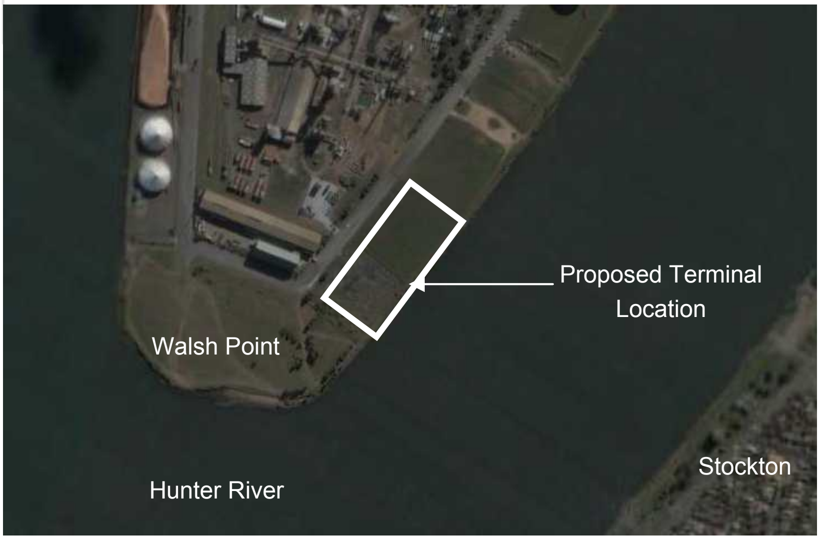
Marstel Terminals Pty Ltd
Proposed Bulk Liquids Storage
Kooragang Island
Preliminary Hazard Analysis



- ND00053–RPTfinal(Rev0)-25Jun07
- 25 June 2007

Marstel Terminals Pty Ltd
Proposed Bulk Liquids Storage
Kooragang Island
Preliminary Hazard Analysis

- ND00053–RPTFinal(Rev0)-25Jun07
- 25 June 2007

Sinclair Knight Merz
ABN 37 001 024 095
100 Christie Street
PO Box 164
St Leonards NSW
Australia 1590
Tel: +61 2 9928 2100
Fax: +61 2 9928 2500
Web: www.skmconsulting.com

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
A	29 Mar 07	-	S.Sylvester	29 Mar 07	Draft RevA
B	25 Apr07	-	S.Sylvester	25Apr07	Draft RevB
C	19Jun07	-	S.Sylvester	19Jun07	Draft RevC
0	25Jun07	A.DiGiunta	S.Sylvester	25Jun07	Final Rev0

Distribution of copies

Revision	Copy no	Quantity	Issued to
A	1	1	H.Marlin
B	1	1	H.Marlin
C	1	1	H.Marlin
0	1	1	R.Gifford

Printed:	18 July 2007
Last saved:	17 July 2007 12:07 PM
File name:	ND00053-RPTFinal(Rev0)-25Jun07
Author:	Steve Sylvester
Project manager:	Steve Sylvester
Name of organisation:	Marstel Terminals Pty Ltd
Name of project:	Proposed Bulk Liquids Storage – Kooragang Island
Name of document:	Preliminary Hazard Analysis
Document version:	0
Project number:	ND00053

EXECUTIVE SUMMARY

Introduction, Objectives & Scope

Marstel Terminals Newcastle Pty Ltd (Marstel) proposes to construct and operate a bulk liquids terminal on Kooragang Island, Newcastle, NSW. As the site will store flammable and combustible liquids, State Environmental Planning Policy No.33, Hazardous & Offensive Developments, applies to the site. Under this policy it will be necessary to demonstrate that the site is not Hazardous and/or Offensive. Hence, a Preliminary Hazard Analysis (PHA) is required. Marstel has commissioned Sinclair Knight Merz to prepare the PHA in support of the EIS submission.

The objectives of the study are to identify whether the site is hazardous and/or offensive and whether it is suitable for location in the industrial zone at Kooragang Island. The scope of work for this study is to conduct a PHA study in accordance with Hazardous Industry Planning Advisory Paper (HIPAP) No.6, Hazard Analysis Guidelines.

Methodology

The methodology selected for the study is that published in HIPAP No.6, Hazard Analysis Guidelines. This methodology will identify hazards, assess consequences, frequencies and risks and compare these to accepted criteria to ensure the site is not hazardous and/or offensive.

Brief Description of Terminal Operations

The terminal will consist of six fuel tanks located in a large bunded area, segregated into smaller intermediate bunds. The tanks will store a range of fuels including diesel, bio-diesel, ethanol, unleaded and premium unleaded petrol. The facility will be located in a Zone 4a industrial area on the eastern side of the Walsh Point peninsular at Kooragang Island. Fuel will be delivered to site by road and marine tanker, with the predominant fuel deliveries by marine tanker. The marine tankers will traverse the Hunter River under the direction of a port pilot and will berth at the P&O wharf on the western side of the Walsh Point peninsular at Kooragang Island. A dedicated fuel unloading facility will be constructed at the wharf and a transfer pipeline will be installed between the berth and the terminal. Road tankers will access the site by Greenfield Road and transfer fuel to the tanks via a dedicated unloading gantry. Fuel will be delivered to market using road tankers. Dedicated road tanker loading bays (3) will be constructed adjacent to Greenfield Road. Tankers will enter the site via a dedicated entry driveway and park within the tanker loading bay. Loading arms will then be connected to the tanker by the tanker driver. The driver will then control the fuel transfer and once complete isolate and disconnect the loading arms. The tanker will then leave site via a separate and dedicated exit driveway.

The site and equipment will be fitted with a number of safety features including floating pans in tanks (preventing flammable gas generation in the tank vapour space), bunding (preventing spills offsite), fire detectors, fire main, fire pumps and fire water tanks and foam deluge systems in the fuel loading gantry.

Hazard and Risk Analysis

A hazard analysis was conducted for the site and a number of hazardous incidents and scenarios identified. Analysis of each scenario identified that the following incidents has the potential to impact offsite:

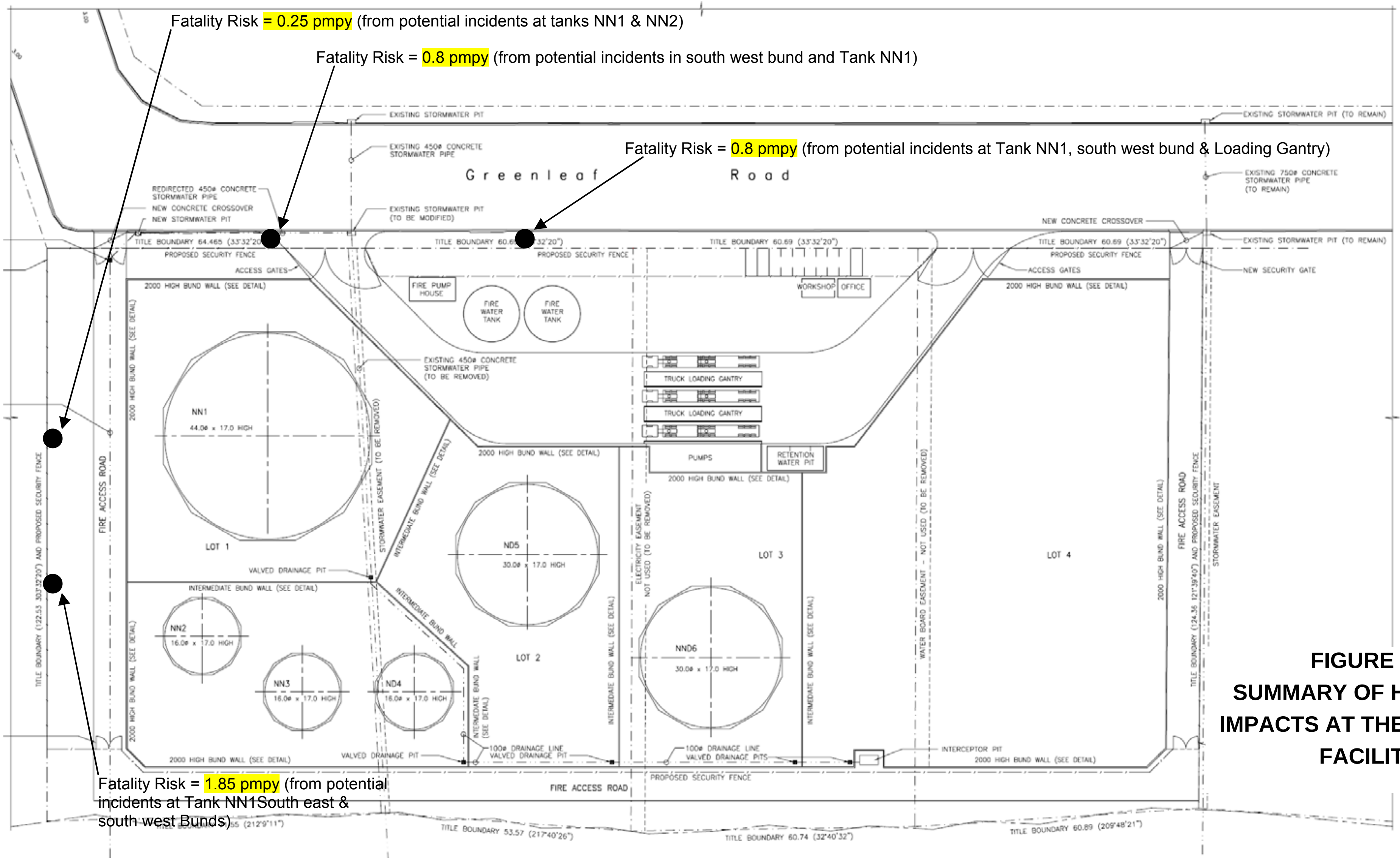
- Flexible line rupture at the bulk liquids transfer wharf, fuel leak, ignition and subsequent pool fire at the wharf;
- Ignition of flammable liquid in the bulk liquids storage tank leading to storage tank roof fire;
- Leak of flammable liquid into the bulk liquids storage tank bund, ignition and full bund fire;
- Transfer pump leak (seal or flange) resulting in spill to the pump bund, ignition and fire; and
- Flammable liquid leak at the gantry, ignition and pool fire in the bunded area of the loading bay.

Each incident above was subjected to a consequence analysis to identify those incidents that would impact offsite. Only three incidents were confirmed to impact offsite, these were

- Ignition of flammable liquid in the large bulk liquids storage tank and one of the small bulk liquids storage tanks leading to storage tank roof fire;
- Leak of flammable liquid into the bulk liquids storage tank bunds, ignition and full bund fire; and
- Flammable liquid leak at the gantry, ignition and pool fire in the bunded area of the loading bay.

These incidents were then assessed for frequency and combined with the results of the consequence analysis to determine the risks. The risks were assessed at various locations along site boundary to identify the maximum points of risk. The highest risks points were then plotted on a site layout drawing, which is shown at **Figure E1**. The highest risk at the site boundary was identified where the two bunds join at the southern boundary. This risk was assessed to be 1.85×10^{-6} chances per annum (p.a.) or 1.85 per million per year (pmpy).

A review of the risk criteria, published in HIPAP No.4 (Risk Criteria for Land Use Safety Planning) indicates that the maximum permissible risk at the site boundary (north & west) is 50 pmpy and 10 pmpy (south). Hence, the maximum assessed risk (1.85pmpy) at the proposed terminal is below the published criteria.



Fatality Risk = 0.25 pmpy (from potential incidents at tanks NN1 & NN2)

Fatality Risk = 0.8 pmpy (from potential incidents in south west bund and Tank NN1)

Fatality Risk = 0.8 pmpy (from potential incidents at Tank NN1, south west bund & Loading Gantry)

Fatality Risk = 1.85 pmpy (from potential incidents at Tank NN1South east & south west Bunds)

FIGURE E1
SUMMARY OF HIGH RISK IMPACTS AT THE MARSTEL FACILITY

Conclusion and Recommendations

The risk analysis conducted in this study has identified that the risks associated with the proposed Marstel terminal do not exceed the criteria published in Hazardous Industry Planning Advisory Paper No.4 (Ref.4). Hence, it is concluded that the proposed Marstel terminal is not Hazardous and Offensive and is only Potentially Hazardous and Offensive within the definition of State Environmental Planning Policy No.33, “Hazardous and Offensive Developments.

Notwithstanding the above conclusion, a number of recommendations were made to ensure the risks are maintained within the as low as reasonably practicable (ALARP) range. These are:

1. It was identified that initiating fires at the bulk liquids transfer wharf (P&O) could grow to unmanageable size before the main fire fighting equipment is employed. Hence, it is recommended that Marstel install a 50kg wheeled dry powder extinguisher at the P&O Wharf.

2. To ensure fire response at the P&O wharf is effective, it is recommended that a separate wharf emergency plan be developed including spills, and potential environmental impact. The plan should be held in a waterproof container at the wharf and be available as part of the wharf operations. The plan should also contain spill response procedures and emergency drills/exercises to be conducted at regular intervals as part of safety preparedness.

3. It was identified that there is a potential for the fuel transfer pipeline (wharf to the terminal) has the potential to be impacted by external excavation. It is therefore recommended that the pipeline be installed with a marker tape over the top of the line (i.e. between the surface and pipeline) indicating “FUEL LINE UNDER”. Pipeline surface markers should also be installed at every 100m to indicate the presence of the pipeline under the footpath location.

4. To ensure that external interference (i.e. excavation) has not or will not impact the pipeline prior to and during its use at each transfer, it is recommended that as part of the fuel transfer procedure, an inspection of the pipeline route be conducted to identify whether there has been any unidentified ground disturbance in the area of the pipeline since the previous transfer. This may indicate to the terminal staff that the line could be impacted.

5. It was identified that the most likely incident at the bulk liquid fuel transfer berth (P&O wharf) is a ruptured flexible line or coupling failure. The fire incident as a result of this scenario was identified to impact to a heat radiation level of 4.7kW/m^2 at a distance of 29m from the flexible hose connection point at the wharf. It is therefore recommended

that the fire monitor be located a minimum of 29m from the wharf hose connection point.

6. The risk assessment of the fire protection system at the fuel loading bays (gantry) assumed that the UV/IR fire detector would be tested annually and that the foam fire system would be tested weekly (i.e. starting of the diesel pumps and checks on the activation of the system valves). It is therefore recommended that the plant maintenance schedules include requirements for the testing of fire detectors at the site annually and weekly tests of the fire pump systems and foam activation valves.

Contents

APPENDICES

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

Abbreviation	**Description**
m^3	cubic metres
PHA	Preliminary Hazard Analysis
EIS	Environmental Impact Statement
HIPAP	Hazardous Industry Planning Advisory Paper
DoP	Department of Planning
QRA	Quantitative Risk Assessment
SEPP	State Environmental Planning Policy
m	Metres
mm	Millimetres
bar	1 atmosphere or 101kPa
kPa	kilo Pascals
NDT	Non Destructive Testing
AS	Australia Standards
ULP	Unleaded Petrol
API	American Petroleum Industry
ADG	Australian Dangerous Goods Code
VRU	Vapour Recovery Unit
NFPA	National Fire Protection Association
ISGOTT	International Safety Guideline for Oil Tankers & Terminals
kg	Kilograms
UV/IR	Ultra Violet/Infra Red
kW/m^2	kilo Watts per square metre
p.a.	per annum
pmpy	Per million per year
FDT	Fractional Dead Time

1. INTRODUCTION

1.1 Background

Marstel Terminals Newcastle Pty Ltd (Marstel) proposes to construct and operate a bulk liquids terminal on Kooragang Island, Newcastle, NSW. The proposed terminal will be used for the import, blending and distribution of high quality fuels and biofuels. Fuels will be delivered to site by ship and truck and distributed to customers by truck.

The facility will store in the order of 58,000m^3 flammable and combustible liquids at full capacity, hence, the site will be subject to the requirements of State Environmental Planning Policy No.33, “Hazardous and Offensive Developments”. To provide the appropriate information in support of the environmental impact statement, a Preliminary Hazard Analysis (PHA) is required. Marstel has commissioned Sinclair Knight Merz to prepare the PHA in support of the EIS submission.

This document details the PHA study for the Marstel terminal at Kooragang Island, NSW.

1.2 Objectives

The objectives of the study are to:

- conduct a PHA study of the Marstel terminal at Kooragang Island, NSW in accordance with the requirements of Hazardous Industry Planning Advisory Paper (HIPAP) No.6, “Guidelines for Hazard Analysis” (Ref.1); and
- report on the findings of the study in support of the EIS.

1.3 Scope of Work

The scope of work is for a PHA study of the proposed Marstel terminal at Kooragang Island, NSW including the following terminal facilities:

- Tank storage areas and bunds;
- Fuel transfer facilities (i.e. pumps and associated pipework);
- Tanker loading/unloading facilities (including loading/unloading gantries, associated pipework and loading bays);
- Marine unloading facilities (located at the P&O wharf on the western side of Kooragang Island); and
- Fuel transfer pipeline from the marine unloading facilities to the terminal.

2. METHODOLOGY

2.1 General Approach

The NSW Department of Planning (DoP) Multi Level Risk Assessment (Ref.2) approach was used for this study. The approach considered the development in context of its location and its technical and safety management control. The Multi Level Risk Assessment Guidelines are intended to assist industry, consultants and the consent authorities to carry out and evaluate risk assessments at an appropriate level for the facility being studied.

The Multi Level Risk Assessment approach is summarised in **Figure 2.1**. There are three levels of assessment, depending on the outcome of preliminary screening. These are:

- **Level 1 – Qualitative Analysis**, primarily based on the hazard identification techniques and qualitative risk assessment of consequences, frequency and risk;
- **Level 2 – Partially Quantitative Analysis**, using hazard identification and the focused quantification of key potential offsite risks; and
- **Level 3 – Quantitative Risk Analysis (QRA)**, based on the full detailed quantification of risks, consistent with Hazardous Industry Planning Advisory paper No.6 – Guidelines for Hazard Analysis.

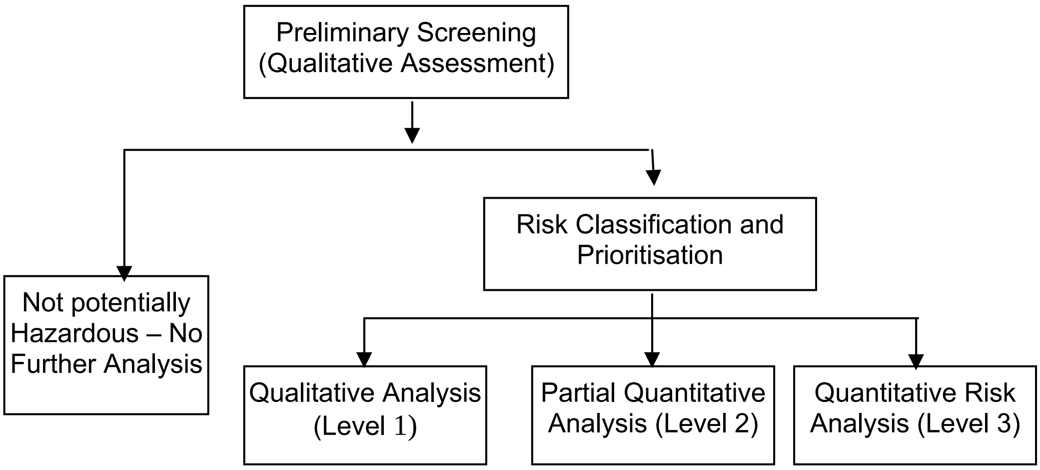


FIGURE 2.1
THE MULTI LEVEL RISK ASSESSMENT APPROACH

The document "Applying SEPP 33" (Ref.3) guideline may also be used to assist in the selection of the appropriate level of assessment. This guideline states the following:

"It is considered that a qualitative PHA may be sufficient in the following circumstances:

- *where materials are relatively non-hazardous (for example corrosive substances and some classes of flammables);*
- *where the quantity of materials used are relatively small;*
- *where the technical and management safeguards are self-evident and readily implemented; and*
- *where the surrounding land uses are relatively non-sensitive.*

In these cases, it may be appropriate for a PHA to be relatively simple. Such a PHA should:

- *identify the types and quantities of all dangerous goods to be stored and used;*
- *describe the storage/processing activities that will involve these materials;*
- *identify accident scenarios and hazardous incidents that could occur (in some cases, it would also be appropriate to include consequence distances for hazardous events);*
- *consider surrounding land uses (identify any nearby uses of particular sensitivity); and*
- *identify safeguards that can be adopted (including technical, operational and organisational), and assess their adequacy (having regards to the above matters).*

A sound qualitative PHA which addresses the above matters could, for some proposals, provide the consent authority with sufficient information to form a judgement about the level of risk involved in a particular proposal".

The proposed Marstel terminal will be located in a heavily industrialised area on Kooragang Island. Sensitive land users are well clear of the site, the closest residential buildings being over 500m to the east in the Stockton/Fern Bay area. Detailed technical and management safeguards are proposed for the Marstel terminal and, hence, under these circumstances, a qualitative assessment may be considered for the project. However, it is noted that the Orica ammonium nitrate plant is located to the west of the proposed Marstel terminal, hence, there is a potential for "domino" effects from incidents at the Marstel terminal to the Orica facility. Based on the separation from sensitive receptors and the potential for domino incidents to adjacent industrial sites, a level 2 analysis has been selected as the most appropriate level of assessment for the site.

2.2 Detailed Approach

The detailed study approach follows that recommended in HIPAP No.6, "Hazard Analysis Guidelines"(Ref.1). The approach is summarised below.

2.2.1 Hazard Analysis

A detailed hazard identification was conducted for the site facilities and operations described in **Section 3**. Where an incident was identified to have potential off site impact, it was included in the recorded hazard identification word diagram (**Appendix A**). The hazard identification word diagram lists incident type, causes, consequences and safeguards. This was performed using the word diagram format suggested in HIPAP No.6 (Ref.1). Each postulated hazardous incident was assessed qualitatively in light of proposed safeguards (technical and management controls). Where a potential offsite impact was identified, the incident was carried into the main report for further analysis. Where the qualitative review in the main report determined that the safeguards were adequate to control the hazard, or that the consequence would obviously have no offsite impact, no further analysis was performed.

The hazard analysis and safety systems review was conducted in discussion with the Marstel terminal operations and management team.

2.2.2 Consequence Analysis

For those incidents qualitatively identified in the hazard analysis to have a potential offsite impact, a detailed consequence analysis was conducted. The analysis modelled the various postulated hazardous incidents and determined impact distances from the incident source. The results were compared to the consequence criteria listed in HIPAP No.4 (Ref.4). Where an incident was identified to result in offsite effect, it was carried forward for frequency analysis. Where an incident was identified to have an offsite effect, and a simple solution was evident (i.e. move the proposed equipment further away from the site boundary), the solution was recommended and no further analysis was performed.

2.2.3 Frequency Analysis

In the event a simple solution for managing consequence impacts was not evident, each incident identified to have potential offsite impact was subjected to a frequency analysis. The analysis considered the initiating event and probability of failure of the safeguards (both hardware and software). The results of the frequency analysis, was carried forward to the risk assessment for combining with the consequence analysis results.

2.2.4 Risk Assessment

As the selected approach for this analysis was a Level 2 assessment (Ref.2), where incidents were identified to impact offsite and where a consequence and frequency analysis was conducted, the consequence and frequency analysis for each incident was combined and compared to the risk criteria published in HIPAP No.4 (Ref.4). Where the criteria were exceeded, a review of the major risk contributors would be performed. Recommendations were then made regarding risk reduction measures.

3. BRIEF DESCRIPTION OF THE MARSTEL TERMINAL FACILITY

3.1 Land Zoning and Adjacent Land Uses

The Marstel terminal is located on the eastern side of Kooragang Island, near Walsh Point, Newcastle, NSW. A regional location of the site is shown at **Figure 3.1**. The proposed land is zoned 4(a) industrial and the proposed facility is permitted in this zoning providing the facility is not classified as "Hazardous or Offensive". The facility currently has only one industrial site within close proximity, the remaining adjacent areas are undeveloped or, in the case of the area to the west, is part of the Hunter River. The surrounding facilities are listed below:

- **East** – Hunter River (500m to residential areas across the river to the east);
- **North** – currently vacant land, with fuel tanks located 200m to the north;
- **West** –Greenleaf Road, Toll Logistics warehouse and Orica across Greenleaf Road; and
- **South** – Walsh point reserve.

The location of these facilities in relation to the proposed Marstel terminal site is shown on **Figure 3.2**. The closest zoned residential area is located to the east, 500m from the site across the arm of the Hunter River between Kooragang Island and Fern Bay.

3.2 General Site Operations

Figure 3.3 shows the proposed layout of the Marstel terminal and **Figure 3.4** shows the layout of the liquids unloading berth at the P&O Wharf on the western side of Kooragang Island.

The liquid unloading berth will be used to transfer the majority of product from ships to the tanks. Road tankers will also be used to deliver specific products, such as ethanol. The fuel will be transferred from the wharf via a pipeline to the terminal. The fuel will be loaded to the tanks by the terminal operators. Fuel will be delivered to customers by road tankers that will be loaded using the dedicated loading bays installed on the western side of the site.

The site is planned to operate for fuel despatch between 0600 and 1600 Monday to Friday and 0600 and 1200 on Saturdays. However, 24 hour operation approval will be sought once noise levels from the facility have been determined and proven to meet amenity criteria at sensitive receptor locations.

Detailed description of each section of the proposed terminal is presented in the following sections.

FIGURE 3.1
REGIONAL LOCATION OF THE MARSTEL TERMINAL

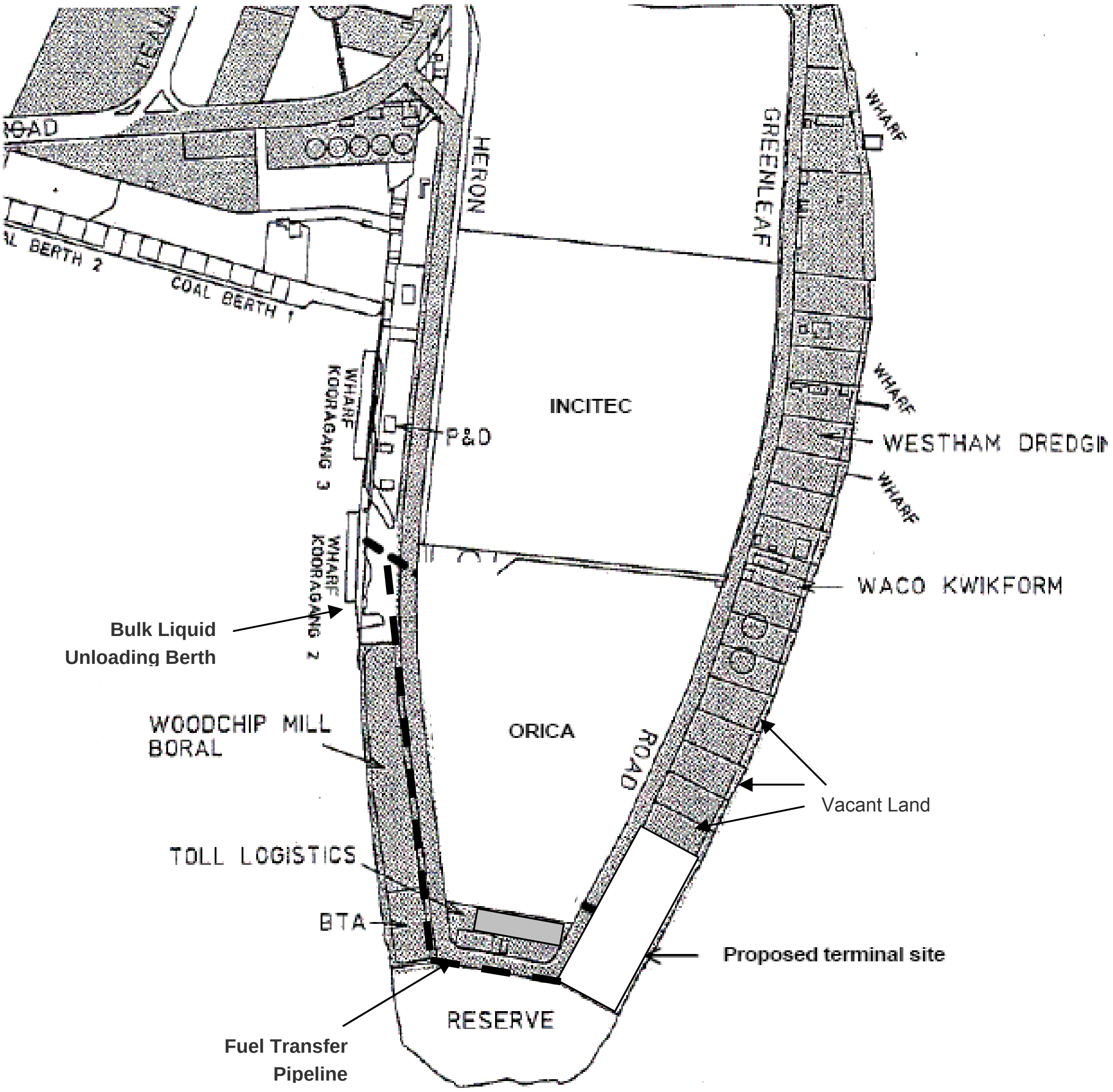


FIGURE 3.2
LOCATION OF THE ADJACENT FACILITIES TO THE MARSTEL TERMINAL

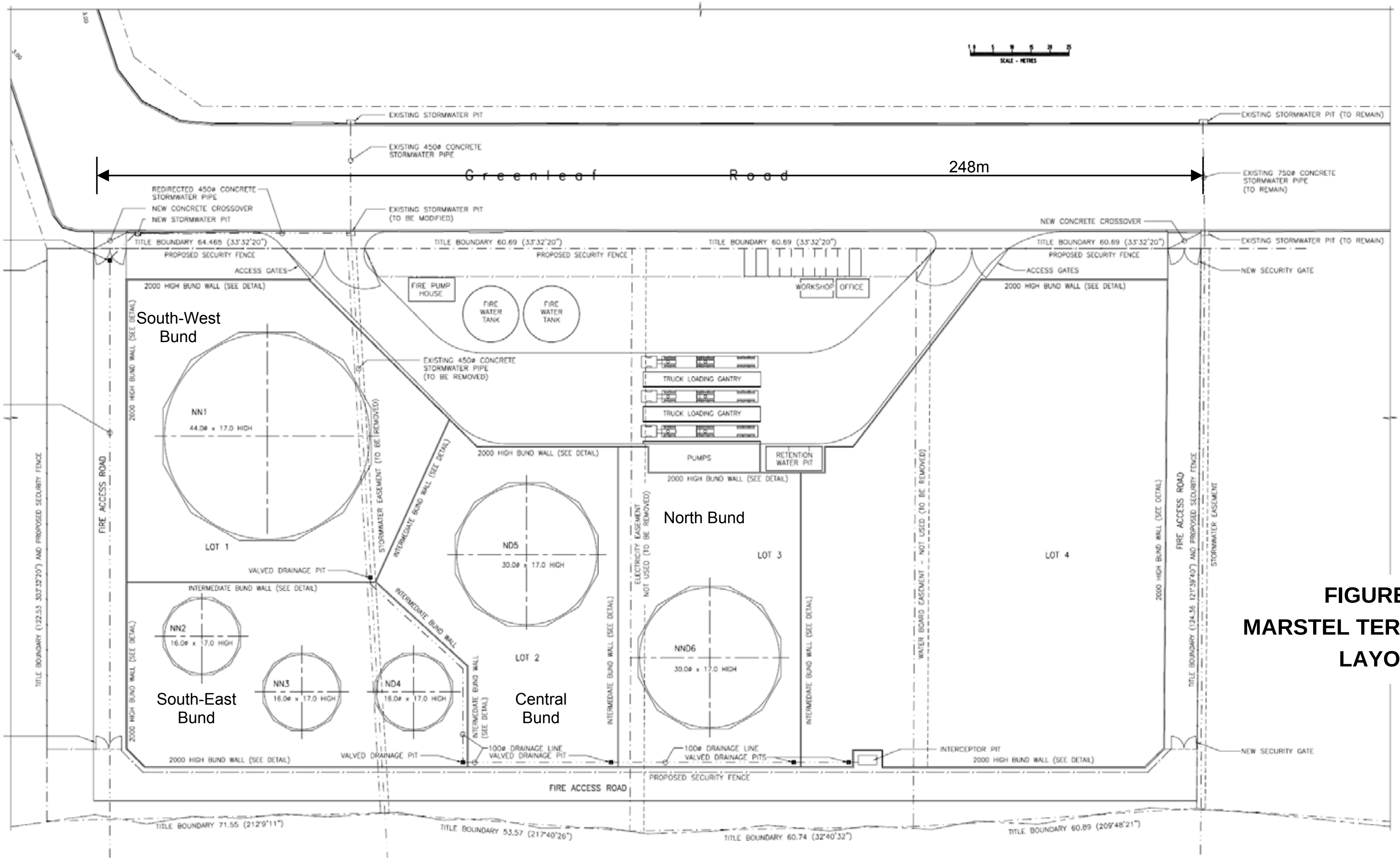


FIGURE 3.3
MARSTEL TERMINAL SITE LAYOUT

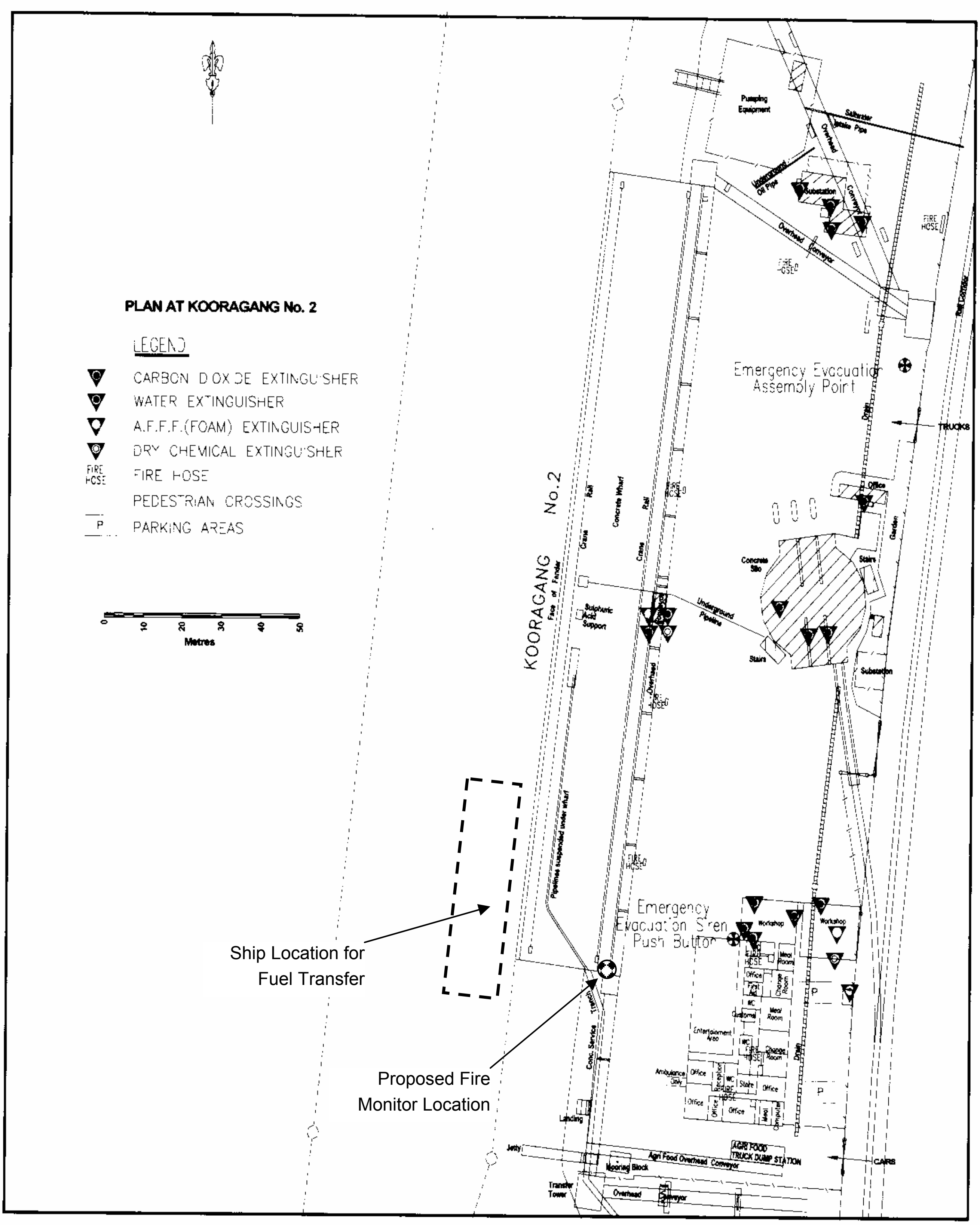

PLAN AT KOORAGANG No. 2
LEGEND
CARBON DIOXIDE EXTINGUISHER
WATER EXTINGUISHER
A.F.F.F.(FOAM) EXTINGUISHER
DRY CHEMICAL EXTINGUISHER
FIRE HOSE
PEDESTRIAN CROSSINGS
P PARKING AREAS
0 10 20 30 40 50
Metres
KOORAGANG No. 2
Face of Fender
Crane
Rail
Concrete Wharf
Pumping Equipment
Saltwater Intake Pipe
Overhead Conveyor
Underground Oil Pipe
Substation
FIRE HOSE
Emergency Evacuation Assembly Point
TRUCKS
Office
Concrete Silo
Stairs
Garden
Sulphuric Acid Support
Underground Pipeline
Substation
Pipelines suspended under wharf
Emergency Evacuation Siren Push Button
Workshop
Meal Room
Office
Change Room
Customs
Entertainment Area
Ambulance Only
Reception
Store
Computer
Landing
Jetty
Mooring Block
Agri Food Overhead Conveyor
AGRI FOOD TRUCK DUMP STATION
CARS
Transfer Tower
Overhead Conveyor
Ship Location for Fuel Transfer
Proposed Fire Monitor Location

FIGURE 3.4

LAYOUT OF THE LIQUIDS UNLOADING BERTH – P&O TERMINAL (WESTERN SIDE OF KOORAGANG ISLAND)

T- ND5

CAPACITY : 12000 cu. m
DIMENSION : 12 m DIA. x 17 m HEIGHT
CONSTRUCTION MATERIAL : C.S.
SAFE FILL LEVEL : - m

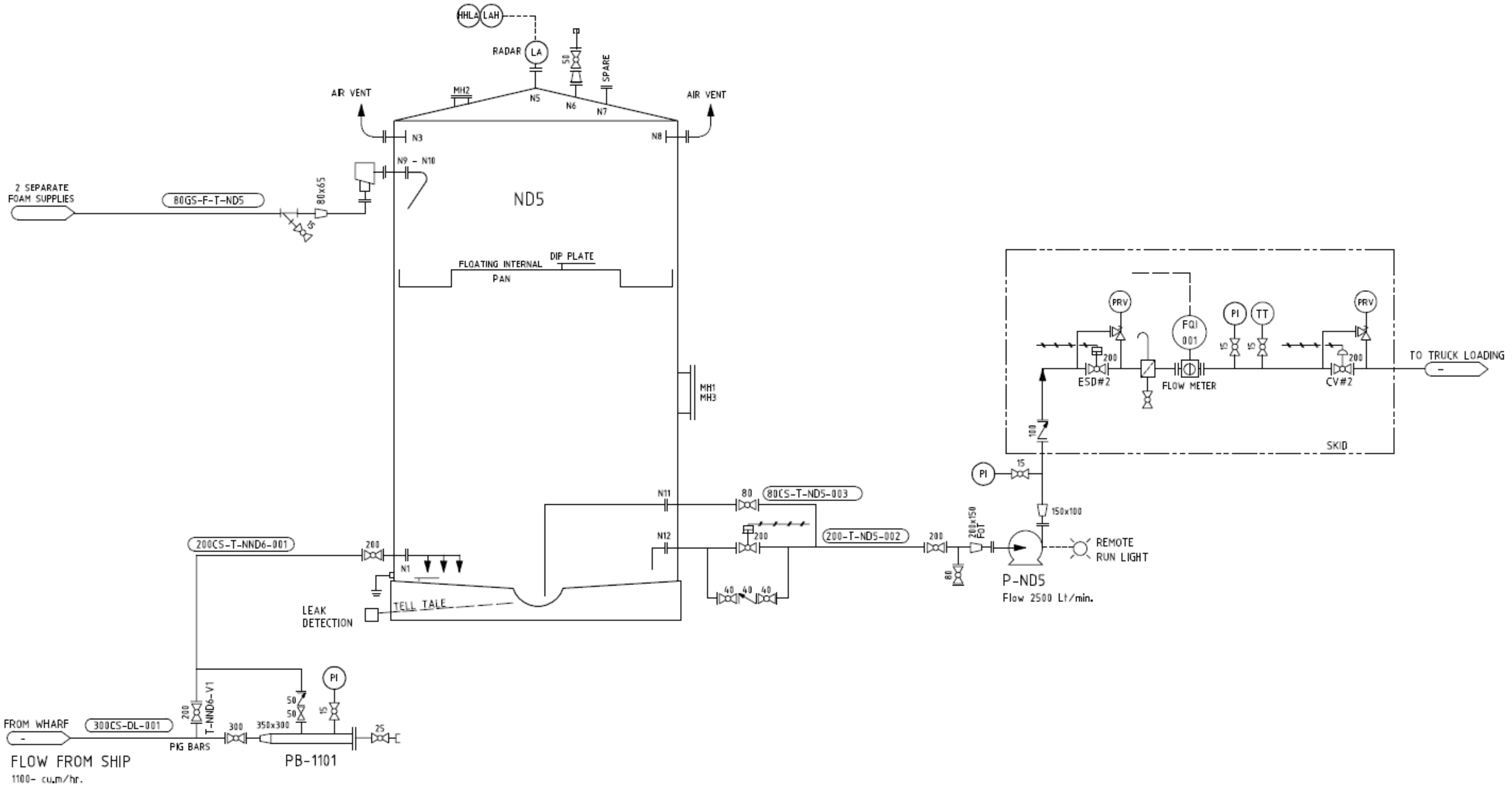


FIGURE 3.5a

PROCESS FLOW DIAGRAM FOR UPL/ETHANOL LIQUID TRANSFER AT THE TERMINAL

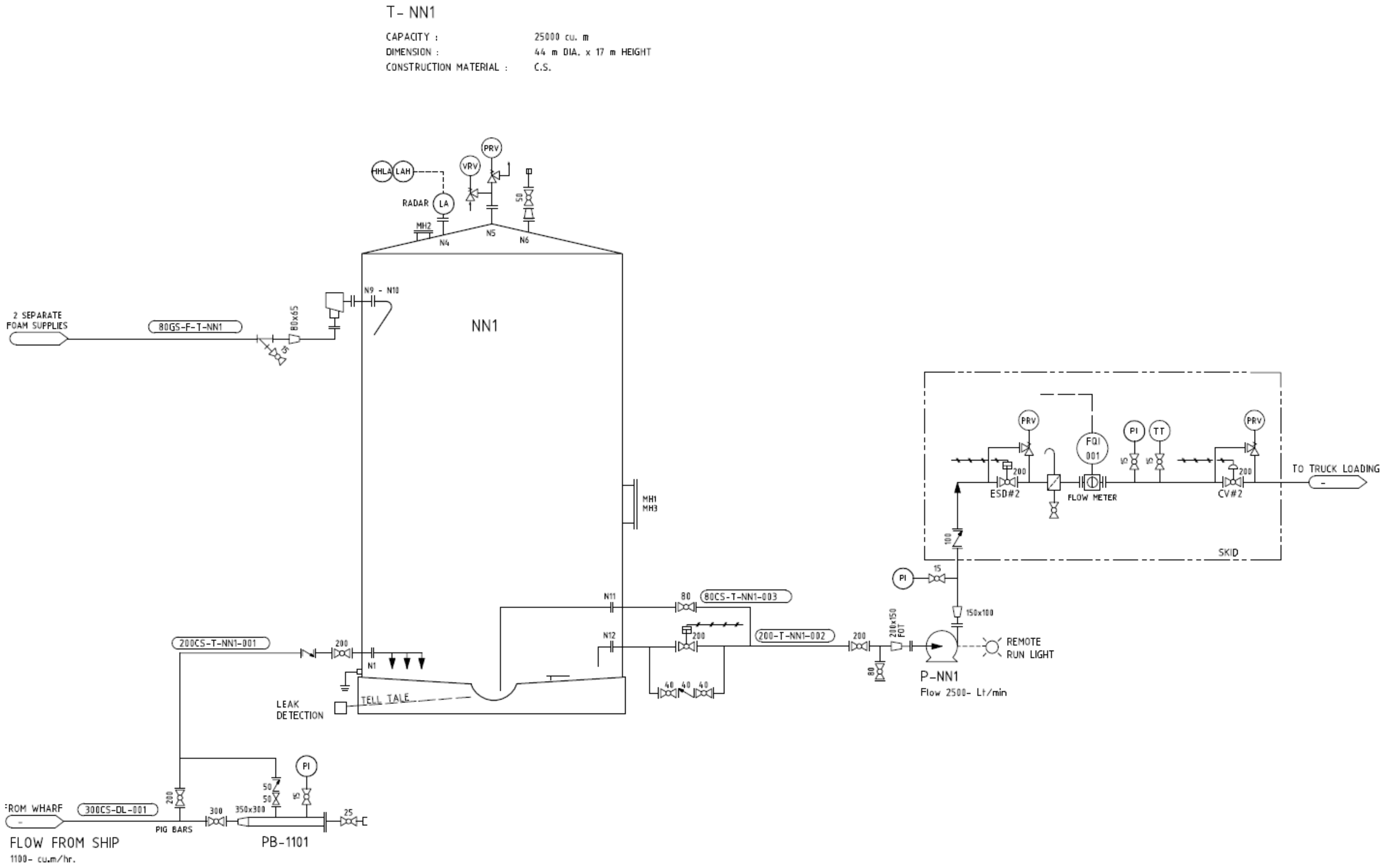


FIGURE 3.5b

PROCESS FLOW DIAGRAM FOR DIESEL LIQUID TRANSFER AT THE TERMINAL

3.3 Liquids Unloading Berth – P&O Terminal

Marstel proposes to use the southern part of the existing P&O berth on the western side of the Walsh Point section of Kooragang Island. **Figure 3.4** shows the layout of the P&O berth and the location of the proposed liquids transfer area.

Bulk liquid tankers will travel from other ports in Australia and overseas and enter the Hunter River directly on arrival at the Newcastle port. Oil delivery planning will obviate the need for tankers to anchor off the port, causing a ship grounding hazard in heavy seas. Once the tanker approaches the port it will be met by a port pilot, who will assist with the navigation duties whilst entering and traversing the Newcastle port entry and hunter river environs. As the tanker approaches the wharf it will be met by tugs that will be used to assist the berthing of the vessel. Key hazard reduction and safety features of this method of harbour entry and berthing are:

- Tanker does not anchor offshore, eliminating the potential for the ship to be driven on the coast by heavy seas;
- Pilot assisted navigation entering and in the harbour, which eliminates the hazard of unfamiliarity with the harbour entry and port navigation requirements; and
- Tug assistance in berthing, which reduces the risk of striking the wharf and damaging the tanker hull leading to release.

Figure 3.5 shows the proposed liquid transfer process flow diagram. The transfer system will consist of the following:

- A ship-side system with a pump and transfer pipework from the ship tanks to the transfer manifold on the ship's deck. The pumps on the ship will transfer the fuel product at a maximum 9 bar pressure. At the transfer manifold, on ship's deck, two valves will be installed; a manual isolation valve and remote/automatic valve. The remote automatic valve can be operated by an emergency button located adjacent to the transfer manifold and within reach of the ship operator.
- Two flexible hose (each 200mm diam.) connected between the ship and shore facility will be used for the transfer of fuel product. The hoses will be made from steel reinforced rubber with a rating of 14 bar. The hoses will be tested at manufacture, and during operation, in accordance with the requirements of the Australian Dangerous Goods Code (Ref.5). The connections at each end of the flexible hose will incorporate in-line butterfly valves to eliminate the potential for any minor releases when the flexible hose is disconnected.
- Shore side facilities, including a flexible hose connection to the shore manifold and two valves (manual and automatic/remote) operating the same as the ship side valves.

Ships will arrive at the berth and tie-up in the southern part of the wharf. The flexible hose will be connected to the ship and wharf pipelines and the valves configured to permit the transfer of liquids from the ship to the terminal. Once the delivery valve has been confirmed by the terminal and ships staff, the ships product transfer is commenced.

3.4 Pipeline Transfer – P&O Berth to Marstel Terminal

The pipeline for transfer of the fuel product will be mostly underground between the liquids transfer berth and the terminal, with the exception of the delivery and receival ends, which will be above ground. The pipeline will be installed in the easement under the footpath section of Heron Road, running parallel to and on the western side of Heron Road (western side of the Walsh Point peninsular) and then on the southern side of Heron Road, where it passes Walsh Point.

The pipeline will be 350mm in diameter and will be fully welded along its entire length. The pipeline construction will involve full weld non-destructive testing (NDT) including, for example, x-ray and magnetic particle testing. The pipeline will be fitted with "pigging" equipment to enable pipeline clearing, cleaning and testing during its lifetime.

Once the ship has established connection to the ship and wharf fittings, and the delivery systems confirmed to be in the correct position, the ships pumps will be started and the product transferred from the ship to the terminal tanks via the pipeline. The flow and tank levels will be continually monitored by ship and shore (terminal) based monitoring and control systems ensure product transfer continues successfully.

On completion of the transfer, the ships pumps will be stopped and the transfer ceased. The flexible hose will be drained to the wharf pipeline and the Isolation valves at the transfer points closed. The hose will then be disconnected using the dry-break couplings. The pipeline will then be cleared using a "pig" to transfer the fuel within the pipeline to the terminal. The pipeline will remain empty during non-transfer operations.

3.5 Tank Storages – Marstel Terminal

Figure 3.3 shows the layout of the proposed Marstel terminal. There are a total of 6 tanks installed at the terminal, containing a variety of flammable and combustible liquids. The tanks will be manufactured from welded steel construction and installed in bunds. Within the main bund there are intermediate bundwalls to segregate the tanks as required by AS1940-2004 (Ref.6). **Table 3.1** lists the tanks, materials stored, storage quantities and dimensions.

TABLE 3.1
MARSTEL TERMINAL STORAGE TANK DETAILS

Tank No.	Product Stored	Tank Diameter (m)	Tank Height (m)	Tank Capacity (m^3)	Intermediate Bund Location*
NN1	Diesel	44	17	25,000	South-West
NN2	Bio-diesel	16	17	3,000	South-East
NN3	Bio-diesel	16	17	3,000	South-East
ND4	Ethanol	16	17	3,000	South-East
ND5	ULP	30	17	12,000	Central
ND6	Premium ULP	30	17	12,000	North

*see Figure 3.3 for bund location

Each tank will be fitted with the following:

- Auto-level gauging;
- High/Low level alarms;
- Multi-level temperature measurement;
- Multi-level sampling equipment;
- Water draining; and
- Low-level product drains for maintenance purposes

The majority of tanks will be filled from the marine unloading facility, at the P&O wharf on the western side of the Kooragang Island Walsh Point peninsular. The liquids will be transferred using the ships pump and via an underground pipeline from the wharf to the terminal. The liquids will be delivered by the pipeline to a manifold at the terminal from which the fuels can be directed by dedicated pipelines to the specific tanks as required.

Ethanol and bio-diesel may be delivered to the terminal by road tanker and unloaded at the road tanker loading bay. Road tankers will enter the loading bay and connect to the ethanol transfer pipework. A dedicated terminal pump will then transfer the ethanol from the tanker to the dedicated ethanol storage tank.

The transfer operations and tank filling will be controlled from a central control room at the terminal. The control room will contain a computer control system that will monitor the tank levels and pipeline flows. Mimic screens will be installed in the control room to assist operators to monitor the terminal operations.

The tank bunds will be fitted with drains that will be piped to the stormwater collection system. Each drain will be fitted with a valve so that the bund drain can be isolated in the event of a product spill into the bund.

Rainwater events will obviously cause bund filling. However, once the rain event has finished, water in the bund will be inspected for contaminants and where no contamination has occurred, bund contents will be released to the bund retention pit, then through an API separation to the river.

3.6 Tanker Filling Facilities – Tanker Loading Bays & Gantries

Fuel will be delivered to customers by road tanker. The road tankers will be loaded at a dedicated road tanker loading facility consisting of three dedicated loading bays and a steel gantry installation with steel colour bond cladding. **Figure 3.3** shows the layout of the site and the location of the tanker loading bays.

Road tankers will enter the site from Greenfield Road at the northern entry drive. The tankers will then enter a loading bay under the direction of a terminal operator. Once aligned in the bay, the tanker brakes will be applied and the appropriate driveaway protection initiated (i.e. brake-lock bars on the load points). This will prevent the drivers from leaving the site whilst still connected to the loading pipework. Once in the loading bay, the earthing connections will be made to prevent the build up of static during the transfer. The gantry will be fed from the product tanks via dedicated pumps and lines. Each gantry bay will be fitted with one diesel, one unleaded petrol and one premium unleaded petrol bottom loading arms, with each arm supporting bio-fuel blending facilities.

The tanker loading operation will be controlled by the vehicle driver using swipe card gantry access. The vehicles will be fitted with overfill and static protection. A dead-man button requiring regular activation by the vehicle driver will be integrated into the gantry emergency shutdown system. Various component interlocks will ensure safe operation during all phases of the truck loading. Once tanker filling is complete, the vehicles will leave via the southern driveway.

3.7 Ancillary Facilities

In addition to the storage and handling equipment at the terminal, a number of additional facilities will be constructed including:

- **Office & Amenities** – an office and amenities building will be constructed adjacent to the north exit driveway. The building will be 7m long by 4m wide by 5m high and will be constructed from steel frame with colour bond cladding and roof.

- **Workshop** – a workshop will be constructed adjacent to the office/amenities building (southern side). The workshop will be 7m long by 4m wide by 5m high and will be constructed from a steel frame and colour bond cladding and roof.
- **Fire Pump House and Water Storage** – a fire pump house will be constructed on site adjacent to the southern exit driveway. The pump house will be 10m long by 5m wide by 5m high and will be constructed from a steel frame and colour bond cladding and roof. The pump house will contain two diesel driven fire pumps drawing fire water from two dedicated onsite fire water tanks. The fire water tank and pump capacities will be determined by a fire safety study conducted for the site.

3.8 Summary of Terminal Safety Features

A number of safety features are installed at the various terminal facilities. These are summarised in the following sub-sections.

3.8.1 Liquids Unloading Berth (P&O Wharf)

The liquids unloading berth at the P&O wharf will be fitted with a number of safety features including:

- Fire monitor, with foam generating facilities, located at a safe operating distance from the unloading operations;
- Emergency automatic/remote isolating valves on the ship and shore pipework (i.e. at the flexible hose connection points);
- Emergency shut down buttons located at the ship and wharf (to activate the remote/automatic isolation valves); and
- Flexible transfer hoses operated and inspected/tested in accordance with the Australian Dangerous Goods code or ADG (Ref.5);

3.8.2 Transfer Pipeline

The transfer pipeline design, construction and operations will incorporate a number of safety features including:

- Fully welded pipeline including non-destructive testing (e.g. x-ray & magnetic particle testing of welds);
- Full pressure test of the line on completion of construction;
- Underground installation to prevent potential external impacts, including anti-corrosion protective coating for underground sections of the line;

- Pressure testing with nitrogen prior and after connection by hose to the ship before the transfer operation commences;
- Line "pigging" after each transfer operation to ensure no dangerous goods are in the line when not in use;
- Annual hydrostatic testing of the transfer line from the wharf to the terminal; and
- Intelligent "pigging" of the line on a regular basis to determine pipeline integrity.

3.8.3 Storage Tanks

The storage tanks will be designed to API650 and operated in accordance with the requirements of AS1940-2004, "The storage and handling of flammable and combustible liquids"(Ref.6). As part of this, the following safety features will be installed:

- Tank level instruments (high and low) with independent high/high alarms;
- Tank vents with anti-flash gauze to prevent potential for sparking and ignition from external sources;
- Floating pans in the Class 3 flammable liquids tanks (e.g. petrol and ethanol);
- Multi level temperature measurements; and
- Water draining facilities to prevent water build up in the tank and potential corrosion in the tank base.

3.8.4 Loading Bays/Gantries

The loading bays and gantries will be fitted with the following safety systems:

- Bottom loading arms, eliminating the need for flexible hoses;
- Electronic card access by drivers, eliminating unauthorised access to the gantry/loading facilities;
- Overfill protection for the tankers and static connections to prevent the potential for electrostatic build-up and spark/ignition source;
- A dead-man button requiring regular activation by the vehicle driver, integrated into the gantry emergency shutdown system;
- Automatic/remote isolation valves at the loading arm feed point to provide loading emergency shut down in the event of incident at the gantry/loading bay;
- Fixed automatic foam deluge system installed throughout the gantry area activated by Ultra Violet/Infra Red fire detection; and
- Vapour Recovery Unit (VRU) to capture the vapours from the road tanker when filling.

3.8.5 Fire Safety Systems

The following fire safety systems and services will be provided for the proposed facility:

- Fire water pumps in accordance with the requirements of NFPA20 (Ref.7);
- Fire water tank to provide a minimum of 90 minutes fire water on site (exact storage capacity of tanks to be determined by Fire Safety Study in accordance with the requirements of AS1940 – Ref.6);
- Fire ring main, with hydrants, monitors and foam generating facilities at selected locations around the terminal facility;
- An access fire road around the bund to provide fire tender access as required;
- Hose reels and fire extinguishers located throughout the facility (installed in accordance with the applicable Australian Standards); and
- Fire protection facilities at the loading gantries (see **Section 3.8.4**).

The site will be staffed at all times during tank loading (from the liquid berths at the P&O wharf) and road tanker transfers.

4. HAZARD IDENTIFICATION

4.1 General Hazard Identification

A hazard identification table has been developed and is presented at **Appendix A**. Those hazards identified to have a potential impact offsite are assessed in detail in the following section of this document.

Table 3.1 lists the type and quantity of DGs stored and handled at the proposed Marstel terminal. It is noted that all goods listed in **Table 3.1** are flammable or combustible liquids and will be stored and handled in accordance with the requirements of the Australian Standard AS1940-2004 (Ref.6). It is noted that the quantity of combustible liquids stored at the proposed terminal will trigger the requirements for compliance with the NSW Occupational health and Safety (Dangerous Goods Amendment) Regulation 2005 (the Regulation). The facility, under this regulation, will be classified as a 'Manifest' site. It is understood that Marstel will develop the appropriate safety management systems to comply with the requirements of the Regulation. **Table 4.2** lists the characteristics of the dangerous goods stored and used at the site.

TABLE 4.2
PROPERTIES OF THE DANGEROUS GOODS PROPOSED FOR STORAGE AT THE MARSTEL BULK LIQUIDS TERMINAL, KOORAGANG ISLAND, NSW

Material Name	Class/ PG	Hazardous Properties
Premium Unleaded and unleaded Petrol	3 – II	Flammable liquid which has a flash point less than 23°C and hence may vaporise at ambient temperature resulting in localised vapour cloud, local flash fire potential and liquid pool fires
Ethanol (Ethyl Alcohol)	3 - II	Flammable liquid which has a flash point less than 23°C and hence may vaporise at ambient temperature resulting in localised vapour cloud, local flash fire potential and liquid pool fires
Combustible Liquid – Diesel	C1	Combustible liquid with a flash point greater than 60.5°C but less than 150°C are classified as C1. Diesel fuel has a flash point of around 90-100°C, hence, is classified as a combustible liquid. Under these circumstances, the liquid does not flash (vaporise) readily at ambient temperature, hence, vapour clouds do not form and flash fires, at ambient temperature do not occur. Localised heating and minor vapour generation may result in ignition and pool fire which may escalate to larger incidents

TABLE 4.2
PROPERTIES OF THE DANGEROUS GOODS PROPOSED FOR STORAGE AT THE MARSTEL BULK LIQUIDS TERMINAL, KOORAGANG ISLAND, NSW

Bio-Diesel	C1	Biodiesel (chemical name – Fatty Acid Esters) may have a range of flash points above and below 150°C. Hence, a specific biodiesel may be classified as C1 or C2. Hence, like diesel, the fuel does not flash (vaporise) readily at ambient temperature and the characteristics are similar to those of diesel.

4.2 Detailed Hazard Identification

4.2.1 Bulk Fuel Delivery – P&O Wharf

Bulk fuel will be delivered to the terminal by ship. Ships will berth at the P&O Wharf, located on the western side of the Walsh Point peninsular of Kooragang Island. The ships will be berthed by a Newcastle Harbourmaster with the assistance of tugs. Once berthed, the ships will be tied to the wharf using double ropes (i.e. two ropes at every tie point). On completion of securing the ship the fuel transfer operations can commence. However, to minimise the potential for impact of spills to the river, an emergency boom containment system will be available at the wharf and ready for installation should a spill occur. A spill response procedure will be developed for boom deployment and training and boom deployment exercises will be conducted annually.

Prior to the commencement of fuel transfer it will be necessary to complete all of the requirements of the International Safety Guide for Oil Tankers and Terminals (ISGOTT). This guide requires a detailed checklist completion under the direction of the Maritime Services before any transfers can be commenced. The standard also requires complete monitoring of the transfer by ships staff and land based (terminal) personnel. Ships staff must monitor pump flows and have a crew member located at the transfer point at all times. Terminal staff must be present at the wharf and monitor tank loading at all times.

Once the approval for transfer has been given by the Maritime Services, the flexible hoses can be connected to the ship and wharf and the system configured for fuel transfer. On completion of equipment configuration, inspection and nitrogen pressure test, the transfer operation can commence. The ship's officer in charge of the transfer will start the ship's pumps and continually monitor the transfer operation. On completion, the ship's officer will shut-down the pumps and the fuel will be drained from the lines into the transfer pipeline. The flexible lines will then be disconnected and the ISGOTT procedures completed prior to the ship leaving the wharf.

A number of hazardous incident may occur during this operation, mainly as a result of leaks from the flexible lines. Whilst the fuel is contained in the pipework and flexible lines, there is a minimal risk of incident, as air is not present in the line during the transfer operation. As the line will be purged with nitrogen prior to discharge, as there are no ignition sources in the line and as the lines are earthed to prevent static build up, this incident has been effectively controlled.

Once the pipelines are full and fuel is being transferred, the flexible lines may leak or rupture due to overpressure or wear (from continual handling). Overpressure protection is provided in flexible line design. The flexible lines will be designed to withhold the full “dead-head” pressure pumps on all ships that will deliver fuel to the terminal. Hence, the overpressure potential has been designed out of the system. However, continual handling of the lines may cause abrasive wear on the line exterior resulting in weak points and the potential for release of fuel to the wharf area. Minor nitrogen leaks would be immediately detected by the wharf/terminal staff and transfer not commenced until line repairs were effected. In the event of an ignition of a minor leak, the fire would be contained in the immediate area of the release and local fire fighting equipment (extinguishers) would be available to commence fire fighting in the area. As the transfer of fuel at the wharf is conducted near the Hunter River, it would be advisable to avoid using any water for minor fires. Hence, first attack fire fighting by ship’s staff and terminal operators should be conducted using fire extinguishers. As the fire is fuelled by a flammable liquid, the capacity of a normal hand held fire extinguisher (dry powder – 9kg) may not be sufficient to control the fire. Hence, **it is recommended that Marstel install a 50kg wheeled dry powder extinguisher at the P&O Wharf**. This will provide sufficient fire fighting capacity for any small fires that may occur at the wharf. As minor fires will be controlled by ship’s and terminal staff, and within the confines of the wharf (i.e. no offsite impact), this incident has not been carried forward for further analysis.

In the unlikely event of a flexible hose split (i.e. catastrophic failure), the hose contents would be released to the wharf. Staff on the ship and at the terminal would immediate identify the split/release and initiate shut down of the delivery by activating the emergency shut down valves at the ships manifold and wharf connection. However, this would not prevent the contents of the hose spilling to the wharf resulting in a pool of flammable liquid. As the wharf is located over the Hunter River, it is possible for the fuel to spill to the river itself, resulting in potential environmental damage. However, the wharf is bunded with a raised concrete edge around the whole wharf. This, in effect, provides a containment bund for any spills. Further, as part of the ISGOTT requirements, a containment boom is installed around the ship and wharf. Hence, in the unlikely event any fuel reaches the river, it will be contained in the immediate area of the wharf. Notwithstanding this, **it is recommended that a separate wharf emergency plan be developed including spills, and potential environmental impact. The plan should be held in a waterproof container at the wharf and be available as part of the wharf operations. The plan should also contain spill response procedures and emergency drills/exercises to be conducted at regular intervals as part of safety preparedness**.

As the wharf is bunded and spill booms are available, this incident has not been carried forward for further analysis under the assumption that dedicated emergency plans will be developed for the site.

In the event of a flexible line rupture, and fuel spill, a pool of flammable liquid will form in the area around the leak point. Ignition of diesel fuel in this incident is highly unlikely, as the fuel does not readily “flash” into vapour. However, petrol and ethanol will vaporise more readily, resulting in a localised flammable vapour close to the release. As ship and terminal staff are present, there will be insufficient time for the flammable vapours to generate into a sizeable cloud before emergency response is initiated. Hence, vapour cloud explosion has not been considered in this scenario. However, immediate ignition of the release would result in a pool fire, within the bunded area on the wharf. Pool fires have the potential to radiate heat to the surrounding area resulting in impact to offsite structures and personnel. There are a number of buildings located on the eastern side of the wharf that may be impacted by a pool fire in the wharf area. Hence, this incident has been carried forward for further analysis and determination of the impact zone around a pool fire at the wharf.

4.2.2 Bulk Fuel Transfer – P&O Wharf to Terminal

The fuel will be delivered to the terminal by an underground pipeline, from the wharf to the terminal area. The pipeline will follow a route along the western side of Heron Road (towards the south), along the northern side of Walsh Point Reserve, and enter the terminal on the south western corner of the site.

The pipeline will be 350mm in diameter and constructed from steel. It will be fully welded along its length and NDT of welds will be conducted on completion of construction to confirm weld integrity. The pipeline will also be “pigged” on completion of transfer to extract all fuel from the line so that any pipeline breaches (e.g. external interference) will not result in environmental release or fire incident. During transfer, fuel flow rates (from the ship and into the terminal) and fuel delivery reconciliation will be performed to identify potential leaks during transfer. Any discrepancies during transfer will initiate an immediate shut down and investigation.

Notwithstanding the above safety features, there is a potential for road works and external construction to impact the pipeline, resulting in breach and fuel release. Whilst this will not occur during none transfer operations (i.e. the line rests without fuel), there is a potential for road work, excavation, etc. to impact the line (i.e. the line is struck and breached) and the excavation filled in without notification to the terminal. This would then result in a release of fuel where the breach had occurred. **It is therefore recommended that the pipeline be installed with a marker tape over the top of the line (i.e. between the surface and pipeline) indicating “FUEL LINE UNDER”. Pipeline surface markers**

should also be installed at every 50m to indicate the presence of the pipeline under the footpath location. It is also recommended that as part of the fuel transfer procedure, that an inspection of the pipeline route be conducted to identify whether there has been any unidentified ground disturbance in the area of the pipeline since the previous transfer. This may indicate to the terminal staff that the line could be impacted.

The management systems for the control of the pipeline have reduced the risks to a very low level, considering the line will not carry fuel for the vast majority of its life. Assuming the installation of the marker tape, pipeline markers and procedures, incidents involving the pipeline are considered to be low risk and therefore have not been carried forward for further analysis.

4.2.3 Terminal Storage Tanks and Associated Equipment

Figure 3.3 shows the proposed terminal layout. The terminal will consist a main bund with the tanks (with volumes >10,000m^3) segregated by 600mm high intermediate bunds. Whilst contained within the tanks, the fuel poses low risk, however, the space above the fuel surface in the tank ("air" gap or ullage space) will contain vapours that evaporate from the surface of the stored liquid. Normally, the concentration of vapours is well above the upper flammable limit of the vapours, hence, there is no potential for explosion and fire. However, when tanks are emptied there is a potential to draw air into the ullage space creating a flammable mixture (i.e. within the flammable range of the vapours when mixed with air). To prevent this occurrence, the flammable liquids tanks at the terminal will all be fitted with floating pans. The floating pans will remain in direct contact with the liquid surface, preventing the release of vapours into the ullage space of the tank. This eliminates the potential for a flammable vapour mix in the tank, as long as the floating pan remains intact. There is a potential for floating pans to sink to the tank bottom, however, this is unlikely.

Notwithstanding the fact that floating pans have been installed in the flammable liquid tanks, there is a potential for floating pans to sink, exposing the fuel surface to potential ignition sources. To prevent ignition, all tanks will be fitted with electrical equipment (level instruments, etc.) that comply with the requirements of the applicable hazardous area into which they are installed. Hence, ignition sources in the tanks have been eliminated.

The safety features installed in the tanks indicate that the risk of tank fire is low, however, this cannot be fully eliminated as tank fires continue to occur in the industry. Hence, a tank fire incident has been carried forward for further analysis to identify the potential for impact to adjacent sites.

In the unlikely event of a tank fire, there is a potential for the fire in the tank to spill into the bund. Tank failure could lead to loss of containment of the tank and the full tank contents spilling into the bund. The bund would contain the spill, however, the subsequent bund fire could impact adjacent sites. In addition, fuel transfer pipework failures in the bund could lead to a spill of flammable/combustible liquid into the bund that if ignited would lead to a bund fire. Further damage of the pipelines and tanks from the fire could release more fuel resulting in a full bund fire. A full bund fire incident has been carried forward for further analysis.

4.2.4 Tanker Loading Transfer Pumps and Associated Pipework

Fuel will be transferred from the tanks to the tanker loading bays/gantries using fuel transfer pumps. A pump gallery will be located on the western side of the bunded area adjoining the north and south bund (see **Figure 3.3**). The pump gallery will be directly adjacent to the pump bays/gantries.

Fuel transfer to the road tankers will be controlled by computer. The filling commencement will be initiated by the road tanker driver using a swipe card (see details in **Section 4.2.5**). Once initiated, the tanker transfer will commence and the specific pump will transfer the fuel to the selected bay/loading arm.

The pumps installed at the terminal will all be fitted with mechanical seals to minimise the potential for leaks at the pump seal housing. In addition, combustible gas detectors will be installed at the low point in the pump bund, to automatically shutdown loading and close control valves (isolating the transfer pipeline) in the event of a product leak. In the unlikely event of a pump leak, the fuel would spill to the ground under the pump and be contained in the pump gallery bund. Hence, there would be no release offsite. Pipework leaks from the pipelines between the tanks and the pumps would all be contained within the main tank bunding at the terminal. Hence, there would be no environmental impact from leaks in these areas.

In the event of an ignition of a fuel leak, a fire in the tank bunded area could result in a major bund fire. This has been assessed in **Section 4.2.3**. An ignition of a transfer pump leak would lead to a bund fire in the pump gallery bund. This could radiate heat into the area to the west with the potential to impact offsite. However, the pump bund is protected by a foam deluge system, which is extended from the fuel loading gantry foam protection system. Notwithstanding this, should the foam system fail to activate, there is a potential for a fire to result in heat radiation impacting the offsite area to the west of the site. Hence, this incident has been carried forward for further analysis.

4.2.5 Loading Bays & Gantries – Fuel Tankers Loading

Tanker drivers will access the truck loading bays from the northern entry driveway. Trucks will enter the designated loading bay and stop adjacent to the specified loading arm. Trucks will be loaded by bottom filling only (i.e. loading arms will be connected to filling points at the bottom of the tanker). The tanker driver will then connect the earthing strap to prevent static electricity generation during the transfer. In order to connect the loading arm, the tanker driver will activate the "driveaway" protection bar that is fitted across the fill points. Pushing down bar, in order to connect the loading arm, will activate the tanker brakes, preventing driveaway by error. Once the loading arm is connected to the tanker, the driver will swipe a card at the computer interface and the computer will automatically configure the valves accordingly. In the event the driver incorrectly selects a loading arm (i.e. connects the wrong arm to the tanker), the computer will identify this error and alarm the driver and terminal operator that an incorrect connection has been made. Once the correct arm is selected and the appropriate connections made, the transfer can commence. Filling is continually monitored by the computer control and by the operator, who remains with the vehicle during the full filling cycle. Once complete (i.e. tanker full), the computer ceases the filling cycle, stops the pump and shuts all isolation valves. The driver can then disconnect the tanker and leave the site, noting that the driver cannot leave until the loading arm is disconnected and the "driveaway" protection bar raised.

Minor spill may occur as a result of connection/disconnection of the loading arm. However, to prevent this dry break couplings are used on all tankers, eliminating the potential for spills from this source. Loading arm leaks may occur at joints and flanges, resulting in minor spills to the ground around the tanker. Premature disconnection of the loading arm could occur due to driver/operator error, resulting in spills around the fill point area. These leaks & spills could have the potential to reach the environment (i.e. Greenfield Street). However, to prevent this, the loading bays are fitted with a "speed-hump" style bunded area, where spills will be contained. In the unlikely event a spill escapes beyond the loading bay bunded area, the drains adjacent to the bay all report to the stormwater retention pit adjacent to the pump gallery (north side). Hence, leaks and spills will not escape offsite and will be contained, preventing any environmental impact.

In the event of a coupling release (by fault or error) or a leak at joints/flanges/valves, the flammable/combustible liquid will form a pool under the leak/spill point. In the event of ignition, a pool fire will result. To minimise the potential for ignition, the terminal will control all ignition sources in the loading bay/gantry area. Smoking will not be permitted on site, including the areas to the west (external areas of offices, workshop, etc.). No work will be permitted in the loading bay/gantry area unless a work permit has been issued, and all equipment in the loading bay/gantry area will be installed in accordance with the appropriate hazardous area classification. Ignition will be unlikely in this area, however, notwithstanding the ignition control, there is still a potential for leak and fire in this area, with impact to the west of the site (Greenleaf Road). Whilst it is recognised that the gantry area is fitted with UV/IR fire detectors and a foam deluge system, that will mitigate the potential impacts, failure of this system to operate may result in offsite consequence impacts to the west (Greenfield Road). Hence, this incident has been carried forward for further analysis.

5. CONSEQUENCE ANALYSIS

5.1 Incidents Carried Forward for Consequence Analysis

The following incidents were carried forward from the hazard analysis component of the study for consequence analysis:

- Flexible line rupture at the bulk liquids transfer wharf, fuel leak, ignition and subsequent pool fire at the wharf;
- Ignition of flammable liquid in the bulk liquids storage tank leading to storage tank roof fire;
- Leak of flammable liquid into the bulk liquids storage tank bund, ignition and full bund fire;
- Transfer pump leak (seal or flange) resulting in spill to the pump bund, ignition and fire; and
- Flammable liquid leak at the gantry, ignition and pool fire in the bunded area of the loading bay.

Each incident has been assessed in detailed in **Appendix B**. All incidents assessed were for fire impacts at specific heat radiation levels. The distances to the specific levels of heat radiation were calculated to determine the impact at the site boundary from each incident.

5.2 Consequence Criteria

Hazardous Industry Planning Advisory Paper No.4, “Risk Criteria for Land Use Safety Planning” (Ref.4), indicates that the maximum permissible heat radiation level at the site boundary is 4.7kW/m^2. Hence, any incident that has a heat radiation impact above this level is carried forward for frequency and risk analysis.

Table 5.1 summarises the impacts from each fire, assessed in detail in **Appendix B**, in tabular format. The table includes the distance to the site boundary for each fire. The assessment and requirement for carry over to the frequency and consequence analysis is included in the comments column at the right hand side of the table.

5.3 Impact Areas for Each incident

5.3.1 Bulk Liquids Berth – P&O Wharf

Figure 3.4 shows the bulk liquids berth location and layout. It can be seen from this area that the heat radiation impact to the north, south, and west will have little impact as the areas to the north and south are open (no structures to impact) and the area to the west is the ship and Hunter River (no other structures apart from the ship). The ship is steel and has a fire protection system installed. This will be activated in the event of fire, therefore there will be no impact in this area. Furthermore, the ship can be moved from the wharf should a fire occur removing the potential for domino incident.

Hence, the impact area at the wharf will be towards the east, where the wharf buildings are located. The distance from the postulated fire to the wharf buildings is 50m. The distance to the site boundary is 75m.

5.3.2 Bulk Storage Tank – Large Tank (44m Diam.)

The largest tank is located in the south-west bund at the front of the site. The bund is located adjacent to Greenleaf Road (West) and the public reserve to the south. A fire in this tank would result in heat radiation that may impact Greenleaf Road, sites to the north and south or the Hunter River area. The distance from this tank to Greenleaf Road is 20m. The distance from Tank NN1 to the site to the south is 25m. The distance from this tank to the site to the north is 175m. As there are no structures in the Hunter River area, assessment in this direction has not been considered.

5.3.3 Bulk Storage Tanks – Medium Size Tanks (30m Diam.)

The medium sized tanks are located in the central and northern bund. The bunds are located adjacent to the Hunter River (east) and the main loading gantry (west) onsite. Greenleaf Road (West) is the closest public area. A fire in this tank would result in heat radiation that may impact Greenleaf Road, sites to the north and south or the Hunter River area. The distance from Tanks ND05 and ND06 to Greenleaf Road is 55m and 75m respectively. The distance from Tanks ND05 and ND06 to the site to the south is 85m and 115m respectively. The distance from Tanks ND05 and ND06 to the site to the north is 125m and 90m respectively. As there are no structures in the Hunter River area, assessment in this direction has not been considered.

5.3.4 Bulk Storage Tanks – Small Tanks (16m Diam.)

The smaller tanks are located in the south east bund, adjacent to the Hunter River (east) and the public reserve to the south. Like the larger tanks, fires will not cause any impact to the Hunter River area. However, fires may impact areas at Greenleaf Road and the sites to the north and south. The distances from Tanks NN2, NN3 and ND04 to Greenleaf Road are 80m, 90m and 90m respectively. The distances from Tanks NN2, NN3 and ND04 to the site to the North are 200m, 180m and 160m respectively. The distances from Tanks NN2, NN3 and ND04 to the site boundary to the south are 15m, 35m and 60m respectively.

5.3.5 Tank Bunded Areas (North and South)

The tank bunds (south-east and south-west) are located close to the site boundary (within 7.5m on the south, west and east sides).The central bund is located within 7.5m of the Hunter River (east) and 45m of Greenleaf Road (west). The central bund is 105m from the site to the north. The northern bund is located adjacent to the Hunter River (7.5m) to the east and 45m from Greenleaf Road (west). The northern bund is located 85m from the site to the north. Fires in these bunds would impact offsite areas where bunds are located close to the site boundary.

5.3.6 Transfer Pump Bund

The pump bund is located on the western side of the main bunded areas. A fire in this bund will not impact the Hunter River area or the adjacent sites to the north and south. The impact zone will be at Greenleaf Road. The distance from the pump bund to Greenleaf Road is 45m

5.3.7 Loading Bay/Gantry Bund

Like the pump bund, the gantry area will not impact the Hunter River or the sites to the north and south. However, Greenfield Road would be impacted by a fire in this area. The distance to Greenleaf road from the loading bay/gantry bund is 25m.

TABLE 5.1
SUMMARY OF CONSEQUENCE AND OFFSITE IMPACTS

Incident	Distance to Specific Heat Radiation Levels (kW/m^2)						Closest Distance to Site Boundary	Comment on Offsite Impact
	15	12.5	8	6	4.7	2		
Wharf Fire – Hose Rupture	18.5	19.8	23.2	26	28.5	41	75	The heat radiation does not impact offsite (4.7kW/m^2)– incident not carried forward
Tank Roof Fire (Large Tank)	31	33.5	40	45	51	75	20 (west) 33 (south)	The heat radiation impacts offsite (4.7kW/m^2)– incident carried forward
Tank Roof Fire (Medium Tank)	21.5	23.5	29	33.5	38	57	55 & 75 (west)	The heat radiation does not impact offsite (4.7kW/m^2)– incident not carried forward
Tank Roof Fire (Small Tank)	6	10.5	17.5	22	26	42	25, 45 & 70 (south)	Only one tank results in heat radiation impacts offsite (4.7kW/m^2)– incident carried forward
Full Bund Fire (south-west)	50	52.5	61	68	74	105	7.5 (south & west)	The heat radiation impacts offsite (4.7kW/m^2)– incident carried forward
Full Bund Fire (south-east)	45	47	55	60	66	94	7.5 (south & west)	The heat radiation impacts offsite (4.7kW/m^2)– incident carried forward
Full Bund Fire (central)	46	48	56	61	67	96	45 (west)	The heat radiation impacts offsite (4.7kW/m^2)– incident carried forward
Full Bund Fire (North)	43	46.5	53	59	64	90	45 (west)	The heat radiation impacts offsite (4.7kW/m^2)– incident carried forward
Pump Bund Fire	19.4	20.5	24.2	27	29.5	42	35 (west)	The heat radiation does not impact offsite (4.7kW/m^2)– incident not carried forward
Loading Bay/Gantry Fire	27	28.5	33	36.5	40	56	25 (west)	The heat radiation impacts offsite (4.7kW/m^2)– incident carried forward

5.4 Impact to P&O Facilities Adjacent to the Liquids Unloading Berth

Figure 3.4 shows the location of the liquids berth and liquids unloading area at the P&O wharf. It can be seen from this layout that the buildings are 50m from the wharf area where the fire may occur. A review of the heat radiation impact distance (4.7kW/m^2) indicates that a fire at the wharf, as a result of a hose rupture, would impact to a distance of 28.5m. Hence, there will be no impact to the buildings at the wharf.

It is also noted that it is proposed to install a fire monitor at the wharf to assist in fire fighting in the unlikely event that a fire occurs. **It is recommended that the fire monitor be located a minimum of 29m from the wharf hose connection point.**

6. FREQUENCY ANALYSIS

6.1 Incidents Carried Forward for Frequency Analysis

The consequence analysis identified that a number of hazardous scenarios had the potential to result in heat radiation impact offsite at levels in excess of published risk criteria (Ref.4). Those incidents identified to have a potential impact offsite were:

- Ignition of flammable liquid in the large bulk liquids storage tank and one of the small bulk liquids storage tanks leading to storage tank roof fire;
- Leak of flammable liquid into the bulk liquids storage tank bunds, ignition and full bund fire; and
- Flammable liquid leak at the gantry, ignition and pool fire in the bunded area of the loading bay.

Each scenario is assessed below for incident frequency.

6.2 Bulk Tank Roof Fires

The frequency of fires in the bulk liquid tanks is a function of the material stored and the tank design. A review of tank fire incidents (Ref.13), indicates that the general fire frequency for a cone roofed tank with highly flammable materials is $1x10^{-4}$per annum (p.a.), the frequency for flammable material is $1x10^{-5}$p.a. These frequencies include tanks that are not fitted with floating pans and, hence, the selection of a frequency of $1x10^{-5}$p.a. for the petrol tanks in this analysis would be conservative as the tanks fitted with floating pans, reducing the likelihood of flammable liquid ignition in the tank.

Marstel will also store diesel fuel in cone roof tanks that are not fitted with floating pans. A review of the fire frequency selected for this study identified that the frequency is based on flammable liquids. Diesel fuel has a much lower flash point than flammable liquids and its propensity to ignite is considerably lower, meaning that the fire frequency for a diesel tank would be expected to be lower. Based on this fuel characteristic, the frequency for a diesel fuel fire has been estimated to be one order of magnitude lower than the general fire frequency for flammable liquid tanks.

Hence, the fire frequency in a floating pan cone roof tank and diesel storage cone roof tank is estimated to be $1x10^{-6}$p.a.

6.3 Tank Bund Fires

A review of the fire frequency for tank bund fires (full bund fire) was conducted (Ref.13). The general fire frequency for full bund fires was estimated to be1x10^{-5}p.a. for flammable liquids. For the diesel fuel tanks, the fire frequency has been estimated to be one order of magnitude less than the published data for flammable liquids, as the diesel fuel is not classified as flammable. Hence, the frequency of a full bund fire of diesel fuel is estimated to be 1x10^{-6}p.a.

6.4 Gantry Fire Frequency

Gantry fires may occur as a result of a fuel leak from a pipe or flexible arm connection. Leaks from pipes and flanges would be minimal and the frequency of these events very low. However, operator error in connecting a flexible line to the tanker or flexible line (arm) failure is a more likely scenario. A review of failure frequencies of flexible connections (Ref.15) indicates the failure frequency for a flexible connection to be 0.015 failures per annum.

In the event fuel is released, it is not an absolute certainty that it will ignite. A review of the probability of fuel ignition after release was conducted and it was identified that a flammable liquid has a probability of ignition of 0.03 for a major leak (i.e. of the type expected at the gantry) (Ref.11).

In the event of a fire, the gantry area has been fitted with fire detectors and a foam sprinkler system. If this fails to initiate, the fire will continue and impact offsite. The failure frequency of the various components of the fire fighting system are detailed below:

- Fire Detector – 0.036 p.a. (using the fractional dead time, or FDT, approach, and based on an annual test frequency, the probability of failure is estimated to be 0.018 (Ref.16)
- Sprinkler System (including fire pump and foam skid) – 0.33p.a. (using the fractional dead time, or FDT, approach, and based on a weekly test frequency, the probability of failure is estimated to be 0.003 (Ref.15)

The fire frequency impacting offsite is therefore estimated using a fault tree shown in **Figure 6.1**. It can be seen from this tree that the fire frequency is 9.43X10^{-6}p.a. This frequency includes the failure probability of all protection systems. Note that this result is conservative as fire fighting by the operators has not been considered in this analysis.

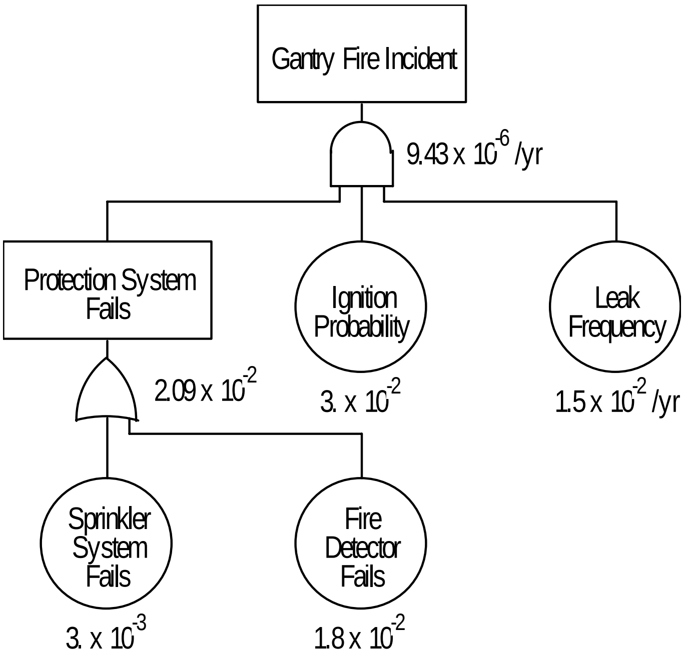


FIGURE 6.1
GANTRY FIRE FREQUENCY – FAULT TREE

7. RISK ANALYSIS

7.1 Frequency of Incidents carried Forward for Risk Analysis

Three incidents were assessed for frequency analysis. The incident frequencies carried forward for risk analysis are:

- Tank roof fire - flammable liquids (Large & Small Tanks) – 1x10^{-5} p.a.
  - combustible liquids (Large & Small Tanks) – 1x10^{-6} p.a.
- Full bund fire - flammable liquids – 1x10^{-5} p.a.
  - combustible liquid – 1x10-6p.a.
- Gantry fire - 9.43x10^{-6} p.a.

The values have been used in the risk analysis conducted below.

7.2 Risks Associated with Tank Roof Fires

A review of the potential for impact at the site boundary from Large (44m diam.) & Small (16m diam.) tank fires was conducted. It was identified that heat radiation in excess of 4.7kW/m^2 can only impact at the southern boundary (Tanks NN1 and NN2) and western boundary (Tank NN1). The risk at each area is conducted in the following sections.

7.2.1 Risks at the Southern Boundary

The heat radiation impact at the southern boundary occurs as a result of tank NN1 and NN2. Heat radiation has the potential to impact people resulting in burns and fatalities, where the level of exposure is high and for an extended duration. To estimate the probability of fatality the probit methodology is used. The probit equation for heat radiation takes the form:

$$Y = k1 + k2 \ln (I^{4/3}t)$$

Where: k1 = -14.9 (Ref.13);

k2 = 2.56 (Ref.13);

I = heat radiation intensity (kW/m^2); and

t = exposure time (s)

The time that a person, in an adjacent industrial facility to the Marstel site, is exposed to the tank roof fire has been estimated to be 60 seconds (i.e. the time taken, conservatively, for a person to evacuate the area). This is considered conservative, as people in adjacent industrial facilities would be expected to be reasonably mobile and would be able to escape from the fire rapidly. Further, people at adjacent facilities are only present during business or daylight hours, which further reduces the fatality probability. However, for conservatism, this has not been included in this analysis.

The relationship between probit and probability of fatality is shown in **Figure 7.1** (Ref.13). The values calculated from the probit equation are compared to the graph and the probability of fatality estimated.

Tank NN1 is 33m from the boundary. The heat radiation level at 33m is 12.5kW/m^2. This value was used in the probit analysis.

Probit (Y) = $-14.9 + 2.56 \ln (12.5^{4/3} \times 60) = 4.2$

From **Figure 7.1** probability of fatality = 0.25

Tank NN2 is 25m from the boundary. The heat radiation level at 33m is 4.9kW/m^2. This value was used in the probit analysis.

Probit (Y) = $-14.9 + 2.56 \ln (4.9^{4/3} \times 60) = 1$

From **Figure 7.1** probability of fatality = 0

Hence, the highest fatality risk impact from tank fires, at the southern boundary, is from a fire in the diesel fuel tank at the closest point on the boundary to the tank (south). The fatality risk is therefore the combination of the incident frequency and the fatality probability. Fatality risk = $0.25 \times 1\text{x}10^{-6}$p.a. = $0.25\text{x}10^{-6}$ chances of fatality p.a. or 0.25pmpy.

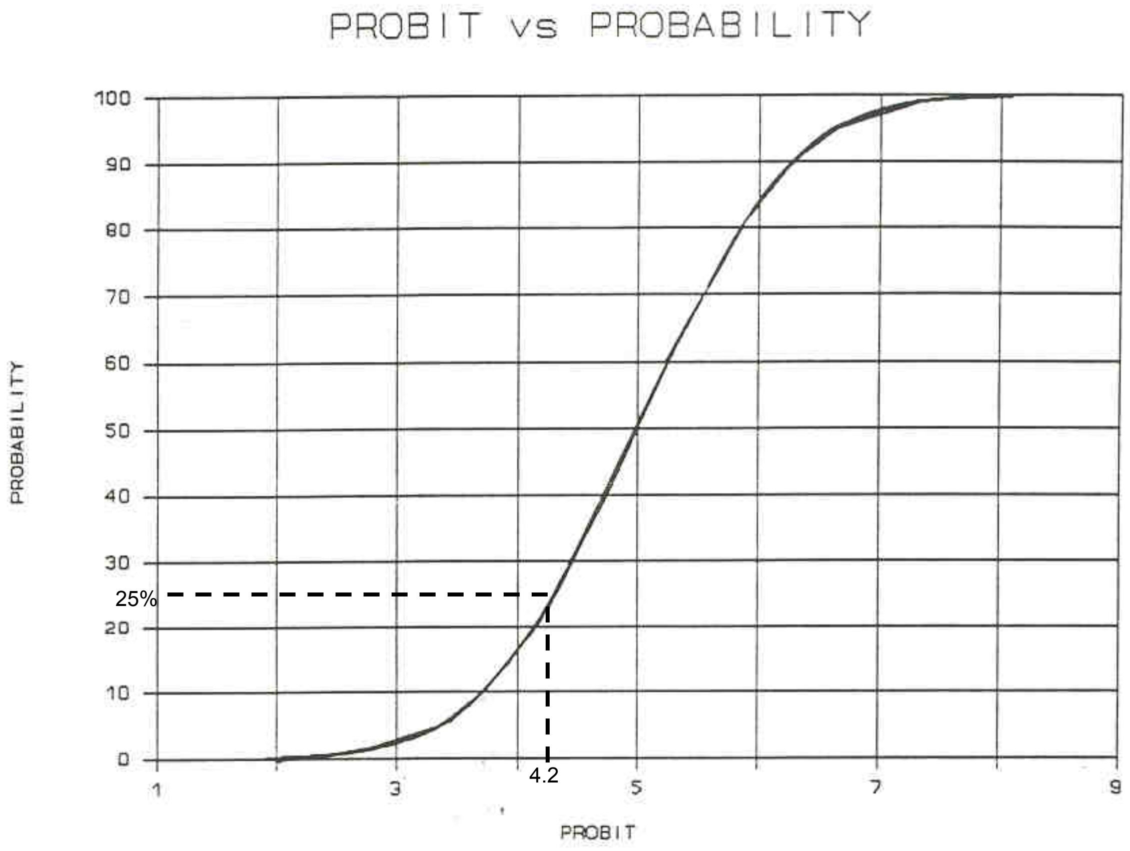


FIGURE 7.1
PROBIT CURVE (Ref.13)

7.2.2 Risk at the Western Boundary (Tank NN1)

The fatality risk at the site boundary to the west, from tank fires, occurs from tank NN1 only. The distance from the tank to the closest point at the site boundary is 20m. The heat radiation impact at this point is 20.6kW/m^2. This value was used in the probit analysis.

Probit (Y) = -14.9 + 2.56 In (20.6$^{4/3}$ x 60) = 5.9

From **Figure 7.1** probability of fatality = 0.8

Hence, the highest fatality risk impact from tank fires, at the western boundary, is from a fire in the diesel fuel tank at the closest point on the boundary to the tank (west). The fatality risk is therefore the combination of the incident frequency and the fatality probability. Fatality risk = 0.8 x 1x10^{-6}p.a. = 0.8x10^{-6} chances of fatality p.a. or 0.8pmpy.

Figure 7.2. shows the estimated fatality risk at the southern and western boundaries.

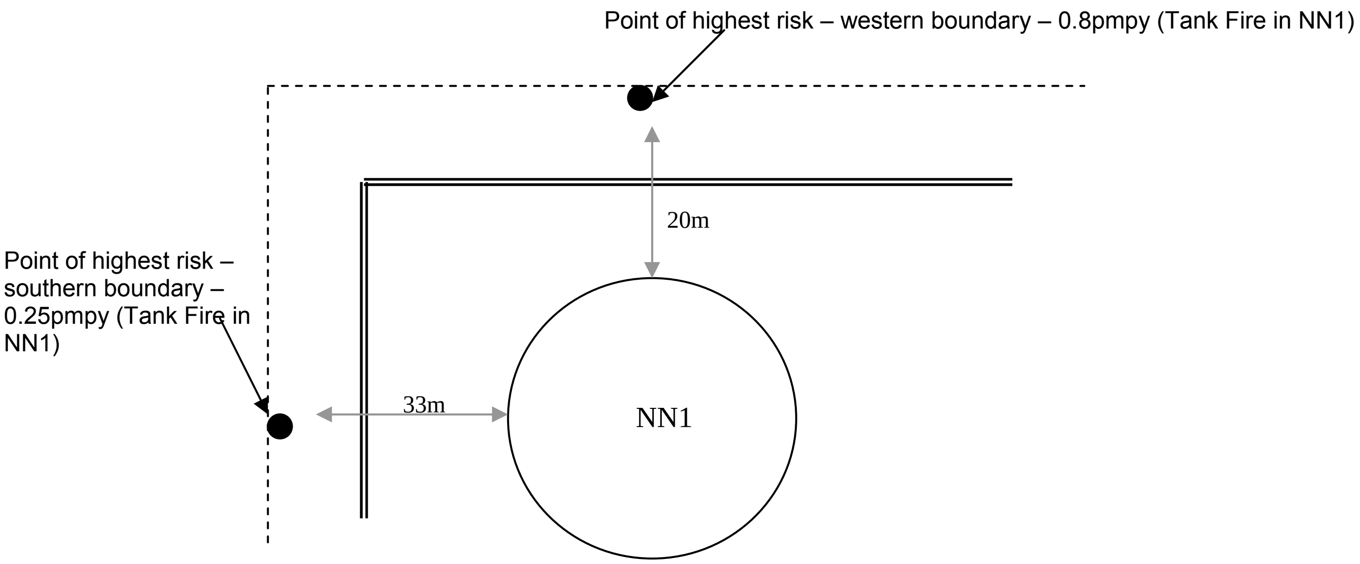


FIGURE 7.2
HIGHEST RISK LOCATION AT THE SOUTHERN & WESTERN SITE BOUNDARY FROM A TANK FIRE IN TANK NN1

7.3 Risks Associated with Full Bund Fires

A full bund fire will impact the site boundary at a level in excess of 20kW/m^2. Applying the probit analysis, this will result in a probability of fatality of 0.8 for a 60 second exposure. The frequency of bund fire is 1x10^{-6}p.a. Hence, the fatality risk is also 0.8x10^{-6} chances of fatality p.a. or 0.8pmpy.

The point of highest risk is where the two bunds (south-west and south-east) meet at the southern boundary. The risk at this point is therefore cumulative and the total risk is 1.6 pmpy.

7.4 Risks Associated with Gantry Fires

The distance to the closest site boundary from the gantry bund is 25m. At this distance, the heat radiation impact is 16kW/m^2. Using this value in the probit analysis results in a probability of fatality of 0.5. The fatality risk is therefore: Fatality risk = 0.5 x 9.43x10^{-6}p.a. = 4.7x10^{-6} chances of fatality p.a. or 4.7pmpy.

There is also a cumulative risk impact as a result of bund fires, tank fires and gantry fires. The cumulative risk impact is assessed in the following sections.

7.5 Summary of Cumulative Risk Impacts

The cumulative risk impact at selected locations around the site boundary was assessed. The cumulative risk impact is the summation of risks from all postulated incidents at the site at any selected point. At specific points around the boundary, risk will maximise due to the location of these points in relation to postulated incidents. The highest risk locations occur at two points; at the southern boundary adjacent to where the two bunds meet and at the western boundary adjacent to the fire water tanks (117m from the south-western corner of the site).

7.6 Cumulative Risk at the Southern Boundary

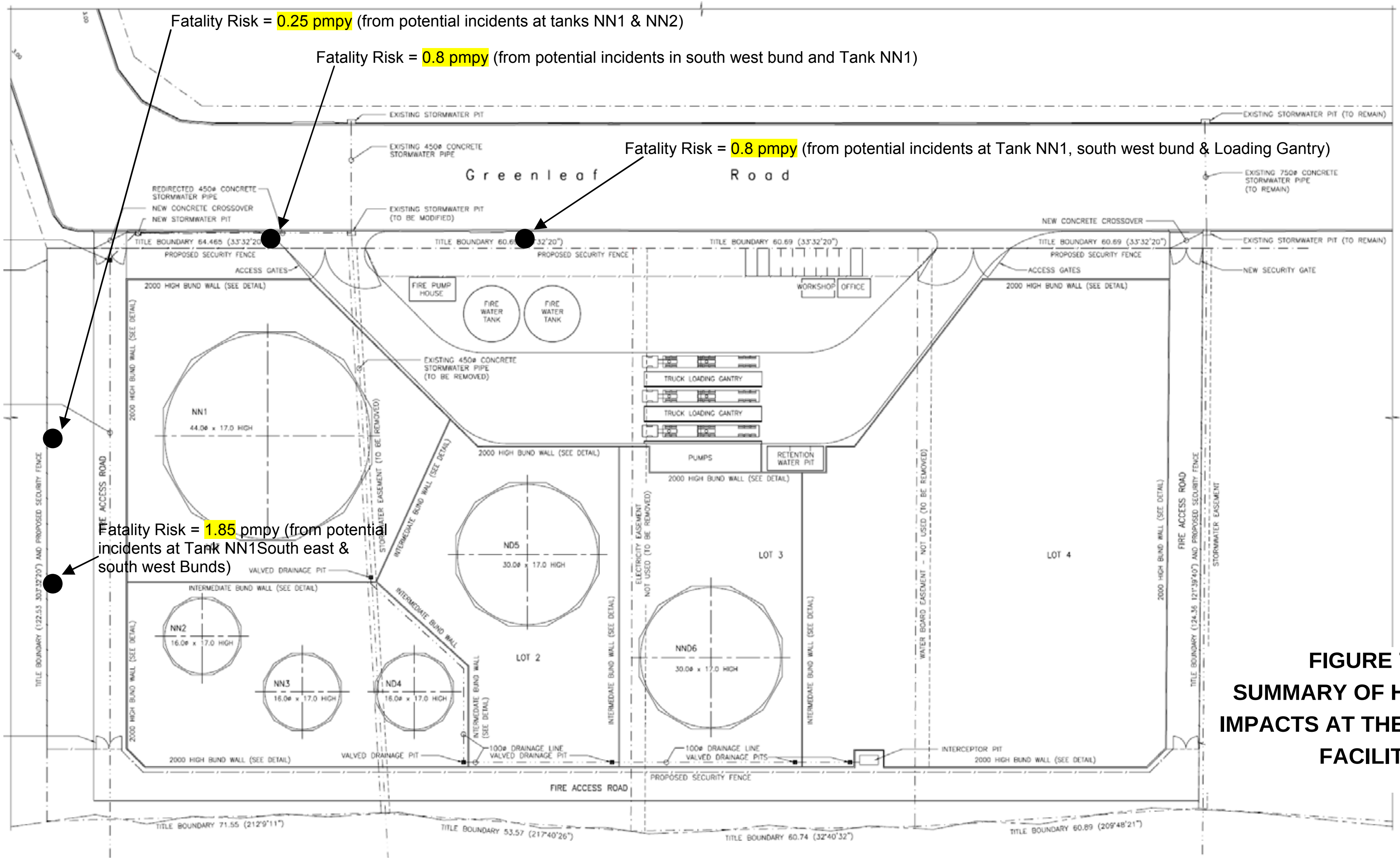
The highest cumulative fatality risks location at the southern boundary is estimated from the summation of risks associated with incidents at the south-western/south-eastern bunds, Tank NN1 and Tank NN2. Assessing these risks using a probit analysis results in the following:

Fatality risk from incidents at the south-eastern bund = 0.8 pmpy:
Fatality risk from incidents at the south western bund = 0.8 pmpy
Fatality risk from incidents at Tank NN1 = 0.25 pmpy
Fatality risk from incidents at Tank NN2 = 0 pmpy
Total = 1.85 pmpy

7.7 Cumulative Risk at the Western Boundary

The highest cumulative fatality risks location at the western boundary is estimated from the summation of risks associated with incidents at the south-western bund, Tank NN1 and the fuel transfer gantry area. The highest risk point is determined iteratively by selecting points along the site boundary and assessing the risks at each point until the maximum risk value is determined. The analysis identified that the highest risk occurs 117m north, along the Greenfield Road boundary, from the south-west corner of the site. The risk was assessed to be 0.8pmpy.

Figure 7.3 shows the highest points of risk plotted on the layout of the site. All other locations at the site boundary are lower risk than the points shown.



Fatality Risk = 0.25 pmpy (from potential incidents at tanks NN1 & NN2)

Fatality Risk = 0.8 pmpy (from potential incidents in south west bund and Tank NN1)

Fatality Risk = 0.8 pmpy (from potential incidents at Tank NN1, south west bund & Loading Gantry)

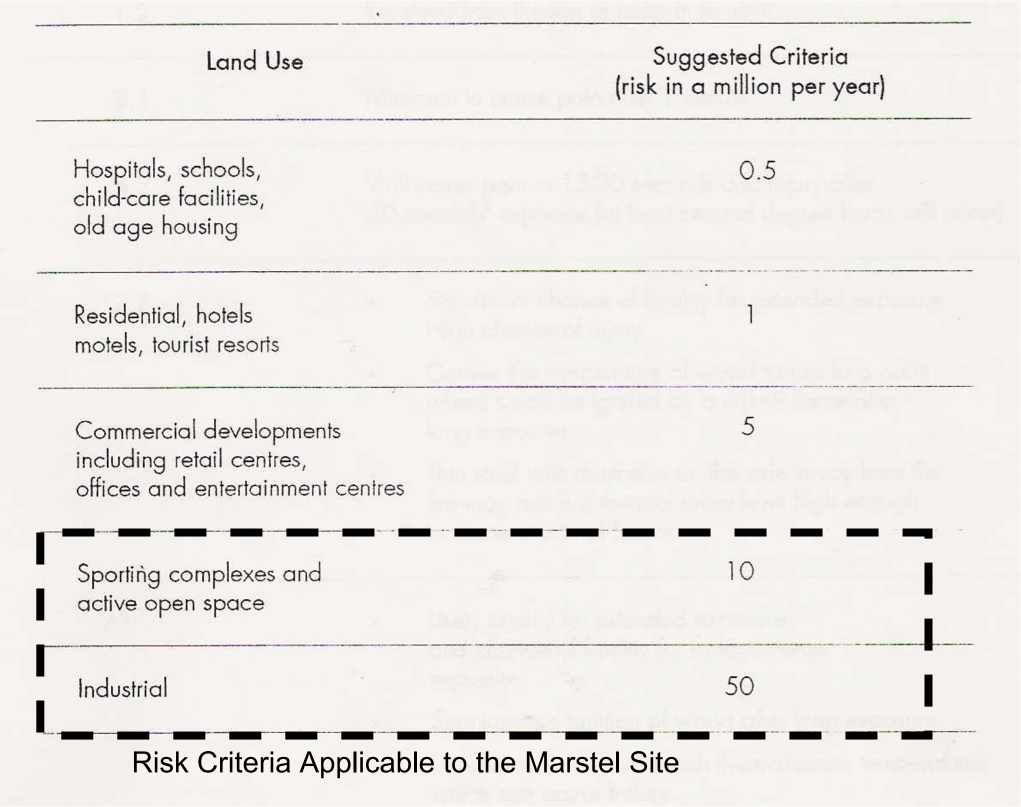
Fatality Risk = 1.85 pmpy (from potential incidents at Tank NN1South east & south west Bunds)

FIGURE 7.3
SUMMARY OF HIGH RISK IMPACTS AT THE MARSTEL FACILITY

7.8 Risk Criteria and Risk Review

Hazardous Industry Planning Advisory Paper No 4 (Ref.4) publishes risk criteria for adjacent facilities. **Table 7.1** presents the risk criteria from HIPAP No.4.

TABLE 7.1
FATALITY RISK CRITERIA FOR LAND USE SAFETY PLANNING



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

Risk Criteria Applicable to the Marstel Site

(Ref.4)

The area surrounding the Marstel site to the north and west is industrial, hence, the maximum permissible levels of risk at the site boundary is 50 chances in a million per year (50pmpy). The area to the south is active open space (i.e. public area accessible on the end of Walsh Point) and, hence, the maximum permissible risk in this area is 10pmpy.

A review of the risks plotted on **Figure 7.3** shows that none of the risks assessed exceed the criteria published in HIPAP No.4. Hence, the site is not within the Hazardous or Offensive category and is only classified as ***Potentially*** Hazardous or Offensive and is therefore permissible in the proposed land zoning.

8. REFERENCES

1. Hazardous Industry Planning Advisory Paper No.6, “Guidelines for Hazard Analysis”, NSW Department of Planning (1992).

2. Multi-Level Risk Assessment, Department of Infrastructure, Planning and Natural Resources – 1997

3. DoP (1994), “Applying SEPP 33”, Hazardous and Offensive Industry Development Application Guidelines

4. Hazardous Industry Planning Advisory paper No.4, “Risk Criteria for Land Use Safety Planning”, Department of Infrastructure, Planning and Natural Resources (1992)

5. The Australian Code for the Transport of Dangerous Goods by Road and Rail (known as the Australian Dangerous Goods Code or ADG), 6th ed., Federal Office of Road Safety, Canberra, ACT (1998).

6. AS1940-2004,”The storage and handling of flammable and combustible liquids”, Standards Association of Australia, Sydney

7. NFPA20-1999, “Installation of Stationary Pumps for Fire Protection”, National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, Massachusetts 02269-9101, USA

8. AS2430.3-2004,”Hazardous Area Classification Part 3: Examples of Area Classification – Flammable Liquids”, Standards Association of Australia, Sydney

9. AS60079.10-2004, “Electrical Apparatus for Explosive Gas Atmospheres – Classification of Hazardous Areas”, Standards Association of Australia, Sydney

10. AS2419.1-2005, “Fire Hydrant Installations Part 1: System Design, Installation and Commissioning”, Standards Association of Australia, Sydney

11. Cox A.W., Lees F.P. & Ang M.L. (1991), Classification of Hazardous Locations”, Institution of Chemical Engineers (IChemE), Rugby, UK

12. Lees, F.P. (1996), “Loss Prevention in the Process Industries”, Butterworth Heinemann, London.

13. Tweeddale, H.M. (1993), "Hazard Analysis and Reduction", School of Chemical Engineering, University of Sydney

14. Johnson, A.D. (1992),"A Model for Predicting Thermal Radiation Hazards from Large-Scale Pool Fires", IChemE Symposium Series No. 130, pp507-524

15. CCPS (1989), "Process Equipment Reliability Data", Centre for Chemical and Process Safety of the American Institute of Chemical Engineers, New York.

16. OREDA (2003) – Offshore Reliability Data (4th ed), prepared by Sintef Industrial Management and published by the OREDA Participants including BP Exploration, ExxonMobil, Norsk Hydro, Phillips Petroleum, Statoil, Shell Exploration, TotalFina

APPENDIX A

HAZARD IDENTIFICATION TABLE

TABLE A1
HAZARD IDENTIFICATION TABLE

Site Area	Cause	Consequence	Safeguard
Liquids Transfer Berth (P&O Wharf)	- Ships enters berth at too high speed	- Potential for ship to strike the wharf resulting in damage to ships hull, hull breach and release of flammable liquid to Hunter River	- Ship is berthed with assistance from Newcastle Ports Pilot (trained in Newcastle berth procedures) - Ships speed is limited during approach to berth (monitored by Pilot) - Berthing assistance is provided by Newcastle Harbour Tugs (prevent direct approach to wharf by ship) - Berthing facilities and operations follow strict ISGOTT procedures - Ships captain is certified master mariner, with extensive ship handling experience - Wharf is fitted with "Fenders" to prevent direct strike of solid wharf components on the ship This incident has not been carried forward to the Hazard Analysis section as the risk of ship impact to the wharf, resulting in liquid release, is extremely low.
Liquid (Fuel) Delivery & transfer using flexible hose	- Hose failure - Connection failure - Human error (incorrect connection) - Ship moves away from berth (wind, failed lines)	- Potential spill on the ships deck - Spill onto the P&O wharf - Potential spill off ships deck or wharf into the Hunter River – environmental impact - Ignition of spill and fire on the wharf and in the contained boom area around the ship	- Personnel (Ship & Shore) in attendance during full fuel delivery/transfer - Wharf area where fuel lines are located is bunded to prevent direct spill to the Hunter River - A spill containment boom will be established around the ship and wharf for all delivery/transfer operations - Site emergency plan will be developed to respond to spills - Spill kit will be available for minor spills - Monitor, with foam generation facilities, will be installed adjacent to the fuel transfer point at a safe distance from the flexible lines (to be established by Fire Safety Study) - Additional fire hydrants located close (within 60m) of the fuel transfer location - Emergency shut off valves installed on pipework, operated automatically or by remote actuation "button" on the ship & shore - Ship is tied up with two lines at every tie point

TABLE A1
HAZARD IDENTIFICATION TABLE

Site Area	Cause	Consequence	Safeguard
Liquid transfer via pipeline	- Pipeline leak due to corrosion, overpressure, poor construction (welding), external interference	- Leak of liquid to environment - Ignition of leak and fire at leak point	- Pipeline will be fully welded steel along the full length (no flanges creating leak sources) - Pipeline welding will be fully non-destructive tested (e.g x-ray and magnetic particle) - Pipeline will be designed to withstand full pump "dead-head" with a conservative factor of safety (i.e. no rupture) - Pipeline will be "pigged" after each delivery to extract all fuel from the line so that no fuel will be present when the line is not in use - Pipeline will be installed underground to minimise the potential for impact from external sources - Pipeline will be hydraulically tested to a pressure in excess of operating pressure on completion of construction - Pipeline transfer will be fully monitored by instruments both on ship and shore facilities (Ii.e. pressure, flow, etc.) - The pipeline will be inspected and tested with an "intelligent" pig on a regular basis (time frame to be determined) to identify potential faults - Pipeline will be protected with an external anti-corrosion protection coating (e.g. HDPE) - Nitrogen will be used to purge the line after each transfer
Fuel storage	- Overfill of tank during tank filling - Spill of fuel into the bund	- Potential offsite release, environmental impact	- Fuel storage is bunded, no offsite release - Tanks are monitored during filling using level instrumentation (level in tanks repeated in the site office) - All tank are fitted with high level instruments and alarms (audible & visual in the site office) - Visual inspection and checking of tank/bund area is performed during the transfer/filling operation - Tank fill volume is passed to ship for monitoring, ship constantly monitors the transferred volume and notifies shore when volume limit is approaching

TABLE A1
HAZARD IDENTIFICATION TABLE

Site Area	Cause	Consequence	Safeguard
Fuel storage	- Overfill of tank during tank filling - Spill of fuel into the bund - Ignition and bund fire	- Potential offsite heat radiation impact to surrounding areas	- Fire main (complying with AS2419-Ref.10), fire pumps (complying with NFPA20 – Ref.7) and fire water tank - Fire hydrants and hose reels close to the storage - Fire monitors with foam generation installed adjacent to the bund (but at safe distance) - Fire contained to bund – bund capacity exceeds largest tank in bund (plus sprinkler allowance) - For the diesel storages, diesel fuel difficult to ignite - Control of ignition sources in the bund area (bund will be classified as a hazardous area in accordance with Australian Standards – e.g. AS2430 (Ref.8) & AS60079 (Ref.9) - All tanks will be regularly inspected for potential leaks and corrosion impact, water build up in the tanks will be drained regularly to prevent internal corrosion potential. - Tank level monitoring will be conducted at all times to identify potential rapid tank level loss indicating potential leaks
Fuel Storage	- Ignition of fuel in the tank	- Tank explosion and tank roof fire - Explosion overpressure and/or Heat radiation impact to surrounding area	- Flammable liquid tanks are all fitted with internal floating pans to eliminate the potential for vapour build up in the ullage space of the tank - All tanks will be fully vented with anti-flash gauze on vents to prevent ignition from entering the tank via the vent - All electrical equipment in the tank will be suitably specified for the specific hazardous area in which it will be installed - Tank temperature monitoring will be installed in all tanks to ensure liquids do not vaporise and generate flammable mixtures in tanks

TABLE A1
HAZARD IDENTIFICATION TABLE

Site Area	Cause	Consequence	Safeguard
Tanker loading pipework & Pumps	- Pipework, valve or flange leak - Pump seal leak	- Release of fuel to bunded area or in area between pumps and gantry - Potential to impact environment if release escapes offsite	- Pipework between tanks and pumps is bunded and leaks will be contained within the tanks bunded area - Pump seals are double mechanical type to minimise the potential for leak - Pump area is bunded to contain spills - Pipework between pumps and gantry is located in a spill containment to prevent spills offsite - Pump operation is only conducted when site is staffed and pump/filling operations can be continually monitored
Tanker loading pipework & Pumps	- Pipework, valve or flange leak - Pump seal leak - Ignition and fire in buned area, at pumps or in area between pumps & gantry	- Release of fuel to bunded area or in area between pumps and gantry - Potential for ignition of fuel leak and fire	- Fire main (complying with AS2419-Ref.10), fire pumps (complying with NFPA20 – Ref.7) and fire water tank - Fire hydrants and hose reels close to the pumps and pipework - Fire monitors with foam generation installed adjacent to the pump bund (but at safe distance) - Control of ignition sources in the pump bund area (bund will be classified as a hazardous area in accordance with Australian Standards – e.g. AS2430 (Ref.8) & AS60079 (Ref.9) - Ignition sources controlled on site (no smoking, hot work controlled by Permit, vehicle access monitored and controlled)
Fuel Tanker loading bays & gantry	- Tanker impacts gantry - Tanker driveaway whilst connected - Gantry loading arm failure (leak/rupture) - Operator error – incorrect connection of loading arm	- Release of fuel into the loading bay - Potential spill and impact to the environment	- Gantry/loading bay area is bunded to contain spills - Tanker loading operation is monitored by tanker drivers and terminal operators during the full transfer operations - Gantry area is under closed circuit television (CCTV) surveillance at all times, with screens in the main site office - Trucks are fitted with driveaway protection to prevent drivers leaving the site whilst the truck is connected to the gantry (via the loading arm) - Loading arms are fully tested at installation and maintained continually throughout the pant’s life - Bollard and “Armco” protection at the entry to the gantry/bay area - Dry break coupling installed on loading arm for connection to the tanker loading point

TABLE A1

HAZARD IDENTIFICATION TABLE

Site Area	Cause	Consequence	Safeguard
Fuel Tanker loading bays & gantry	- Fuel leak, ignition and fire	- Heat radiation impact - Potential spill and impact to the environment	- UV/IR fire detection installed in the gantry area - Foam sprinkler/deluge system installed over the gantry area - Fire main, hydrants and hose reels installed in the gantry area - Monitors with foam generation equipment installed adjacent to the gantry area - Control of ignition sources in the gantry area (gantry area will be classified as a hazardous area in accordance with Australian Standards – e.g. AS2430 (Ref.8) & AS60079 (Ref.9) - Computer controlled filling system operated by the tanker driver using a “swipe-card” - Operator & driver in full attendance during all transfer operations – alarm can be immediately raised in the event of spill & fire - Emergency button shut down (stops pump & isolates delivery valves) located in the gantry bays

APPENDIX B

CONSEQUENCE ANALYSIS

The following incidents have been assessed for consequence impact:

- Flexible line rupture at the bulk liquids transfer wharf, fuel leak, ignition and subsequent pool fire at the wharf;
- Ignition of flammable liquid in the bulk liquids storage tank leading to storage tank roof fire;
- Leak of flammable liquid into the bulk liquids storage tank bund, ignition and full bund fire;
- Transfer pump leak (seal or flange) resulting in spill to the pump bund, ignition and fire; and
- Flammable liquid leak at the gantry, ignition and pool fire in the bunded area of the loading bay.

B1 FLEXIBLE LINE RUPTURE - FIRE

B1.1 Fuel Leak Scenario

The transfer of bulk flammable/combustible liquids will be conducted using two 200mm hoses connected to the ship/shore. In the event of a hose rupture, it is feasible that only one hose would fail at any given time, hence, only single hose failure has been considered in this study.

The hose will be connected from the ship to the shore and will be about 20m long. The volume of fuel in the hose is therefore:

$$V = \pi/4 \times D^2 \times L = \pi/4 \times 0.2^2 \times 20 = 0.628\text{m}^3 \text{ or } 628 \text{ litres}$$

In the event of a rupture, the release will be immediately shut down using the isolation valves at the ship shore. Hence, the remaining hose volume will spill to the wharf and spread across the wharf. The liquid will spread to a thickness of 0.005mm (Ref.11 – main report) which will result in a pool diameter of:

$$D = (0.628/0.005 \times 4/\pi)^{0.5} = 12.65\text{m}$$

In the event of an ignition, the pool diameter of the fire will be 12.65m. This diameter has been used to estimate the impact to surrounding areas and to identify the location of the fire monitor.

Figure B.1 shows an illustration of a typical pool fire in a tank. It can be seen from this illustration that the flame burns above the tank walls and is affected by wind, causing the flame to tilt with the wind direction. Where a fire burns at ground level (i.e. a free pool fire), the walls height is not considered in the analysis.

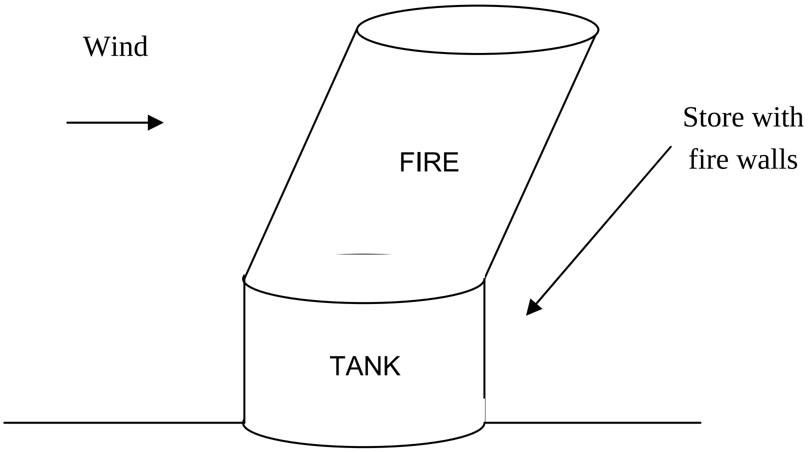


FIGURE B.1
EXAMPLE OF TYPICAL FIRE IN A STORE

The fire will act as a cylinder with heat from the cylindrical flame radiating to the surrounding area. A number of mathematical models may be used for estimating the heat radiation impacts at various distances from the fire. The point source method is adequate for assessing impacts in the far field, however, a more effective approach is the view factor method, which uses the flame shape to determine the fraction of heat radiated from the flame to a target. The radiated heat is also reduced by the presence of water vapour and carbon dioxide in the air. The formula for estimating the heat radiation impact at a set distance is:

$$Q = E \, F \, \tau$$

Where: Q = incident heat flux at the receiver (kW/m^2)
E = surface emissive power of the flame (kW/m^2)
F = view factor between the flame and the receiver
τ = atmospheric transmissivity

Figure B.2 shows the heat radiation path for the fire. It can be seen from this figure that flame tilt and height above ground level will have impacts on the amount of heat flux received by the target.

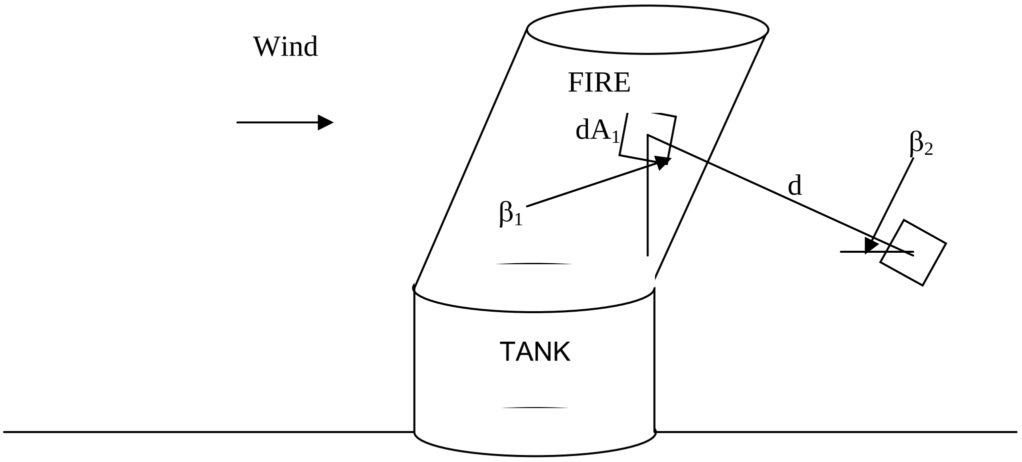


FIGURE B.2
HEAT RADIATION IMPACT ON A TARGET FROM A CYLINDRICAL FLAME

The calculation of the view factor (F) in **Figure B.2** depends upon the shape of the flame and the location of the flame to the receiver. F is calculated using an integral over the surface of the flame, S. The formula can be shown as:

$$F = \int\int_S \frac{\cos\beta_1 \cos\beta_2}{\pi d^2}$$

(see **Section B.2.3** for development of this formula)

The above formula may be solved using the double integral or using a numerical integration method in spread sheet form. This is explained in **Section B1.2**.

B1.2 Development of the Numerical Integration Model

Introduction

The spreadsheet calculator (SSC) determines the radiation flux experienced at a “target” originating from a cylindrical fire. It is intended typically for fires of flammable liquids (Class 3) though it can be used with any material so long as the “emissivity” of the flame is known. This is the heat flux at the surface of the flame and is given in kilo Watts per square metre (kW/m^2). The other parameters needed are: diameter of the fire, height of the fire walls, distance to target, height of flame, tilt of flame caused by wind. It is assumed that the walls have some height although there is no reason not to use the calculator for pool fires at ground level by entering a zero height.

Design Basis

The SSC is designed on the basis of finite elements. The fire is assumed to be in the shape of a cylinder of the same diameter as the equivalent pool diameter. The height of the fire can be calculated using the following formula:

$$L = 42D\left(\frac{m}{\rho_o (gD)^{0.5}}\right)^{0.61}$$

(Ref.12 – Main Report)

where: L= mean flame height (m)
D= pool diameter (m)
ρ_o= ambient air density (typically 1.2 kg/m3)
m= mass burning rate (kg/m2s) = 0.0667, based on 5mm/min burn down rate (Ref.13 – Main Report)
g= acceleration due to gravity (9.81 m/s2)

Once the flame height is known, the surface of the cylinder can be divided into many separate plane surfaces. To do this, a plan view of the fire was drawn and the relevant distances and angles allocated. The plan view is for the target and the base of the fire in the same horizontal plane.

The angle “theta” is varied from zero to 90 degrees in intervals of 2.5 degrees. Zero deg. represents the straight line joining the centre of the tank to the target (x0, x1, x2) while 90 deg. is the point at the extreme left hand side of the fire base. In this way the fire surface is divided up into elements of the same angular displacement. Note the tangent to the circle in plan. This tangent lies at an angle, gamma, with the line joining the target to where the tangent touches the circle (x4). This angle varies from 90 deg at the closest distance between the tank and the target (x0) and gets progressively smaller as theta increases. As theta increases, the line x4 subtends an angle phi with x0. By similar triangles we see that the angle gamma is equal to 90-theta-phi. This angle is important because the sine of the angle give us the proportion of the projected area of the plane. When gamma is 90 deg, sin(gamma) is 1.0, meaning that the projected area is 100% of the actual area.

Before the value of theta reaches 90 degrees the line x4 becomes tangential to the circle. The fire cannot be seen from the rear and negative values appear in the view factors to reflect this. The SSC filters out all negative contributions.

For the simple case, where the fire is of unit height, the view factor of an element is simply given by the expression:

VF = ∆A. sin(gamma)/(π. x4. x4) .... Eq 1

where ∆A is the area of an individual element at ground level.

Note the denominator (π. x4. x4) is a term that describes the inverse square law for radiation assumed to be distributed evenly over the surface of a sphere.

Applying the above approach, we see the value of x4 increase as theta increase, and the value of sin(gamma) decreases as theta increase. This means that the contribution of the radiation from the edge of the circular fire drops off quite suddenly compared to a view normal to the fire. Note that the SSC adds up the separate contributions of Eq 1 for values of theta between zero until x4 makes a tangent to the circle.

It is now necessary to do two things: (i) to regard the actual fire as occurring on top of a fire wall (store) and (ii) to calculate and sum all of the view factors over the surface of the fire from its base to its top. The overall height of the flame is divided into 10 equal segments. The same geometric technique is used. The value of x4 is used as the base of the triangle and the height of the flame plus the tank, as the height. The hypotenuse is the distance from target to the face of the flame (called X4'). The angle of elevation to the element of the fire (alpha) is the arctangent of the height over the ground distance. From the cos(alpha) we get the projected area for radiation. Thus there is a new combined distance and an overall equation becomes:

VF = ∆A. sin(gamma).cos(alpha)/(π. x4'. x4') .... Eq 2

The SCC now turns three dimensional. The vertical axis represents the variation in theta from 0 to 90 deg representing half a projected circle. The horizontal axis represents increasing values of flame height in increments of 10%. The average of the extremes is used (e.g. if the fire were 10 m high then the first point would be the average of 0 and 1 i.e. 0.5 m), the next point would be 1.5 m and so on).

Thus the surface of the flame is divided into 360 equal area increments per half cylinder making 720 increments for the whole cylinder. Some of these go negative as described above and are not counted because they are not visible. Negative values are removed automatically.

The sum is taken of the View Factors in Eq.2. Actually the sum is taken without the ∆A term. This sum is then multiplied by ∆A which is constant. The value is then multiplied by 2 to give both sides of the cylinder. This is now the integral of the incremental view factors. It is dimensionless so when we multiply by the emissivity at the "face" of the flame, which occurs at the same diameter as the fire base (o pool), we get the radiation flux at the target.

B1.3 Analysis Results

Prior to the development of the model, parameters were developed (e.g. pool equivalent diameter, flame height, SEP, wind tilt, etc.).

Flame Height:

$$L = 42D\left(\frac{m}{\rho_0 (gD)^{0.5}}\right)^{0.61}$$

where: L= mean flame height (m)
D= pool diameter (m)
ρo= ambient air density (typically 1.2 kg/m3)
m= mass burning rate (kg/m2s) = 0.0667, based on 5mm/min burn down rate (Ref.9)
g= acceleration due to gravity (9.81 m/s2)

Using a diameter of 12.65m, the flame height is 20.95m.

Wind Tilt is estimated to be 30^o

Surface Emissive Power (SEP) – is a function of the fire magnitude (i.e. diameter and height), which governs the amount of heat at the surface of the fire. Larger fires tend to generate larger quantities of soot or smoke, which shields the more luminous components of the flame. Large diameter pool fires average an SEP of about $20kW/m^2$. The average SEP of an 80m kerosene fire is about $10kW/m^2$, suggesting the correlation is conservative (Ref.9).

The correlation Johnson (Ref.14 – Main Report) give the following formula for calculating the SEP of a flame:

SEP = SEPm exp(-sD) + Es (1-exp(-sD))

Where: SEP = the total surface emissive power of the flame
SEPm = the maximum surface emissive power of luminous spots on a large hydrocarbon fuel flame (140kW/m2)
SEPs = the surface emissive power of a smokey flame (20kW/m2)
S = 0.12m-1 (an experimentally determined parameter)
D = diameter of the pool

Based on the above formula, the calculated SEP for the diesel fire is $46.3kW/m^2$.

Transmissivity – is the reduction in heat radiation due to the presence of water vapour and carbon dioxide in the atmosphere between the radiation source and the target. This can be calculated using the following formula:

$$\text{Transmissivity} = 1.006 - 0.01171(\log10X(H_2O) - 0.02368(\log_{10}X(H_2O)))^2 - 0.03188(\log_{10}X(CO_2) + 0.001164(\log_{10}X(CO_2)))^2$$ (Ref.13 – Main Report)

Where: $X(H_2O)$ = (RH x L x Smm x 2.88651 x 102)/T
$X(CO_2)$ = L x 273/T
RH = relative humidity
L = path length in metres
Smm = saturated water vapour pressure in mm mercury (= 17.535 @ 293K)
T = temperature in degrees Kelvin (293K)

The distance from the flame to the closest on site building at the wharf is about 50m, relative humidity is selected as 70% (0.7). Using these values and the values listed above, the transmissivity parameter is calculated to be 0.75.

Summary of Inputs to the SCC Model

Using the methodology presented in Section B2 the following inputs have been developed for the heat radiation model.

Fire Diameter	12.65m
Fire height	20.95m
Flame tilt	30 degrees
SEP	46.3kW/m2
Transmissivity	0.75

Consequence Analysis (SCC Model Results)

The SCC model was entered into a Microsoft Excel spread sheet and the data above input to the model. The heat radiation at the closest building on site (50m) was estimated to be 1.25kW/m^2.

The SCC was applied to determine the distance to selected heat radiation. The summary of results is presented in **Table B1**.

TABLE B1
DISTANCE TO SELECTED HEAT RADIATION IMPACT FLEXIBLE HOSE RUPTURE AND FIRE

Heat Radiation Level (kW/m^2)	Distance (m)
35	14.5
23	16.3
15	18.5
12.5	19.8
8	23.2
6	26
4.7	28.5
2	41

B2 TANK ROOF FIRE

The terminal has a total of 6 tanks, located in four bunded areas. There are three basic tank sizes:

- A large tanks for storage of diesel (NN1) - tank dimensions are 44m diameter x 17m high;
- Medium size tanks (2) for the storage of unleaded petrol (ND5 & ND6) – tank dimensions are 30m diameter x 17m high; and
- Smaller tanks for the storage of ethanol and biodiesel – tank dimensions are 16m diameter x 17m high.

The flammable liquid tanks are designed with floating roof pans to eliminate the potential for the generation of vapours in the space between the tank roof and fuel surface. In the event that a floating pan sinks and the fuel ignites in the space between the fuel surface and tank roof, the explosion will displace the roof leaving a fire burning at the tank surface. It is noted that tank roof design will result in roof failure without explosive force to the tank walls, hence, retaining the wall integrity and containing the fire.

The methodology used in **Section B1** was applied to each tank to determine the distance to selected heat radiation levels. The following values were used in the analysis:

	Large Tank	**Medium Tank**	**Small Tank**
Tank Diam	44m	30m	16m
Tank Height	17m	17m	17m
SEP	20.6kW/m^2	23.3kW/m^2	37.6kW/m^2
Fire Height	49.8m	38.2m	m
Flame Tilt	30^o	30^o	30^o

The results of the analysis are summarised in **Table B2**.

TABLE B2
DISTANCE TO SELECTED HEAT RADIATION IMPACT
TANK ROOF FIRES

Heat Radiation Level (kW/m^2)	**Large Tank**	**Medium Tanks**	**Small Tanks**
	Distance (m)	**Distance (m)**	**Distance (m)**
35	Not Reached*	Not Reached*	Not Reached*
23	22 (max 20.6kW/m^2)	15 (max 23.3kW/m^2)	Not Reached*
15	31	21.5	6 (max 14.3kW/m^2)
12.5	33.5	23.5	10.5
8	40	29	17.5
6	45	33.5	22
4.7	51	38	26
2	75	57	42

B3 FULL BUND FIRE

The tanks are located in four bunded areas on site (see **Figure 3.3**, main report). The bund areas are as follows:

- South West Bund – 3,813m^2;
- South East Bund – 2,780m^2;
- Central Bund – 2,870m^2; and
- Northern Bund – 2,560m^2.

In the event of a leak of liquid into the bund, there is a potential for the leak to ignite resulting in a bund fire. In the event the fire continues, there is a potential for the fire to impact and damage tanks, releasing further flammable liquid and eventually resulting in a full bund fire.

The fire would burn in the bund creating a cylindrical flame above the bund. The equivalent diameter of the fire is related to the bund area and can be calculated as follows:

South West Bund – $D = (4/\pi \times 3{,}813)^{0.5} = 69.7\text{m}$

South East Bund – $D = (4/\pi \times 2{,}780)^{0.5} = 59.5\text{m}$

Central Bund – $D = (4/\pi \times 2{,}870)^{0.5} = 60.5\text{m}$

Northern Bund – $D = (4/\pi \times 2{,}560)^{0.5} = 57.1\text{m}$

Based on the fire diameters above, the following data was applied to the SCC (see **Section B1**).

	South West Bund	**South East Bund**	**Central Bund**	**Northern Bund**
Fire Diam	69.7m	59.5m	60.5m	57.1m
SEP	20kW/m^2	20kW/m^2	20kW/m^2	20.1kW/m^2
Fire Height	68.6m	61.5m	62.2m	59.71m
Flame Tilt	30°	30°	30°	30°

The results of the analysis are summarised in **Table B3**.

TABLE B3
DISTANCE TO SELECTED HEAT RADIATION IMPACT
FULL BUND FIRE

Heat Radiation Level (kW/m^2)	South West Bund	South East Bund	Central Bund	Northern Bund
	Distance (m)	Distance (m)		
35	-	-	-	-
Max - 20	46	41	42	40
15	50	45	46	43
12.5	52.5	47	48	46.5
8	61	55	56	53
6	68	60	61	59
4.7	74	66	67	64
2	105	94	96	90

B4 PUMP LEAK (SEAL/FLANGE/VALVE) – PUMP BUND FIRE

Fuel loading/transfer pumps are located in a bunded area on the western side of the main tank bunds. In the event of a leak at the pump seal, flanges or valves, the leak will accumulate in the pump bund and if ignited will result in a pool fire in the bund.

The bund is 25m long by 6m wide, having an area of $150m^2$. The equivalent fire diameter is calculated by:

$$D = (4/\pi \times 150)^{0.5} = 13.8m$$

Based on a fire diameter of 13.8m, the following data was applied to the SCC (see **Section B1**).

	Pump Bund
Fire Diam	13.8m
SEP	$42.9kW/m^2$
Fire Height	22.25m
Flame Tilt	30^o

The results of the analysis are summarised in **Table B4**.

TABLE B4
DISTANCE TO SELECTED HEAT RADIATION IMPACT
PUMP BUND FIRE

Heat Radiation Level (kW/m^2)	Distance (m)
35	15.2
23	17
15	19.4
12.5	20.5
8	24.2
6	27
4.7	29.5
2	42

B5 Gantry Leaks, Ignition and Fire

Tanker loading is conducted in the gantry area using a bottom loading process. The tanker driver connects the loading gantry arm to the tanker and commences loading using a swipe card to initiate a computer control loading process. In the event the loading arm is not connected correctly (i.e. error), there is a potential for the arm to release resulting in a spill of liquid and the formation of a pool in the loading bay

In the event of an ignition of the fuel spill, a pool fire will result. The fire may spread and fill the full gantry bund, however, the bund is fitted with a foam sprinkler system that activates automatically in the event of a fire. In the event of a failure of the sprinkler system to activate, the pool fire has the potential to impact offsite areas to the west.

The bunded area around the loading bay/gantry is 30m long by 20m wide. The equivalent fire diameter is:

$$D = (4/\pi \times 600m)^{0.5} = 27.6m$$

Based on a fire diameter of 27.6m, the following data was applied to the SCC (see **Section B1**).

	Gantry Bund
Fire Diam	27.6m
SEP	24.4kW/m^2

Fire Height	36m
Flame Tilt	30^o

The results of the analysis are summarised in **Table B3**.

TABLE B3
DISTANCE TO SELECTED HEAT RADIATION IMPACT GANTRY BUND FIRE

Heat Radiation Level (kW/m^2)	Distance (m)
Max Reached 24.4	23.7
23	24.1
15	27
12.5	28.5
8	33
6	36.5
4.7	40
2	56