary of compliance of HIPAP 4 risk criteria – Stage 1

Description and land use	HIPAP 4 Criteria (per year)	Criterion Met
Individual fatality risk		
Hospitals, child-care facilities and old age housing (sensitive land use).	5×10^{-7}	Yes
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1×10^{-6}	Yes
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres (commercial land use).	5×10^{-6}	Yes
Sporting complexes and active open space areas (recreational land use).	1×10^{-5}	Yes
For industrial sites, individual fatality risk level should, **as a target**, be contained within the boundaries of the site where applicable.	5×10^{-5}	No [Note 1]
Injury risk – heat radiation exceeding 4.7 kW/m²		
Residential and sensitive use.	5×10^{-5}	Yes
Injury risk – explosion overpressure exceeding 7 kPa		
Residential and sensitive use.	5×10^{-5}	Yes
Risk of property damage and accident propagation – 23 kW/m² heat flux		
Neighbouring potentially hazardous installations or at land zoned to accommodate such installations.	5×10^{-5}	No [Note 2]
Risk of property damage and accident propagation – 14 kPa explosion overpressure		
Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings.	5×10^{-5}	Yes
Note. 1. See discussion in Section 10.2 2. See discussion in Section 10.3.		

10.1. Injury risk

Injury heat radiation and explosion overpressure contours (conservatively approximated to be within the LFL cloud) do not extend into the nearest residential and sensitive land use areas. Therefore, the PKBLT site meets the HIPAP 4 injury risk criteria.

10.2. Individual fatality risk

Figure 10.1 shows the individual fatality risk contour levels for the PKBLT operations. HIPAP 4 states that the 5 x 10^{-5} per year criterion should, as a **target**, be contained within the boundaries of the site where applicable.

The 5 x 10^{-5} per year risk contour extends into the Gurungaty waterway east of Site 2 (up to 10 m from site boundary). This does not meet the **target** of retaining the risk contour within the site boundary where applicable. The risk is generated by the effects of jet fires orientated to the east extending offsite. The road tanker loading bays on site are elevated approximately 3 m above the waterway providing additional protection. The affected area is a shallow waterway, which precludes ship or boat access, and is within the port area, which restricts public access. Hence it is unlikely people will be present in this area and exposed to the risk.

The remaining risk contours do not reach recreational, commercial, residential or sensitive land uses. It is noted that the office buildings on adjacent installations are zoned as industrial land. Commercial land uses in the HIPAP 4 guidelines refer to commercial areas as buildings where the general public may be able to access.

Note that all 30 kL, 50 kL and 1.5 ML tanks were modelled in flammable service despite Tank 11 being typically storing combustible liquid and Tank 16 is an oily water tank. This shows that the fatality risk contours comply with HIPAP 4 criteria if the 30 kL, 50 kL and 1.5 ML tanks are in flammable liquid service.

10.3. Property damage and propagation risk

Damage and propagation risk due to heat radiation impacts were assessed for PKBLT site to determine the potential for escalation to neighbouring facilities. The concern is an accident at PKBLT may trigger a hazardous event on a neighbouring facility.

Figure 10.2 shows the 5 x 10^{-5} per year contour associated with heat radiation and risk of damage and propagation to neighbouring potentially hazardous installations. This figure shows that the risk contour extends into the waterway. This land is not zoned to accommodate potentially hazardous installations and the development meets the HIPAP 4 risk criteria.

Figure 10.3 shows the 5 x 10^{-5} per year contour associated with the LFL cloud to represent the maximum extent of the explosion overpressure and the risk of damage and propagation to neighbouring potentially hazardous installations. The 5 x 10^{-5} per year propagation risk contour associated with LFL cloud is retained within the Site 2 boundary and meets the HIPAP 4 risk criteria.

Figure 10.1: Individual fatality risk contours – Stage 1

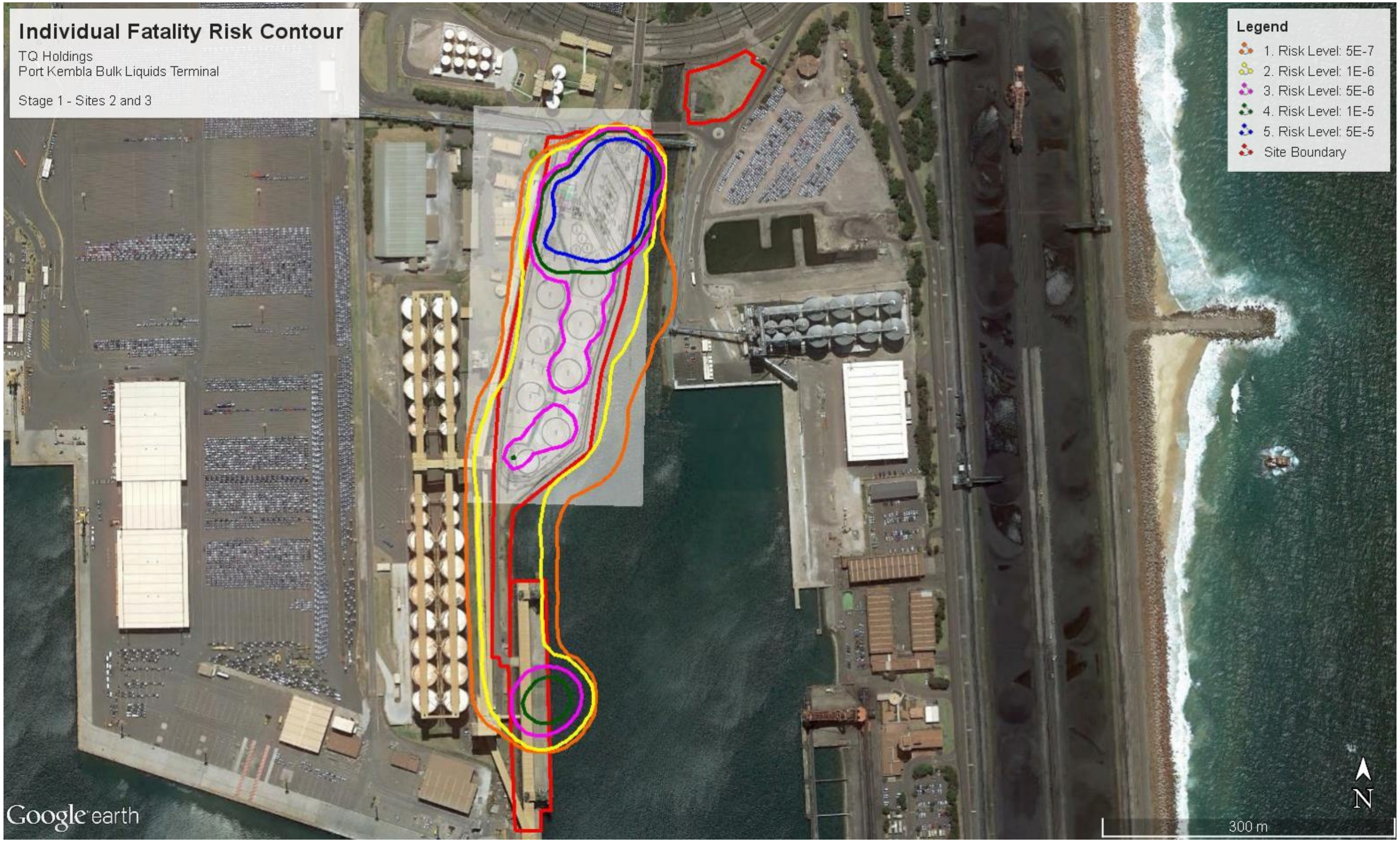


Figure 10.2: Heat radiation damage and propagation risk contour – Stage 1

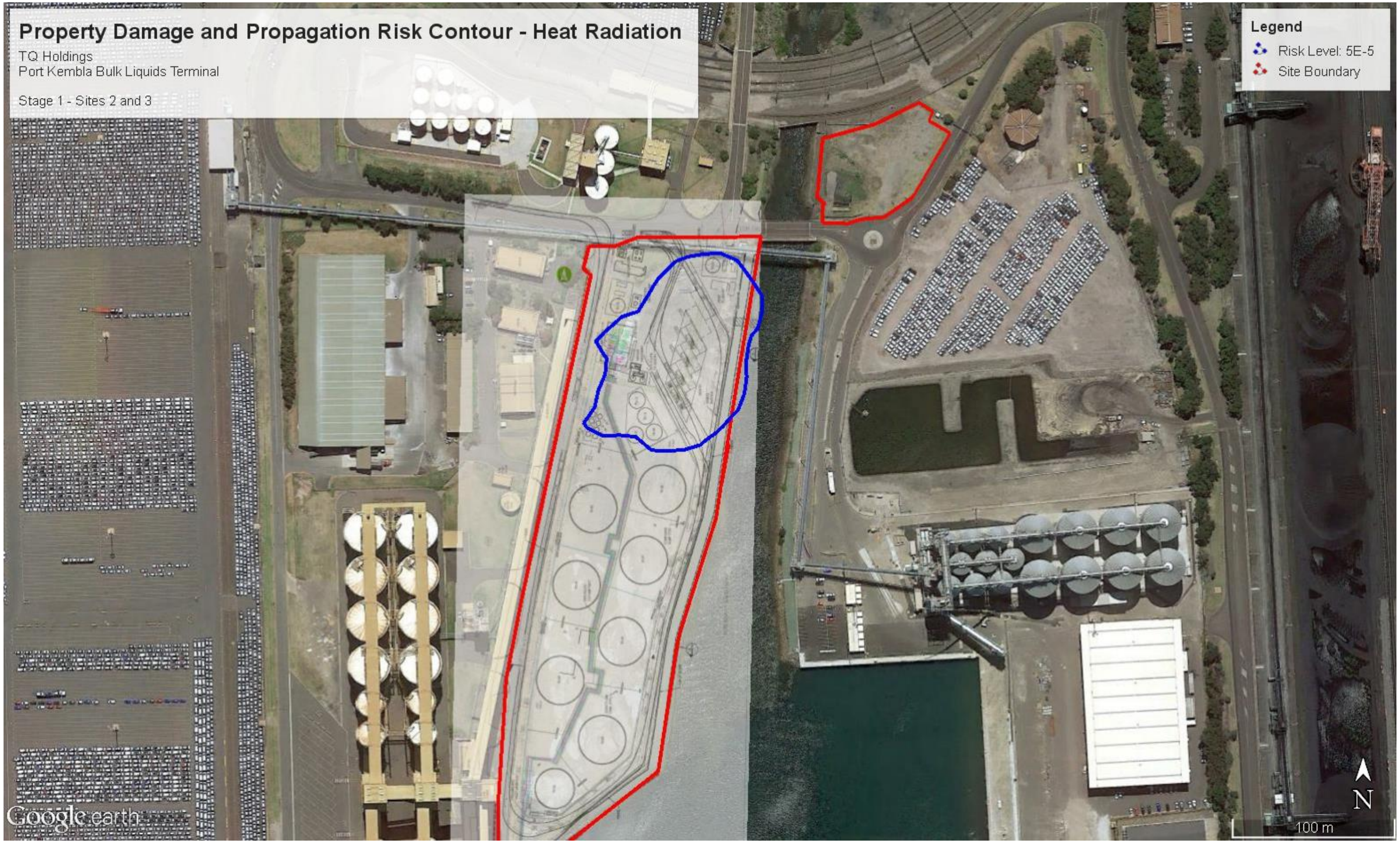


Figure 10.3: LFL cloud damage and propagation risk contour – Stage 1

10.4. Stage 2 development

10.4.1. Stage 2 background

Stage 1 of the development involves developing Sites 2 and 3. Stage 2 will involve developing Site 1 and will comprise the following:

- Seven combustible liquid storage tanks
- Five flammable liquid storage tanks
- Slops tanks to collect any waste product or spills
- Construction of bund walls around the site
- Fire system, utilities, stormwater and pavements
- Installation of fourth MLA and connection pipe to Site 2
- Pump bay and product piping to allow the transfer of product from Site 1 to Site 2.

The additional capacity for Stage 2 will allow throughput to increase to approximately 2,900 ML per annum. The tanks will increase the bulk liquid storage capacity by 131 ML from Stage 1 capacity. The development of Stage 2 will be determined by market demand.

This section of the report outlines the Site 1 tank storage basis, and presents preliminary individual fatality and property damage and propagation risk contours for the PKBLT with Stages 1 and 2 in operation.

Note that Stage 2 development in this section refers to Stage 1 and Stage 2 in operation.

Section 2.1 describes in further detail the background of the approved Development Application (DA) (Approval SSD 15_7264) and proposed modifications to the DA.

10.4.2. Tank storage

Table 10.2 shows the storage tank contents and capacities for the flammable and combustible bulk and slops storage tanks on Site 1. It includes the tank numbers as revised for this modification and the original tank numbers for the approved Development Application (Approval SSD 15_7264) (Ref. 15).

Table 10.2: Storage tank contents and capacities - Site 1

Tank no. (Approved DA)	Product	Diameter (m)	Height (m)	Tank volume (m^3)
TK-01	Diesel	20	21.5	6,000
TK-02	Diesel	20	21.5	6,000
TK-03	Diesel	20	21.5	6,000
TK-04	Diesel	29	28.9	18,000
TK-05	Diesel	29	28.9	18,000

Tank no. (Approved DA)	Product	Diameter (m)	Height (m)	Tank volume (m^3)
TK-06	Diesel	29	28.9	18,000
TK-07	Gasoline	29	28.9	18,000
TK-08	Gasoline	29	28.9	18,000
TK-09	Gasoline	29	28.9	18,000
TK-10	Gasoline	10	21.5	1,500
TK-11	Gasoline	10	21.5	1,500
TK-12	Diesel	10	21.5	1,500
TK-13	Diesel	3	4.8	32
TK-14	Diesel	3	4.8	32
TK-15	Oily Water	3	4.8	32
TK-16	Gasoline	3	4.8	32
TK-17	Gasoline	3	4.8	32
TK-18	Gasoline	3	4.8	32

10.4.3. Risk Analysis

Individual fatality and property damage and propagation risk contours were developed for the Stage 2 development based on two inputs:

- Risk contours for the Stage 1 development as reported in Section 10.2 and 10.3 of this report
- Risk contours for Site 1 as reported in the PHA for the approved DA (Approval SSD 15_7264). Refer to the PHA for the QRA basis, consequence and frequency results for Site 1 (Ref. 1).

10.4.4. Findings

The risk contours for the Stage 2 development were assessed against the HIPAP 4 criteria outlined in Section 4.3.7.

The individual fatality risk contours associated with Stage 2 development is shown in Figure 10.4. The damage and propagation risk contours associated with the Stage 2 development is shown in Figure 10.5.

Table 10.3 summarises the compliance against the fatality and propagation risk criteria for the preliminary Stage 2 design.

Figure 10.4: Individual fatality risk contours – Stage 2

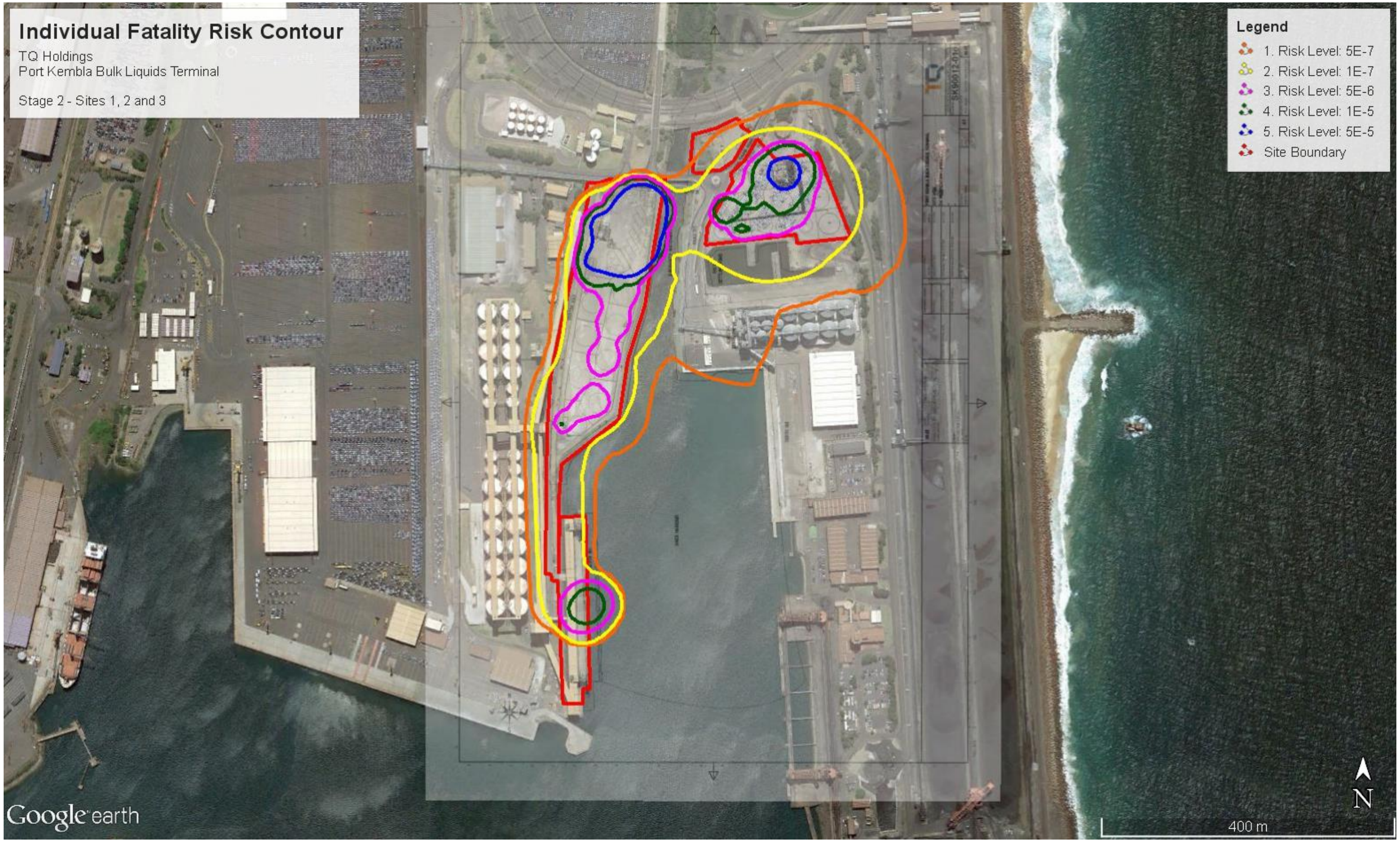


Figure 10.5: Heat radiation damage and propagation risk contour – Stage 2

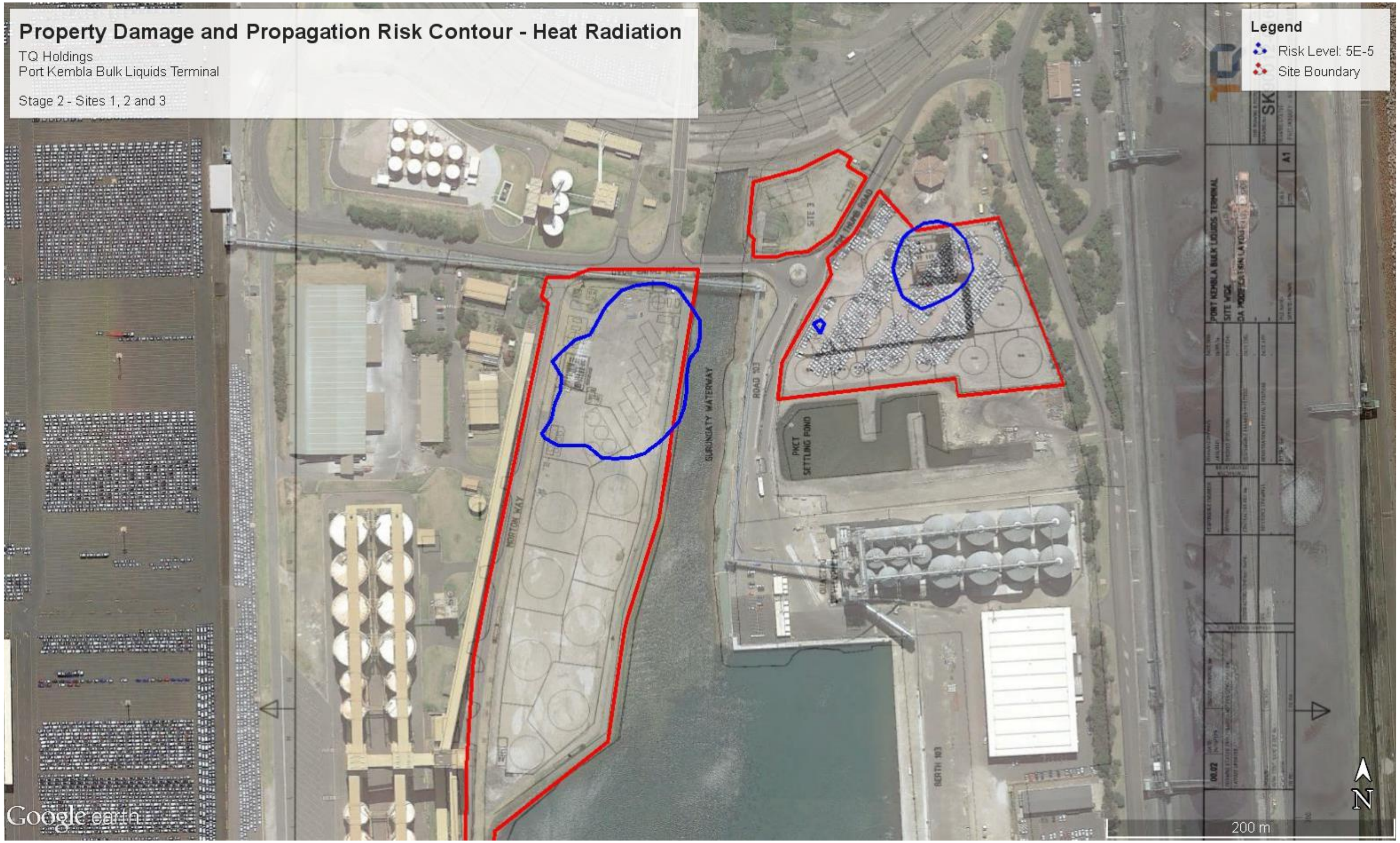


Table 10.3: Summary of compliance of HIPAP 4 risk criteria – Stage 2

Description and land use	HIPAP 4 Criteria (per year)	Criteria Met
Individual fatality risk		
Hospitals, child-care facilities and old age housing (sensitive land uses).	5×10^{-7}	Yes
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1×10^{-6}	Yes
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres (commercial land use).	5×10^{-6}	Yes
Sporting complexes and active open space areas (recreational land use).	1×10^{-5}	Yes
For industrial sites, individual fatality risk level should, **as a target**, be contained within the boundaries of the site where applicable.	5×10^{-5}	No Note 1
Injury risk – heat radiation exceeding 4.7 kW/m^2		
Residential and sensitive use.	5×10^{-5}	Yes
Injury risk – explosion overpressure exceeding 7 kPa		
Residential and sensitive use.	5×10^{-5}	Yes
Risk of property damage and accident propagation – 23 kW/m^2 heat flux		
Neighbouring potentially hazardous installations or at land zoned to accommodate such installations.	5×10^{-5}	No Note 1
Risk of property damage and accident propagation – 14 kPa explosion overpressure		
Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings.	5×10^{-5}	Yes
Note. 1. Refer to the discussion below.		

Injury risk

Injury heat radiation and explosion overpressure (conservatively approximately to be within the LFL cloud) contours for the Stage 2 development do not extend into the nearest residential and sensitive land use areas.

Individual fatality risk

The individual fatality risk contours for the Stage 2 development (Figure 10.4) shows that:

- The 5×10^{-5} per year risk contour extends into the Gurungaty waterway. This finding is attributed to Site 2 as shown in Figure 10.1. As reported in Section 10.2, this is a shallow waterway, which precludes ship or boat access, and is within the port area, which restricts public access. Hence it is unlikely people will be present in this area and exposed to the risk. The 5 x 10^{-5} fatality risk contour do not extend offsite on Site 1 and has not changed since the original PHA associated with the approved DA (Ref. 1).

- The remaining fatality risk contours do not reach recreational, commercial, residential or sensitive land uses.

Property damage and propagation risk

The maximum extent of the explosion overpressure was conservatively approximately to be within the LFL cloud. The 5 × 10^{-5} per year propagation risk contour associated with LFL cloud is not generated for Site 1, and is retained within the Site 2 boundary (see Figure 10.3). Therefore the HIPAP 4 criteria relating to explosion overpressure is met.

The heat radiation propagation risk contours for the Stage 2 development (Figure 10.5) shows that:

- The 5 x 10^{-5} per year risk contour extends into the land north of Site 1 (up to 5 m from site boundary). This finding is attributed to Site 1 operations. This land is zoned to accommodate potentially hazardous installations. Therefore, the 5 x 10^{-5} propagation risk contour would not meet the HIPAP 4 risk criteria. It is noted that there is currently no equipment, structures or dangerous goods in the area the risk contour extends into.

This finding was reported in the original PHA (Ref. 1). Options to reduce the propagation risk discussed in the original PHA include:

- Fire detection and foam suppression systems provided in the pump bay. This was not accounted for in the risk model due to the uncertainty in their ability to reduce the immediate impact of the incident. However it would reduce the severity of the fire.
- Hydrocarbon spill detection provided in the pump bay sump. This was not accounted for in the risk model as a large release and immediate ignition has occurred. However it would reduce the severity of the fire.

The PHA is based on a preliminary design of the site. As the detailed design progresses, particularly for the Site 1 pump bay area, further refinements to the design to minimise risks associated with this section of the plant would be incorporated in accordance with the current consent conditions.

10.4.5. Comparison with risk contours in approved DA

The individual fatality and propagation risk contours for the Stage 2 development (Sites 1, 2 and 3) were compared with the risk contours for the development for the approved DA (Approval SSD 15_7264). The risk contours associated with Site 1 were taken directly from the PHA associated with the approved DA (Ref. 1). References to equipment and tank locations in this section are to the site layout associated with the modification.

In reference to the fatality risk contours for Stage 2 development (Figure 10.4) and approved DA (Figure 10.6), the observations are as follows:

- The risk contours around the berth and Site 1 have not changed.
- The 5 x 10^{-5} (blue) per year risk contour extending into the Gurungaty waterway, east of Site 2, has reduced from 20 m from the site boundary to 10 m. This is due to the minor relocation of the road tanker gantry further away from the eastern site boundary.
- The 1 x 10^{-5} (green) per year risk contour has reduced so that it is retained on Site 2 as the pump bay bund area is reduced from 1215 m^2 to 390 m^2
- The 5 x 10^{-6} (pink) per year risk contour has increased at the inlet manifold (but still remains onsite), and reduced near the pump bay as the bund area has been reduced.
- The 1 x 10^{-6} (yellow) and 5 x 10^{-7} (orange) per year risk contours have reduced:
  - Along the east of Site 2 boundary as the shorelines have been relocated so that it runs through the centre of Site 2
  - Along the west of Site 2 boundary, away from the Graincorp site, due to separation into north and south bunds.

In reference to the propagation risk contours for Stage 2 development (Figure 10.5) and approved DA (Figure 10.7), the observations are as follows:

- The risk contour around the berth have not changed and is not generated.
- The risk contour around Site 1 have not changed.
- The 5 x 10^{-5} (blue) per year risk contour has increased (but is still retained onsite) and is now concentrated around the loading gantry and pump bay due to the high online time of the pumps. The risk contour still extends into the waterway.

Figure 10.6: Individual fatality risk contours – Approved DA

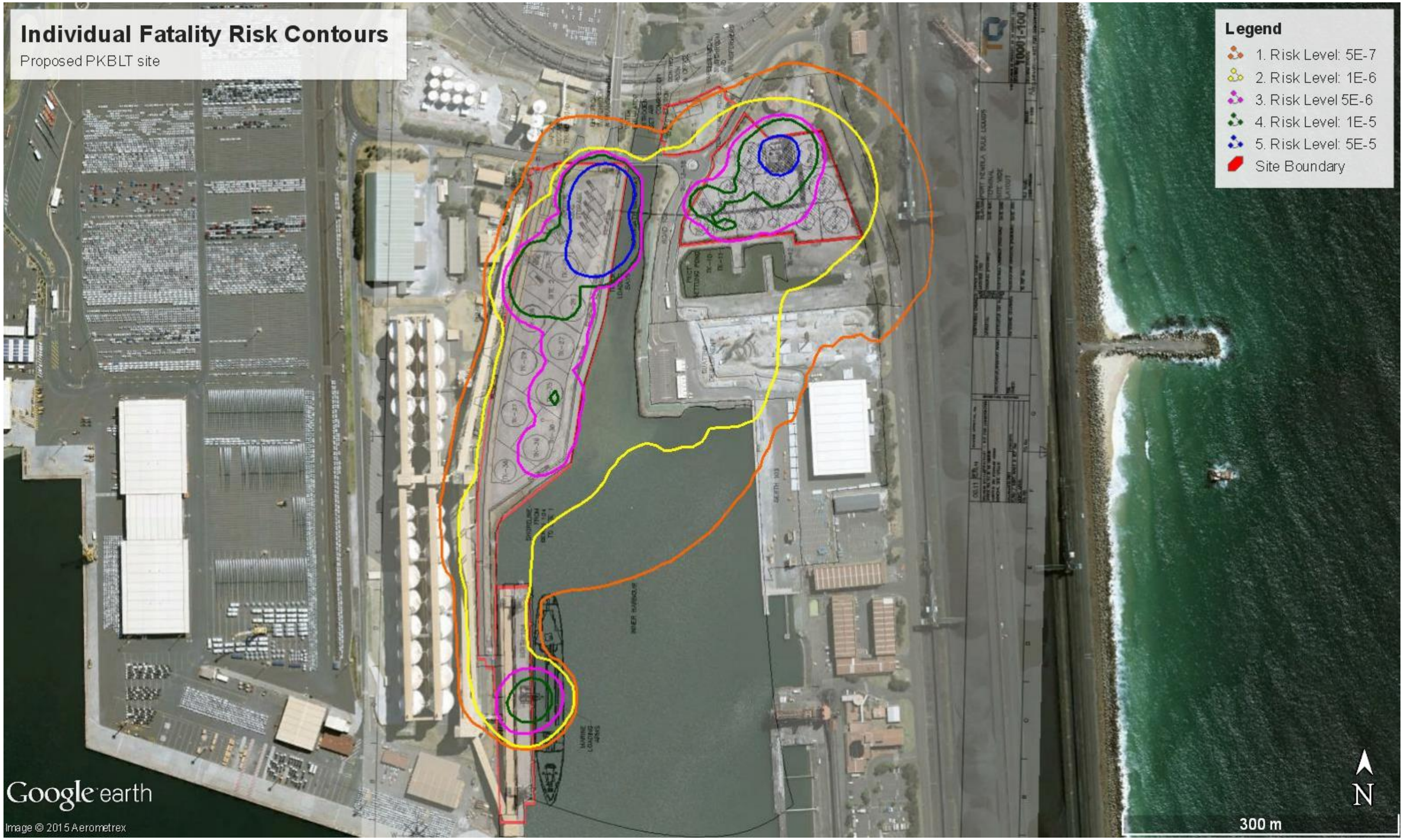


Figure 10.7: Damage and propagation risk contour – Approved DA

10.5. Assessment of cumulative risk

The final SEARs require TQ Holdings to estimate the cumulative risk that PKBLT site presents to the existing risk profile for the area (if any). As there is no quantitative risk model for the existing site and surrounding development available in the public domain, the change to the cumulative risk model was assessed qualitatively.

The existing land uses adjacent to the PKBLT site include:

- Coal stockpiles to the east of Site 1 at PKCT
- Grain silos to the west of Site 2 at the Grain Terminal
- Grain silos to the south of Site 1 at the Quattro development.

The main risks associated with the coal stockpiles are coal dust explosions and stockpile fires. Dust explosion risks are typically managed by design and codes and standards. Consequences are typically limited to structural damage onsite. The separation distance from the coal stockpile to the nearest tank on PKBLT site 2 is 380 m. Escalation from a coal stockpile fire to the nearest tank is not considered credible based on the separation distance.

The main risk associated with grain silo storage is dust explosions. These consequences are typically retained onsite. As a result, the fatality risk is retained onsite.

In the absence of risk models for adjacent developments in the area, a qualitative assessment of their risk indicates that there is low cumulative risk in the area as risk contours typically remain onsite for all developments.

11. CONCLUSIONS

11.1. SEPP 33 analysis findings

The SEPP 33 analysis found that the quantities of Class 3 PG II, ie gasoline, stored onsite for the Stage 1 development exceeded the threshold quantities stated in the SEPP 33 guideline (Ref.13). The proposed development is '*potentially hazardous'* and a PHA study is required.

The SEPP 33 analysis also found that a route evaluation study is required as weekly vehicle movements of Class 3 PG II materials are above the SEPP 33 transport screening threshold levels. This requirement is addressed in the Traffic Impact Assessment by Cardno in accordance with HIPAP No. 11 guideline.

11.2. Preliminary Hazard Analysis findings

11.2.1. Stage 1 development

A quantitative PHA was completed for the preliminary design of the Stage 1 development. The results of the PHA are compared with the HIPAP 4 criteria in Table 11.1.

Table 11.1: Summary of compliance of HIPAP 4 risk criteria – Stage 1

Description and land use	HIPAP 4 Criteria (per year)	Criterion Met
Individual fatality risk		
Hospitals, child-care facilities and old age housing (sensitive land use).	5×10^{-7}	Yes
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1×10^{-6}	Yes
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres (commercial land use).	5×10^{-6}	Yes
Sporting complexes and active open space areas (recreational land use).	1×10^{-5}	Yes
For industrial sites, individual fatality risk level should, **as a target**, be contained within the boundaries of the site where applicable.	5×10^{-5}	No [Note 1]
Injury risk – heat radiation exceeding 4.7 kW/m²		
Residential and sensitive use.	5×10^{-5}	Yes
Injury risk – explosion overpressure exceeding 7 kPa		
Residential and sensitive use.	5×10^{-5}	Yes
Risk of property damage and accident propagation – 23 kW/m² heat flux		
Neighbouring potentially hazardous installations or at land zoned to accommodate such installations.	5×10^{-5}	No [Note 1]

Description and land use	HIPAP 4 Criteria (per year)	Criterion Met
Risk of property damage and accident propagation – 14 kPa explosion overpressure		
Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings.	5 x 10^{-5}	Yes
Note. 1. See discussion below.		

The 5 x 10^{-5} per year individual fatality risk contour extends into the Gurungaty waterway east of Site 2 (up to 10 m from site boundary). The main risk contributor is a jet fire from the road tanker loading gantry area.

Whilst this does not meet the **target** of retaining the risk contour within the site boundary, the following points are noted:

- Fire detection is provided in the road tanker loading bay area. A terminal ESD will be activated on fire detection stopping the gantry loading pumps and closing tank actuated valves. The jet fire will rapidly reduce in size limiting the duration of any offsite impact.
- The affected area is a shallow waterway, which precludes ship or boat access, and is within the port area, which restricts public access.
- The site is elevated approximately 3 m above the waterway providing additional protection from an incident. Hence it is considered unlikely people will be present in this area and exposed to the risk.

The 5 x 10^{-5} per year heat radiation escalation risk contour extends into the Gurungaty waterway east of Site 2 (up to 10 m from site boundary). The main risk contributor is a jet fire from the road tanker loading gantry area. The criteria applies to neighbouring potentially hazardous installations or land zoned to accommodate such installations. The land does not currently contain a potentially hazardous facility and given its nature (shallow, narrow, water way) it is not considered credible that a potentially hazardous facility will be constructed on the boundary.

11.2.2. Stage 2 development

Individual fatality and property damage and propagation risk contours were constructed for the Stage 2 development based on the risk contours associated with the Stage 1 development (ie Site 2 layout redesign) and Site 1 risk contours from the approved DA, Ref. 1. This shows that the HIPAP 4 criteria compliance finding is the same as that reported in Table 11.1.

As identified in the PHA (Ref. 1) for the approved DA (Approval SSD 15_7264), the 5 × 10^{-5} per year risk escalation contour extends into the land north of Site 1 (up to 5 m from site boundary). The area is zoned to accommodate potentially hazardous installations. It is noted that there is currently no equipment, structures or dangerous goods in the area the risk contour extends into, and the PHA is based on a preliminary design of the site. As the detailed design progresses, particularly for the Site 1 pump bay area, further refinements to the design to minimise risks associated with this section of the plant would be incorporated in accordance with the current consent conditions.

11.2.3. Comparison with approved DA

The comparison of fatality risk contours associated with the Stage 2 development and the approved DA shows that the contours around Site 2 have been reduced and do not extend as far into the waterway and into the Graincorp site. This is due to the redesign of Site 2 for this modification ie shoreline relocation and separation into north and south bunds. The risk contours around the berth and Site 1 have not changed from the approved DA.

The comparison of escalation risk contours associated with the Stage 2 development and the approved DA shows that the contour around Site 2 have increased around the loading gantry and new pump bay area due to the higher pump online time. However, this still meets HIPAP 4 criteria.

APPENDIX A. SEPP 33 ANALYSIS

A1. Methodology

The screening process published in the NSW Department of Planning and Environment (DPE) guideline *Hazardous & Offensive Development Application Guidelines – Applying SEPP33 (January 2011)* (Ref.13) was used to establish whether the development is '*potentially hazardous*'. The analysis did not include assessing the site as '*potentially offensive*'. This is covered in the Traffic Impact Assessment in another section of the Environmental Impact Statement (EIS).

State Environmental Planning Policy (SEPP 33) defines '*potentially hazardous*' as follows:

> *'Potentially hazardous industry' means a development for the purposes of an industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:*
>
> *(a) to human health, life or property; or*
>
> *(b) to the biophysical environment, and:*
>
> *includes a hazardous industry and a hazardous storage establishment.'*

To determine whether a proposed development is '*potentially hazardous'*, the screening in SEPP 33 considers the type and quantity of hazardous materials to be stored on the site and the distance of the storage area to the nearest site boundary, as well as the expected number of transport movements.

'Hazardous materials' are defined within the SEPP 33 guideline as substances that fall within the classification of the Australian Dangerous Goods (ADG) Code.

A2. Dangerous goods

A2.1. Types and quantities of DG

A list of expected types and quantities of Dangerous Goods (DG) to be stored or handled at the development at Stage 1, together with the relevant SEPP 33 screening threshold is presented in Table A.2. This is based on the storage tank capacities summarised in Table A.1.

A2.2. Storage arrangements

Storage arrangements are as described in Section 3 of the Preliminary Hazard Analysis (PHA) report.

The SEPP 33 threshold quantity of Class 3 PG II materials is 10 to 20 tonnes based on the distance of the Site 2 bund wall to the site boundary of approximately 5 m. Although C1 combustible liquid is classified as a dangerous good, it is stored in the same bund as Class 3 PG II materials. According to the SEPP 33 guidelines, these combustible liquids should also be considered as Class 3 PG II materials. Table A.2 shows that the total quantity of Class 3 PG II materials on Port Kembla Bulk Liquids Terminal (PKBLT) site is 114,800 tonnes which is above the SEPP 33 threshold quantity.

Therefore, the development is '*potentially hazardous'* and a PHA is required for the site.

A2.3. Transport

SEPP 33 guideline specifies that a '*proposed development may be potentially hazardous if the number of generated traffic movements (for significant quantities of hazardous materials entering or leaving the site) is above the annual or weekly cumulative vehicle movements*' (Ref.13). For PKBLT, road tanker movements carrying Class 3 PG II materials need to be considered. If a site generates greater than 45 vehicle movements of Class 3 PG II materials per week, the proposal is considered to be potentially hazardous, and a transport route evaluation study should be completed in accordance with the DPE *HIPAP 11: Route Selection*.

TQ Holdings has advised that daily vehicle movements to and from the site will be approximately 209 road tankers, of which 35% is attributed to Class 3 PG II materials. This equates to approximately 512 vehicle movements per week of Class 3 PG II materials, which is greater than the SEPP 33 screening threshold of 45 vehicle movements per week.

As a result, the development is '*potentially hazardous*' with respect to transportation and a route evaluation study in accordance with *HIPAP 11: Route Selection* will be required. This requirement is covered in Cardno's Traffic Impact Assessment.

Table A.1: Storage tank contents and capacities - Site 2 (Stage 1)

Tank	Product	Diameter (m)	Height (m)	Tank volume (m^3) (Max SFL)
TK-01	Diesel	29	28.9	18,400
TK-02	Diesel	29	28.9	18,400
TK-03	Diesel	29	28.9	18,400
TK-04	Diesel	24	28.8	12,200
TK-05	Gasoline	29	28.9	18,400
TK-06	Gasoline	29	28.9	18,400
TK-07	Gasoline	29	28.9	18,400
TK-08	Gasoline	29	28.9	18,400
TK-09	Gasoline	9.8	21	1,510
TK-10	Gasoline	9.8	21	1,510
TK-11	Diesel [1]	9.8	21	1,510
TK-12	Ethanol	9.8	21	1,510
TK-13	Gasoline	3	5.1	30
TK-14	Gasoline	3	8	50
TK-15	Gasoline	3	8	50
TK-16	Oily water [1]	3	5.1	30
TK-41	Gasoline	3	5.1	30
TK-42	Gasoline	3	5.1	30
IBC	Up to 16 mixed IBCs	-	-	16

Note:
1. These tanks were included in the risk model as storing gasoline (flammable liquid) to allow for flexibility in future operation.

Table A.2: SEPP 33 hazardous material storage screening summary

Material	Purpose	UN no.	DG class	Quantity stored on site		SEPP 33 threshold and determination
				m^3	tonnes	
Site 2						
Flammable	Storage	1203	3 PG II	78,270	57,900	Threshold quantity for Class 3 PG II is based on distance of bund wall from nearest site boundary. Based on Figure 9 in SEPP 33 (Ref. 13) and minimum of 5 m distance to bund wall, the threshold quantity is 10 to 20 tonnes[Note 1].
Combustible	Storage	3075	-	68,960	56,900	No threshold identified for Combustibles C1, based on SEPP 33. However, since diesel is stored in the same bund as Class 3 PG II materials, total inventory of diesel would be classified as Class 3 PG II.
Total Class 3 PG II materials on Site 2					114,800	Total Class 3 PG II storage on Site 2 (including C1 Combustible liquid because it is stored in the same bund) exceed SEPP 33 threshold quantity of 10-20 tonnes. Development is considered '*potentially hazardous*' and a PHA is required
Note 1: The distance of bund wall from nearest site boundary was taken to be 5 m based on Site 2 layout.						

APPENDIX B. QRA OPERATIONAL BASIS

The information in the following table was supplied and approved by TQ Holdings.

	Proposed Operation (Stage 1)		
Overview			
	Value	**Unit**	**Comments**
Site Throughput Total	2,947	ML/year	Calculated based on: - Road tanker movements and average tanker load for each road tanker (B-doubles). Note: Export is via road tanker only.
Incoming Product Transfer			
	Value	**Unit**	**Comments**
(Ship Import) Transfer Rate	1,250	m^3/hr	Ship import rate via 4 parallel lines. 1,250 m^3/hr is the maximum flow through one shoreline directed into a single tank. Typical transfer rate is 1,000 m^3/hr but maximum is used to be conservative. This is equivalent to 7 m/s in tank inlet piping.
(Ship Import) Transfer Pressure	10	barg	Discharge pressure at the berth manifold was designed for 9 barg. TQ Holdings have confirmed using 10 barg to be conservative.
(Ship Import) Ship Volume	50,000 to 120,000	m^3	-
(Ship Import) Number of Marine Loading Arms (MLAs)	4	-	Maximum number of MLAs.
(Ship Import) Transfer Duration	17	hr	Assume that 4 MLAs are connected up to ship. Average ship volume is assumed to be 85,000 m^3.
(Ship Import) Online Time	544	hours/year	32 vessels per year.
(Ship Import) % Wharf Online Time	6%	per year	Calculated based on: - Number of hours online per year
(Ship Import) % Product Split (Combustible: Flammable)	65:35	-	Basis of design

	Value	Unit	Comments
(Ship Import) Pigging Frequency	-	-	Pigging is done at the end of the each shipment. Once per shoreline.
(EtOH Unloading) Transfer Rate	72,000	L/hour	1,200 litres/minute.
(EtOH Unloading) Transfer Pressure	10	barg	-
(EtOH Unloading) Transfer Frequency	1	transfer/day	-
(EtOH Unloading) Road Tanker Load	50,000	L/tanker	Typical delivery of ethanol will be by B-double road tanker.
(EtOH Unloading) Number of Hose Connections	2,920	times/year	Assume 3 connections for B-double road tanker.
(EtOH Unloading) Online Time	253	hours/year	Calculated based on: - Average road tanker load - Average transfer rate
(EtOH Unloading) % Gantry Online Time	3%	per year	Calculated based on: - Number of hours online per year
(Biodiesel Unloading) Transfer Rate	72,000	L/hour	Calculated based on transfer rate of 1200 litres/minute.
(Biodiesel Unloading) Transfer Pressure	10	barg	Reducing to 6 barg at the gantry
(Biodiesel Unloading) Transfer Frequency	2	transfers/day	Basis of design
(Biodiesel Unloading) Road Tanker Load	50,000	L/tanker	Typical delivery of biodiesel will be by B-double road tanker.
(Biodiesel Unloading) Number of Hose Connections	5,840	times/year	Assume 3 connections for B-double road tanker.
(Biodiesel Unloading) Online Time	507	hours/year	Calculated based on: - Average road tanker load - Average transfer rate
(Biodiesel Unloading) % Gantry Online Time	6%	per year	Calculated based on: - Number of hrs online per year
VRU regeneration gasoline circulation pump online time	12 hours	per day	Based on typical unit performance

Outgoing Product Transfer	Value	Unit	Comments
(Product Loading) Road Tanker (Export) Throughput Total	2,947,448	m^3/year	Based on road tanker movements and average tanker load for each road tanker (B-doubles)
(Product Loading) Road Tanker Movements	206	per day	Assumed 65:35 combustible/flammable
(Product Loading) Road Tanker Load	39,200	L/tanker	Expected numbers of trucks: B-double trucks (50%): 50,000 L/truck Single trucks (40%): 31,000 L/truck Rigid trucks (10%): 18,000 L/truck
(Product Loading) Road Tanker Loading Time	25	minutes/loadout	-
(Product Loading) Road Tanker Loading Pressure	6	barg	-
(Product Loading) Road Tanker Loading Rate (3 arms)	432,000	litres/hour	2400 litres/minute per loading arm. Each arm will fill different compartment (allowing different products for each compartment on a B-double). Total loading rate is based on filling rate of 3 arms (max at a given time)
(Product Loading) % Gantry Online Time	100%	per year	Calculated based on: 206 vehicles/day across all products Average time to load is 25 minutes 24 hours of operation in a day
(Product Loading) % Loading Bay Online Time	60%	per year	Calculated based on: 206 vehicles/day across all products Average time to load is 25 minutes Assume product loading occurs equally across 6 loading bays
(Product Loading) Number of Hose Connections	263,165	times/year	Assume 1 connections for rigid and single trucks, and 3 connections for B-Double trucks.

APPENDIX C. HAZARD IDENTIFICATION REGISTER

The following table shows the revision history of the Hazard Identification (HAZID) Register, the register was prepared for stage 2 operations and includes all stage 1 operations.

Revision	Date	Comments	By	Checked
3	04-Dec-2015	Issued for inclusion in PHA	M. Braid	S. Chia

HAZID REGISTER

Project: 20950 TQ Holdings Port Kembla Bulk Liquids Terminal
Last Risk Register Rev: 3
Rev Date: 4-Dec-15

ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
1	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 flammable liquids	Flammable liquid leak at wharf / shoreline / manifold	1. Valve stem leak 2. Flange / gasket leak 3. Pipework leak 4. Marine loading arm (MLA) swivel joint leak 5. External corrosion 6. Mechanical damage (eg. vehicle, third party maintenance from other berth users) 7. Line valve (eg. drain) accidentally / inadvertently opened	1. Pipework design for Class 3 flammable liquids 2. Regular / preventative maintenance (eg pipework, MLA) 3. Construction standards (eg painting) 4. Standard Operating Procedures (SOPs) (eg ship unloading) 5. Mechanical protection of line (eg bollards)	1. Operator surveillance "walking the line" 2. Closed Circuit Televisions (CCTVs) at berth monitored at control room 3. Marine Security Identification Card (MSIC) controlled access 4. Emergency Shutdown (ESD) 5. Hazardous area classification 6. Fire / foam monitors 7. Vessel fire systems at berth 8. Port authority / Site Emergency Response Procedures (ERP)	1. Spill into harbour and environmental issue 2. Jet / spray fire (if ignited) 3. Spill onto berth, mist and pool evaporation, flash fire if sufficient vapours and ignited	Site will have dedicated foam systems (specific for ethanol and class 3 fuel products)	Yes
2	Berth 104	Fire / explosion (following release)	Ship Import	Class C1 combustible liquids	Combustible liquid leak at wharf / shoreline / manifold	See ID 1	See ID 1	See ID 1	1. Spill into harbour and environmental issue 2. Pool fire (if ignited)	-	Yes
3	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 flammable liquids	Marine loading arm failure leading to flammable liquid release (operational)	1. Ship movement (bad weather, poor monitoring) 2. Poor connection 3. Emergency scenario where ship required to pull away from berth 4. MLA / trolley movement 5. Operator error	1. Mooring around vessel secured to berth 2. MLA design incorporates position sensors and alarm 3. MLA disconnect and emergency release coupling (ERC) 4. Operational procedures (Port authority) 5. MLA operating limits 6. Control interlocks on MLA movement and trolley 7. SOPs 8. MLA (ship side) coupling connection sensors 9. Anchor point for trolley	1. SOPs (pressure test MLA connections prior to discharge) 2. Operator detection and response 3. CCTVs 4. Position sensor on MLA to detect movement out of range 5. ESD (fire alarm and shutdown) 6. Fire / foam monitors 7. ERP	1. Spill into harbour and environmental issue 2. Jet / spray fire (if ignited) 3. Spill onto berth, mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
4	Berth 104	Fire / explosion (following release)	Ship Import	Class C1 combustible liquids	MLA failure leading to combustible liquid release (operational)	See ID 3	See ID 3	See ID 3	1. Spill into harbour and environmental issue 2. Pool fire (if ignited)	-	Yes
5	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 flammable liquids	MLA failure (parked position)	1. High winds 2. Operator error	1. Anchor point for trolley 2. MLAs drained of product following transfer	1. Operator detection and response 2. CCTVs 3. ERP	1. Minor spill into harbour and environmental issue 2. Minor jet / spray fire (if ignited) 3. Minor spill onto berth, mist and pool evaporation, flash fire if sufficient vapours and ignited	-	No - small quantity in comparison to other flammable material inventories on site
6	Berth 104	Fire / explosion (following release)	Ship Import	Class C1 combustible liquids	MLA failure (parked position)	See ID 5	See ID 5	See ID 5	1. Minor spill into harbour and environmental issue 2. Minor pool fire (if ignited)	-	No - small quantity in comparison to other flammable material inventories on site
7	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 / C1	Loss of containment (LOC) of flammable liquid	1. Security breach	1. Port restricted area 2. MSIC card required 3. Port security and patrols 4. Pipeline emptied and resting on nitrogen blanket	1. Operator detection and response 2. CCTVs	1. LOC, and fire (if ignited)	-	No - outside scope
8	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 / C1	Fire at berth	See IDs 1, 3 and 5	See IDs 1, 3 and 5 1. Isolation of potential ignition sources on the berth	1. Grain conveyors have some inherent protection (eg concrete / steel structure) 2. Fire / foam monitors 3. Vessel fire systems at berth 4. Port Authority / Site ERP	1. Escalated event to conveyors (Graincorp) 2. Escalated event to ship	-	No - outside scope
9	Berth 104	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	LOC of flammable liquid during draining and pigging (pig launcher)	1. Operator error (incorrectly isolates pig chamber prior to opening door) 2. Draining of MLA	1. Pig station / seal design 2. Lock-in pin (indicates if pressure still present) 3. Pig indicators 4. SOPs 5. Preventative maintenance (monthly, yearly checks)	1. Operator detection and response 2. CCTVs 3. ESD / emergency isolation points 4. ERP	1. Jet / spray fire (if ignited) 2. Spill onto berth, mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
10	Berth 104	Fire / explosion (following release)	Pigging	Class C1 combustible liquids	LOC of combustible liquid during draining and pigging (pig launcher)	1. Operator error (incorrectly isolates pig chamber prior to opening door)	See ID 9	See ID 9	1. Pool fire (if ignited)	-	Yes
11	Berth 104	Fire / explosion (following release)	Slops	Class 3 / C1	LOC of flammable liquid	1. Connection failure with vacuum truck 2. Operator error 3. Corrosion	1. Operator attendance 2. SOPs 3. Materials of construction for slop storage and handling	1. Spill cleanup kit 2. Fire extinguishers / protection	1. Minor spill (less than 100L), and fire (if ignited), potential for injury	-	Yes
12	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Tank overfill during ship import leading to flammable liquid release	1. Failure of level indicator 2. Human error / failure to line up or change over to correct tank (terminal side) 3. Human error / ship fails to stop pumping when instructed (ship side)	1. SOPs 2. Automated control system 3. High level alarm and operator response 4. High High level and terminal ESD (including wharf valves) 5. Independent level detection 6. Terminal to ship communication protocols 7. Bund wall height only 1.8m and good natural ventilation around site (reduces potential for vapour cloud formation)	1. Operator detection and response 2. Fills intermediate bund with detection (level and / or hydrocarbon) 3. Hazardous area classification 4. Fire system on adjacent tanks (for cooling) / AS1940 compliant 5. Foam pourers on all storage tanks / AS 1940 compliant	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE, if sufficient vapours and ignited	Once design has been finalised, a fire protection systems review will be undertaken.	Yes
13	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	Tank overfill during ship import leading to combustible liquid release	See ID 12	See ID 12	See ID 12	1. Pool fire (if ignited)	See ID 12	Yes
14	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Flammable liquid sent into combustible storage tanks during ship import	1. Valve misalignment / human error	1. SOPs 2. Online density measurement in shoreline, transfer line and tank 3. Automated control and level protection system	1. Frangible tank roof 2. Storage tanks have vent reliefs (partially effective) 3. Intertank transfer pump and piping 4. Hazardous area classification 5. Fire / foam protection (provided on all tanks)	1. Overfill leading to LOC of flammable liquid and fire (if ignited) 2. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited) 3. Product contamination	-	Yes
15	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	LOC from pipework (within terminal) leading to flammable liquid release	1. Corrosion 2. External impact 3. Maintenance work 4. Pressure surge 5. Thermal jacking of pipeline pressure 6. Operator error (eg valve left open) 7. Product theft	1. Regular maintenance and inspection 2. Mechanical protection 3. Traffic management (eg. Road markings, speed limits, one way zones) 4. Thermal relief valves 5. Pipeline / equipment designed for expected maximum operating pressures (eg. surge analysis) 6. SOPs 7. Site security fence / restricted access	1. Operator patrols 2. CCTV 3. Controlled access (swipe cards onto site) 4. Driver induction 5. Isolation valves 6. Fire protection 7. ESD	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited 3. Product contamination	-	Yes
16	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	LOC from pipework (within terminal) leading to combustible liquid release	See ID 15	See ID 15	See ID 15	1. Pool fire (if ignited)	-	Yes

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ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
17	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Flammable liquid leak from tank	1. Tank rupture 2. Fitting leak on tank connection 3. Corrosion of tank base / weld 4. Faulty fabrication 5. Metal fatigue 6. Blocked vent 7. Mechanical impact (eg crane)	1. Tanks designed to American Petroleum Institute (API) standards 2. Hydrotested when constructed 3. Lining on bottom of tank 4. Preventative maintenance / inspection 5. By design, minimising connection points below tank liquid point 6. ITP QA QC / Fabrication 7. Safe work systems (eg Permission to work (PTW), lifting studies)	1. Operator detection and response 2. Intermediate bund with detection (level and / or hydrocarbon) and alarm 3. SOP / routine dewatering 4. In-tank water monitoring system 5. Splash shields provided around storage tanks close to external bund 6. Fire system on adjacent tanks (for cooling) / AS1940 compliant 7. Foam pourers on all storage tanks / AS 1940 compliant	1. Pool fire and potential full surface bund fire 2. Flash fire	-	Yes
18	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	Combustible liquid leak from tank	See ID 17	See ID 17	See ID 17	1. Pool fire and potential full surface bund fire (if ignited)	-	Yes
19	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Leak of pump in vicinity of storage tank leading to release of flammable liquid	1. Pump seal failure 2. Pumping against closed valve on pump discharge	1. Preventative maintenance procedures 2. Pump seal design	1. Regular patrols 2. Level / hydrocarbon detection 3. Hazardous area classification 4. Fire detection around pump bay 5. Terminal ESD 6. Site ERP	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	Fire design review still to be completed as part of detailed design (eg. Pump bay area)	No. Pump in vicinity of storage tank is used for dewatering
20	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Leak of pump in vicinity of storage tank leading to release of combustible liquid	See ID 19	See ID 19	See ID 19	1. Pool fire (if ignited)	See ID 19	No. Pump in vicinity of storage tank is used for dewatering
21	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Pump bay area inside bund	1. Pump seal failure 2. Pumping against closed valve on pump discharge 3. Leak in bund where pumps sit	See ID 19	1. Regular patrols 2. Level / hydrocarbon detection in bund 3. Fire detection around pump bay 4. Terminal ESD 5. Site ERP	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	Site layout still to optimised (in particular site 1 transfer pumps)	Yes
22	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Pump bay area inside bund	See ID 21	See ID 19	See ID 21	1. Pool fire (if ignited)	See ID 21	Yes
23	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Tank overfill during tank-to-tank transfer leading to flammable liquid release	1. Failure of level indicator 2. Human error / failure to line up or change over to correct tank	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE, if sufficient vapours and ignited	To be covered in HAZOP	Yes
24	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Tank overfill during tank-to-tank transfer leading to combustible liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire (if ignited)	See ID 23	Yes
25	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Flammable liquid sent into combustible storage tanks during tank-to-tank transfer	See ID 14	See ID 14	See ID 14	1. Overfill leading to LOC of flammable liquid and fire (if ignited) 2. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited)	-	Yes
26	Site 1 Storage	Fire / explosion (following release)	Recirculation	Class 3 / C1	Recirculation to incorrect tank	1. Human error / wrong line-up	See ID 14	See ID 14	1. Overfill leading to LOC of flammable liquid and fire (if ignited) 2. Quality off-spec	-	Yes
27	Site 1 Storage	Fire / explosion (following release)	Recirculation	Class 3 flammable liquids	Recirculation via mixing nozzle into tank with insufficient liquid level	1. Insufficient liquid level	1. Control system and interlock on mixing nozzle operation 2. SOPs (sufficient liquid level)	1. SOPs (eg. Manual dipping) 2. Tank level detection 3. Frangible tank roof 4. Hazardous area classification 5. Fire system on adjacent tanks (for cooling) / AS1940 compliant 6. Foam pourers on all storage tanks / AS 1940 compliant	1. Damage to internal floating roof (IFR), increase in vapour emissions. Potential for explosion inside tank (if ignited)	-	Yes
28	Site 1 Storage	Fire / explosion (following release)	Recirculation	Class C1 combustible liquids	Recirculation via mixing nozzle into tank with insufficient liquid level	See ID 27	See ID 27	See ID 27	1. Vapour formation, and potential to form flammable diesel mist. Potential for explosion inside tank (if ignited)	-	Yes
29	Site 1 Storage	Fire / explosion (following release)	Working tank	Class 3 flammable liquids	Product loading pump leak leading to release of flammable liquid	See ID 19	See ID 19	See ID 19	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
30	Site 1 Storage	Fire / explosion (following release)	Working tank	Class C1 combustible liquids	Product loading pump leak leading to release of combustible liquid	See ID 19	See ID 19	See ID 19	1. Pool fire (if ignited)	-	Yes
31	Site 1 Storage	Fire / explosion (following release)	Working tank	Class 3 / C1	Pump runs dry	1. Insufficient liquid in tank 2. Wrong valve line-up / blocked line	1. Level control system 2. Low level trip 3. SOPs 4. Limit switches for inlet and outlet valves / pump permissives	1. Pump low flow protection 2. Terminal ESD 3. Fire detection around pump bay 4. Site ERP	1. Damage to pump, potential mechanical failure / explosion 2. Suck air into piping (in event of low tank level), flammable mixture formation and explosion in pump/ piping	-	No - does not lead to release of flammable/combustible liquid
32	Site 1 Storage	Fire / explosion (following release)	Blending (In-tank)	Class 3 flammable liquids	Tank overfill during P98 and ULP blending (in tank) leading to flammable liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE if sufficient vapours and ignited	See ID 23	Yes
33	Site 1 Storage	Fire / explosion (following release)	Blending (In-tank)	Class C1 combustible liquids	Tank overfill during biodiesel and diesel blending (in tank) leading to combustible liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire (if ignited)	See ID 23	Yes
34	Site 1 Storage	Fire / explosion (following release)	Dewatering	Class 3 flammable liquids	Release of flammable liquid to bund	1. Tank drain valve left open 2. Tank sampling valve left open (operator error)	1. SOPs	1. High level alarm and inlet valve closed on slops tank 2. High High level trip initiates terminal ESD 3. Bunding 4. Fire protection system 5. Site ERP	1. Overfill of slops tank, pool fire and potential full surface bund fire 2. Flash fire	-	Yes
35	Site 1 Storage	Fire / explosion (following release)	Dewatering	Class C1 combustible liquids	Release of combustible liquid to bund	See ID 34	See ID 34	See ID 34	1. Overfill of slops tank, pool fire (if ignited)	-	Yes
36	Site 1 Storage	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	LOC of flammable liquid during pigging (pig receiver)	1. High pressure nitrogen used for pushing pigs	1. Emergency relief vents on tanks 2. Pigging vents on IFR 3. Diffuse fill nozzle in storage tank	1. Operator detection and response 2. Terminal ESD 3. ERP	1. Damage to IFR due to nitrogen blowby, increased vapour emissions 2. Damage to tank roof due to nitrogen blowby, potential to blow roof off 3. Jet / Spray fire (if ignited) 4. Mist and pool evaporation, flash fire if sufficient vapours and ignited	See ID 23	Yes - included as release from ship import pipeline
37	Site 1 Storage	Fire / explosion (following release)	Pigging	Class C1 combustible liquids	LOC of combustible liquid during pigging (pig receiver)	See ID 36	See ID 36	See ID 36	1. Damage to tank roof due to nitrogen blowby, potential to blow roof off 2. Pool fire (if ignited)	See ID 23	Yes - included as release from ship import pipeline

ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
38	Site 1 Storage	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	Release of stored energy when opening pig receiver	1. Locked in pressure / operator error 2. Operator error (incorrectly isolates pig chamber prior to opening door)	1. SOPs 2. Pig receiver design prevents opening when pressurised	1. Pig receiver pressure indication 2. Pig receiver locking plug has integral pressure relief	1. Equipment damage and potential injury / fatality	-	No - does not lead to release of flammable/combustible liquid
39	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Tank overfill during ship import leading to flammable liquid release	See ID 12	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE, if sufficient vapours and ignited	See ID 12	Yes
40	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	Tank overfill during ship import leading to combustible liquid release	See ID 12	See ID 12	See ID 12	1. Pool fire (if ignited)	See ID 12	Yes
41	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Flammable liquid sent into combustible storage tanks during ship import	See ID 14	See ID 14	See ID 14	1. Overfill leading to LOC of flammable liquid and fire (if ignited) 2. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited)	-	Yes
42	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	LOC from pipework (within terminal) leading to flammable liquid release	See ID 15	See ID 15	See ID 15	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
43	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	LOC from pipework (within terminal) leading to combustible liquid release	See ID 15	See ID 15	See ID 15	1. Pool fire (if ignited)	-	Yes
44	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Flammable liquid leak from tank	See ID 17	See ID 17	See ID 17	1. Pool fire and potential full surface bund fire 2. Flash fire	-	Yes
45	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	Combustible liquid leak from tank	See ID 17	See ID 17	See ID 17	1. Pool fire and potential full surface bund fire	-	Yes
46	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Leak of pump in vicinity of storage tank leading to release of flammable liquid	See ID 19	See ID 19	See ID 19	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	See ID 19	No. Pump in vicinity of storage tank is used for dewatering
47	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Leak of pump in vicinity of storage tank leading to release of combustible liquid	See ID 19	See ID 19	See ID 19	1. Pool fire (if ignited)	See ID 19	No. Pump in vicinity of storage tank is used for dewatering
48	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Pump bay area inside bund	See ID 21	See ID 19	See ID 21	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	Site layout still to optimised (in particular site 2 transfer pumps)	Yes
49	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Pump bay area inside bund	See ID 21	See ID 19	See ID 21	1. Pool fire (if ignited)	See ID 48	Yes
50	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Tank overfill during tank-to-tank transfer leading to flammable liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE, if sufficient vapours and ignited	-	Yes
51	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Tank overfill during tank-to-tank transfer leading to combustible liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire (if ignited)	-	Yes
52	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Flammable liquid sent into combustible storage tanks during tank-to-tank transfer	See ID 14	See ID 14	See ID 14	1. Overfill leading to LOC of flammable liquid and fire (if ignited) 2. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited)	-	Yes
53	Site 2 Storage	Fire / explosion (following release)	Recirculation	Class 3 flammable liquids	Recirculation to incorrect tank leading to release of flammable liquid	See ID 26	See ID 14	See ID 14	1. Overfill leading to LOC of flammable liquid and fire (if ignited) 2. Quality off-spec	-	Yes
54	Site 2 Storage	Fire / explosion (following release)	Recirculation	Class 3 flammable liquids	Recirculation via mixing nozzle into tank with insufficient liquid level	See ID 27	See ID 27	See ID 27	1. Damage to internal floating roof (IFR), increase in vapour emissions. Potential for explosion inside tank (if ignited)	-	Yes
55	Site 2 Storage	Fire / explosion (following release)	Recirculation	Class C1 combustible liquids	Recirculation via mixing nozzle into tank with insufficient liquid level	See ID 27	See ID 27	See ID 27	1. Vapour formation, and potential to form flammable diesel mist. Potential for explosion inside tank (if ignited)	-	Yes
56	Site 2 Storage	Fire / explosion (following release)	Working tank	Class 3 flammable liquids	Product loading pump leak leading to release of flammable liquid	See ID 19	See ID 19	See ID 19	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
57	Site 2 Storage	Fire / explosion (following release)	Working tank	Class C1 combustible liquids	Product loading pump leak leading to release of combustible liquid	See ID 19	See ID 19	See ID 19	1. Pool fire (if ignited)	-	Yes
58	Site 2 Storage	Fire / explosion (following release)	Working tank	Class 3 / C1	Pump runs dry	See ID 31	See ID 31	See ID 31	1. Damage to pump, potential mechanical failure / explosion 2. Suck air into piping (in event of low tank level), flammable mixture formation and explosion in tank	-	No - does not lead to release of flammable/combustible liquid
59	Site 2 Storage	Fire / explosion (following release)	Blending (In-tank)	Class 3 flammable liquids	Tank overfill during P98 and ULP blending (in tank) leading to flammable liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE if sufficient vapours and ignited	-	Yes
60	Site 2 Storage	Fire / explosion (following release)	Dewatering	Class 3 flammable liquids	Release of flammable liquid to bund	See ID 34	See ID 34	See ID 34	1. Overfill of slops tank, pool fire and potential full surface bund fire 2. Flash fire	-	Yes
61	Site 2 Storage	Fire / explosion (following release)	Dewatering	Class C1 combustible liquids	Release of combustible liquid to bund	See ID 34	See ID 34	See ID 34	1. Overfill of slops tank, pool fire (if ignited)	-	Yes
62	Site 2 Storage	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	LOC of flammable liquid during pigging (pig receiver)	See ID 36	See ID 36	See ID 36	1. Damage to IFR due to nitrogen blowby, increased vapour emissions 2. Damage to tank roof due to nitrogen blowby, potential to blow roof off 3. Jet / Spray fire (if ignited) 4. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
63	Site 2 Storage	Fire / explosion (following release)	Pigging	Class C1 combustible liquids	LOC of combustible liquid during pigging (pig receiver)	See ID 36	See ID 36	See ID 36	1. Damage to tank roof due to nitrogen blowby, potential to blow roof off 2. Pool fire (if ignited)	-	Yes
64	Site 2 Storage	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	Release of stored energy when opening pig receiver	See ID 38	See ID 38	See ID 38	1. Equipment damage and potential injury / fatality	-	No - does not lead to offsite impacts
65	Site 2 Storage	Fire / explosion (following release)	Additive injection	Class 3 flammable liquids	LOC during handling and operation	1. Poor connection 2. Manual handling (dropped load, puncture)	1. SOPs for inventory control and level monitoring. 2. Fit-for-purpose dosing equipment (stainless steel lines used)	1. Hazardous area classification 2. Spill kits 3. Fire fighting equipment (eg. Extinguishers)	1. Spill and pool fire (if ignited), minor impact due to low quantity	There will be a variety of hazards, class 3 was chosen as representative for HAZID. Additives can be stored in 20L to 30m3 vessels.	No - small quantity in comparison to other flammable material inventories on site

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ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
66	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class 3 flammable liquids	Flammable liquid leak during road tanker export / import	1. Failure of flexible connections / hose / loading arm 2. Leak from valves or fittings 3. Damaged road tanker	1. SOPs for loadout (driver inspection prior to loading) 2. Safe work systems (eg driver induction) 3. Preventative maintenance	1. Driver always present 2. CCTVs 3. Dead man system 4. Hazardous area classification 5. Truck area bunded and collects to a central area with fire trap 6. ESD 7. Fire detection and foam deluge (road gantry)	1. Jet / spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
67	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class C1 combustible liquids	Combustible liquid leak during road tanker export / import	See ID 66	See ID 66	See ID 66	1. Pool fire (if ignited)	-	Yes
68	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class 3 flammable liquids	Overfill of road tanker during road tanker export leading to release of flammable liquid	1. Driver error / incorrect parcel size entered / incorrect compartment connected 2. Tanker compartment not drained prior to loading	1. SOPs for loadout (driver inspection prior to loading) 2. Safe work systems (eg driver induction) 3. Road tanker details (including compartment sizes and safe fills) are registered on the loading system 4. Truck ID in loading bay prior to loading	1. Scully system (high level protection) 2. Hazardous area classification 3. Truck area bunded and collects to a central area with fire trap 4. ESD 5. Fire detection and foam deluge (road gantry)	1. Jet / spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
69	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class C1 combustible liquids	Overfill of road tanker during road tanker export leading to release of combustible liquid	See ID 68	See ID 68	See ID 68	1. Pool fire (if ignited)	-	Yes
70	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class 3 flammable liquids	Road tanker driveaway whilst still connected (after road tanker export) leading to release of flammable liquid	1. Driver error	1. SOPs 2. Truck brake interlock 3. Safe work systems	1. CCTV 2. Hazardous area classification 3. Fire detection and protection	1. Jet / Spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
71	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class C1 combustible liquids	Road tanker driveaway whilst still connected (after road tanker export) leading to release of combustible liquid	See ID 70	See ID 70	See ID 70	1. Pool fire (if ignited)	-	Yes
72	Site 2 Gantry	Fire / explosion (following release)	Blending (In-line)	Class 3 flammable liquids	Overfill of road tanker during ethanol and ULP blending (in line) leading to release of flammable liquid	1. Failure of level indicator 2. Human error / failure to line up or change over to correct tank	See ID 68	See ID 68	1. Jet / spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
73	Site 2 Gantry	Fire / explosion (following release)	Blending (In-line)	Class 3 flammable liquids	Overfill of road tanker during ULP and P98 blending (in line) leading to release of flammable liquid	See ID 72	See ID 68	See ID 68	1. Jet / spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
74	Site 2 Gantry	Fire / explosion (following release)	Blending (In-line)	Class C1 combustible liquids	Overfill of road tanker during biodiesel and diesel blending (in line) leading to release of combustible liquid	See ID 72	See ID 68	See ID 68	1. Pool fire (if ignited)	-	Yes
75	Site 2 Gantry	Fire / explosion (following release)	Road tanker import	Class 3 flammable liquids	Overfill of ethanol tank during road tanker import	1. Tank level gauge failure reading low level 2. Valve misalignment and material sent into wrong tank 3. Driver error	See ID 12	See ID 12	1. Jet / Spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
76	Site 2 Gantry	Fire / explosion (following release)	Road tanker import	Class C1 combustible liquids	Overfill of biodiesel tank during road tanker import	See ID 75	See ID 12	See ID 12	1. Pool fire (if ignited)	-	Yes
77	Site 2 Gantry	Fire / explosion (following release)	Road tanker import	Class 3 flammable liquids	Flammable liquid (ethanol) sent into combustible storage tanks during road tanker import	See ID 14	See ID 14	See ID 14	1. Product loss of quality 2. In worst case overfill leading to LOC of flammable liquid and fire (if ignited) 3. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited)	-	Yes
78	Site 2 Gantry	Fire / explosion (following release)	Vapour Recovery Unit	Class 3 / C1	Leak at vapour recovery unit	1. Failure of vessel due to corrosion 2. Overflow of hydrocarbon product into Vapour Recovery Unit (VRU) 3. Overloading (depressuring wharf line, road gantry)	1. Liquid knock out vessel upstream of VRU and high level alarm 2. Preventative maintenance	1. Operator patrols 2. Operator monitoring of system 3. By design / VRU will have flame / detonation arrestor	1. Release of vapour 2. Potential for fires (flash) and environmental impact	-	No - small hydrocarbon inventory
79	Site 3	Exposure to personnel	Nitrogen system	Nitrogen	Use of nitrogen instead of air in confined spaces during maintenance	1. Human error	1. Dedicated fittings for air and nitrogen 2. Labelling 3. SOPs 4. Safe work practices (PTWs) 5. Continuous monitoring of oxygen in confined space	-	1. Potential asphyxiation	-	No - does not lead to offsite impacts
80	Site 3	Exposure to personnel	Nitrogen system	Nitrogen	LOC of liquid nitrogen	1. Mechanical failure during refilling activities	1. Safe work practices 2. 3rd party nitrogen supplier 3. Mechanical protection (eg bollards)	-	1. Cold burns, exposure to asphyxiant	-	No - does not lead to offsite impacts
81	Site 3	Exposure to personnel	Electrical	Energy source	Exposure to live electrical equipment / conductors	1. Human error 2. Damaged equipment	1. Safe work practices (PTW, LOTO, isolations) 2. No high voltage equipment onsite 3. IP2X 4. Electrical equipment tested and tagged	1. Residual-current devices on outlets for portable equipment	1. Electrocution, potential for fatality	-	No - does not lead to offsite impacts
82	Site 3	General Discussion	Electrical	Air	Non-intrinsically safe equipment causing an ignition in a flammable atmosphere	-	1. Safe work practices (inductions) 2. No mobile phones onsite 3. IS equipment used onsite	1. Design reviews 2. Installation QA / QC	1. Potential fatality	This underpins credit taken for hazardous area classification and minimising ignition probability on site.	No - does not lead to offsite impacts
83	Site 3	General Discussion	Air	Air	Not considered a major safety issue	-	-	-	-	-	No - not a major safety issue
84	Site 3	Waste products and materials	Oily water	Oily water	Uncontrolled discharge of oily water	1. Stormwater / contamination	1. Stormwater in areas where hydrocarbon leaks can occur, are collected and sent to wastewater treatment 2. Sluice gate to contain contaminated water onsite	-	1. Environmental impact 2. Breach of license conditions	-	No - not a major safety issue
85	Site 3	General Discussion	General	-	Workshop / office fire	1. Electrical fire 2. Poor house keeping (oily rags) 3. Kitchen fire 4. Spillage of hydrocarbon in workshop / hot work	1. Housekeeping 2. All electrical equipment tested and tagged 3. Building will be BCA compliant 4. Safe work practices (eg draining of equipment)	1. Building located in non-hazardous areas 2. Building has smoke detectors 3. Fire extinguishers	1. Fire, potential for injury	-	No - does not lead to offsite impacts
86	Sitewide	Natural Occurrence	General	-	Tank / equipment damage from weather event	1. Strong winds 2. Earthquake 3. Flooding 4. Lightning strikes	1. Tanks designed to API 2. Site above 1 in 100 year flood zone 3. Lightning protection	-	1. LOC leading to fire (if ignited)	-	No - outside scope
87	Sitewide	External Dependencies	General	-	Incident on neighbouring facility	1. Fire in neighbouring facility / grain silo dust explosion, escalating to tanks	1. Facility designed to AS1940	1. ERP	1. Potential for injury to site personnel, evacuation required.	Not considered a major safety issue and risk onto site	No - outside scope
88	Sitewide	External Dependencies	General	-	Derailment of train on neighbouring facility	1. Driver error 2. Track integrity failure	1. Train speed limits 2. SOPs	-	1. Potential for injury worst case	Team consider this to be a very unlikely circumstance	No - outside scope
89	Sitewide	External Dependencies	General	-	Aircraft crash	1. Pilot error 2. Bad weather 3. Engine failure	1. Not on major flight path	-	1. LOC leading to fire (if ignited)	-	No - outside scope

ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
90	Sitewide	Security Issues	General	-	Breach of security / sabotage	1. Disgruntled employee 2. Intruder	1. Background checks / MSIC requirement 2. Access control	1. CCTV 2. Secured site 3. Port authority security patrols 4. Operator patrols	1. Equipment loss or damage, fuel loss	-	No - outside scope
91	Sitewide	Sudden release of energy	General	-	Use of hoses with compressed air / nitrogen	1. High pressure gas	1. Safe work practices 2. Preventative maintenance procedures 3. Depressuring of lines after use 4. Hose fitting design to prevent quick disconnect under pressure	1. Vent valves on all hosed connections to allow safe venting before disconnecting	1. Potential fatality	-	No - does not lead to offsite impacts
92	Sitewide	General Discussion	General	-	Construction of plant adjacent to operating site	1. Phased development	1. Site development has considered in the design minimising the impact of construction activities when various plant areas are in operation. 2. NT undertaking construction HAZID and safety study once program is finalised	-	1. Potential hot work / construction activities interaction with flammable product movements. In worst case accident, LOC leading to fire / explosion (if ignited)	-	No - outside scope

APPENDIX D. CONSEQUENCE ANALYSIS

The following consequences were evaluated to determine the characteristics of unignited and ignited scenarios of hydrocarbon releases for the proposed Port Kembla Bulk Liquids Terminal:

- Jet fires
- Pool fires
- Flash fires
- Tank roof fires
- Tank bund fires.

D1. Jet fire

Jet fire results are summarised in Table D.1. These tables provide the dimensions of the jet fires for each identified release conditions (ie based on the product type and pressure) for release sizes less than 25 mm, as per the rule set outlined in Table 4.2. Additionally, distance to heat radiation levels of interest (as per Table 4.4) are also reported.

These results represent continuous release without isolation which represents the worst case scenario for any given leak.

Table D.1: Jet Fire Consequence Results

Component/ Equipment	Product	Pressure (barg)	Hole size (mm)	Release rate (kg/s)	Jet Fire (at wind speed 5 m/s)						
					Length (m)	Width (m)	Horizontal Distance to Heat Radiation from Leak (m)				
							23 kW/m^2	20 kW/m^2	14 kW/m^2	10 kW/m^2	4.7 kW/m^2
Berth - Ship Import Shoreline/Inlet Manifold Pumps/Pipework	Gasoline	10	2	0.1	3	1	5	5	5	6	7
			6	0.7	8	3	13	13	15	16	19
			22	9.3	25	11	42	43	47	51	63
Pumps/Pipework Road Gantry - Tanker Export Vapour Recovery Unit	Gasoline	6	2	0.1	3	1	4	5	5	5	6
			6	0.5	8	3	12	13	14	15	18
			22	7.3	23	10	39	40	44	47	58
Berth - Ship Import Shoreline/Inlet Manifold Pumps/Pipework Road Gantry - Tanker Import	Diesel	10	2	0.1	3	1	5	5	5	6	7
			6	0.7	8	3	13	13	14	15	19
			22	9.4	24	10	41	43	46	50	61
Pumps/Pipework Road Gantry - Tanker Export	Diesel	6	2	0.1	3	1	4	4	6	5	6
			6	0.6	7	3	12	12	13	14	17
			22	7.4	23	10	38	40	43	46	57
Road Gantry - Tanker Import Pumps/ Pipework	Ethanol	10	2	0.1	5	2	6	7	7	7	8
			6	0.7	14	6	17	17	18	20	23
			22	6.9	35	15	46	47	50	53	61

D2. Pool fire

Pool fire results are summarised in Table D.2. The reported results include the release rate, equivalent pool diameter and distance to heat radiation levels of interest (as specified in Table 4.4).

In this assessment, liquid hydrocarbon from a leak was assumed to form a circular pool (spreading in all directions), unless limited by the bund. Subsequently, the pool fire dimensions were calculated assuming equilibrium where the burn rate equals the release rate of the material.

The fire duration and potentially the size of a pool fire is dependent upon the time to detect and stop a leak. These results represent continuous release without isolation which represents the worst case scenario for any given leak. The size of the liquid pool in most areas may also be limited by bunds, the terrain and drainage.

The limiting size used in the QRA for different release locations were:

- Berth 104: 254 m^2
  - Basis – Limited by the width of the berth.
  - Equivalent to 18 m pool diameter.
- Shoreline: Not limited
  - Basis – Assumed that the pool fire was not limited in size as there is no bunding/ kerbing included in current design
- Transfer pipework:
  - Basis – Assumed that the pool fire is limited in size by the width of the compound.
  - Equivalent to 75 m pool diameter.
- Inlet Manifold: 130 m^2
  - Basis – Manifold is located within area that is bunded on three sides and kerbed on the fourth side which would limit pool growth for large releases.
  - Equivalent to 13 m pool diameter.
- Pump Bay: 390 m^2
  - Basis – Pumps are located within bunded pump bay which would limit pool growth for large releases.
  - Equivalent to 22 m pool diameter.
- Road Tanker Gantry:
  - Basis – Limited by the kerbing provided around each loading bay (5 m x 25 m) and drainage which would limit pool growth for large releases.
  - Equivalent to 13 m pool diameter.

- Vapour Recovery Unit: 110 m^2
  - Basis – VRU is located within bunded area which would limit pool growth for large releases.
  - Equivalent to 12 m pool diameter.
- Additives IBCs: 35 m^2
  - Basis – IBCs stored within kerbed area which would limit pool growth for large releases.
  - Equivalent to 6.7 m pool diameter.

Table D.2: Pool Fire Consequence Results

Component/ Equipment	Product	Pressure (barg)	Hole size (mm)	Release rate (kg/s)	Equivalent Pool Diameter (m)	Pool Fire (at wind speed 5 m/s) Horizontal Distance to Heat Radiation from Pool Centre (m)					
						Flame Length	23 kW/m^3	20 kW/m^2	14 kW/m^2	10 kW/m^2	4.7 kW/m^2
Berth 104 - Ship Import	Gasoline	10	85	138	18	24	31	32	36	39	46
			RUP (250)	260*	18	24	31	32	36	39	46
Shoreline/Pipework (Outside of bunds)	Gasoline	10	85	138	52	56	74	77	84	91	109
			RUP (300)	260*	71	73	96	99	108	117	141
Site 2 Inlet Manifold	Gasoline	10	85	138	13	18	25	27	31	34	40
			RUP (300)	260*	13	18	25	27	31	34	40
Transfer Pipework - Tanks to Pump Bay	Gasoline	10	85	138	75	76	100	104	113	122	148
			RUP (300)	260*	75	76	100	104	113	122	148
Site 2 Pump Bay (Tank-to-tank transfer)	Gasoline	10	85	138	22	28	38	40	45	49	58
			RUP (250)	260*	22	28	38	40	45	49	58
Site 2 Pump Bay (Road Tanker Export)	Gasoline	6	85	30*	22	28	38	40	45	49	58
			RUP (250)	30*	22	28	38	40	45	49	58
Road Gantry - Export	Gasoline	6	85	30*	13	18	23	24	27	29	35
			RUP (200)	30*	13	18	23	24	27	29	35
VRU	Gasoline	6	85	-	12	17	22	24	26	29	34
			RUP (200)	-	12	17	22	24	26	29	34
Additives IBC	Gasoline	atm	RUP	-	6.7	11	13	14	16	17	20
Berth 104 - Ship Import	Diesel	10	85	140	18	23	30	32	35	38	45
			RUP (250)	288*	18	23	30	32	35	38	45
Shoreline/Pipework (Outside of bunds)	Diesel	10	85	140	53	56	74	76	84	91	109
			RUP (300)	288*	76	76	99	103	112	122	147
Site 2 Inlet Manifold	Diesel	10	85	138	13	18	25	27	31	34	40

Component/ Equipment	Product	Pressure (barg)	Hole size (mm)	Release rate (kg/s)	Equivalent Pool Diameter (m)	Pool Fire (at wind speed 5 m/s) Horizontal Distance to Heat Radiation from Pool Centre (m)					
						Flame Length	23 kW/m^3	20 kW/m^2	14 kW/m^2	10 kW/m^2	4.7 kW/m^2
			RUP (300)	288*	13	18	25	27	31	34	40
Transfer Pipework - Tanks to Pump Bay	Diesel	10	85	138	75	75	98	102	111	121	145
			RUP (300)	288*	75	75	98	102	111	121	145
Site 2 Pump Bay (Tank-to-tank transfer)	Diesel	10	85	107	22	28	35	36	39	42	50
			RUP (250)	288*	22	28	35	36	39	42	50
Site 2 Pump Bay (Road Tanker Export)	Diesel	6	85	33*	22	28	35	36	39	42	50
			RUP (250)	33*	22	28	35	36	39	42	50
Road Gantry - Export	Diesel	6	85	33*	13	14	21	22	23	25	30
			RUP (200)	33*	13	14	21	22	23	25	30
Road Gantry - Biodiesel Import	Diesel	10	85	18*	13	14	21	22	23	25	30
			RUP (200)	18*	13	14	21	22	23	25	30
Site 2 Pump Bay	Ethanol	10	85	16*	390	22	23	27	28	31	35
			RUP (300)	16*	390	22	23	27	28	31	35
Road Gantry - Ethanol Import	Ethanol	10	85	16*	13	15	17	18	19	21	27
			RUP (200)	16*	13	15	17	18	19	21	27

Note:
1. * indicates that the release rate is limited by the process/transfer flow rate
2. Where appropriate, pool growth from large liquid releases of liquid are limited by physical restriction on site (eg by design - kerbing and bunding). These include areas such as the berth, the transfer manifold and pump manifold.

D3. Flash fire

Vapour clouds result from the evaporation of light components of releases of gasoline which pool on the ground. Similar to pool fires, the maximum size of a pool can be limited by bund walls. The limiting sizes are described in Section D2 (Pool fires).

The rate of evaporation and the dispersion characteristics from a spill are dependent on the weather conditions. The modelling showed that flammable clouds only develop under very stable and low wind speed condition (represented by F2 weather stability class).

Flash fire modelling was only undertaken for gasoline due to the presence of hydrocarbon 'light ends' (typically C4-C5), which are not prevalent for heavier fuels such as diesel. Typical vapour clouds from gasoline spills are denser than air.

Flash fire modelling for ethanol indicate that the flammable vapour cloud downwind distances are very small and less than the pool diameter. Hence, it was assumed that pool fire is the more likely scenario as the small vapour cloud may directly flash back to the source pool resulting in a pool fire.

Flash fire scenarios modelled can be summarised into the following categories:

- Major leaks from storage tanks resulting in pool evaporation of full bund contents resulting in flammable vapour cloud (Table D.3).
- Tank overfill resulting in pool evaporation of intermediate bund contents resulting in flammable vapour cloud (Table D.3).
- Operational releases: small, medium and large releases (Table D.4).

Note that the 'Buncefield scenario' where tank overfill resulting in a cascading, splash zone generating larger volumes of vapour with corresponding large dispersion distances was not modelled. This is due to the ducted overflow piping design provided on gasoline and ethanol tanks directing overflow to the bunds. Refer to Appendix D5 for information on assigning tank bund consequences to tank overfill and major leak scenarios.

Modelling results for flash fires are reported in terms of fire width and length to 100% LFL concentrations.

Flash fires were modelled for steady state (equilibrium) case assuming a continuous release without isolation or detection, and therefore represent the worst case cloud size. Ignition of the cloud before equilibrium would result in a smaller flash fire.

Table D.3: Flash Fire Consequence Results – Storage Tanks (Major Leak and Tank Overfill – Pool evaporation)

Tank ID	Product	Bund Area (m2)	Equivalent Pool Diameter (m)	Mass in tank (tonnes)	Flash Fire - Distance to LFL from Leak (m) - F2		
					Evap Rate (kg/s)	Length	Width
TK-05 (Site 2 South Bund)	Gasoline	8950	65	13172	15	87	166
TK-06 (Site 2 South Bund)	Gasoline	8950	65	13172	15	87	166
TK-07 (Site 2 North Bund)	Gasoline	7935	75	13172	19	103	197
TK-08 (Site 2 North Bund)	Gasoline	7935	75	13172	19	103	197
TK-05 (Internal Bund)	Gasoline	2130	52	13172	10	65	126
TK-06 (Internal Bund)	Gasoline	1920	32	13172	4	35	70
TK-07 (Internal Bund)	Gasoline	1445	43	13172	7	51	99
TK-08 (Internal Bund)	Gasoline	1620	45	13172	7	55	108
TK-09 (Internal Bund)	Gasoline	2340	55	1058	10	69	84
TK-10 (Internal Bund)	Gasoline	2340	55	1058	10	69	84
TK-11 (Internal Bund)	Gasoline [1]	2340	55	1058	10	69	84
TK-09 (Smaller Bund)	Gasoline	625	28	1058	3	33	60
TK-10 (Smaller Bund)	Gasoline	625	28	1058	3	33	60
TK-11 (Smaller Bund)	Gasoline [1]	625	28	1058	3	33	60
TK-13 (Smaller Bund)	Gasoline	1715	28	15	3	29	57
TK-14 (Smaller Bund)	Gasoline	1715	28	30	3	29	58
TK-15 (Smaller Bund)	Gasoline	1715	28	30	3	29	58
TK-16 (Smaller Bund)	Oily water [1]	1715	28	15	3	29	57
TK-41 (Internal Bund)	Additive	180	15	15	1	8	16
TK-42 (Internal Bund)	Additive	180	15	15	1	8	16

Note:
1. These tanks were modelled as flammable liquids (ie gasoline).

Table D.4: Flash Fire Consequence Results – Operational

Component/ Equipment	Product	Pressure (barg)	Hole size (mm)	Release rate (kg/s)	Equivalent Pool Diameter (m)	Flash Fire - Distance to LFL (m) - F2		
						Evap Rate (kg/s)	Length	Width
Berth 104 - Ship Import	Gasoline	10	2	0.1	4	0.04	-	-
			6	0.7	11	0.4	-	-
			22	9	18	1	15	26
			85	138	18	1	16	32
			RUP (250)	260	18	1	17	32
Shoreline/Pipework (Outside of bunds)	Gasoline	10	2	0.1	4	0.04	-	-
			6	0.7	11	0.4	-	-
			22	9	43	5	43	78
			85	138	167	72	247	450
			RUP (300)	260	230	134	372	653
Site 2 Inlet Manifold	Gasoline	10	2	0.1	4	0.04	-	-
			6	0.7	11	0.4	-	-
			22	9	13	0.7	8	16
			85	138	13	0.8	10	20
			RUP (250)	260	13	0.8	10	20
Transfer Pipework - Tanks to Pump Bay	Gasoline (Pressurised Leak)	10	2	0.1	4	0.04	-	-
			6	0.7	11	0.4	-	-
			22	9	43	5	43	78
			85	138	75	19	103	197
			RUP (300)	260	75	19	103	197
Site 2 Pump Bay (Tank-to-tank transfer)	Gasoline	10	2	0.1	4	0.04	-	-
			6	0.7	11	0.4	-	-
			22	9	22	1	18	34
			85	138	22	1	22	41
			RUP (300)	260	22	1	22	41
Site 2 Pump Bay (Road Tanker Export)	Gasoline	6	2	0.1	4	0.04	-	-
			6	0.5	11	0.4	-	-
			22	7	22	1	18	34
			85	30	22	1	22	41
			RUP (200)	30	22	1	22	41
Transfer Pipework - (Road Tanker Export) Road Gantry - Export	Gasoline	6	2	0.1	3	0.04	-	-
			6	0.5	7	0.2	-	-
			22	7	13	0.6	7	15
			85	30	13	0.2	10	19
			RUP (200)	30	13	0.2	10	19

D4. Tank roof fire

The tank top full surface area fire scenario was assessed to represent the collapse of internal floating roof resulting in a full surface roof fire and subsequent collapse of the external roof. The tank roof fire consequence results are presented in Table D.5.

D5. Tank bund fire

The tank bund fire scenario was assessed for mechanical failure/leaks and tank overfill causes. The consequence of a tank overfill was based on 15 minute overfill during ship import operation[1]. As a worst case, this is equivalent to filling the intermediate bund. Therefore, intermediate bund fires were assigned to tank overfill scenarios. Bund sizes and tank bund fire consequence results are presented in Table D.6.

The tank mechanical failure/leaks consequence varies for tank types based on their capacities:

- Intermediate bund fire events for tanks where the entire content volume would only fill the intermediate bund volume:
  - On Site 2, this includes flammable tanks (TK-09, TK-10, TK-12, TK-13, TK-14, TK-15, TK-16, TK-41 and TK-42) and combustible tanks (TK-11).
- Full bund fire events for tanks where the volume would fill the entire compound bund:
  - On Site 2 North Compound, this includes flammable tanks (TK-07 and TK-08) and combustible tank (TK-01)
  - On Site 2 South Compound, this includes flammable tanks (TK-05 and TK-06) and combustible tanks (TK-02, TK-03 and TK-04).

[1] A 15 minutes overfill duration is based on hydrocarbon leak detection in the bund and operator response to stop the incoming flow to the tank. The facility is manned during ship import and the tank is also provided with SIL 2 high level trip and flow detection in the ducted overflow piping that will initiate an emergency shutdown of the entire terminal.

Table D.5: Tank Roof Fire Consequence Results

Tank No	Diameter (m)	Height (m)	Typical Product	Distance (m) to Heat Radiation from Tank Centre					
				Flame Length	23 kW/m²	20 kW/m²	14 kW/m²	10 kW/m²	4.7 kW/m²
TK-01	29	28.9	Diesel	34	45	47	52	56	67
TK-02	29	28.9	Diesel	34	45	47	52	56	67
TK-03	29	28.9	Diesel	34	45	47	52	56	67
TK-04	24	28.9	Diesel	29	38	40	44	48	57
TK-05	29	28.9	Gasoline	35	46	48	52	57	68
TK-06	29	28.9	Gasoline	35	46	48	52	57	68
TK-07	29	28.9	Gasoline	35	46	48	52	57	68
TK-08	29	28.9	Gasoline	35	46	48	52	57	68
TK-09	9.8	21.0	Gasoline	14	19	20	23	25	29
TK-10	9.8	21.0	Gasoline	14	19	20	23	25	29
TK-11	9.8	21.0	Diesel [1]	14	19	20	23	25	29
TK-12	9.8	21.0	Ethanol	12	14	14	15	17	22
TK-13	3	8.0	Gasoline	6	7	8	9	10	12
TK-14	3	8.0	Gasoline	6	7	8	9	10	12
TK-15	3	8.0	Gasoline	6	7	8	9	10	12
TK-16	3	8.0	Oily Water [1]	6	7	8	9	10	12
TK-41	3	5.1	Additive	6	7	8	9	10	12
TK-42	3	5.1	Additive	6	7	8	9	10	12

Note:
1. These tanks were modelled as flammable liquids (ie gasoline).

Table D.6: Tank Bund Fire Consequence Results

Bund ID	Bund Type	Bund Contents	Bund Surface Area (m^2)	Equivalent Diameter (m)	Modelled Product	Distance (m) to Heat Radiation from Bund Centre					
						Flame Length	23 kW/m^2	20 kW/m^2	14 kW/m^2	10 kW/m^2	4.7 kW/m^2
Site 2 North Compound	External	TK-01/07/08 + smaller	7935	75	Gasoline	76	100	104	113	122	148
Site 2 North Compound	External	TK-01/07/08 + smaller	7935	75	Diesel	75	98	102	111	121	145
Site 2 South Compound	External	TK-02/03/04/05/06	8950	65	Gasoline	67	89	93	101	110	132
Site 2 South Compound	External	TK-02/03/04/05/06	8950	65	Diesel	66	87	90	98	107	128
TK-01 Bund	Internal	TK-01	2345	41	Diesel	46	59	62	67	73	87
TK-02 Bund	Internal	TK-02	1615	45	Diesel	49	65	67	74	80	96
TK-03 Bund	Internal	TK-03	1945	35	Diesel	40	52	55	60	65	78
TK-04 Bund	Internal	TK-04	1335	41	Diesel	46	59	62	67	73	87
TK-05 Bund	Internal	TK-05	2130	52	Gasoline	56	74	77	84	91	109
TK-06 Bund	Internal	TK-06	1920	32	Gasoline	38	50	52	57	61	73
TK-07 Bund	Internal	TK-07	1445	43	Gasoline	48	63	65	71	77	92
TK-08 Bund	Internal	TK-08	1620	45	Gasoline	50	66	69	75	81	97
TK-09-16 Overall Bund	Internal	TK-09-16	2340	55	Gasoline	58	77	80	88	95	114
TK-09-16 Overall Bund	Internal	TK-09-16	2340	55	Ethanol	47	61	64	71	78	101
TK-09-12 Internal Bund	Smaller Internal	TK-09-12	650	29	Gasoline	34	45	47	52	56	67
TK-09-12 Internal Bund	Smaller Internal	TK-09-12	650	29	Ethanol	28	35	36	39	43	54
TK-13-16 Internal Bund	Smaller Internal	TK-13-16	1715	28	Gasoline	34	45	47	52	56	67
TK-41/42 Bund	Internal	TK-41/42	180	11	Gasoline	16	22	24	28	30	36

1. For consequence modelling purposes, Site 2 North Compound was assumed as a rectangular bund where the width was 75 m. This was used to define the maximum pool diameter.
2. For consequence modelling purposes, Site 2 South Compound was assumed as a rectangular bund where the width was 65 m. This was used to define the maximum pool diameter.

APPENDIX E. FREQUENCY ANALYSIS

E1. Equipment leak frequencies

Table E.1 gives the historical equipment leak frequencies. Data from the OGP Risk Assessment Data Directory was used where available (Ref. 10). For process equipment, the 'Full Releases' leak frequencies were used.

Table E.1: Historical equipment leak frequencies

Equipment type and size	Frequency (per year) by Hole Size[1]					Source
	2 mm	6 mm	22 mm	85 mm	Full bore	
Process piping (50 mm)	5.5×10^{-5}	1.8×10^{-5}	7.0×10^{-6}	-	-	OGP
Process piping (150 mm)	2.6×10^{-5}	8.5×10^{-6}	2.7×10^{-6}	6.0×10^{-7}	-	OGP
Process piping (300 mm)	2.3×10^{-5}	7.6×10^{-6}	2.4×10^{-6}	3.7×10^{-7}	1.7×10^{-7}	OGP
Flange, raised face (50 mm)	2.6×10^{-6}	7.6×10^{-7}	1.2×10^{-6}	-	-	OGP
Flange, raised face (150 mm)	3.7×10^{-6}	1.1×10^{-6}	9.0×10^{-7}	6.0×10^{-7}	-	OGP
Flange, raised face (300 mm)	5.9×10^{-6}	1.7×10^{-6}	1.4×10^{-6}	1.8×10^{-7}	3.4×10^{-7}	OGP
Valve Actuating (50 mm)	2.4×10^{-4}	7.3×10^{-5}	3.0×10^{-5}	-	-	OGP
Valve Actuating (150 mm)	2.2×10^{-4}	6.6×10^{-5}	1.9×10^{-5}	8.6×10^{-6}	-	OGP
Valve Actuating (300 mm)	2.1×10^{-4}	6.3×10^{-5}	1.8×10^{-5}	2.4×10^{-6}	6.0×10^{-6}	OGP
Valve Manual (50 mm)	2.0×10^{-5}	7.7×10^{-6}	4.9×10^{-6}	-	-	OGP
Valve Manual (150 mm)	3.1×10^{-5}	1.2×10^{-5}	4.7×10^{-6}	2.4×10^{-6}	-	OGP
Valve Manual (300 mm)	4.3×10^{-5}	1.7×10^{-5}	6.5×10^{-6}	1.2×10^{-6}	1.7×10^{-6}	OGP
Instrument fitting	1.8×10^{-4}	6.8×10^{-5}	2.5×10^{-5}	-	-	OGP
Filter	1.3×10^{-3}	5.1×10^{-4}	1.9×10^{-4}	3.5×10^{-5}	2.0×10^{-5}	OGP
Pump Centrifugal	5.1×10^{-3}	1.8×10^{-3}	5.9×10^{-4}	9.7×10^{-5}	4.8×10^{-5}	OGP
Tank Rupture	-	-	-	-	3.0×10^{-6}	OGP
Loading arm – per connection per operating hour (Road Tanker & Ships)	-	-	3.0×10^{-7}	-	3.0×10^{-8}	TNO Purple Book
Catastrophic Tank Leak (Small and Medium Tanks)	-	-	-	-	1.60×10^{-5}	UK HSE
Large Tank Leak (Small and Medium Tanks)	-	-	-	-	1.00×10^{-4}	UK HSE
Notes: 1. Piping release frequencies are per metre-year.						

E2. Parts count

A typical parts count was completed for the site areas and operations type where a potential for hydrocarbon release was identified, based on industry experience for similar terminals.

The site was rationalised into seven systems including:

- WHF (Wharf)
- MAN (Manifold)
- RTU (Road Tanker Unloading)

- RTL (Road Tanker Loading)
- PMP (Pumps)
- PPW (Pipework)
- VRU (Vapour Recovery Unit).

Table E.2: Systems defined for the QRA

ID	Scenario description	Area Description
WHF-001	Ship Import (Gasoline)	Wharf: Ship Import
WHF-002	Ship Import (Diesel)	Wharf: Ship Import
MAN-001	Site 2 Manifold Ship Import (Gasoline)	Site 2 Manifold: Ship Import
MAN-002	Site 2 Manifold Ship Import (Diesel)	Site 2 Manifold: Ship Import
MAN-003	Site 2 Manifold RT Import (Ethanol)	Site 2 Manifold: Road Tanker Import
MAN-004	Site 2 Manifold RT Import (Biodiesel)	Site 2 Manifold: Road Tanker Import
MAN-005	Site 2 Manifold TT Transfer (Gasoline)	Site 2 Manifold: Tank to Tank Transfer
MAN-006	Site 2 Manifold TT Transfer (Diesel)	Site 2 Manifold: Tank to Tank Transfer
MAN-007	Site 2 Manifold RT Export (Gasoline)	Site 2 Manifold: Road Tanker Export
MAN-008	Site 2 Manifold RT Export (Diesel)	Site 2 Manifold: Road Tanker Export
RTL-001	Road Tanker Export 1-6 (Gasoline)	Road Tanker Export
RTL-002	Road Tanker Export 1-6 (Diesel)	Road Tanker Export
RTU-001	Road Tanker Import 1 (Ethanol)	Road Tanker Import
RTU-002	Road Tanker Import 1 (Biodiesel)	Road Tanker Import
PMP-001	Pump RT Import (Ethanol)	Site 2 Pump: Road Tanker Import
PMP-002	Pump RT Import (Biodiesel)	Site 2 Pump: Road Tanker Import
PMP-003	Pump TT Transfer (Gasoline)	Site 2 Pump: Tank to Tank Transfer
PMP-004	Pump TT Transfer (Diesel)	Site 2 Pump: Tank to Tank Transfer
PMP-005	Pump RT Export (Gasoline)	Site 2 Pump: Road Tanker Export
PMP-006	Pump RT Export (Diesel)	Site 2 Pump: Road Tanker Export
PPW-001	Pipework Ship Import (Gasoline)	Pipework: Ship Import
PPW-002	Pipework Ship Import (Diesel)	Pipework: Ship Import
PPW-003	Pipework RT Import (Ethanol)	Pipework: Road Tanker Import
PPW-004	Pipework RT Import (Biodiesel)	Pipework: Road Tanker Import
PPW-005	Pipework TT Transfer (Gasoline)	Pipework: Tank to Tank Transfer
PPW-006	Pipework TT Transfer (Diesel)	Pipework: Tank to Tank Transfer
PPW-007	Pipework RT Export (Gasoline)	Pipework: Road Tanker Export
PPW-008	Pipework RT Export (Diesel)	Pipework: Road Tanker Export
VRU-001	Vapour Recovery Unit (Gasoline)	Vapour Recovery Unit

A typical parts count sheet used for the QRA is presented on the following page. The example below applies for the Site 2 manifold during ship import of gasoline (MAN-001). The complete parts count sheets for all the sections are not reproduced in this report.

Parts Count Sheet

CLIENT	Cardno
JOB DESC	National Terminals PKBLT PHA
Area Code	MAN
Area Desc	Site 2 Manifold: Ship Import
Section No	001
Initiating Event ID	MAN-001
Event Description	Site 2 Manifold Ship Import (Gasoline)
Release Type	L

Equipment Item	Tag	Number	Move-ments per year	Op. Hrs per year	Leak Frequency per Hole Size in mm x 10 (Leaks/Year) 002	006	022	085	500	999	RUP
Instrument fitting	PIP_FTA	5		190	1.96E-05	7.39E-06	2.72E-06				
Flanges ANSI Raised Face - 50mm	FLG_RF_050	20		190	1.13E-06	3.30E-07	5.22E-07				
Flanges ANSI Raised Face - 300mm	FLG_RF_300	48		190	6.16E-06	1.77E-06	1.47E-06	1.91E-07			3.55E-07
Valve (manual) - 50mm	VLM_050	10		190	4.35E-06	1.67E-06	1.07E-06				
Valve (manual) - 300mm	VLM_300	10		190	9.35E-06	3.69E-06	1.41E-06	2.61E-07			3.69E-07
Valve (automated) - 300mm	VLA_300	10		190	4.56E-05	1.37E-05	3.91E-06	5.22E-07			1.30E-06
Filter	VES_FLT	4		190	1.13E-04	4.43E-05	1.65E-05	3.04E-06			1.74E-06
Process Piping - 300mm	PIP_300	120		190	6.00E-05	1.98E-05	6.26E-06	9.65E-07			4.43E-07

E3. Online time factor

An online factor was applied to the leak frequencies of each identified section (as provided in Table E.2). The online time factor reduces the leak frequency based on the proportion of time that the equipment is used.

The online time factors were calculated based on the terminal operational data provided, summarised in Table E.5.

E4. Ignition probability

The ignition probability values used in this study were based on the assessment done by Cox, Less and Ang (Ref.12). The probabilities are based on the release rate and the phase of the fluid assessed. The ignition probability values used in the QRA are provided in Table E.3.

Using the values described in Table E.3, further analysis was undertaken to calculate the ignition probabilities of the assessed flammable substances that result into fires. These values are presented in Table E.4.

Release of combustible liquids such as diesel are more difficult to ignite due to their high flash point. In this study, an assumption was factored to the ignition probability for diesel to be one-tenth that of flammable liquids such as gasoline.

Table E.3: Ignition probabilities

Mass Flow Rate	Ignition probability of a gas or mixture	Ignition probability of a liquid.	Fraction of explosions given ignition of a gas, liquid or mixture	Explosion probability of a gas or mixture	Explosion probability of a liquid
<1 kg/s	0.01	0.01	0.04	0.0004	0.0004
1 - 50 kg/s	0.07	0.03	0.12	0.0084	0.0036
>50 kg/s	0.3	0.08	0.3	0.09	0.024

Table E.4: Ignition probabilities for fires

Mass Flow rate	Immediate Ignition of gas/mixed resulting in fire	Delayed Ignition of gas/mixed resulting in fire	Immediate Ignition of liquid resulting in fire
<1 kg/s	0.0096	0.0004	0.0096
1 - 50 kg/s	0.0616	0.0084	0.0264
>50 kg/s	0.21	0.09	0.056

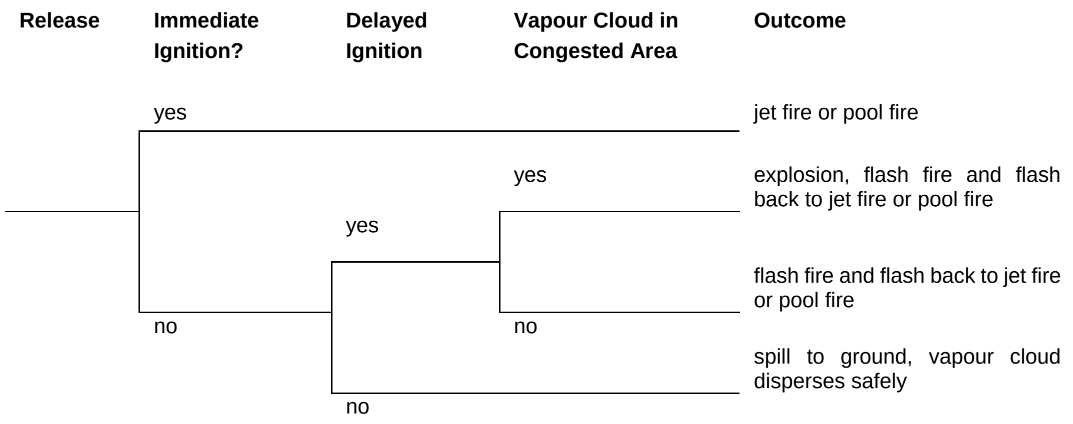
The ignition probabilities for all sections (as provided in Table E.2) and relevant leak sizes assessed in the QRA are summarised in Table E.5.

E5. Event tree analysis

A release of flammable liquid (e.g. gasoline, diesel, and ethanol) may lead to a variety of consequences, including jet fire, pool fire, flash fire and vapour cloud explosion - subject to the occurrence of particular events following the release (e.g. ignition).

An event tree is a logic diagram that identifies, for a single initiating event, a variety of consequences resulting from the success or failure of systems intended to mitigate that event. The frequency of these consequences is then estimated using the event tree logic and probabilistic analyses.

The possible outcomes following loss of containment of a flammable or combustible liquid are described in the event trees shown below.



The event tree probabilities used in the QRA model are presented in Table E.5, which includes:

- Operating time (online time factor)
- Ignition probability adjustment factor
- Release rates
- Probability of immediate ignition
- Probability of delayed ignition.

The event tree analyses were undertaken for all leak sizes applicable to all identified sections to generate the outcome frequencies for all leak events identified. The outcome frequencies (fire) for all leak events are presented in Section E6.

E6. Outcome frequencies

The release and fire outcome frequencies for all events are summarised in Table E.6.

Table E.5: Event Tree Probabilities

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
WHF-001	Ship Import (Gasoline)	190	1	002	WHF-001-002	0.077	0.0096	0.0004
			1	006	WHF-001-006	0.69	0.0096	0.0004
			1	022	WHF-001-022	9.3	0.0616	0.0084
			1	085	WHF-001-085	138	0.21	0.09
			1	RUP	WHF-001-RUP	260	0.21	0.21
WHF-002	Ship Import (Diesel)	354	0.1	002	WHF-002-002	0.078	0.00096	0.00004
			0.1	006	WHF-002-006	0.70	0.00096	0.00004
			0.1	022	WHF-002-022	9.4	0.00616	0.00084
			0.1	085	WHF-002-085	140	0.021	0.009
			0.1	RUP	WHF-002-RUP	288	0.021	0.021
MAN-001	Site 2 Manifold Ship Import (Gasoline)	190	1	002	MAN-001-002	0.077	0.0096	0.0004
			1	006	MAN-001-006	0.69	0.0096	0.0004
			1	022	MAN-001-022	9.3	0.0616	0.0084
			1	085	MAN-001-085	138	0.21	0.09
			1	RUP	MAN-001-RUP	260	0.21	0.21
MAN-002	Site 2 Manifold Ship Import (Diesel)	354	0.1	002	MAN-002-002	0.078	0.00096	0.00004
			0.1	006	MAN-002-006	0.70	0.00096	0.00004
			0.1	022	MAN-002-022	9.4	0.00616	0.00084
			0.1	085	MAN-002-085	140	0.021	0.009
			0.1	RUP	MAN-002-RUP	288	0.021	0.021
MAN-003	Site 2 Manifold RT Import (Ethanol)	253	1	002	MAN-003-002	0.080	0.0096	0.0004
			1	006	MAN-003-006	0.72	0.0096	0.0004
			1	022	MAN-003-022	9.6	0.0616	0.0084
			1	085	MAN-003-085	16	0.0616	0.0084
			1	RUP	MAN-003-RUP	16	0.21	0.21
MAN-004	Site 2 Manifold RT Import (Biodiesel)	507	0.1	002	MAN-004-002	0.078	0.00096	0.00004
			0.1	006	MAN-004-006	0.70	0.00096	0.00004
			0.1	022	MAN-004-022	9.4	0.00616	0.00084
			0.1	085	MAN-004-085	18	0.00616	0.00084

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
			0.1	RUP	MAN-004-RUP	18	0.021	0.021
MAN-005	Site 2 Manifold TT Transfer (Gasoline)	378	1	002	MAN-005-002	0.077	0.0096	0.0004
			1	006	MAN-005-006	0.69	0.0096	0.0004
			1	022	MAN-005-022	9.3	0.0616	0.0084
			1	085	MAN-005-085	138	0.21	0.09
			1	RUP	MAN-005-RUP	365	0.21	0.21
MAN-006	Site 2 Manifold TT Transfer (Diesel)	702	0.1	002	MAN-006-002	0.078	0.00096	0.00004
			0.1	006	MAN-006-006	0.70	0.00096	0.00004
			0.1	022	MAN-006-022	9.4	0.00616	0.00084
			0.1	085	MAN-006-085	140	0.021	0.009
			0.1	RUP	MAN-006-RUP	288	0.021	0.021
MAN-007	Site 2 Manifold RT Export (Gasoline)	8,760	1	002	MAN-007-002	0.061	0.0096	0.0004
			1	006	MAN-007-006	0.54	0.0096	0.0004
			1	022	MAN-007-022	7.3	0.0616	0.0084
			1	085	MAN-007-085	30	0.0616	0.0084
			1	RUP	MAN-007-RUP	30	0.21	0.21
MAN-008	Site 2 Manifold RT Export (Diesel)	8,760	0.1	002	MAN-008-002	0.061	0.00096	0.00004
			0.1	006	MAN-008-006	0.55	0.00096	0.00004
			0.1	022	MAN-008-022	7.4	0.00616	0.00084
			0.1	085	MAN-008-085	33	0.00616	0.00084
			0.1	RUP	MAN-008-RUP	33	0.021	0.021
RTL-001	Road Tanker Export 1-6 (Gasoline)	1,828 Note 1	1	002	RTL-001-002	0.061	0.0096	0.0004
			1	006	RTL-001-006	0.54	0.0096	0.0004
			1	022	RTL-001-022	7.3	0.0616	0.0084
			1	085	RTL-001-085	30	0.0616	0.0084
			1	RUP	RTL-001-RUP	30	0.21	0.21
RTL-002	Road Tanker Export 1-6 (Diesel)	3,394 Note 1	0.1	002	RTL-002-002	0.061	0.00096	0.00004
			0.1	006	RTL-002-006	0.55	0.00096	0.00004
			0.1	022	RTL-002-022	7.4	0.00616	0.00084
			0.1	085	RTL-002-085	33	0.00616	0.00084
			0.1	RUP	RTL-002-RUP	33	0.021	0.021

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
RTU-001	Road Tanker Import 1 (Ethanol)	253	1	002	RTU-001-002	0.080	0.0096	0.0004
			1	006	RTU-001-006	0.72	0.0096	0.0004
			1	022	RTU-001-022	9.6	0.0616	0.0084
			1	085	RTU-001-085	16	0.0616	0.0084
			1	RUP	RTU-001-RUP	16	0.21	0.21
RTU-002	Road Tanker Import 1 (Biodiesel)	507	0.1	002	RTU-002-002	0.078	0.00096	0.00004
			0.1	006	RTU-002-006	0.70	0.00096	0.00004
			0.1	022	RTU-002-022	9.4	0.00616	0.00084
			0.1	085	RTU-002-085	18	0.00616	0.00084
			0.1	RUP	RTU-002-RUP	18	0.021	0.021
PMP-001	Pump RT Import (Ethanol)	253	1	002	PMP-001-002	0.080	0.0096	0.0004
			1	006	PMP-001-006	0.72	0.0096	0.0004
			1	022	PMP-001-022	9.6	0.0616	0.0084
			1	085	PMP-001-085	16	0.0616	0.0084
			1	RUP	PMP-001-RUP	16	0.21	0.21
PMP-002	Pump RT Import (Biodiesel)	507	0.1	002	PMP-002-002	0.078	0.00096	0.00004
			0.1	006	PMP-002-006	0.70	0.00096	0.00004
			0.1	022	PMP-002-022	9.4	0.00616	0.00084
			0.1	085	PMP-002-085	18	0.00616	0.00084
			0.1	RUP	PMP-002-RUP	18	0.021	0.021
PMP-003	Pump TT Transfer (Gasoline)	378	1	002	PMP-003-002	0.077	0.0096	0.0004
			1	006	PMP-003-006	0.69	0.0096	0.0004
			1	022	PMP-003-022	9.3	0.0616	0.0084
			1	085	PMP-003-085	138	0.21	0.09
			1	RUP	PMP-003-RUP	365	0.21	0.21
PMP-004	Pump TT Transfer (Diesel)	702	0.1	002	PMP-004-002	0.078	0.00096	0.00004
			0.1	006	PMP-004-006	0.70	0.00096	0.00004
			0.1	022	PMP-004-022	9.4	0.00616	0.00084
			0.1	085	PMP-004-085	140	0.021	0.009
			0.1	RUP	PMP-004-RUP	288	0.021	0.021
PMP-005	Pump RT Export (Gasoline)	1,566	1	002	PMP-005-002	0.061	0.0096	0.0004

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
		Note 2	1	006	PMP-005-006	0.54	0.0096	0.0004
			1	022	PMP-005-022	7.3	0.0616	0.0084
			1	085	PMP-005-085	30	0.0616	0.0084
			1	RUP	PMP-005-RUP	30	0.21	0.21
PMP-006	Pump RT Export (Diesel)	4,073	0.1	002	PMP-006-002	0.061	0.00096	0.00004
			0.1	006	PMP-006-006	0.55	0.00096	0.00004
			0.1	022	PMP-006-022	7.4	0.00616	0.00084
			0.1	085	PMP-006-085	33	0.00616	0.00084
			0.1	RUP	PMP-006-RUP	33	0.021	0.021
PPW-001	Pipework Ship Import (Gasoline)	190	1	002	PPW-001-002	0.077	0.0096	0.0004
			1	006	PPW-001-006	0.69	0.0096	0.0004
			1	022	PPW-001-022	9.3	0.0616	0.0084
			1	085	PPW-001-085	138	0.21	0.09
			1	RUP	PPW-001-RUP	260	0.21	0.21
PPW-002	Pipework Ship Import (Diesel)	354	0.1	002	PPW-002-002	0.0775	0.00096	0.00004
			0.1	006	PPW-002-006	0.698	0.00096	0.00004
			0.1	022	PPW-002-022	9.37	0.00616	0.00084
			0.1	085	PPW-002-085	140	0.021	0.009
			0.1	RUP	PPW-002-RUP	288	0.021	0.021
PPW-003	Pipework RT Import (Ethanol)	253	1	002	PPW-003-002	0.080	0.0096	0.0004
			1	006	PPW-003-006	0.72	0.0096	0.0004
			1	022	PPW-003-022	9.6	0.0616	0.0084
			1	085	PPW-003-085	16	0.0616	0.0084
			1	RUP	PPW-003-RUP	16	0.21	0.21
PPW-004	Pipework RT Import (Biodiesel)	507	0.1	002	PPW-004-002	0.078	0.00096	0.00004
			0.1	006	PPW-004-006	0.70	0.00096	0.00004
			0.1	022	PPW-004-022	9.4	0.00616	0.00084
			0.1	085	PPW-004-085	18	0.00616	0.00084
			0.1	RUP	PPW-004-RUP	18	0.021	0.021
PPW-005	Pipework TT Transfer (Gasoline)	378	1	002	PPW-005-002	0.077	0.0096	0.0004
			1	006	PPW-005-006	0.69	0.0096	0.0004

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
			1	022	PPW-005-022	9.3	0.0616	0.0084
			1	085	PPW-005-085	138	0.21	0.09
			1	RUP	PPW-005-RUP	365	0.21	0.21
PPW-006	Pipework TT Transfer (Diesel)	702	0.1	002	PPW-006-002	0.078	0.00096	0.00004
			0.1	006	PPW-006-006	0.70	0.00096	0.00004
			0.1	022	PPW-006-022	9.4	0.00616	0.00084
			0.1	085	PPW-006-085	140	0.021	0.009
			0.1	RUP	PPW-006-RUP	288	0.021	0.021
PPW-007	Pipework RT Export (Gasoline)	8760	1	002	PPW-007-002	0.061	0.0096	0.0004
			1	006	PPW-007-006	0.54	0.0096	0.0004
			1	022	PPW-007-022	7.3	0.0616	0.0084
			1	085	PPW-007-085	30	0.0616	0.0084
			1	RUP	PPW-007-RUP	30	0.21	0.21
PPW-008	Pipework RT Export (Diesel)	8760	0.1	002	PPW-008-002	0.061	0.00096	0.00004
			0.1	006	PPW-008-006	0.55	0.00096	0.00004
			0.1	022	PPW-008-022	7.4	0.00616	0.00084
			0.1	085	PPW-008-085	33	0.00616	0.00084
			0.1	RUP	PPW-008-RUP	33	0.021	0.021
VRU-001	Vapour Recovery Unit (Gasoline)	4380	1	002	VRU-001-002	0.061	0.0096	0.0004
			1	006	VRU-001-006	0.54	0.0096	0.0004
			1	022	VRU-001-022	7.3	0.0616	0.0084
			1	085	VRU-001-085	30	0.0616	0.0084
			1	RUP	VRU-001-RUP	30	0.21	0.21

1. Operating time is per loading bay.
2. Operating time is per loading pump.

Table E.6: Outcome Frequencies – Proposed Operation

Scenario ID	Total Release Frequency	Flash Fire Frequency	Jet Fire/Pool Fire Frequency
WHF-001_002	9.20×10^{-5}	3.64×10^{-8}	8.83×10^{-7}
WHF-001_006	3.21×10^{-5}	1.27×10^{-8}	3.08×10^{-7}
WHF-001_022	2.40×10^{-4}	1.89×10^{-6}	1.48×10^{-5}
WHF-001_085	8.01×10^{-5}	5.70×10^{-6}	1.68×10^{-5}
WHF-001_RUP	2.49×10^{-5}	4.12×10^{-6}	5.22×10^{-6}
WHF-002_002	3.28×10^{-4}	1.31×10^{-8}	3.15×10^{-7}
WHF-002_006	1.21×10^{-4}	4.85×10^{-9}	1.17×10^{-7}
WHF-002_022	4.69×10^{-4}	3.91×10^{-7}	2.89×10^{-6}
WHF-002_085	1.53×10^{-4}	1.35×10^{-6}	3.21×10^{-6}
WHF-002_RUP	4.86×10^{-5}	9.99×10^{-7}	1.02×10^{-6}
MAN-001_002	2.59×10^{-4}	1.03×10^{-7}	2.49×10^{-6}
MAN-001_006	9.27×10^{-5}	3.67×10^{-8}	8.90×10^{-7}
MAN-001_022	3.39×10^{-5}	2.67×10^{-7}	2.09×10^{-6}
MAN-001_085	4.98×10^{-6}	3.54×10^{-7}	1.05×10^{-6}
MAN-001_RUP	4.21×10^{-6}	6.99×10^{-7}	8.84×10^{-7}
MAN-002_002	4.81×10^{-4}	1.92×10^{-8}	4.62×10^{-7}
MAN-002_006	1.72×10^{-4}	6.88×10^{-9}	1.65×10^{-7}
MAN-002_022	6.29×10^{-5}	5.25×10^{-8}	3.88×10^{-7}
MAN-002_085	9.25×10^{-6}	8.15×10^{-8}	1.94×10^{-7}
MAN-002_RUP	7.82×10^{-6}	1.61×10^{-7}	1.64×10^{-7}
MAN-003_002	3.45×10^{-4}	1.37×10^{-7}	3.31×10^{-6}
MAN-003_006	1.23×10^{-4}	4.89×10^{-8}	1.18×10^{-6}
MAN-003_022	4.51×10^{-5}	3.56×10^{-7}	2.78×10^{-6}
MAN-003_085	6.63×10^{-6}	5.23×10^{-8}	4.08×10^{-7}
MAN-003_RUP	5.61×10^{-6}	9.30×10^{-7}	1.18×10^{-6}
MAN-004_002	6.90×10^{-4}	2.76×10^{-8}	6.63×10^{-7}
MAN-004_006	2.47×10^{-4}	9.87×10^{-9}	2.37×10^{-7}
MAN-004_022	9.02×10^{-5}	7.53×10^{-8}	5.56×10^{-7}
MAN-004_085	1.33×10^{-5}	1.11×10^{-8}	8.17×10^{-8}
MAN-004_RUP	1.12×10^{-5}	2.30×10^{-7}	2.35×10^{-7}
MAN-005_002	5.15×10^{-4}	2.04×10^{-7}	4.94×10^{-6}
MAN-005_006	1.84×10^{-4}	7.29×10^{-8}	1.77×10^{-6}
MAN-005_022	6.73×10^{-5}	5.30×10^{-7}	4.14×10^{-6}
MAN-005_085	9.89×10^{-6}	7.03×10^{-7}	2.08×10^{-6}
MAN-005_RUP	8.36×10^{-6}	1.39×10^{-6}	1.76×10^{-6}
MAN-006_002	9.56×10^{-4}	3.82×10^{-8}	9.17×10^{-7}
MAN-006_006	3.42×10^{-4}	1.37×10^{-8}	3.28×10^{-7}
MAN-006_022	1.25×10^{-4}	1.04×10^{-7}	7.69×10^{-7}
MAN-006_085	1.84×10^{-5}	1.62×10^{-7}	3.86×10^{-7}
MAN-006_RUP	1.55×10^{-5}	3.19×10^{-7}	3.26×10^{-7}
MAN-007_002	6.68×10^{-3}	2.65×10^{-6}	6.41×10^{-5}
MAN-007_006	2.21×10^{-3}	8.76×10^{-7}	2.12×10^{-5}
MAN-007_022	7.87×10^{-4}	6.21×10^{-6}	4.85×10^{-5}
MAN-007_085	8.77×10^{-5}	6.91×10^{-7}	5.40×10^{-6}
MAN-007_RUP	1.11×10^{-4}	1.84×10^{-5}	2.33×10^{-5}

Scenario ID	Total Release Frequency	Flash Fire Frequency	Jet Fire/Pool Fire Frequency
MAN-008_002	1.19×10^{-2}	4.77×10^{-7}	1.14×10^{-5}
MAN-008_006	4.27×10^{-3}	1.70×10^{-7}	4.10×10^{-6}
MAN-008_022	1.56×10^{-3}	1.30×10^{-6}	9.60×10^{-6}
MAN-008_085	2.29×10^{-4}	1.91×10^{-7}	1.41×10^{-6}
MAN-008_RUP	1.94×10^{-4}	3.98×10^{-6}	4.07×10^{-6}
RTL-001_002	6.81×10^{-3}	2.70×10^{-6}	6.54×10^{-5}
RTL-001_006	2.37×10^{-3}	9.41×10^{-7}	2.28×10^{-5}
RTL-001_022	1.07×10^{-2}	8.45×10^{-5}	6.60×10^{-4}
RTL-001_085	1.62×10^{-1}	1.28×10^{-3}	9.97×10^{-3}
RTL-001_RUP	1.01×10^{-3}	1.68×10^{-4}	2.12×10^{-4}
RTL-002_002	1.26×10^{-2}	5.05×10^{-7}	1.21×10^{-5}
RTL-002_006	4.41×10^{-3}	1.76×10^{-7}	4.23×10^{-6}
RTL-002_022	1.99×10^{-2}	1.66×10^{-5}	1.23×10^{-4}
RTL-002_085	3.00×10^{-1}	2.51×10^{-4}	1.85×10^{-3}
RTL-002_RUP	1.88×10^{-3}	3.86×10^{-5}	3.95×10^{-5}
RTU-001_002	1.03×10^{-4}	4.07×10^{-8}	9.85×10^{-7}
RTU-001_006	3.63×10^{-5}	1.44×10^{-8}	3.49×10^{-7}
RTU-001_022	8.89×10^{-5}	7.00×10^{-7}	5.47×10^{-6}
RTU-001_085	5.13×10^{-3}	4.04×10^{-5}	3.16×10^{-4}
RTU-001_RUP	8.18×10^{-6}	1.36×10^{-6}	1.72×10^{-6}
RTU-002_002	2.05×10^{-4}	8.20×10^{-9}	1.97×10^{-7}
RTU-002_006	7.27×10^{-5}	2.90×10^{-9}	6.98×10^{-8}
RTU-002_022	1.78×10^{-4}	1.48×10^{-7}	1.09×10^{-6}
RTU-002_085	1.03×10^{-2}	8.56×10^{-6}	6.31×10^{-5}
RTU-002_RUP	1.64×10^{-5}	3.36×10^{-7}	3.44×10^{-7}
PMP-001_002	1.61×10^{-4}	6.36×10^{-8}	1.54×10^{-6}
PMP-001_006	5.68×10^{-5}	2.25×10^{-8}	5.46×10^{-7}
PMP-001_022	1.89×10^{-5}	1.49×10^{-7}	1.17×10^{-6}
PMP-001_085	3.14×10^{-6}	2.47×10^{-8}	1.93×10^{-7}
PMP-001_RUP	1.39×10^{-6}	2.30×10^{-7}	2.92×10^{-7}
PMP-002_002	3.21×10^{-4}	1.28×10^{-8}	3.08×10^{-7}
PMP-002_006	1.14×10^{-4}	4.54×10^{-9}	1.09×10^{-7}
PMP-002_022	3.79×10^{-5}	3.16×10^{-8}	2.33×10^{-7}
PMP-002_085	6.27×10^{-6}	5.24×10^{-9}	3.86×10^{-8}
PMP-002_RUP	2.78×10^{-6}	5.71×10^{-8}	5.83×10^{-8}
PMP-003_002	7.19×10^{-4}	2.85×10^{-7}	6.90×10^{-6}
PMP-003_006	2.54×10^{-4}	1.01×10^{-7}	2.44×10^{-6}
PMP-003_022	8.47×10^{-5}	6.68×10^{-7}	5.22×10^{-6}
PMP-003_085	1.40×10^{-5}	9.98×10^{-7}	2.95×10^{-6}
PMP-003_RUP	6.21×10^{-6}	1.03×10^{-6}	1.30×10^{-6}
PMP-004_002	1.33×10^{-3}	5.33×10^{-8}	1.28×10^{-6}
PMP-004_006	4.72×10^{-4}	1.89×10^{-8}	4.53×10^{-7}
PMP-004_022	1.57×10^{-4}	1.31×10^{-7}	9.69×10^{-7}
PMP-004_085	2.61×10^{-5}	2.30×10^{-7}	5.47×10^{-7}

Scenario ID	Total Release Frequency	Flash Fire Frequency	Jet Fire/Pool Fire Frequency
PMP-004_RUP	1.15×10^{-5}	2.37×10^{-7}	2.42×10^{-7}
PMP-005_002	6.95×10^{-3}	2.75×10^{-6}	6.67×10^{-5}
PMP-005_006	2.46×10^{-3}	9.74×10^{-7}	2.36×10^{-5}
PMP-005_022	8.19×10^{-4}	6.45×10^{-6}	5.04×10^{-5}
PMP-005_085	1.36×10^{-4}	1.07×10^{-6}	8.36×10^{-6}
PMP-005_RUP	6.01×10^{-5}	9.97×10^{-6}	1.26×10^{-5}
PMP-006_002	2.58×10^{-3}	1.03×10^{-7}	2.48×10^{-6}
PMP-006_006	9.13×10^{-4}	3.65×10^{-8}	8.77×10^{-7}
PMP-006_022	3.04×10^{-4}	2.54×10^{-7}	1.87×10^{-6}
PMP-006_085	5.04×10^{-5}	4.21×10^{-8}	3.10×10^{-7}
PMP-006_RUP	2.23×10^{-5}	4.59×10^{-7}	4.69×10^{-7}
PPW-001_002	6.48×10^{-4}	2.57×10^{-7}	6.22×10^{-6}
PPW-001_006	2.14×10^{-4}	8.48×10^{-8}	2.06×10^{-6}
PPW-001_022	6.76×10^{-5}	5.33×10^{-7}	4.16×10^{-6}
PPW-001_085	1.04×10^{-5}	7.41×10^{-7}	2.19×10^{-6}
PPW-001_RUP	4.79×10^{-6}	7.94×10^{-7}	1.01×10^{-6}
PPW-002_002	1.20×10^{-3}	4.81×10^{-8}	1.16×10^{-6}
PPW-002_006	3.98×10^{-4}	1.59×10^{-8}	3.82×10^{-7}
PPW-002_022	1.26×10^{-4}	1.05×10^{-7}	7.73×10^{-7}
PPW-002_085	1.94×10^{-5}	1.71×10^{-7}	4.06×10^{-7}
PPW-002_RUP	8.89×10^{-6}	1.83×10^{-7}	1.87×10^{-7}
PPW-003_002	8.65×10^{-5}	3.43×10^{-8}	8.31×10^{-7}
PPW-003_006	2.86×10^{-5}	1.13×10^{-8}	2.74×10^{-7}
PPW-003_022	9.03×10^{-6}	7.12×10^{-8}	5.56×10^{-7}
PPW-003_085	1.39×10^{-6}	1.10×10^{-8}	8.57×10^{-8}
PPW-003_RUP	6.39×10^{-7}	1.06×10^{-7}	1.34×10^{-7}
PPW-004_002	1.73×10^{-4}	6.91×10^{-9}	1.66×10^{-7}
PPW-004_006	5.72×10^{-5}	2.28×10^{-9}	5.49×10^{-8}
PPW-004_022	1.81×10^{-5}	1.51×10^{-8}	1.11×10^{-7}
PPW-004_085	2.78×10^{-6}	2.32×10^{-9}	1.71×10^{-8}
PPW-004_RUP	1.28×10^{-6}	2.63×10^{-8}	2.69×10^{-8}
PPW-005_002	2.89×10^{-4}	1.14×10^{-7}	2.77×10^{-6}
PPW-005_006	9.54×10^{-5}	3.78×10^{-8}	9.16×10^{-7}
PPW-005_022	3.01×10^{-5}	2.38×10^{-7}	1.86×10^{-6}
PPW-005_085	4.65×10^{-6}	3.30×10^{-7}	9.76×10^{-7}
PPW-005_RUP	2.13×10^{-6}	3.54×10^{-7}	4.48×10^{-7}
PPW-006_002	5.36×10^{-4}	2.14×10^{-8}	5.15×10^{-7}
PPW-006_006	1.77×10^{-4}	7.08×10^{-9}	1.70×10^{-7}
PPW-006_022	5.60×10^{-5}	4.67×10^{-8}	3.45×10^{-7}
PPW-006_085	8.63×10^{-6}	7.60×10^{-8}	1.81×10^{-7}
PPW-006_RUP	3.96×10^{-6}	8.15×10^{-8}	8.33×10^{-8}
PPW-007_002	2.99×10^{-3}	1.18×10^{-6}	2.87×10^{-5}
PPW-007_006	9.88×10^{-4}	3.91×10^{-7}	9.48×10^{-6}
PPW-007_022	3.12×10^{-4}	2.46×10^{-6}	1.92×10^{-5}

Scenario ID	Total Release Frequency	Flash Fire Frequency	Jet Fire/Pool Fire Frequency
PPW-007_085	4.81×10^{-5}	3.79×10^{-7}	2.96×10^{-6}
PPW-007_RUP	2.21×10^{-5}	3.67×10^{-6}	4.64×10^{-6}
PPW-008_002	2.99×10^{-3}	1.19×10^{-7}	2.87×10^{-6}
PPW-008_006	9.88×10^{-4}	3.95×10^{-8}	9.48×10^{-7}
PPW-008_022	3.12×10^{-4}	2.60×10^{-7}	1.92×10^{-6}
PPW-008_085	4.81×10^{-5}	4.02×10^{-8}	2.96×10^{-7}
PPW-008_RUP	2.21×10^{-5}	4.54×10^{-7}	4.64×10^{-7}
VRU-001_002	2.78×10^{-3}	1.10×10^{-6}	2.66×10^{-5}
VRU-001_006	9.82×10^{-4}	3.89×10^{-7}	9.43×10^{-6}
VRU-001_022	3.27×10^{-4}	2.58×10^{-6}	2.01×10^{-5}
VRU-001_085	5.42×10^{-5}	4.27×10^{-7}	3.34×10^{-6}
VRU-001_RUP	2.40×10^{-5}	3.98×10^{-6}	5.04×10^{-6}

E7. Storage tank incident frequencies

E7.1. Tank roof fire

The tank roof fire frequencies used in the QRA study were calculated based on the most recent Large Atmospheric Storage Tank Fire (LASTFIRE) Project Update 2012 (Ref.16).

LASTFIRE Project Update 2012 indicates that there have been no full-surface tank roof fires recorded for IFR tanks. The rim seal fire frequency for an IFR tank is given as 4.4×10^{-5} per year.

A tank roof fire frequency for Internal Floating Roof (IFR) tanks of 4.4×10^{-6} per year was adopted for this study. This accounts for rim seal fire detection on all IFR tanks that would prevent escalation to a full surface tank roof fire by applying foam to the floating pan.

The tank roof fire frequency for flammable slops and additive tanks is 2.1×10^{-5} per year (Ref. 16).

The tank roof fire frequencies for combustible bulk and slops tanks were calculated based on escalation from a flammable tank roof fire and accounts for spray water cooling provided on the combustible tanks.

E7.2. Tank bund fire

Both intermediate and full bund fires were assessed in the QRA. The tank bund fire frequencies were calculated using the event tree analyses. Derivations of these frequencies are provided below.

Tank overfill frequency

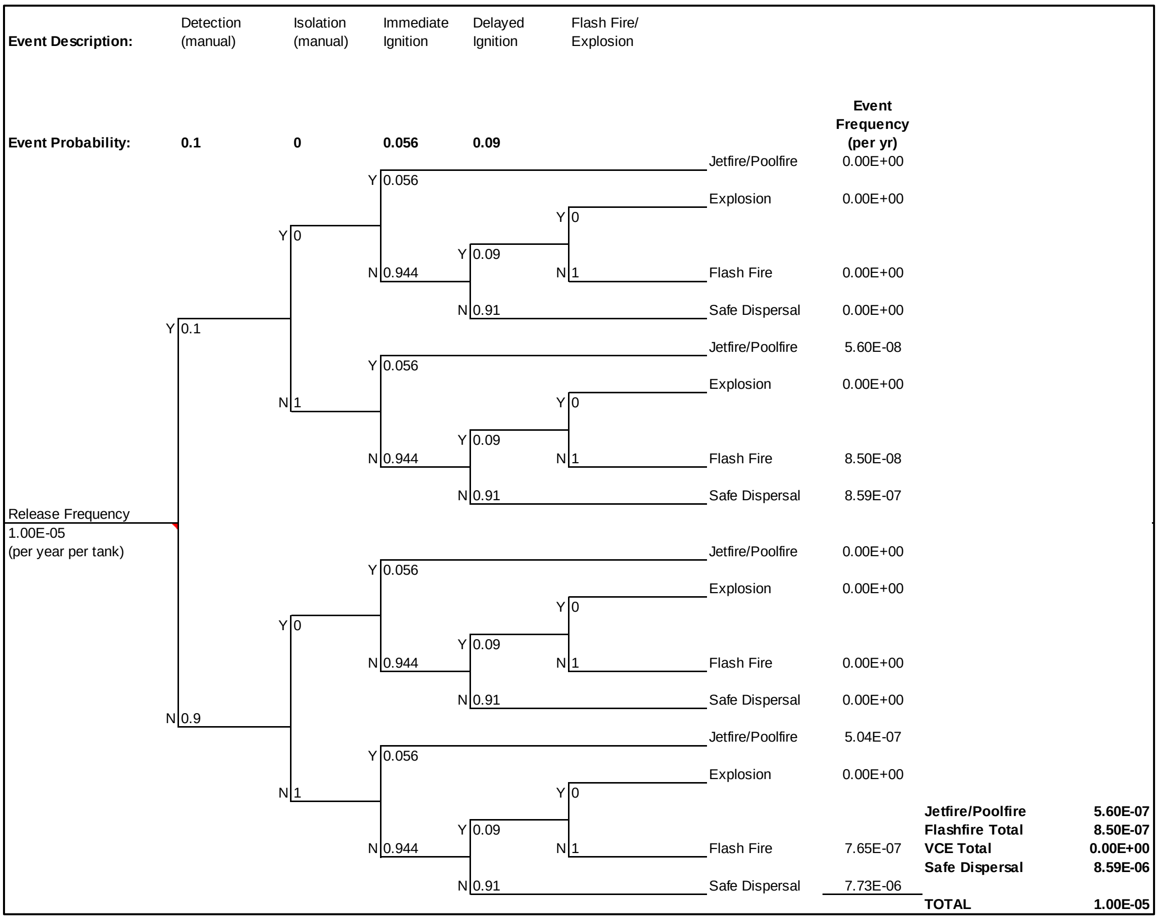
This frequency was applied for all intermediate bund fire events. An event tree was developed using tank overfill frequency as the base frequency for the analysis, shown in Figure E.1. This is deemed to be appropriate for small bund fires as these type of failures are easier to isolate (eg closing valves, ESD and pumps), allowing quicker response and minimising the resulting pool size.

The frequency of a tank overfill leading to a large spill was estimated to be 1 x 10^{-5} per year (due to operator error during valve line-up or tank level gauge failure) based on the following configuration:

- All tanks are fitted with a radar level gauge system
- All tanks are fitted with a second radar level instrument and operator action, assuming sufficient time to respond and stop inlet flow
- All tanks are fitted with an independent SIL 2 rated level gauging system with high high level set point that automatically leads to filling operations shutdown
- Flow detection would be provided within the duct, triggering terminal ESD
- Hydrocarbon detection in the intermediate bund sump and operator response.

The frequency of small bund fire used in the QRA was determined to be 5.6 x 10^{-7} per tank-year.

Figure E.1: Event tree for tank overfill scenario



Tank mechanical failure frequency

An event tree was developed using summation of major tank failure and rupture frequencies as the base frequency of the analysis (1.16 x 10^{-4} per tank-year), where:

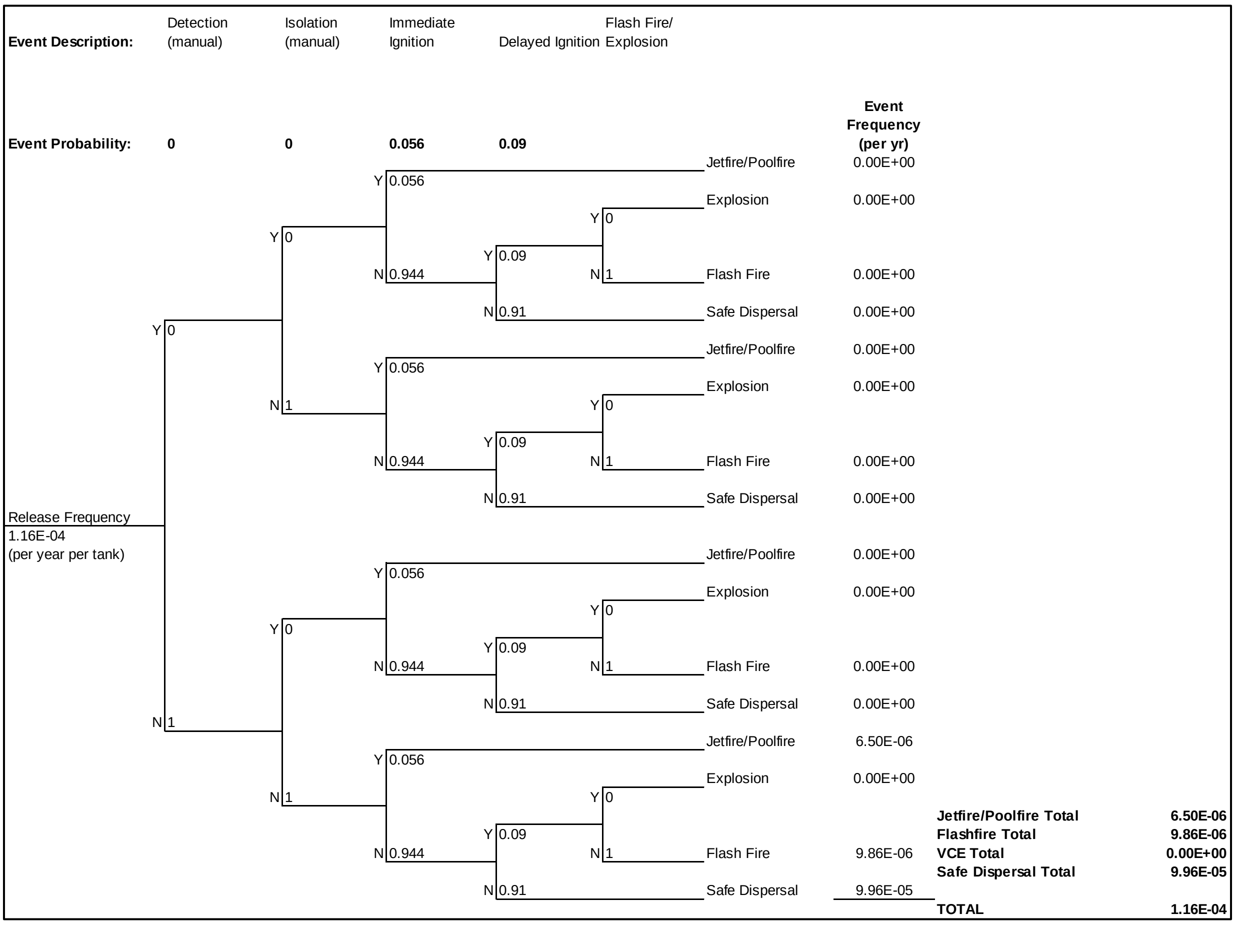
- Large tank leak (1.0 x 10^{-4} per tank-year, UK HSE (Ref. 17))
- Catastrophic tank leak (1.6 x 10^{-5} per tank-year, UK HSE (Ref.17)).

The event tree is shown in Figure E.2.

This is deemed to be appropriate for large bund fires as these failures are difficult to isolate depending on the leak source location and may result in large pool size (restricted by the bund area).

Using the event tree analysis, the frequency of large bund fires was determined to be 6.50 x 10^{-6} per tank-year.

Figure E.2: Event tree for tank failure/rupture scenario



E8. Additive IBC storage

A pool fire involving up to 16 IBCs (next to pump bay area) containing flammable liquid was assumed to be due to a catastrophic failure of one IBC and immediate ignition of the resulting pool.

The catastrophic failure of one plastic IBC was determined to be equivalent to catastrophic failure of ‘Small and Medium Atmospheric Tanks’, with a frequency of 1.6 x 10^{-5} per vessel year (Ref.17). This value is multiplied by probability of immediate or delayed ignition of flammable liquid/mixture leading to a fire in Table E.4 to obtain the fire frequency.

APPENDIX F. WEATHER DATA AND ANALYSIS

F1. Data source

Historical meteorological weather data for the proposed terminal was obtained from the Bureau of Meteorology (BoM). The acquired data sets were based on readings from the Automatic Weather Station (AWS) at Port Kembla NTC (AWS 068253) which is located approximately 3 km away.

F2. Pasquill stability class

Gifford (Ref.18) defines the conditions for different stability classes as summarised in Table F.1.

Table F.1: Meteorological Conditions Defining the Pasquill-Gifford Stability Classes

Surface wind speed, m/s	Daytime insolation			Night time conditions	
	Strong	Moderate	Slight	Thin overcast or >4/8 low cloud	≥ 3/8 cloudiness
<2	A	A-B	B	F	F
2-3	A-B	B	C	E	F
3-4	B	B-C	C	D	E
4-6	C	C-D	D	D	D
>6	C	C	D	D	D

F3. Representative stability class and wind speed

Suitable analysis of the obtained raw data was performed to obtain the representative weather conditions (including wind speed and stability classes) appropriate for the QRA. For the purpose of the study, the data were consolidated into six different representative weather conditions which are:

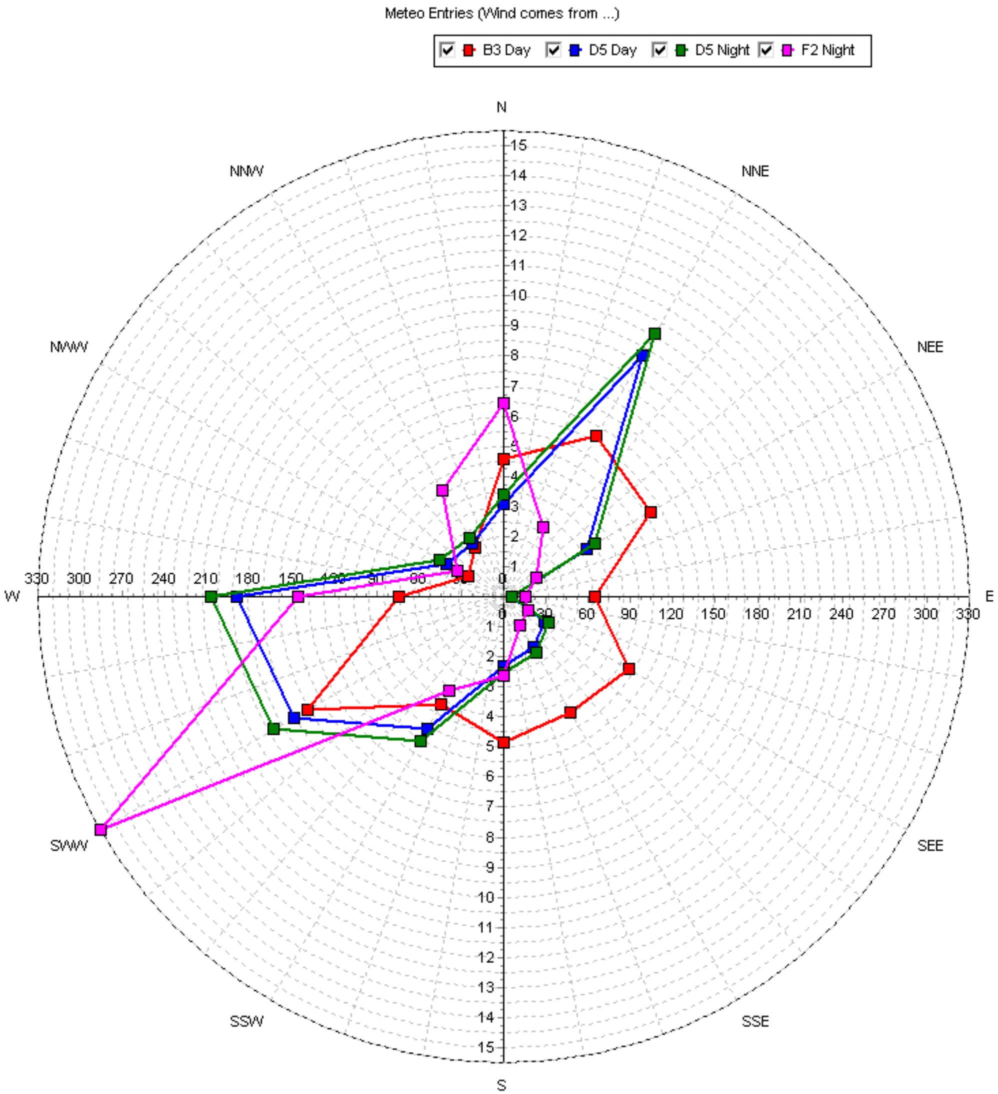
- Pasquill Stability Class: B; wind speed 3 m/s (B3)
- Pasquill Stability Class: D; wind speed 5 m/s (D5)
- Pasquill Stability Class: F; wind speed 2 m/s (F2).

The meteorological data sets used for the QRA are presented in Table F.2. Additionally, the wind rose map is also provided in Figure F.1.

Table F.2: Meteorological data sets used for the QRA

Direction wind *from* (degrees true)	B3		D5		F2		Total Day	Total Night
	Day	Night	Day	Night	Day	Night		
0	4.58	0	3.09	3.38	0	6.42	7.67	9.80
30	6.17	0	9.25	10.13	0	2.66	15.42	12.79
60	5.66	0	3.20	3.50	0	1.25	8.86	4.76
90	3.03	0	0.25	0.28	0	0.73	3.28	1.00
120	4.84	0	1.59	1.75	0	0.93	6.44	2.68
150	4.45	0	1.96	2.15	0	1.09	6.41	3.24
180	4.87	0	2.31	2.53	0	2.64	7.18	5.17
210	4.13	0	5.06	5.54	0	3.59	9.19	9.13
240	7.55	0	8.06	8.82	0	15.52	15.61	24.34
270	3.49	0	8.89	9.73	0	6.85	12.38	16.58
300	1.37	0	2.22	2.44	0	1.76	3.59	4.19
330	1.91	0	2.06	2.25	0	4.06	3.97	6.31

Figure F.1: Wind rose distribution



APPENDIX G. ASSESSMENT OF BUNCEFIELD RECOMMENDATIONS

The final SEARs under *Hazard and Risk* issues requires TQ Holdings to apply the relevant recommendations arising from the final Buncefield Investigation to PKBLT site. The recommendations are listed below and the corresponding status for the PKBLT site. The PKBLT site is currently in the development application stage. As a result, specific details relating to equipment integrity, workforce responsibilities and fire protection requirements have yet to be finalised. As a result, the majority of these recommendations should be addressed in future studies and as part of the PKBLT MHF Safety Case report.

Table G.1: Buncefield recommendations – response table

Buncefield Recommendation		**Requirement for Project**
1	The competent authority and operators of Buncefield type sites should develop and agree a common methodology to determine the SIL level for overfill prevention systems in line with EN61511. This methodology should take account of : • The existence of nearby sensitive resources or populations • The nature and intensity of depot operations • Realistic reliability expectations for tank gauging systems; and • The extent/rigour of operator monitoring. Application of the methodology should be clearly demonstrated in the COMAH safety report.	To comply with the Buncefield recommendations, a Safety Requirement Specification (SRS) style document should be developed. The SRS details the lifecycle management of Safety Instrumented Functions (SIFs). This will include the requirement for SIL allocation and verification of SIFs. Safety integrity level (SIL) requirements for overfill prevention systems against AS IEC 61511 should be assessed as part of the design process. There are no sensitive locations in the vicinity of PKBLT due to its location in a special uses Port area. TQ Holdings should develop the SIL allocation methodology. The MHF Safety Case should clearly outline the methodology taken. Relevant maintenance and testing regimes to meet AS IEC 61511 should be in place based on the outcome of the SIL allocation study and the equipment and systems selection process.

Buncefield Recommendation		Requirement for Project
2	Operators of Buncefield type sites should, as a priority, review and amend as necessary their management systems for maintenance of equipment and systems to ensure their continuing integrity in operation. This should include, but not be limited to reviews of the following: • The arrangements and procedures for periodic proof testing of storage tank overfill prevention systems to minimise the likelihood of any failure that could result in loss of containment; any revisions identified pursuant to this review should be put into immediate effect • The procedures for implementing changes to equipment and systems to ensure any such changes do not impair the effectiveness of equipment and systems in preventing loss of containment or in providing emergency response.	TQ Holdings should implement a management system for: • periodic proof testing of storage tank overfill prevention systems. This should be done prior to site commissioning • procedure to implement changes to equipment and systems. The Management of Change (MOC) process should be refined and outlined in the MHF Safety Case report. Refer to Recommendation 1 – covering lifecycle management of SIFs.
3	Operators of Buncefield type sites should protect against loss of containment of gasoline and other highly flammable liquids by fitting a high integrity, automatic operating overfill prevention system that is physically and electrically separate from the tank gauging system.	The method of preventing a loss of containment due to overfill should be determined during the SIL allocation study. Refer to Recommendation 1 – covering lifecycle management of SIFs.
4	Overfill protection systems (comprising means of level detection, logic/ control equipment and independent means of flow control) should be engineered, operated, and maintained to achieve and maintain an appropriate level of safety integrity in accordance with the requirements of BS EN 61511.	Refer to Recommendation 1 – covering lifecycle management of SIFs.
5	All elements of an overfill protection system should be proof tested in accordance with the validated arrangements and procedures sufficiently frequently to ensure the specified safety integrity level is maintained in practice in accordance with the requirements of BS EN 61511.	Refer to Recommendation 1.

Buncefield Recommendation		Requirement for Project
6	The sector should put in place arrangements to ensure the receiving site (as opposed the transmitting location) has ultimate control of tank filling. The receiving site should be able to safely terminate or divert a transfer without depending on the actions of a remote third party, or on the availability of communications to a remote location. These arrangements will need to consider upstream implications for the pipeline network, other facilities on the system and refineries.	PKBLT site will be receiving bulk petroleum liquids by ship tankers. TQ will have control over the filling of the Site 1 and 2 tanks from ships. Operators will be present onsite to monitor ship transfer operations. There will be a written procedure and competency based training available for all transfer activities. TQ Holdings' operators will be able to initiate ESD at the berth or from the control room. High level trip in any tank will initiate terminal ESD and terminate ship transfer.
7	In conjunction with Recommendation 6, the sector and the Competent Authority should undertake a review of the adequacy of existing safety arrangements, including communications, employed by those responsible for pipeline transfers of fuel.	Refer to Recommendation 6.
8	The sector, including its supply chain of equipment manufacturers and suppliers, should review and report without delay on the scope to develop improved components and systems, including but not limited to the following: • Alternative means of ultimate high level detection for overfill prevention that do not rely on components internal to the storage tank, with the emphasis on ease of inspection, testing, reliability and maintenance; • Increased dependability of tank level gauging systems through improved validation of measurements and trends, allowing warning of faults and through using modern sensors with increased diagnostic capability; and • Systems to control and log override actions.	Refer to Recommendation 1 – covering lifecycle management of SIFs.

Buncefield Recommendation		Requirement for Project
9	Operators of Buncefield-type sites should introduce arrangements for the systematic maintenance of records to allow a review of all product movements together with the operation of the overfill prevention systems and any associated facilities. The arrangements should be fit for their design purpose and include, but not be limited to, the following factors: • The records should be in a form that is readily accessible by third parties without the need for specialist assistance; • The records should be available both on site and at a different location; • The records should be available to allow periodic review of the effectiveness of control measures by the operator and the Competent Authority, as well as for root cause analysis should there be an incident; • A minimum period of retention of one year.	TQ Holdings to develop a system for maintaining a record of tank movements and operation of overfill protection systems.
10	The sector should agree with the Competent Authority on a system of leading and lagging performance indicators for process safety performance.	TQ should develop Process Safety leading and lagging indicators that are monitored and reported on regularly. KPIs are a requirement of the WHS regulations. This should be described in the MHF Safety Case.

Buncefield Recommendation		Requirement for Project
11	Operators of Buncefield-type sites should review the classification of places within COMAH sites where explosive atmospheres may occur and their selection of equipment and protective systems (as required by the Dangerous Substances and Explosive Atmospheres Regulations 2002). This review should take into account the likelihood of undetected loss of containment and the possible extent of an explosive atmosphere following such an undetected loss of containment. Operators in the wider fuel and chemicals industries should also consider such a review, to take account of events at Buncefield.	PKBLT should undertake a Hazardous Area Classification consistent with the requirements of the relevant Australian Standards. Equipment located within hazardous areas should be selected, installed and maintained in accordance the relevant standards. Hydrocarbon monitoring and alarm systems will be installed in gasoline tank bunds. Gasoline tanks will also have overflow piping to direct any overfill stream to grade and into the bund. This will eliminate the liquid cascade effect which encourages mixing with air and forming a flammable and potentially explosive cloud.
12	Following on from Recommendation 11, operators of Buncefield-type sites should evaluate the siting and/or suitable protection of emergency response facilities such as fire fighting pumps, lagoons or manual emergency switches.	Firewater storage tank, associated pumps and foam systems are currently located on the north-west and north-east corner of Site 2. A manual fire call point system complying with AS 1670 will be provided along the wharf and escape routes to raise an alarm at FRNSW. The suitability of the location of firewater protection systems and ESD push buttons should be reviewed in the Fire Safety Study (FSS) and when developing the Emergency Response Plan (ERP).

Buncefield Recommendation		Requirement for Project
13	Operators of Buncefield-type sites should employ measures to detect hazardous conditions arising from loss of primary containment, including the presence of high levels of flammable vapours in secondary containment. Operators should without delay undertake an evaluation to identify suitable and appropriate measures. This evaluation should include, but not be limited to, consideration of the following: • Installing flammable gas detection in bunds containing vessels or tanks into which large quantities of highly flammable liquids or vapour may be released; • The relationship between the gas detection system and the overfill prevention system. Detecting high levels of vapour in secondary containment is an early indication of loss of containment and so should initiate action, for example through the overfill prevention system, to limit the extent of any further loss; • Installing CCTV equipment to assist operators with early detection of abnormal conditions. Operators cannot routinely monitor large numbers of passive screens, but equipment is available that detects and responds to changes in conditions and alerts operators to these changes.	Means of detecting overfill of flammable liquid from tanks should be developed during the detailed design phase of the Project.
14	Operators of new Buncefield-type sites or those making major modifications to existing sites (such as installing a new storage tank) should introduce further measures including, but not limited to, preventing the formation of flammable vapour in the event of tank overflow. Consideration should be given to modifications of tank top design and to the safe re-routing of overflowing liquids.	PKBLT is a new bulk petroleum liquids site. To reduce the risk associated with tank overfill leading to a Buncefield-type consequence, TQ Holdings has added ducted overflow piping within the tank design. This would safely direct an overflow from a floating roof tank to a safe location at grade, and eliminate the possibility of a large flammable cloud forming due to cascading flammable liquid and droplet formation.

Buncefield Recommendation		Requirement for Project
15	The sector should begin to develop guidance without delay to incorporate the latest knowledge on preventing loss of primary containment and on inhibiting escalation if loss occurs. This is likely to require the sector to collaborate with the professional institutions and trade associations.	Not applicable to operator – industry wide requirement
16	Operators of existing sites, if their risk assessments show it is not practicable to introduce measures to the same extent as for new ones, should introduce measures as close to those recommended by Recommendation 14 as is reasonably practicable. The outcomes of the assessment should be incorporated into the safety report submitted to the Competent Authority.	Recommendation 14 has been incorporated in PKBLT tank design.

Buncefield Recommendation		Requirement for Project
17	The Competent Authority and the sector should jointly review existing standards for secondary and tertiary containment with a view to the Competent Authority producing revised guidance by the end of 2007. The review should include, but not be limited to the following: • Developing a minimum level of performance specification of secondary containment (typically this will be bunding); • Developing suitable means for assessing risk so as to prioritise the programme of engineering work in response to the new specification; • Formally specifying standards to be achieved so that they may be insisted upon in the event of lack of progress with improvements; • Improving firewater management and the installed capability to transfer contaminated liquids to a place where they present no environmental risk in the event of loss of secondary containment and fires; • Providing greater assurance of tertiary containment measures to prevent escape of liquids from site and threatening a major accident to the environment.	TQ Holdings should apply the latest codes and standards relating to tank and bund design.
18	Revised standards should be applied in full to new build sites and to new partial installations. On existing sites, it may not be practicable to fully upgrade bunding and site drainage. Where this is so operators should develop and agree with the Competent Authority risk-based plans for phased upgrading as close to new plant standards as is reasonably practicable.	TQ Holdings should apply the latest codes and standards to the design of the site.

Buncefield Recommendation		Status at PKBLT
19	The sector should work with the Competent Authority to prepare guidance and/or standards on how to achieve a high reliability industry through placing emphasis on the assurance of human and organisational factors in design, operation, maintenance, and testing. Of particular importance are: • Understanding and defining the role and responsibilities of the control room operators (including in automated systems) in ensuring safe transfer processes; • Providing suitable information and system interfaces for front line staff to enable them to reliably detect, diagnose and respond to potential incidents; • Training, experience and competence assurance of staff for safety critical and environmental protection activities; • Defining appropriate workload, staffing levels and working conditions for front line personnel; • Ensuring robust communications management within and between sites and contractors and with operators of distribution systems and transmitting sites (such as refineries); • Prequalification auditing and operational monitoring of contractors' capabilities to supply, support and maintain high integrity equipment; • Providing effective standardised procedures for key activities in maintenance, testing, and operations; • Clarifying arrangements for monitoring and supervision of control room staff; and • Effectively managing changes that impact on people, processes and equipment.	TQ Holdings to develop Health Safety Environment Quality (HSEQ) Management Systems to address the following requirements: • Identification of roles and responsibilities • Competence management system in place. • Adequate staffing arrangements including shift work. Shift work is adequately managed to control risks from fatigue • Operating procedures include shift handover, log books etc. • Active monitoring programme and a set of leading and lagging indicators. These should be developed as part of the MHF Safety Case.

Buncefield Recommendation		Status at PKBLT
20 - 22	Not applicable - Recommendations for the industry sector and competent authority	
23	The sector should set up arrangements to collate incident data on high potential incidents including overfilling, equipment failure, spills and alarm system defects, evaluate trends, and communicate information on risks, their related solutions and control measures to the industry.	Not applicable to operator – industry wide requirement
24	The arrangements set up to meet Recommendation 23 should include, but not be limited to, the following: • thorough investigation of root causes of failures and malfunctions of safety and environmental protection critical elements during testing or maintenance, or in service; • developing incident databases that can be shared across the entire sector, subject to data protection and other legal requirements. Examples exist of effective voluntary systems that could provide suitable models; • collaboration between the workforce and its representatives, duty holders and regulators to ensure lessons are learned from incidents, and best practices are shared.	TQ Holdings to develop and implement a system for incident investigation.
25	In particular, the sector should draw together current knowledge of major hazard events, failure histories of safety and environmental protection critical elements, and developments in new knowledge and innovation to continuously improve the control of risks. This should take advantage of the experience of other high hazard sectors such as chemical processing, offshore oil and gas operations, nuclear processing and railways.	Refer to Recommendation 23.
2. Emergency Preparedness for, response to and recovery from incidents		
Assessing the potential for a Major Incident		

Buncefield Recommendation		Status at PKBLT
1	Operators of Buncefield-type sites should review their emergency arrangements to ensure they provide for all reasonably foreseeable emergency scenarios arising out of credible major hazard incidents, including vapour cloud explosions and severe multi-tank fires that, before Buncefield, were not considered realistically credible. The Competent Authority should ensure that this is done.	The ERP should be prepared in accordance with HIPAP 1 as part of the development approval process. As part of the MHF Safety Case process, the ERP should be reviewed with Fire and Rescue NSW (FRNSW) to ensure that all Major Incident scenarios have been considered in the ERP.
2 & 3	Not applicable - Action for the competent authority	
4	Operators should review and where necessary revise their on-site emergency arrangements to ensure that relevant staff are trained and competent to execute the plan and should ensure that there are enough trained staff available at all times to perform all the actions required by the on-site emergency plan.	Emergency exercises on a range of scenarios should be held regularly. Shift rosters will involve checks to ensure that there are sufficient trained personnel available onsite to execute the ERP. The ERP should account for potential changes in required resourcing in an emergency situation.
5	For Buncefield-type sites, operators should evaluate the siting and/or suitable protection of emergency response facilities such as the emergency control centre, fire fighting pumps, lagoons or manual switches, updating the safety report as appropriate and taking the necessary remedial actions.	Refer to Recommendation 12.
6	Operators should identify vulnerable critical emergency response resources and put in place contingency arrangements either on or off site in the event of failure at any time of the year and make appropriate amendments to the on-site emergency plan. This should include identifying and establishing an alternative emergency control centre with a duplicate set of plans and technical information.	Refer to Recommendation 12.
7	For COMAH sites, if the operator relies on an off-site Fire and Rescue Service to respond, the operator's plan should clearly demonstrate that there are adequate arrangements in place between the operator and the service provider. The Competent Authority will need to check that this is done	A Fire Safety Study should be prepared for PKBLT to determine the site firewater demand requirements. This is required as part of the post-development approval stage by NSW DPE and should be reviewed and approved by FRNSW. As part of the MHF Safety Case, TQ Holdings should submit the ERP to FRNSW for approval regarding appropriate support during Major Incident events. FRNSW should periodically attend the site for exercises and conduct annual audit of the site fire protection systems.

Buncefield Recommendation		Status at PKBLT
Warning and Informing the Public		
8	COMAH site operators should review their arrangements to communicate with residents, local businesses and the wider community, in particular to ensure the frequency of communications meets local needs and to cover arrangements to provide for dealing with local community complaints. They should agree the frequency and form of communications with local authorities and responders, making provision where appropriate for joint communications with those bodies.	This should be covered during the ERP development.
9 - 32	Not applicable to MHF operators	
Investigation of the Explosion Mechanism		
1 - 3	Not applicable to MHF operators	
Land use planning and the control of societal risk around major hazard sites		
1 - 18	Not applicable to MHF operators	

APPENDIX H. REFERENCES

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Port Kembla Bulk Liquids Terminal
(SSD 7264 - MOD1)

APPENDIX

C

AIR QUALITY REVIEW

Cardno
Shaping the Future

Final Report

TQ Holdings Australia – Project Modification Air Quality and Greenhouse Gas Assessment

Document control number: AQ-NW-001-21608

Date: 1 November 2016

TQ Document Number: PJ-PK-0001-REPT-023

Pacific Environment Limited

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Version	Date	Comment	Prepared by	Reviewed by
R1	01.11.16	Final	Angelo Rouggos	Damon Roddis

Adelaide

35 Edward Street,
Norwood SA 5067
PO Box 3187, Norwood SA 5067
Ph: +61 8 8332 0960
Fax: +61 7 3844 5858

Brisbane

Level 19, 240 Queen Street
Brisbane Qld 4000
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

Melbourne

Level 17, 31 Queen Street
Melbourne Vic 3000
Ph: +61 3 9036 2637
Fax: +61 2 9870 0999

Perth

Level 1, Suite 3
34 Queen Street, Perth WA 6000
Ph: +61 8 9481 4961
Fax: +61 2 9870 0999

Sydney Head Office

Suite 1, Level 1, 146 Arthur Street
North Sydney, NSW 2060
Ph: +61 2 9870 0900
Fax: +61 2 9870 0999

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1 Introduction

This Project Modification report is being produced as an addendum to Pacific Environment's "TQ Holdings Australia – Air Quality and Greenhouse Gas Assessment" (**PEL, 2015**).

Included is a review of the air quality impacts from the change in location of the Vapour Recovery Unit (VRU) and new emission sources resulting from changes in tank sizes, quantity and locations across the bulk liquids terminal in Port Kembla ("the Project").

2 Project Modification

TQ Holdings Australia (hereafter referred as "TQ Holdings") are planning to develop the terminal project in an amended sequence to that outlined in the original Environmental Impact Statement (EIS). Initially, TQ Holdings was planning to build Stage 1 on Sites 1 and 2. However, now the project execution strategy is to develop Stage 1 on Site 2 only, leaving Site 1 available for the future Stage 2 of the Project. This modification has resulted in a changed location of the VRU and some tank additions, removals and modifications (location, size and fuel contents) across the terminal.

The site plan for the Project Modification is presented in **Figure 2-1**. Note that Site 1 is currently planned to remain as per the original layout, but will be built out in a later development stage.

Figure 2-1: Project Modification Site Plan (**TQ Holdings, 2016**)

3 Tank Venting Emissions

3.1 Introduction

To characterise the changes in Project emissions from the modification, a comparison of the predicted tank venting emissions from the existing and proposed site plan has been completed. This is in addition to incorporating the VRU location change.

The Response to Submissions report by Pacific Environment (**PEL, 2016**) is used as the primary reference document in this section as the document presents monthly emission estimations for tank venting and assesses additional receptor locations compared with **PEL, 2015** (see **Table 3-1** and **Figure 3-1**) around the project boundary.

Table 3-1: Sensitive Receptors

Sensitive Receptor ID	Location	Easting (m)	Northing (m)	Elevation (m)
1	Coniston Public School	305898	6187146	14
2	Wollongong Greenhouse Park	306632	6186758	7
3	Wollongong Baptist Church	306330	6187818	7
4	Coniston Train Station	305701	6187237	18
5	392 Keira St, Wollongong	306248	6187287	8
6	42 Swan St, Wollongong	306376	6187564	6
7	163 Kembla St, Wollongong	306639	6187527	4
8	179 Corrimal St, Wollongong	306867	6187491	5
9	314 Gladstone Ave, Mt St Thomas	304462	6186661	26
10	240 Gladstone Ave, Mt St Thomas	304947	6186741	22
11	350 Gladstone Ave, Mt St Thomas	304113	6186711	16
12	111 Gladstone Ave, Mt St Thomas	305421	6186970	19
13	33 Five Islands Rd, Cringila	304840	6184069	4
14	Entrance to Site	306614	6186000	1
15	Boundary / Around the Site	306344	6185866	6
16	Boundary / Around the Site	306367	6185325	3
17	Boundary / Around the Site	305985	6185763	4
18	Boundary / Around the Site	306921	6185643	6
19	Boundary / Around the Site	306955	6184826	5
20	Boundary / Around the Site	305889	6185091	2
21	Boundary / Around the Site	306379	6184686	4
22	Boundary / Around the Site	306479	6185907	5
23	Boundary / Around the Site	306812	6186084	6

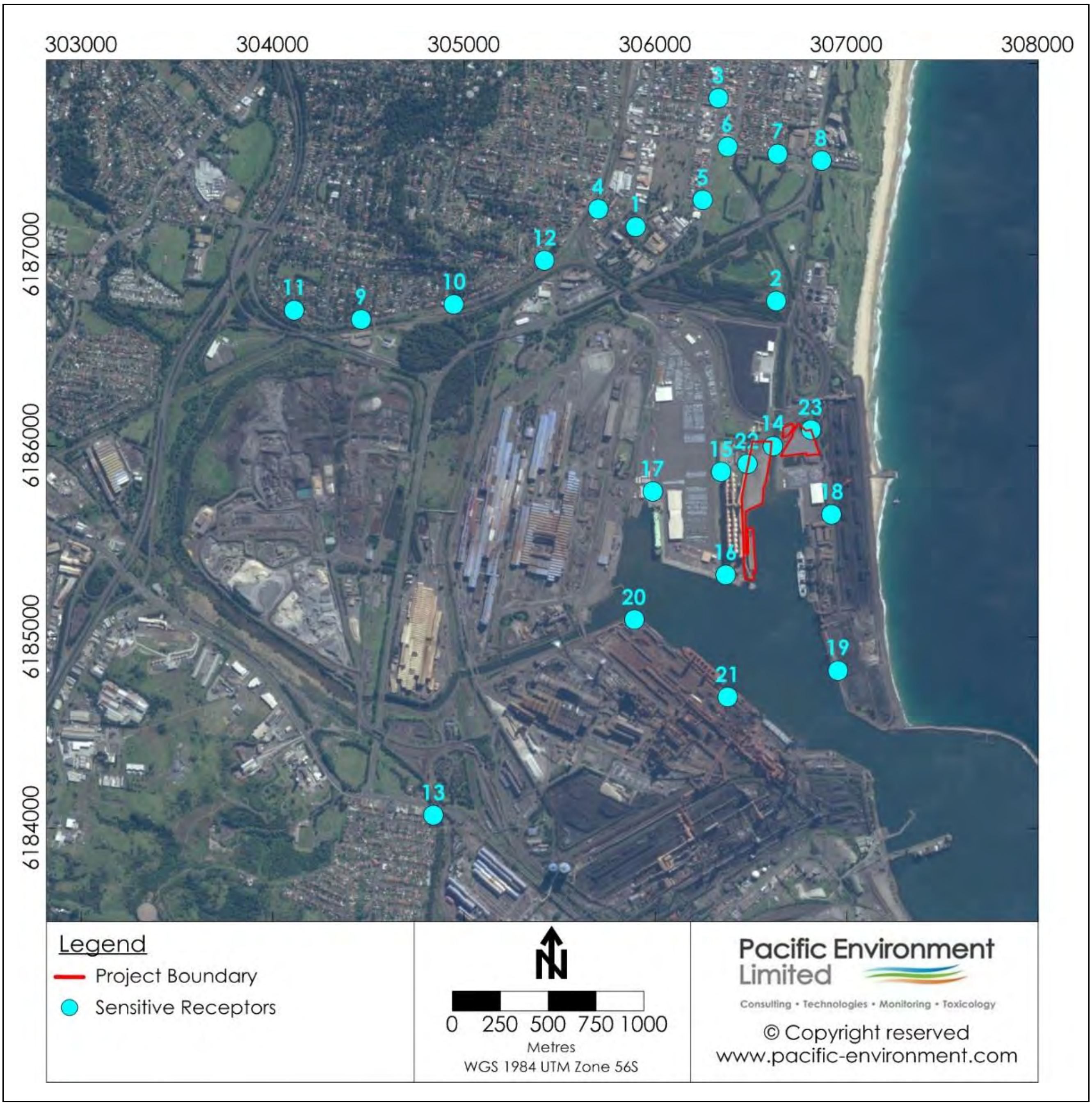

Figure 3-1: Sensitive Receptor Locations

3.2 Assessment

3.2.1 Vapour Recovery Unit

As shown in **Figure 2-1**, the vapour recovery unit (VRU) has been relocated (by approximately 70 m) within the terminal boundary since PEL (**2016**). To determine the air quality impact of this change, Pacific Environment has remodelled the impacts at the sensitive receptors associated with the new VRU location.

3.2.2 Tank Venting

PEL, 2016 presents outputs from the computer software TANKS (version 4.09d) used to estimate hydrocarbon emissions from both fixed and floating roof tanks for the Project. The results are summarised in **Table 3-2**, where emissions were modelled for tanks in the original project development Stages 1, 2 and 3 across Site 1, 2 and 3 for the worst case operational phase.

As stated previously, Site 1 (corresponding to revised Stage 2 of future operations) will remain as per the original environmental assessment. However as part of the proposed modification at Site 2 and Site 3, the following changes are set to occur:

- TK-39 will now contain Additive instead of Slops, and location shifted on Site 2;
- TK-40 now above ground fixed roof tank and will contain Additive instead of slops, and location shifted on Site 2
- The fire water tanks (TK-21, TK-22) remain on Site 2;
  - Not modelled in the air quality assessment.
- Increase of tank sizes;
  - TK-30 (volume increase from 0.03 ML to 0.05 ML).
  - TK-31 (volume increase from 0.03 ML to 0.05 ML).
- Removal of tanks from Site 2;
  - TK-25 (18 ML flammable liquid storage tank) and
- Addition of tanks to Site 2;
  - TK-10-Mod (1.51 ML flammable liquid tank).
  - TK-11-Mod (1.51 ML flammable liquid tank).

The tank identification numbers for Site 2 and 3 have been amended since PEL (**2016**), however for simplicity, the tank identification numbers listed above refer to those presented in PEL (**2016**).

The emission estimation program TANKS was again used to quantify the anticipated emissions from the Project Modification, with the subsequent emissions shown in **Table 3-2**.

As shown in **Table 3-2**, a reduction of 714 kg/yr of hydrocarbon emissions are predicted from the changes outlined above, representing an approximate 1.7% decrease on predicted tank venting emissions at the site. It is also highlighted that the predicted emission reductions are anticipated to occur on Site 2, which is the area closest to the majority of the sensitive receptors north west of the Project.

Table 3-2: Estimated Hydrocarbon Mass Emission Rates from TANKS for Original and Modified Operations

Development Stage	Site Location	Tank ID	Response to Submissions Emissions (kg/yr) (PEL, 2016)	Project Modification Emissions (kg/yr)	Difference (Project Mod – RTS) (kg/yr)
Stage 1	Site 1	TK-01	110	110	0
		TK-02	279	279	0
		TK-03	279	279	0
		TK-04	786	786	0
		TK-05	786	786	0
		TK-06	786	786	0
		TK-07	3,030	3,030	0
		TK-08	3,000	3,000	0
		TK-09	3,009	3,009	0
		TK-11	1,214	1,214	0
		TK-12	26	26	0
		TK-13	756	756	0
		TK-14	756	756	0
		TK-16	756	756	0
		TK-17	756	756	0
		TK-18	756	756	0
		TK-23	1,214	1,214	0
		TK-24	1,214	1,214	0
Stage 2	Site 2	TK-25	3,030	*tank removed*	-3,030
		TK-26	3,000	3,000	0
		TK-27	3,009	3,009	0
		TK-28	786	786	0
		TK-29	786	786	0
		TK-30	756	1123	367
		TK-31	756	1123	367
		TK-32	756	756	0
		TK-33	756	756	0
Stage 3	Site 2	TK-34	3,030	3030	0
		TK-35	3,000	3000	0
		TK-36	786	786	0
		TK-37	531	531	0
		TK-39	756	*now contains additive*	-756
		TK-40	0 (underground tank)	*now contains additive*	0
Not Detailed	Site 2	TK-10-Mod	*tank not in original assessment*	1,168	1,168
		TK-11-Mod	*tank not in original assessment*	1,168	1,168
		TOTAL (kg/yr)	**41,245**	**40,531**	**-714**

Presented in **Table 3-3** is the predicted ground level concentration at the most impacted sensitive receptor (with all receptor ground level concentration predictions shown in **Appendix A**). Note that the results of the road tanker loadout scenario have accounted for the VRU location change only, given that the tank venting emissions are comparable to PEL (**2016**). The results indicate that there are not anticipated to be any exceedances of the NSW EPA air quality criteria at any of the receptors assessed.

Table 3-3: Maximum 1-hour glcs at the Most Impacted Sensitive Receptor for Tank Venting and Road Tanker Loadout Scenario

	Odour (OU)[1]	Benzene (mg/m^3)	Toluene (mg/m^3)	Xylene (mg/m^3)	Ethylbenzene (mg/m^3)	PAH (as Benzo[a]pyrene) (mg/m^3)
	1-second	1-hour	1-hour	1-hour	1-hour	1-hour
Most Impacted Receptor (SR15)	2	0.0053	0.042	0.049	0.0089	0.000007
Criteria	2	0.029	0.36	0.19	8.0	0.0004
% of Criterion	100%	18%	12%	26%	0%	2%

Note: [1] 99th percentile, 1-second nose response
All other results reported as 99.9th percentile, 1-hour average

Additionally, an odour concentration of 2 odour units (OU) has been predicted at the site boundary; however, odour concentrations at the residential receptors are less than 1 OU as shown in **Appendix A**. While it is not meaningful to discuss odour units in less than whole numbers, results have been presented to one decimal place to illustrate the spatial variability in prediction.

Furthermore, the maximum concentration predictions presented are the aggregate of the tank venting and road tanker loadout scenarios. A source-apportionment for these maximum predicted impacts indicates that tank venting is anticipated to constitute only a relatively minor portion of the total predicted values (between 1 and 10 percent). The dominant contribution to maximum predicted concentrations is therefore anticipated to be associated with road tanker loadout, which has been remodelled based upon the change in the Project Modification.

The results indicate that there is anticipated to be minor changes to the ground level concentrations during the road tanker loadout and tank venting scenario from the Project Modification.

4 Greenhouse Gas Assessment

The impact of the Project Modification at the terminal facility is not anticipated to result in any material changes to the greenhouse gas emissions predicted in PEL (**2015**), and hence it has not been assessed further in this report.

A summary of the annual GHG emissions (scope 1 and 2) is provided in **Table 4-1.**

Table 4-1: Summary of Annual Greenhouse Gas Emissions (**PEL, 2015**)

	Scope 1 Emissions (t CO_2-e)	Scope 2 Emissions (t CO_2-e)	
Stage	Diesel	Electricity (per Stage)	Electricity (Cumulative)
1	69	3,171	-
2	108	1,582	4,753
3	154	826	5,580
Post Stage 3	154	6,143	-

The electricity and diesel consumption is anticipated to increase from Stage 1 through to Stage 2 as product throughput increases. Post Stage 2, it has been evaluated that approximately 6,150 tonnes of CO_2 emissions will result from electricity usage annually and 150 tonnes of CO_2 emissions will be associated with diesel usage annually from the terminal.

5 Construction Impacts

It is not anticipated that the modifications to the operation of the terminal will result in any material changes to the construction assessment presented in PEL (**2015**). That is, the conclusion that the potential construction impacts from the Project are considered to be minimal remains valid.

6 Conclusion

Pacific Environment has completed an addendum report to the original air quality and greenhouse gas assessment for the TQ Holdings Australia Project.

The results of the dispersion modelling from PEL (**2016**) indicated that there are no privately owned receptors, recreation areas or on-site locations predicted to exceed the NSW EPA's ground level concentration criteria for the air quality metrics assessed or appropriate nose-response criterion for odour. Therefore, it is expected that given the small location change of the vapour recovery unit and anticipated decrease in total emissions to atmosphere from tank breathing, these conclusions will remain. That is, the operation of the bulk liquids terminal will have negligible impact on the air quality in Port Kembla and surrounding townships.

7 References

Pacific Environment Limited (2015). "TQ Holdings Australia – Air Quality and Greenhouse Gas Assessment", November 2015.

Pacific Environment Limited (2016). "Response to Submissions – Air Quality and Greenhouse Gas: TQ Holdings Bulk Liquids Terminal, Port Kembla", March 2016.

Appendix A

Sensitive Receptor Ground Level Concentrations

Discrete Receptor ID	Odour	Benzene			Toluene			Xylene			Ethylbenzene			PAH (as Benzo[a]pyrene)		
	1-second (OU)	1-hour Assessment Criterion (mg/m^3)														
	2	0.029			0.36			0.19			8			0.0004		
	Total	Tank Breathing	RTL	Total	Tank Breathing	RTL	Total	Tank Breathing	RTL	Total	Tank Breathing	RTL	Total	Tank Breathing	RTL	Total
1	0.1	1.1E-05	2.6E-03	2.6E-03	8.5E-05	2.1E-02	2.1E-02	1.0E-04	2.4E-02	2.4E-02	1.8E-05	4.4E-03	4.5E-03	1.6E-08	3.6E-06	3.7E-06
2	0.2	2.2E-05	3.6E-03	3.6E-03	1.7E-04	2.8E-02	2.9E-02	2.1E-04	3.3E-02	3.4E-02	3.8E-05	6.1E-03	6.1E-03	3.2E-08	5.0E-06	5.0E-06
3	0.1	6.8E-06	9.3E-04	9.4E-04	5.4E-05	7.4E-03	7.4E-03	6.4E-05	8.7E-03	8.8E-03	1.2E-05	1.6E-03	1.6E-03	1.0E-08	1.3E-06	1.3E-06
4	0.1	8.8E-06	2.0E-03	2.0E-03	7.0E-05	1.6E-02	1.6E-02	8.2E-05	1.8E-02	1.9E-02	1.5E-05	3.4E-03	3.4E-03	1.3E-08	2.8E-06	2.8E-06
5	0.1	9.6E-06	2.0E-03	2.0E-03	7.6E-05	1.6E-02	1.6E-02	9.0E-05	1.9E-02	1.9E-02	1.6E-05	3.4E-03	3.4E-03	1.4E-08	2.8E-06	2.8E-06
6	0.1	8.3E-06	1.2E-03	1.2E-03	6.6E-05	9.5E-03	9.5E-03	7.7E-05	1.1E-02	1.1E-02	1.4E-05	2.0E-03	2.1E-03	1.2E-08	1.7E-06	1.7E-06
7	0.1	9.0E-06	1.2E-03	1.2E-03	7.1E-05	9.3E-03	9.4E-03	8.4E-05	1.1E-02	1.1E-02	1.5E-05	2.0E-03	2.0E-03	1.3E-08	1.6E-06	1.7E-06
8	0.1	9.7E-06	1.3E-03	1.3E-03	7.7E-05	1.0E-02	1.0E-02	9.1E-05	1.2E-02	1.2E-02	1.7E-05	2.2E-03	2.2E-03	1.4E-08	1.8E-06	1.8E-06
9	0	6.0E-06	6.0E-04	6.0E-04	4.7E-05	4.7E-03	4.8E-03	5.6E-05	5.6E-03	5.6E-03	1.0E-05	1.0E-03	1.0E-03	8.9E-09	8.3E-07	8.4E-07
10	0	7.1E-06	9.5E-04	9.6E-04	5.6E-05	7.5E-03	7.6E-03	6.6E-05	8.9E-03	9.0E-03	1.2E-05	1.6E-03	1.6E-03	1.1E-08	1.3E-06	1.3E-06
11	0	4.7E-06	4.6E-04	4.7E-04	3.7E-05	3.7E-03	3.7E-03	4.4E-05	4.3E-03	4.4E-03	8.0E-06	7.9E-04	8.0E-04	7.2E-09	6.4E-07	6.5E-07
12	0.1	9.6E-06	1.9E-03	1.9E-03	7.6E-05	1.5E-02	1.5E-02	8.9E-05	1.8E-02	1.8E-02	1.6E-05	3.3E-03	3.3E-03	1.4E-08	2.7E-06	2.7E-06
13	0	6.5E-06	6.1E-04	6.2E-04	5.2E-05	4.8E-03	4.9E-03	6.1E-05	5.7E-03	5.7E-03	1.1E-05	1.0E-03	1.0E-03	9.6E-09	8.5E-07	8.6E-07
14	1.9	1.4E-04	3.9E-03	4.1E-03	1.1E-03	3.1E-02	3.2E-02	1.3E-03	3.6E-02	3.8E-02	2.5E-04	6.6E-03	6.9E-03	2.1E-07	5.4E-06	5.6E-06
15	1.6	1.0E-04	5.2E-03	5.3E-03	7.9E-04	4.1E-02	4.2E-02	9.3E-04	4.8E-02	4.9E-02	1.7E-04	8.8E-03	8.9E-03	1.4E-07	7.2E-06	7.3E-06
16	0.4	3.3E-05	2.3E-03	2.3E-03	2.6E-04	1.8E-02	1.9E-02	3.0E-04	2.2E-02	2.2E-02	5.5E-05	3.9E-03	4.0E-03	4.7E-08	3.2E-06	3.3E-06
17	0.4	2.7E-05	3.2E-03	3.3E-03	2.1E-04	2.6E-02	2.6E-02	2.5E-04	3.0E-02	3.1E-02	4.6E-05	5.5E-03	5.6E-03	4.0E-08	4.5E-06	4.6E-06
18	0.9	4.8E-05	2.7E-03	2.8E-03	3.8E-04	2.1E-02	2.2E-02	4.5E-04	2.5E-02	2.6E-02	8.1E-05	4.6E-03	4.7E-03	6.8E-08	3.8E-06	3.8E-06
19	0.2	1.7E-05	1.5E-03	1.5E-03	1.4E-04	1.2E-02	1.2E-02	1.6E-04	1.4E-02	1.4E-02	2.9E-05	2.6E-03	2.6E-03	2.6E-08	2.1E-06	2.1E-06
20	0.2	1.8E-05	1.5E-03	1.6E-03	1.4E-04	1.2E-02	1.2E-02	1.7E-04	1.4E-02	1.5E-02	3.0E-05	2.6E-03	2.7E-03	2.6E-08	2.1E-06	2.2E-06
21	0.2	1.5E-05	1.5E-03	1.5E-03	1.2E-04	1.2E-02	1.2E-02	1.4E-04	1.4E-02	1.4E-02	2.6E-05	2.5E-03	2.5E-03	2.3E-08	2.0E-06	2.1E-06
22	2.1	2.3E-04	4.0E-03	4.2E-03	1.8E-03	3.2E-02	3.3E-02	2.1E-03	3.7E-02	3.9E-02	3.8E-04	6.8E-03	7.2E-03	3.1E-07	5.6E-06	5.9E-06
23	2.1	1.3E-04	3.3E-03	3.4E-03	1.0E-03	2.6E-02	2.7E-02	1.2E-03	3.1E-02	3.2E-02	2.2E-04	5.6E-03	5.8E-03	1.9E-07	4.6E-06	4.8E-06
Max Receptor	2.1	5.3E-03			4.2E-02			4.9E-02			8.9E-03			7.3E-06		
% of Criterion	100%	18%			12%			26%			0%			2%		

Port Kembla Bulk Liquids Terminal
(SSD 7264 - MOD1)

APPENDIX

D

NOISE & VIBRATION REVIEW

Cardno
Shaping the Future

Final Report

TQ Holdings Australia – Project Modification Noise and Vibration Assessment

Document control number: AC-NW-001-21608

Date: 31 October 2016

TQ Document Number: PJ-PK-0001-REPT-024

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Technologies Consulting Monitoring

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Document control number:	AC-NW-001-21608
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Adelaide

35 Edward Street,
Norwood SA 5067
PO Box 3187, Norwood SA 5067
Ph: +61 8 8332 0960
Fax: +61 7 3844 5858

Brisbane

Level 19, 240 Queen Street
Brisbane Qld 4000
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

Melbourne

Level 17, 31 Queen Street
Melbourne Vic 3000
Ph: +61 3 9036 2637
Fax: +61 2 9870 0999

Perth

Level 1, Suite 3
34 Queen Street, Perth WA 6000
Ph: +61 8 9481 4961
Fax: +61 2 9870 0999

Sydney Head Office

Suite 1, Level 1, 146 Arthur Street
North Sydney, NSW 2060
Ph: +61 2 9870 0900
Fax: +61 2 9870 0999

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1 Introduction

This Project Modification report has been prepared as an addendum to Pacific Environment's "TQ Holdings Australia – Noise and Vibration Assessment for Proposed Port Kembla Bulk Liquids Terminal" (**PEL, 2015**).

This report includes a revised noise impact assessment considering the noise impacts from a revised project layout from the proposed Project Modification of the bulk liquids terminal in Port Kembla ("the Project").

2 Project Modification

TQ Holdings Australia (hereafter referred as "TQ Holdings") are planning to develop the terminal project in an amended sequence to that outlined in the original Environmental Impact Statement (EIS). Initially, the TQ Holdings was planning to build Stage 1 on Sites 1 & 2. The project execution strategy has been revised to develop Stage 1 on Site 2 only, leaving Site 1 available for the future development Stage of the Project. This modification has resulted in some changes to the terminal areas including the pump bays and bunding splits on Site 2.

The site plan for the Project Modification is presented in **Figure 2-1**. Note that Site 1 is currently planned to remain as per the original layout, but will be built out in a later development stage.

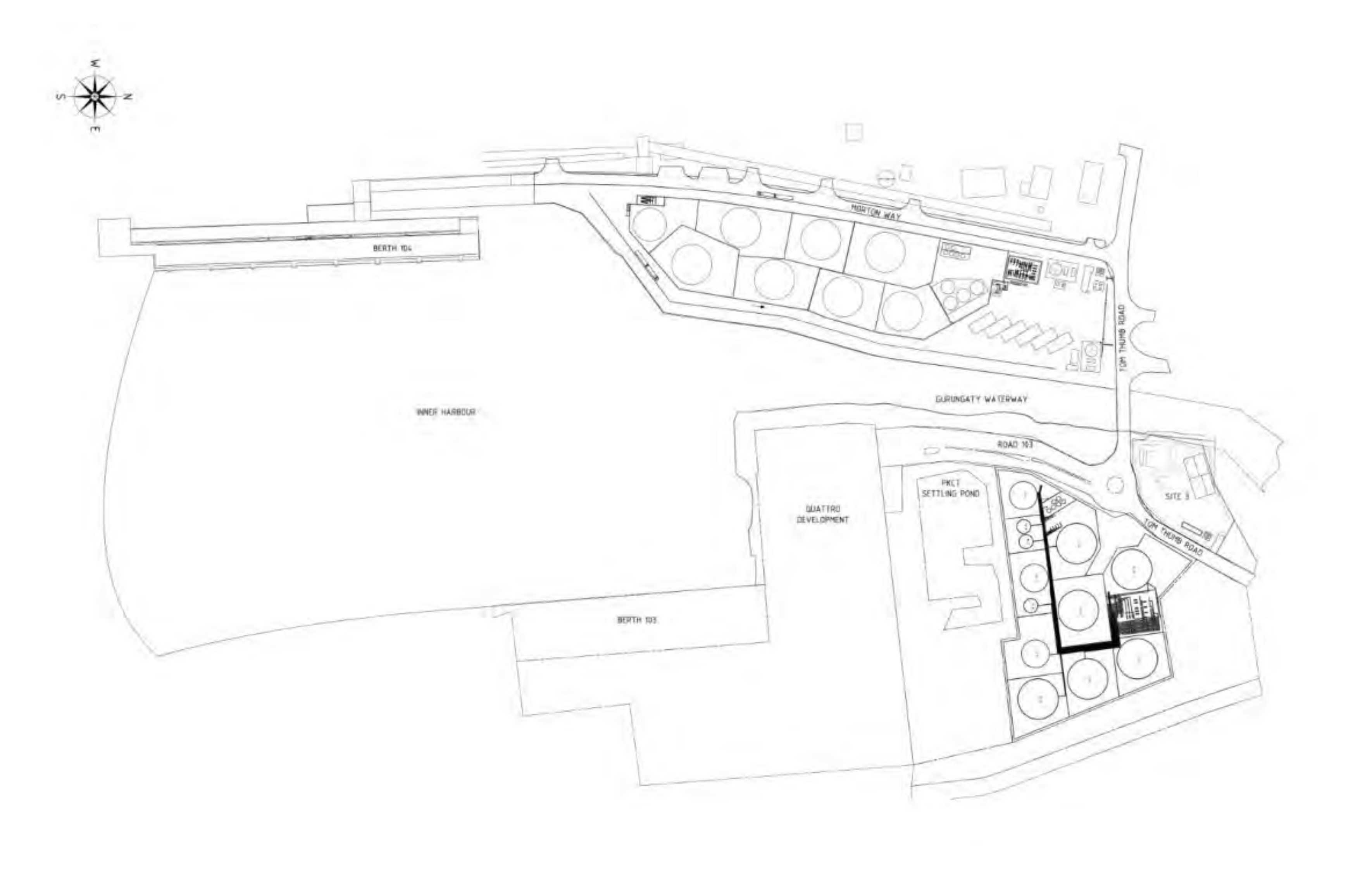

Figure 2-1: Project Modification (Site 2) (**TQ Holdings, 2016**)

3 Operational Noise

3.1 Introduction

The project specific noise criteria, modelling methodology, meteorological conditions and sound power levels for the operational sources are presented in PEL (**2015**).

Note that an additional night-time meteorological condition (F-class, 2 m/s south east wind) was evaluated in the Response to Submissions report by Pacific Environment (**2016**), and has been incorporated here. That is, inversion conditions with winds blowing towards the sensitive receivers surrounding the Project.

The source locations as per the site plan (see **Figure 2-1)** are presented in **Appendix A**. The HVAC system, air compressor, vapour recovery unit and loading/product pumps were moved in this assessment to reflect the changes of the Project Modification.

3.2 Sensitive Receiver Locations

Shown in **Figure 3-1** are all sensitive receivers assessed. A full list with street addresses is presented in **Appendix B**.

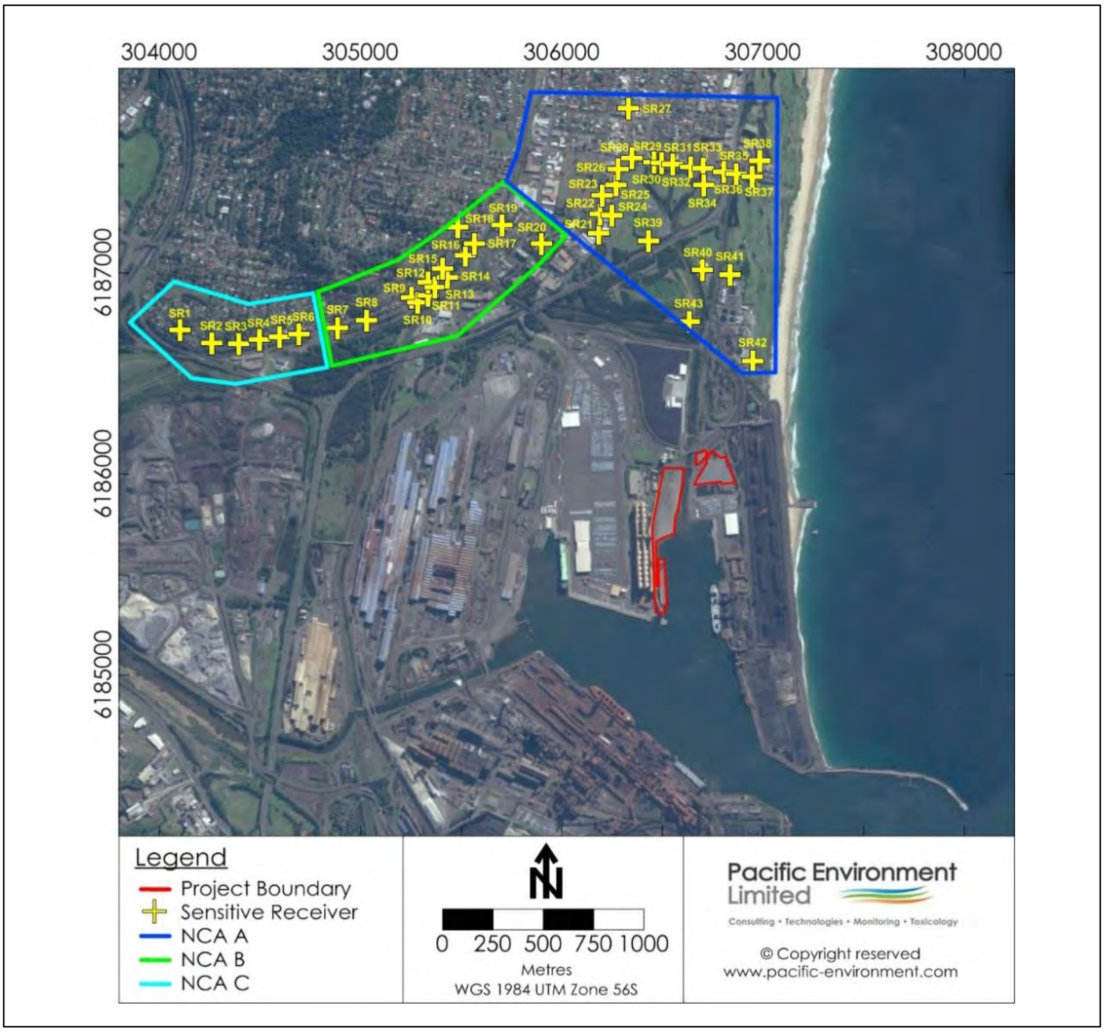

Figure 3-1: Receiver Locations

3.3 Operational Noise

Predicted noise levels for the most impacted receivers are presented in **Table 3-1** for the Project Modification.

The complete noise modelling results are presented in **Appendix C**, with noise contours shown in **Appendix D**.

All receivers shown in the table are predicted to receive acceptable noise levels for all assessed meteorological conditions during the terminal operations when assessed against the Industrial Noise Policy (INP) and Industrial Noise Guideline (ING). Results were within similar ranges to those predicted in the EIS and only changed marginally with the revised configuration.

Table 3-1: Predicted Operational Noise at Most Impacted Sensitive Receivers

Receiver ID	Receiver Type	Criteria $L_{Aeq,15min}$			Predicted Noise Level $L_{Aeq,15min}$ dB(A)					
		Day	Eve	Night	Day 1 (Neutral)	Eve/Night 2 (Neutral)	Eve/Night 3 (NE wind)	Eve/Night 4 (E wind)	Eve/Night 5 (SE wind)	Eve/Night 6 (SE wind)
NCA A										
21	Passive Recreation Area	50	50	50	30	31	27	36	36	37
24	Residence	56	44	39	30	30	27	35	36	36
27	Place of Worship	50	50	50	27	28	24	31	34	34
36	Residence	56	44	39	30	31	27	29	36	37
40	Commercial	65	65	65	35	36	33	35	40	41
42	Active Recreation Area	55	55	55	40	41	40	39	44	46
43	Active Recreation Area	55	55	55	39	39	38	41	44	45
NCA B										
16	Residence	53	46	38	30	31	30	36	36	37
18	School	45	-	-	30	31	31	36	36	37
20	School	45	-	-	32	33	30	38	38	39
NCA C										
5	Residence	46	47	43	25	26	32	32	32	32

3.4 Low Frequency Noise

3.4.1 Methodology

An assessment for potential impacts relating to low frequency noise has been conducted using guidance from the INP.

Noise levels were predicted as C-weighted noise levels. The difference between the A and C weighted noise have been used to predict whether low frequency impacts are likely to occur. The C-weighted noise levels were calculated for privately owned receivers for the modelled Project Modification.

3.4.2 Low Frequency Noise Modelling Results and Assessment

Presented in **Table 3-2** are the most affected receivers from low frequency noise. The predicted C-weighted noise levels for all privately owned receivers are presented in **Appendix B**.

Table 3-2: Predicted Low Frequency Noise at Most Impacted Sensitive Receivers

Receiver ID	Receiver Type	Criteria 24 hr Operation	Predicted Noise Level Differences $L_{Ceq,15min} - L_{Aeq,15min}$ dB					
			Day 1 (Neutral)	Eve/Night 2 (Neutral)	Eve/Night 3 (NE wind)	Eve/Night 4 (E wind)	Eve/Night 5 (SE wind)	Eve/Night 6 (Neutral)
NCA A								
36	Residence	$L_C - L_A$ <15 dB	15	14	15	14	11	11
NCA B								
16	Residence	$L_C - L_A$ <15 dB	15	14	14	11	11	11
NCA C								
5	Residence	$L_C - L_A$ <15 dB	16	15	12	12	12	12

At some receivers, the difference between the A and C weighted noise levels was found to be greater than 15 dB. However, when comparing the predicted frequency data with the draft ING low frequency guidance, no additional penalties would apply. These results are consistent with the currently approved project and are not expected to result in any significant changes to noise levels at the most impacted receivers.

In the Response to Submissions report (**PEL, 2016**),a comparison of project low frequency contributions against the background L_{A90} frequency data collected during attended noise monitoring was compared with the frequency data predicted at the most impacted receptors. The low frequency 63Hz and 125Hz octave bands are not expected to significantly contribute to the current ambient background noise levels.

3.5 Sleep Disturbance

3.5.1 Methodology

Sleep disturbance events have the potential to be caused by short high level noise events from operations. These can be caused by a number of activities and equipment items including trucks being loaded, engine start-ups and revving, tonal reversing alarms, warning and system alarms.

A noise level of L_{Amax} 120 dB(A) has been assumed to represent typical maximum noise level events from a truck air break release or similar peak noise events.

3.5.2 Sleep Disturbance Noise Modelling Results and Assessment

The predicted maximum noise level results at the most sensitive residential receivers are presented in **Table 3-3**. Results are below the sleep disturbance criteria for all receivers for the Project Modification. Complete noise modelling results are presented **Appendix B**.

Table 3-3: Predicted L_{Amax} Noise Levels at Most Impacted Sensitive Receivers

		Criteria L_{Amax}	Predicted Noise Level L_{Amax} dB(A)				
			Eve/Night	Eve/Night	Eve/Night	Eve/Night	Eve/Night
Receiver ID	Receiver Type	Night	2 (Neutral)	3 (NE winds)	4 (E winds)	5 (SE winds)	6 (Neutral)
NCA A							
32	Residence	50	37	33	37	42	43
NCA B							
24	Residence	50	38	34	38	43	44
NCA C							
5	Residence	50	33	39	33	39	39

3.6 Cumulative Noise

Cumulative noise impacts similar to those predicted in the EIS are expected. Cumulative noise levels resulting from existing industry around the proposed facility were accounted for when setting the amenity noise limits. As predicted noise levels meet the intrusive and amenity noise criteria, cumulative industrial noise impacts are not anticipated.

4 Operational Vibration

No significant operational vibration sources are anticipated to impact on the nearest residential or industrial areas from operations at the facility.

5 Construction Noise and Vibration

It is not anticipated that the modifications to the operation of the terminal will result in any significant changes to the construction noise and vibration predictions presented in PEL (**2015**) and the response to submissions. Predictions in PEL (**2015**) indicate that the noise from construction works at the terminal will be well below the project specific assessment criteria at residential receivers. Similar construction impacts on adjacent industrial sites are expected to those presented in the response to submissions for this Project Modification.

6 Conclusion

An assessment of noise and vibration impacts from the Project Modification at the bulk liquids terminal in Port Kembla has been conducted. The Project Modification is not anticipated to result in any significant changes to the outcomes presented in the noise assessment for the Environmental Impact Statement or the Response to Submissions.

In relation to operational noise; there are no exceedances of noise criteria predicted, no anticipated annoying characteristics or operational vibration impacts.

The construction noise and vibration impacts will be below the project specific assessment criteria at all residential receivers assessed. Construction noise and vibration impacts on adjacent industrial sites are expected to be equivalent to those presented in the response to submissions for the original SSD application.

7 References

Pacific Environment Limited (2015). "TQ Holdings Australia – Noise and Vibration Assessment for Proposed Port Kembla Bulk Liquids Terminal", November 2015.

Pacific Environment Limited (2016). "Response to Submissions - Noise and Vibration: TQ Holdings Bulk Liquids Terminal, Port Kembla", March 2016.

TQ Holdings Australia (2016), "Site Plan".

Appendix A

Source Locations

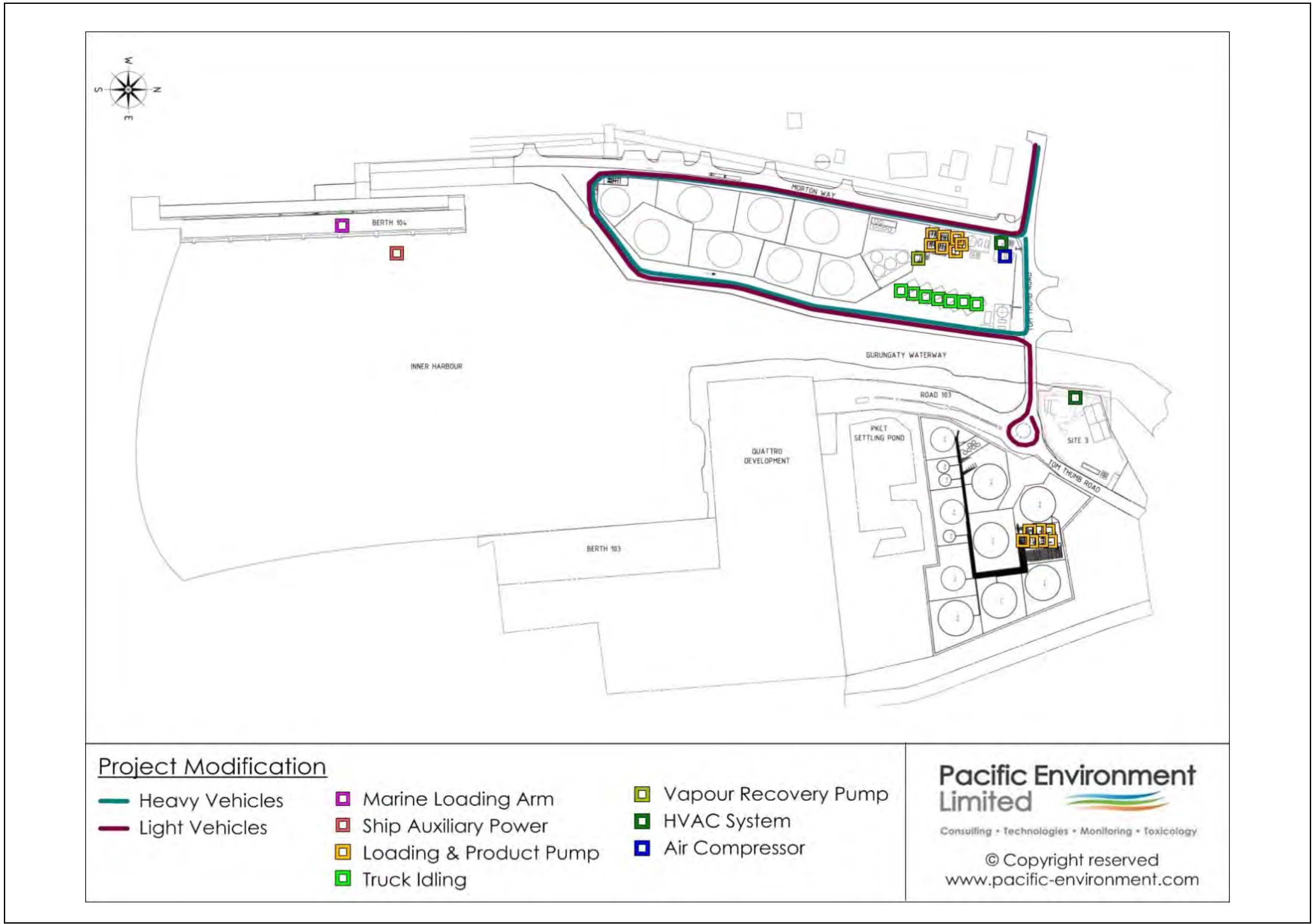

Figure A-1: Source Locations for Project Modification

Appendix B

Receiver Detail

Noise Catchment Area	Sound Receiver ID	Type	Address	Easting (m)	Northing (m)
C (residential)	SR1	Residence	352 Gladstone Ave, Mt St Thomas	304103	6186718
	SR2	Residence	84 Taronga Ave, Mt St Thomas	304259	6186650
	SR3	Residence	326 Gladstone Ave, Mt St Thomas	304393	6186649
	SR4	Residence	310 Gladstone Ave, Mt St Thomas	304496	6186667
	SR5	Residence	290 Gladstone Ave, Mt St Thomas	304598	6186681
	SR6	Residence	272 Gladstone Ave, Mt St Thomas	304694	6186695
B	SR7	Residence	248 Gladstone Ave, Mt St Thomas	304887	6186727
	SR8	Residence	228 Gladstone Ave, Mt St Thomas	305031	6186763
	SR9	Residence	Lot 16 Gladstone Ave, Mt St Thomas	305253	6186878
	SR10	Residence	139 Gladstone Ave, Mt St Thomas	305284	6186853
	SR11	Residence	133 Gladstone Ave, Mt St Thomas	305335	6186889
	SR12	Residence	176 Gladstone Ave, Coniston	305336	6186952
	SR13	Residence	119 Gladstone Ave, Coniston	305371	6186929
	SR14	Residence	109 Gladstone Ave, Coniston	305432	6186979
	SR15	Residence	160 Gladstone Ave, Coniston	305406	6187023
	SR16	Residence	146A Gladstone Ave, Coniston	305520	6187088
	SR17	Residence	140 Gladstone Ave, Coniston	305564	6187145
	SR18	School	Cedars Christian College	305482	6187227
	SR19	Commercial	Coniston Train Station	305701	6187237
	SR20	School	Coniston Public School	305898	6187146
A	SR21	Passive Recreation Area	Coniston Cemetery	306183	6187197
	SR22	Residence	147 Kenny St, Coniston	306191	6187294
	SR23	Residence	135 Kenny St, Coniston	306199	6187387
	SR24	Residence	392 Keira St, Coniston	306248	6187287

Noise Catchment Area	Sound Receiver ID	Type	Address	Easting (m)	Northing (m)
A	SR25	Residence	372 Keira St, Coniston	306269	6187438
	SR26	Residence	362 Keira St, Coniston	306280	6187515
	SR27	Place of Worship	Wollongong Baptist Church	306330	6187818
	SR28	Residence	46 Swan St, Wollongong	306348	6187570
	SR29	Commercial	215 Church St, Wollongong	306457	6187552
	SR30	Commercial	38 Swan St, Wollongong	306497	6187546
	SR31	Residence	93 Evans St, Wollongong	306549	6187541
	SR32	Residence	168 Kembla St, Wollongong	306639	6187527
	SR33	Commercial	34 Swan St, Wollongong	306701	6187520
	SR34	Commercial	JJ Kelly Park	306704	6187439
	SR35	Commercial	Lot 1 Swan St, Wollongong	306805	6187502
	SR36	Residence	179 Corrimal St, Wollongong	306867	6187491
	SR37	Commercial	16 Swan St, Wollongong	306946	6187480
	SR38	Commercial	Wollongong Golf Club	306984	6187558
	SR39	Active Recreation Area	JJ Kelly Park	306429	6187160
	SR40	Commercial	Wollongong Heliport	306697	6187016
A (recreation area)	SR41	Active Recreation Area	Wollongong Golf Course	306837	6186991
	SR42	Active Recreation Area	Wollongong Golf Course	306950	6186563
	SR43	Active Recreation Area	Wollongong Greenhouse Park	306632	6186758

Appendix C

Noise Modelling Results

Table B-1: Project Modification Operational Modelling Results

Period Condition ID Receiver ID	Predicted Noise Level $LA_{eq,15min}$ dB(A) Day 1	Eve/Night 2	Eve/Night 3	Eve/Night 4	Eve/Night 5	Eve/Night 6
SR1	21	23	29	29	29	29
SR2	22	23	29	29	29	29
SR3	23	24	30	30	30	30
SR4	25	26	32	32	32	32
SR5	25	26	32	32	32	32
SR6	25	26	32	32	32	32
SR7	26	27	32	32	32	33
SR8	28	29	34	34	34	35
SR9	27	28	33	34	34	34
SR10	24	25	29	30	30	31
SR11	23	23	25	29	29	29
SR12	28	29	31	34	34	35
SR13	26	27	30	33	33	33
SR14	28	29	31	35	35	35
SR15	28	29	30	35	35	35
SR16	30	31	30	36	36	37
SR17	30	31	30	36	36	37
SR18	30	31	31	36	36	37
SR19	28	30	27	35	35	36
SR20	32	33	30	38	38	39
SR21	30	31	27	36	36	37
SR22	26	27	23	31	32	32
SR23	28	29	25	34	35	35
SR24	30	30	27	35	36	36
SR25	29	30	26	34	35	36
SR26	28	29	25	33	35	35
SR27	27	28	24	31	34	34
SR28	28	29	26	32	35	35
SR29	29	30	26	32	35	36
SR30	29	30	26	32	36	36
SR31	29	30	26	30	36	36
SR32	29	30	27	30	36	37
SR33	29	30	26	30	36	36
SR34	30	31	27	31	37	37
SR35	30	31	27	29	36	37
SR36	30	31	27	29	36	37
SR37	30	31	27	28	36	37
SR38	31	32	28	29	37	38
SR39	30	30	27	33	35	36
SR40	35	36	33	35	40	41
SR41	35	36	34	34	40	41
SR42	40	41	40	39	44	46
SR43	39	39	38	41	44	45

Table B-2: Project Modification C-Weighted Noise Modelling Results

Period Condition ID Receiver ID	Predicted Noise Level $LA_{eq,15min}$ dB(A) Day 1	Eve/Night 2	Eve/Night 3	Eve/Night 4	Eve/Night 5	Eve/Night 6
SR1	38	38	41	41	41	41
SR2	39	39	41	41	41	42
SR3	39	39	42	42	42	42
SR4	41	41	44	44	44	44
SR5	41	41	44	44	44	44
SR6	41	42	44	44	44	45
SR7	41	41	44	44	44	44
SR8	43	43	45	46	46	46
SR9	42	42	44	44	44	45
SR10	40	41	42	43	43	44
SR11	40	40	40	42	42	43
SR12	42	42	42	45	45	45
SR13	41	41	42	44	44	45
SR14	42	42	43	45	45	46
SR15	42	42	42	45	45	46
SR16	44	44	44	47	47	48
SR17	44	44	44	47	47	48
SR22	42	42	40	44	44	45
SR23	43	43	41	45	46	46
SR24	44	44	42	46	47	47
SR25	44	44	41	45	46	47
SR26	43	43	41	45	46	47
SR28	44	44	41	44	46	47
SR31	44	44	41	44	47	47
SR32	44	44	42	44	47	47
SR36	44	44	42	43	47	48

Table B-3: Project Modification Sleep Disturbance Modelling Results

Period / Condition ID / Receiver ID	Predicted Noise Level $LA_{eq,15min}$ dB(A) Eve/Night 2	Eve/Night 3	Eve/Night 4	Eve/Night 5	Eve/Night 6
SR1	30	36	30	36	36
SR2	31	37	31	37	37
SR3	32	37	32	37	38
SR4	32	38	32	38	38
SR5	33	39	33	39	39
SR6	33	39	33	39	39
SR7	34	40	34	40	40
SR8	35	41	35	41	41
SR9	36	41	36	41	42
SR10	34	39	34	39	39
SR11	31	32	31	37	37
SR12	36	37	36	42	42
SR13	36	36	36	41	42
SR14	37	37	37	42	43
SR15	36	37	36	42	42
SR16	37	37	37	42	43
SR17	37	37	37	42	43
SR22	36	32	36	41	42
SR23	37	33	37	42	43
SR24	38	34	38	43	44
SR25	37	33	37	42	43
SR26	36	32	36	42	42
SR28	36	32	36	42	42
SR31	37	33	37	42	43
SR32	37	33	37	42	43
SR36	37	33	37	42	43

Appendix D

Noise Contours

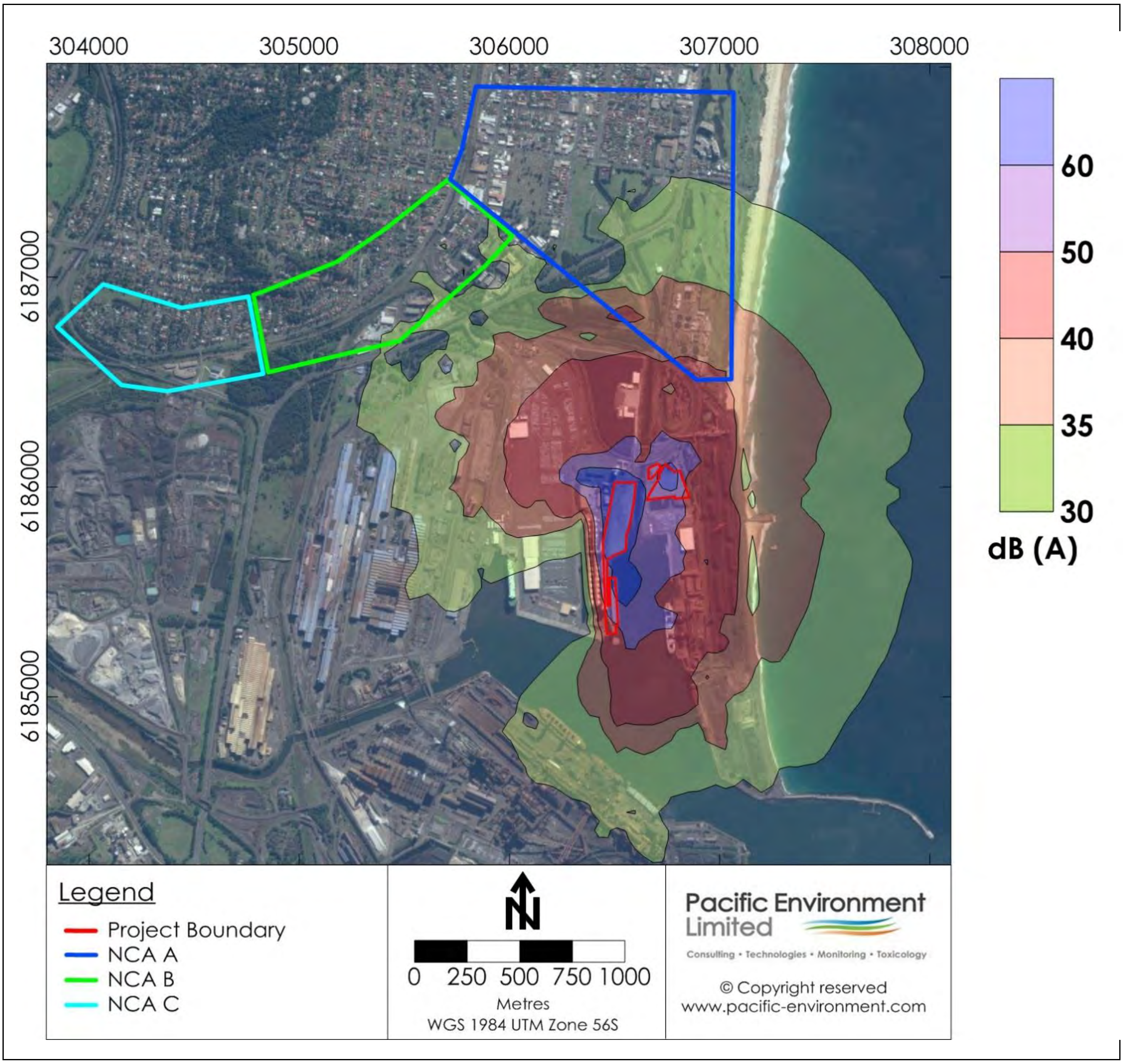

Figure D-1: Daytime (neutral conditions)

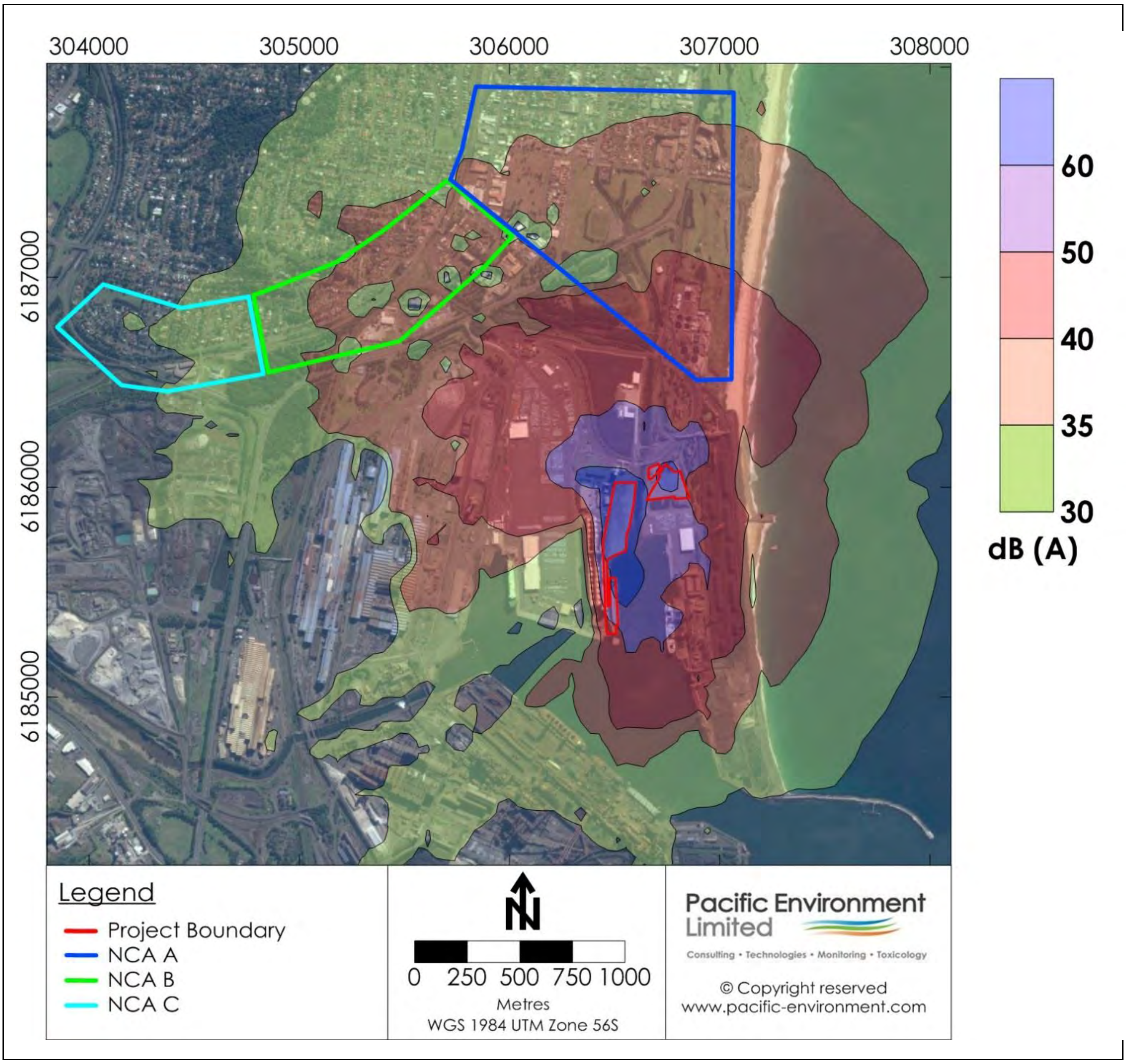

Figure D-2: Night-time (inversion conditions, 2 m/s south-east winds)

Port Kembla Bulk Liquids Terminal
(SSD 7264)

APPENDIX

E

HUMAN HEALTH RISK ANALYSIS

Environmental Risk Sciences Pty Ltd
PO Box 2537
Carlingford NSW 2118

Phone: +61 2 9614 0297
Fax: +61 2 8215 0657
Email: Jackie@enrisks.com.au

www.enrisks.com.au

4 November 2016

Cardno
Level 1
47 Bureli Street
Wollongong NSW 2500

Attn: Alex Larance

Human Health Risk Assessment – Port Kembla Bulk Liquids Terminal: Review of Project Modification

Environmental Risk Sciences Pty Ltd (enRiskS) completed the report: Human Health Risk Assessment – Port Kembla Bulk Liquids Terminal, Report reference PJ-PK-0001-REPT-012_00-01, dated 12 November 2015 (referred to as the HHRA). Letter reports providing responses to submissions was also provided by enRiskS (dated 17 March and 9 May 2016).

Subsequent to the completion of the HHRA (and provision of responses to submissions), a modification to the project was proposed. The original project involved the completion of both Stages 1 and 2. The proposed modification involves the completion of Stage 1 on Site 2 only, with Site 1 to remain available for future stages of the project. This modification has resulted in some tank additional, removals and modifications (to the size, location and fuel contents) on the site.

As the HHRA is dependent on the Air Quality and Greenhouse Gas Assessment (AQGGA) completed by Pacific Environment Limited, the Project Modification Report prepared by Pacific Environment Limited (dated 1 November 2016) in relation to changes to air quality associated with the proposed project modification, has been reviewed to determine if this affects the conclusions presented in the HHRA.

The AQGGA for the Project Modification Report presents a conservative estimate of maximum 1-hour average concentrations at 23 receptor locations within the community and on the site boundary (refer to **Figure 1**). In addition, the modelled annual average concentration at the 23 receptor locations has also been provided by Pacific Environment Limited for the purpose of this review. The annual average concentration assumes that emissions from tank breathing and road tanker loading occur on every hour of the day for a full year. This is highly conservative and will have resulted in an overestimation of annual average concentrations at each of the receptors.

The acute and chronic health impacts at the 23 receptor locations have been revised in accordance with the methodology outlined in the HHRA and response to submissions letter, with the revised calculations presented in **Tables 1 and 2**.

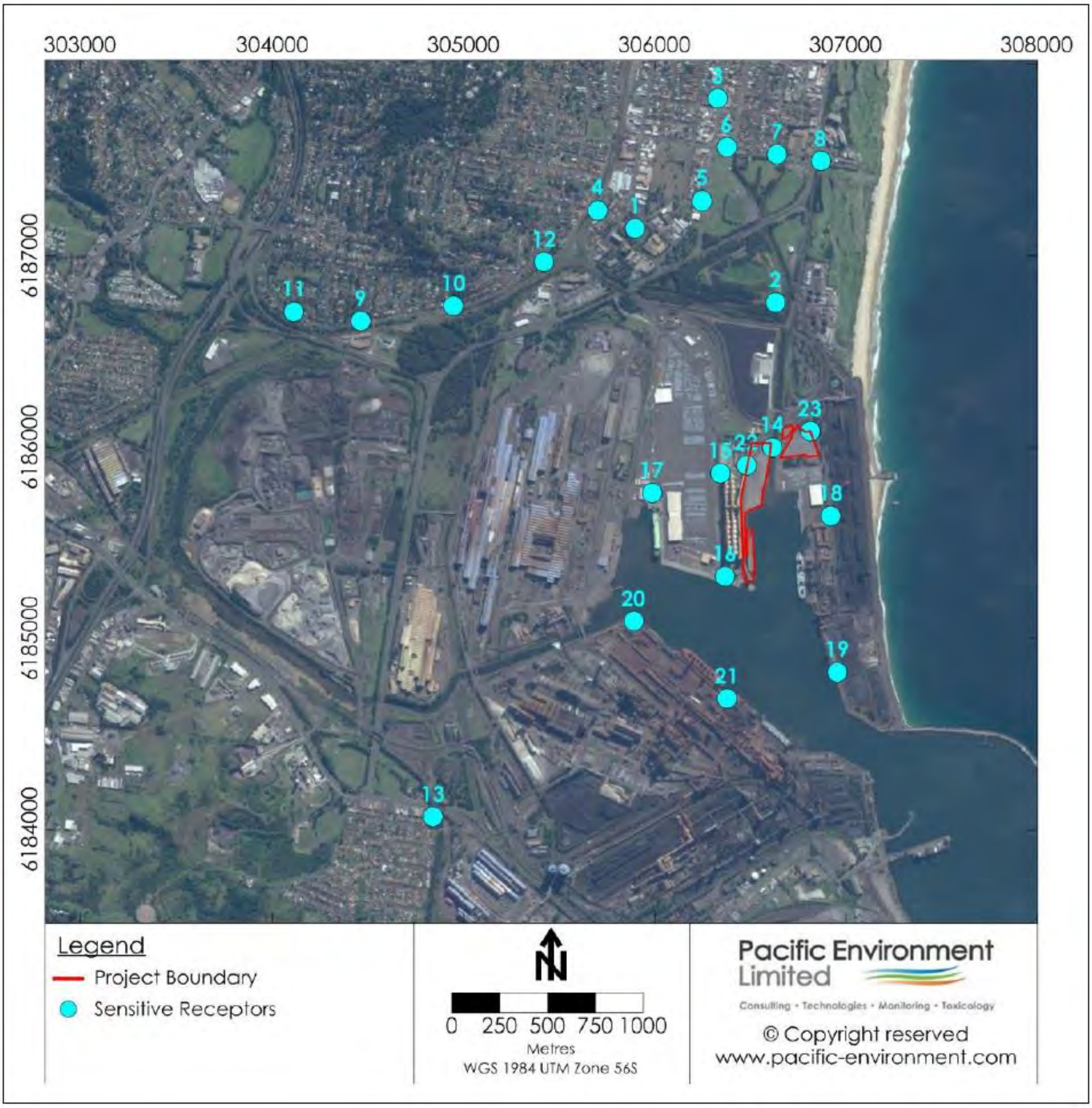

Figure 1 Location of Sensitive Receptors Modelled in Air Quality Assessment

Table 1: Revised Assessment of Acute Inhalation Exposures from Tank Venting and Road Tanker Loading (all concentrations in mg/m³)

ID	Receptor Location	Benzene		Toluene		Ethylbenzene		Xylenes		Total HI
		Guideline	0.029	Guideline	4.5	Guideline	22	Guideline	2.2	
		Max 1-hr average	HI	Max 1-hr average	HI	Max 1-hr average	HI	Max 1-hr average	HI	
1	Coniston Public School	2.6E-03	9.0E-02	2.1E-02	4.7E-03	4.5E-03	2.0E-04	2.4E-02	1.1E-02	0.1
2	Wollongong Greenhouse Park	3.6E-03	1.2E-01	2.9E-02	6.4E-03	6.1E-03	2.8E-04	3.4E-02	1.5E-02	0.1
3	Wollongong Baptist Church	9.4E-04	3.2E-02	7.4E-03	1.6E-03	1.6E-03	7.3E-05	8.8E-03	4.0E-03	0.04
4	Coniston Train Station	2.0E-03	6.9E-02	1.6E-02	3.6E-03	3.4E-03	1.5E-04	1.9E-02	8.6E-03	0.08
5	392 Keira St, Wollongong	2.0E-03	6.9E-02	1.6E-02	3.6E-03	3.4E-03	1.5E-04	1.9E-02	8.6E-03	0.08
6	42 Swan St, Wollongong	1.2E-03	4.1E-02	9.5E-03	2.1E-03	2.1E-03	9.5E-05	1.1E-02	5.0E-03	0.05
7	163 Kembla St, Wollongong	1.2E-03	4.1E-02	9.4E-03	2.1E-03	2.0E-03	9.1E-05	1.1E-02	5.0E-03	0.05
8	179 Corrimal St, Wollongong	1.3E-03	4.5E-02	1.0E-02	2.2E-03	2.2E-03	1.0E-04	1.2E-02	5.5E-03	0.05
9	314 Gladstone Ave, Mt St Thomas	6.0E-04	2.1E-02	4.8E-03	1.1E-03	1.0E-03	4.5E-05	5.6E-03	2.5E-03	0.02
10	240 Gladstone Ave, Mt St Thomas	9.6E-04	3.3E-02	7.6E-03	1.7E-03	1.6E-03	7.3E-05	9.0E-03	4.1E-03	0.04
11	350 Gladstone Ave, Mt St Thomas	4.7E-04	1.6E-02	3.7E-03	8.2E-04	8.0E-04	3.6E-05	4.4E-03	2.0E-03	0.02
12	111 Gladstone Ave, Mt St Thomas	1.9E-03	6.6E-02	1.5E-02	3.3E-03	3.3E-03	1.5E-04	1.8E-02	8.2E-03	0.08
13	33 Five Islands Rd, Cringila	6.2E-04	2.1E-02	4.9E-03	1.1E-03	1.0E-03	4.5E-05	5.7E-03	2.6E-03	0.03
14	Entrance to Site	4.1E-03	1.4E-01	3.2E-02	7.1E-03	6.9E-03	3.1E-04	3.8E-02	1.7E-02	0.2
15	Site boundary	5.3E-03	1.8E-01	4.2E-02	9.3E-03	8.9E-03	4.0E-04	4.9E-02	2.2E-02	0.2
16	Site boundary	2.3E-03	7.9E-02	1.9E-02	4.2E-03	4.0E-03	1.8E-04	2.2E-02	1.0E-02	0.09
17	Site boundary	3.3E-03	1.1E-01	2.6E-02	5.8E-03	5.6E-03	2.5E-04	3.1E-02	1.4E-02	0.1
18	Site boundary	2.8E-03	9.7E-02	2.2E-02	4.9E-03	4.7E-03	2.1E-04	2.6E-02	1.2E-02	0.1
19	Site boundary	1.5E-03	5.2E-02	1.2E-02	2.7E-03	2.6E-03	1.2E-04	1.4E-02	6.4E-03	0.06
20	Site boundary	1.6E-03	5.5E-02	1.2E-02	2.7E-03	2.7E-03	1.2E-04	1.5E-02	6.8E-03	0.06
21	Site boundary	1.5E-03	5.2E-02	1.2E-02	2.7E-03	2.5E-03	1.1E-04	1.4E-02	6.4E-03	0.06
22	Site boundary	4.2E-03	1.4E-01	3.3E-02	7.3E-03	7.2E-03	3.3E-04	3.9E-02	1.8E-02	0.2
23	Site boundary	3.4E-03	1.2E-01	2.7E-02	6.0E-03	5.8E-03	2.6E-04	3.5E-02	1.6E-02	0.1
									Acceptable Total HI	**≤1**

Table 2: Revised Assessment of Chronic Inhalation Exposures from Tank Venting and Road Tanker Loading (all concentrations in mg/m^3)

ID	Receptor Location#	Benzene		Toluene		Ethylbenzene		Xylenes		BaP		Total HI
		Guideline	0.0017	Guideline	5	Guideline	0.26	Guideline	0.22	Guideline	0.00000012	
		Annual average	HI	Annual average	HI	Annual average	HI	Annual average	HI	Annual average	HI	
1	Coniston Public School	2.9E-05	1.7E-02	2.3E-04	4.6E-05	4.9E-05	1.9E-04	2.7E-04	1.2E-03	4.0E-08	3.3E-01	0.4
2**	Wollongong Greenhouse Park	1.8E-04	1.3E-02	1.4E-03	3.4E-05	3.0E-04	1.4E-04	1.6E-03	8.7E-04	2.5E-07	2.5E-01	0.3
3	Wollongong Baptist Church	1.0E-05	5.9E-03	8.2E-05	1.6E-05	1.8E-05	6.9E-05	9.6E-05	4.4E-04	1.4E-08	1.2E-01	0.1
4	Coniston Train Station	1.8E-05	1.1E-02	1.4E-04	2.8E-05	3.1E-05	1.2E-04	1.7E-04	7.7E-04	2.5E-08	2.1E-01	0.2
5	392 Keira St, Wollongong	2.4E-05	1.4E-02	1.9E-04	3.8E-05	4.1E-05	1.6E-04	2.2E-04	1.0E-03	3.3E-08	2.8E-01	0.3
6	42 Swan St, Wollongong	1.5E-05	8.8E-03	1.2E-04	2.4E-05	2.6E-05	1.0E-04	1.4E-04	6.4E-04	2.1E-08	1.8E-01	0.2
7	163 Kembla St, Wollongong	2.3E-05	1.4E-02	1.8E-04	3.6E-05	3.9E-05	1.5E-04	2.1E-04	9.5E-04	3.2E-08	2.7E-01	0.3
8	179 Corrimal St, Wollongong	3.3E-05	1.9E-02	2.6E-04	5.2E-05	5.6E-05	2.2E-04	3.1E-04	1.4E-03	4.6E-08	3.8E-01	0.4
9	314 Gladstone Ave, Mt St Thomas	4.4E-06	2.6E-03	3.5E-05	7.0E-06	7.5E-06	2.9E-05	4.1E-05	1.9E-04	6.1E-09	5.1E-02	0.05
10	240 Gladstone Ave, Mt St Thomas	7.5E-06	4.4E-03	5.9E-05	1.2E-05	1.3E-05	5.0E-05	7.0E-05	3.2E-04	1.0E-08	8.3E-02	0.09
11	350 Gladstone Ave, Mt St Thomas	3.1E-06	1.8E-03	2.5E-05	5.0E-06	5.3E-06	2.0E-05	2.9E-05	1.3E-04	4.3E-09	3.6E-02	0.04
12	111 Gladstone Ave, Mt St Thomas	1.3E-05	7.6E-03	1.0E-04	2.0E-05	2.2E-05	8.5E-05	1.2E-04	5.5E-04	1.8E-08	1.5E-01	0.2
13	33 Five Islands Rd, Cringila	6.6E-06	3.9E-03	5.2E-05	1.0E-05	1.1E-05	4.2E-05	6.2E-05	2.8E-04	9.2E-09	7.7E-02	0.08
14*	Entrance to Site	1.6E-04	3.0E-02	1.3E-03	8.3E-05	2.7E-04	3.3E-04	1.5E-03	2.2E-03	2.2E-07	5.9E-01	0.6
15*	Site boundary	2.0E-04	3.8E-02	1.6E-03	1.0E-04	3.4E-04	4.2E-04	1.9E-03	2.8E-03	2.8E-07	7.5E-01	0.8
16*	Site boundary	7.1E-05	1.3E-02	5.6E-04	3.6E-05	1.2E-04	1.5E-04	6.6E-04	9.6E-04	9.9E-08	2.6E-01	0.3
17*	Site boundary	1.2E-04	2.3E-02	9.9E-04	6.3E-05	2.1E-04	2.6E-04	1.2E-03	1.7E-03	1.7E-07	4.5E-01	0.5
18*	Site boundary	8.0E-05	1.5E-02	6.3E-04	4.0E-05	1.4E-04	1.7E-04	7.5E-04	1.1E-03	1.1E-07	2.9E-01	0.3
19*	Site boundary	3.7E-05	7.0E-03	2.9E-04	1.9E-05	6.3E-05	7.8E-05	3.5E-04	5.1E-04	5.2E-08	1.4E-01	0.1
20*	Site boundary	4.7E-05	8.8E-03	3.7E-04	2.4E-05	8.0E-05	9.8E-05	4.4E-04	6.4E-04	6.5E-08	1.7E-01	0.2
21*	Site boundary	4.0E-05	7.5E-03	3.2E-04	2.0E-05	6.9E-05	8.5E-05	3.8E-04	5.5E-04	5.6E-08	1.5E-01	0.2
22*	Site boundary	1.4E-04	2.6E-02	1.1E-03	7.0E-05	2.5E-04	3.1E-04	1.4E-03	2.0E-03	2.0E-07	5.3E-01	0.6
23*	Site boundary	1.2E-04	2.3E-02	9.4E-04	6.0E-05	2.0E-04	2.5E-04	1.1E-03	1.6E-03	1.7E-07	4.5E-01	0.5
											Acceptable Total HI	≤1

The assessment of inhalation exposures for all residential locations is based on inhalation exposures occurring for 24 hours per day, 365 days per year for a lifetime. Exposure adjustment factors in other areas such as workplace or recreational areas are noted below

* Calculated HI includes exposure adjustment factor of 0.32 to address exposures by workers, rather than residents at these receptor locations

** Calculated HI includes exposure adjustment factor of 0.12 to address recreational exposures at the park, rather than residents at these receptor locations

The revised risk calculations presented in **Tables 1 and 2** show that the total HI at each receptor location is below the target risk level of ≤1 for both acute and chronic exposures and is therefore considered to be acceptable.

Based on the assessment undertaken there are no acute or chronic impacts on the health of the local community surrounding the project. This conclusion remains unchanged from that presented in the HHRA and response to submissions.

Limitations

Environmental Risk Sciences has prepared this letter for the use of Cardno and TQ Holdings Australia Pty Ltd (TQ) in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this technical working paper.

It is prepared in accordance with the scope of work and for the purpose outlined in this letter. This letter should be read in conjunction with the report: Human Health Risk Assessment – Port Kembla Bulk Liquids Terminal, Report reference PJ-PK-0001-REPT-012_00-01, dated 12 November 2015, and response to submissions letters dated 17 March and 9 May 2016.

Environmental Risk Sciences has made no independent verification of information provided beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

This letter was prepared October and November 2016 and is based on the information provided and reviewed at that time. Environmental Risk Sciences disclaims responsibility for any changes that may have occurred after this time.

This letter should be read in full. No responsibility is accepted for use of any part of this letter in any other context or for any other purpose or by third parties. This letter does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

If you require any additional information or if you wish to discuss any aspect of this letter please do not hesitate to contact me on (02) 9614 0297 or 0425 206 295.

Yours sincerely,

Dr Jackie Wright (Fellow ACTRA)
Principal/Director
Environmental Risk Sciences Pty Ltd