



**PRELIMINARY HAZARD ANALYSIS,  
STAGE 5 EXPANSION MODIFICATIONS,  
BITUMEN STORAGE AND HANDLING,  
TERMINALS PTY LTD, PORT BOTANY, NSW**

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***5 April 2011***

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**Preliminary Hazard Analysis, Terminals Pty Ltd,  
Stage 5 Modifications - Bitumen**

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<b>Rev</b>	<b>Date</b>	<b>Description</b>	<b>Reviewed By</b>
A	18/10/10	Draft for Comment	Terminals
B	3/11/10	Final Issue	Terminals
C	10/11/10	Heaters Information Updated	Terminals
D	14/2/11	Layout Updated	Terminals
E	17/2/11	Section 3.1.2 Updated	Terminals
F	25/3/11	Tanks 271 and 272 Re-incorporated	Terminals
G	5/4/11	Tank 275 Deleted	Terminals

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# EXECUTIVE SUMMARY

Terminals Pty Ltd (Terminals) is proposing to install a bitumen import, processing, storage and road tanker loading facility at the Port Botany terminal. This facility is proposed to be installed in the existing Stage 5 area adjacent to Simblist Road.

As part of the project requirements, a Preliminary Hazard Analysis (PHA) is required. This report details the results from the analysis.

The risks associated with the Stage 5 tanks, associated equipment and bitumen facilities at the Terminals site, Port Botany, have been assessed and compared against the DoP risk criteria.

In summary:

## 1. Fires:

- No risk of injury or fatality at residential areas or other sensitive land uses as the separation distance is large, i.e. 1 km or larger to residential areas;
- As the estimated radiant heat levels from potential fire events are approximately 12.6 kW/m<sup>2</sup> or lower at neighbouring industrial facilities, the likelihood of fatality at these locations is acceptably low and there exists a high probability of escape; and
- Propagation to neighbouring industrial facilities is not expected given that the significant levels of radiant heat are largely contained on-site.

## 2. Vapour explosions:

- These are considered rare events for these types of facilities and materials, and hence the risk of injury, fatality and/or propagation at residential areas or other sensitive land uses (i.e. more than 1 km away) or at neighbouring facilities is not considered intolerable.

3. The shipping and road transport activities associated with this project are commensurate with the zoning for the Port Botany area and are not considered intolerable.

## 4. Societal risk is qualitatively concluded to be acceptable given:

- Few events analysed in the study have the potential for off-site impact and, for the ones that do, their likelihood is acceptably low; and
- The population density in the Port Botany area is relatively low.

Therefore, the results of this PHA show that the risks associated with the proposed changes comply with the DoP guidelines for tolerable fatality, injury,

irritation, propagation and societal risk. Also, risks to the biophysical environment from potential hazardous events are broadly acceptable.

Additionally, the proposed bitumen handling and storage equipment have no significant impact to the cumulative individual risk contours (for future development planning) as presented in the Port Botany Land Use Safety Study by DUAP in 1996.

The primary reason for the low risk levels from the proposed changes is that significant consequential impacts from potential hazardous events (mainly radiant heat from fires) do not extend far from the relevant processing areas.

It is assumed that the proposed changes will be reviewed via the HAZOP methodology, a fire safety study will be performed and the existing safety management systems and emergency response plans will be updated to reflect the proposed changes.

The following recommendations are made from this review:

1. Include in the existing Terminals safety management system procedures for safely emptying and opening a bitumen tank or vessel given the risk of fires on contact with air.
2. Procedures need to be developed to routinely handle and remove carbonaceous deposits (possibly with iron sulphides which can result in a pyrophoric material) inside the bitumen tanks and vessels. If not routinely removed, the carbonaceous deposits may provide an ignition hazard when they are exposed to a sudden increase in temperature or oxygen supply. Also, solid deposits can float on the bitumen surface and these can interfere with level instruments.
3. Develop procedures to control the risk of hydrogen sulphide exposure to personnel in the vicinity of the bitumen handling equipment or those who are required to enter confined spaces associated with the bitumen equipment.
4. Develop procedures for heating a tank from cold given the risk of a boilover event from water in the tank being heated and evaporating.
5. Perform a SIL study on the proposed bitumen storage and processing facility to ensure the instrumented protective loops are suitably designed and are of adequate reliability for the potential hazardous events that can occur.
6. Ensure the transformer room / area is adequately designed to prevent fire propagation either from a transformer explosion / fire event, e.g. damage to the electrical switch gear, or from a switchroom fire.

# GLOSSARY

ACARRE	Australian Centre for Advanced Risk and Reliability Engineering
API	American Petroleum Institute
AS	Australian Standard
ASME	American Society for Mechanical Engineers
BLB	Bulk Liquids Berth
CCTV	Closed circuit television
CS	Carbon steel
DECCW	Department of Environment, Climate Change and Water
DG	Dangerous Good
DoP	NSW Department of Planning
DUAP	Department of Urban Affairs and Planning
EIS	Environmental Impact Statement
ESD	Emergency shutdown
FHA	Final hazard analysis
HAZAN	Hazard analysis
HAZOP	Hazard and operability study
HIPAP	Hazardous Industry Planning Advisory Paper
ISO	International Standards Organisation
LEL	Lower explosion limit
LPG	Liquefied petroleum gas
LNG	Liquefied natural gas
ML	Megalitre
PHA	Preliminary hazard analysis
PMPY	Per million per year
PPE	Personnel protective equipment
PULP	Premium unleaded petrol

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QRA	Quantitative risk assessment
ROV	Remotely operated valves
ROSOV	Remotely operated shut-off valves
SEP	Surface emissive power
SPC	Sydney Ports Corporation
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value
TNO	The Netherlands Organisation of Applied Scientific Research
TPL	Terminals Pty Ltd
UEL	Upper explosive limit
ULP	Unleaded petrol
VIE	Vacuum insulated expander
WW	Waste water

# REPORT

## 1 INTRODUCTION

### 1.1 BACKGROUND

Terminals Pty Ltd (Terminals) is proposing to install a bitumen import, processing, storage and road tanker loading facility at the Port Botany terminal. This facility is proposed to be installed in the existing Stage 5 area adjacent to Simblist Road.

The main features of the proposal are summarised as follows:

- Bitumen feed stock will be imported via BLB1 (Bulk Liquids Berth) and transferred to two heated 10 ML tanks;
- Bitumen feedstock will be processed to meet grade specifications and transferred to four 1ML day tanks;
- Specific bitumen grades will be transferred from the day tanks into road tankers via two new road tanker loading bays; and
- Loaded trucks will deliver bitumen to the customers.

The site has undergone a number of approvals since it was established in 1979. The Stage 5, 1997 approved project was the last of the five major expansion projects the company has undertaken at this site. The Stage 5 expansion project initially proposed the installation of approximately 12 tanks and associated equipment. However, only one tank was originally installed (Tank 270) with a new road tanker unloading / loadout facility.

In 2008, Terminals sought and gained approval for the installation of two new larger tanks in the Stage 5 area. These tanks are presently being built on site. Each tank will be 10,000 m<sup>3</sup> and are designed to store fuels such as diesel or unleaded petrol (ULP). An updated FHA was prepared and approved for the installation of these two tanks (Ref 1).

In 2009, Terminals sought and gained approval for the installation of two new smaller tanks in the Stage 5 area. These tanks are yet to be installed. Each tank will be 1,750 m<sup>3</sup> and will also be designed to store fuels such as diesel or unleaded petrol (ULP). An updated FHA was prepared and approved for the installation of these two tanks (Ref 2) but this project has not reached the pre-construction study phase which includes HAZOP, Fire Safety Study and finalised FHA.

Therefore, there are currently five tanks installed and approved for installation in the Stage 5 area of the terminal, i.e.:

- Tank 270 (original 5,000 m<sup>3</sup> tank - approved);
- Tanks 273 and 274 (10,000 m<sup>3</sup> tanks - approved); and
- Tanks 271 and 272 (1,750 m<sup>3</sup> tanks – approved but subject to pre-construction studies being approved).

The proposed bitumen facility is in addition to these five tanks with the exception of Tank 274. This tank is now proposed to store bitumen.

As part of the project requirements, a Preliminary Hazard Analysis (PHA) is required. This PHA has been prepared in accordance with the guidelines published by the NSW Department of Planning (DoP) Hazardous Industry Planning Advisory Paper (HIPAP) No 6 (Ref 3). Terminals have appointed Pinnacle Risk Management Pty Ltd (Pinnacle Risk Management) to prepare this Preliminary Hazard Analysis report.

As a revised FHA was prepared for the abovementioned five tanks in 2009 (Ref 2) then this analysis is an update of this report, i.e. all five Stage 5 tanks are included.

## **1.2 OBJECTIVES**

The main aims of this PHA study are to:

- Identify the credible, potential hazardous events associated with the existing and proposed Stage 5 expansion equipment;
- Evaluate the level of risk associated with the identified potential hazardous events to surrounding land users, including other Port Botany companies and their operations, and compare the calculated risk levels with the risk criteria published by the DoP in HIPAP No 4 (Ref 4);
- Review the adequacy of the proposed safeguards to prevent and mitigate the potential hazardous events; and
- Where necessary, submit recommendations to Terminals to ensure that the proposed modifications are operated and maintained at acceptable levels of safety and effective safety management systems are used.

## **1.3 SCOPE**

This PHA assesses the credible, potential hazardous events and corresponding risks associated with the Stage 5 equipment at the Terminals Port Botany facility with the potential for off-site impacts.

In summary, the assessment includes:

- The new equipment and operations associated with the bitumen import, processing, storage and road tanker loading facility;

- The existing tank 270 (currently used to store diesel) and the four approved tanks (271, 272, 273 and 274) and their associated equipment;
- On-site pipelines and the proposed new bitumen pipeline in the pipeline corridor from the Bulk Liquids Berth to site; and
- The existing Stage 5 road tanker loading bay that will be used for fuel export / import.

Off-site transport risk is not included in this PHA as off-site traffic impacts are to be assessed in the Review of Environmental Factors.

Qualitative assessment of the use of the berth operations and shipping activities is included in this report. The BLB is a purpose built wharf specifically for transferring hazardous cargo such as the materials stored at Port Botany, e.g. LPG, and it is used by a number of companies. Hoses are currently used without unacceptable levels of risk.

## **1.4 METHODOLOGY**

In accordance with the approach recommended by the DoP in HIPAP 6 (Ref 3) the underlying methodology of the PHA is risk-based, that is, the risk of a particular potentially hazardous event is assessed as the outcome of its consequences and likelihood.

The PHA has been conducted as follows:

- Initially, the Stage 5 equipment and its location were reviewed to identify credible, potential hazardous events, their causes and consequences. Proposed safeguards were also included in this review;
- As the equipment is located at a significant distance from other land users and the changes to the site are relatively moderate (the site already has 65 tanks), the consequences of each potential hazardous event were estimated to determine if there is any possible unacceptable off-site impacts;
- Included in the analysis is the risk of propagation between the Stage 5 equipment and the existing equipment (both onsite and off-site);
- Where adverse off-site impacts can occur, the likelihood of each potential hazardous event was reviewed, using appropriate techniques / methods, to check if there is any significant increase to existing risk levels and if the risk levels are within the criteria in HIPAP 4 (Ref 4); and
- A comparison is made to the existing Port Botany regional study (Ref 5) to determine if there is any impact on cumulative risk.

## **1.5 FINDINGS AND RECOMMENDATIONS**

The risks associated with the Stage 5 tanks, associated equipment and bitumen facilities at the Terminals site, Port Botany, have been assessed and compared against the DoP risk criteria.

In summary:

### **1. Fires:**

- No risk of injury or fatality at residential areas or other sensitive land uses as the separation distance is large, i.e. 1 km or larger to residential areas;
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### **2. Vapour explosions:**

- These are considered rare events for these types of facilities and materials, and hence the risk of injury, fatality and/or propagation at residential areas or other sensitive land uses (i.e. more than 1 km away) or at neighbouring facilities is not considered intolerable.

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Therefore, the results of this PHA show that the risks associated with the proposed changes comply with the DoP guidelines for tolerable fatality, injury, irritation, propagation and societal risk. Also, risks to the biophysical environment from potential hazardous events are broadly acceptable.

Additionally, the proposed bitumen handling and storage equipment have no significant impact to the cumulative individual risk contours (for future development planning) as presented in the Port Botany Land Use Safety Study by DUAP in 1996.

The primary reason for the low risk levels from the proposed changes is that significant consequential impacts from potential hazardous events (mainly radiant heat from fires) do not extend far from the relevant processing areas.

It is assumed that the proposed changes will be reviewed via the HAZOP methodology, a fire safety study will be performed and the existing safety management systems and emergency response plans will be updated to reflect the proposed changes.

The following recommendations are made from this review:

1. Include in the existing Terminals safety management system procedures for safely emptying and opening a bitumen tank or vessel given the risk of fires on contact with air.
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3. Develop procedures to control the risk of hydrogen sulphide exposure to personnel in the vicinity of the bitumen handling equipment or those who are required to enter confined spaces associated with the bitumen equipment.
4. Develop procedures for heating a tank from cold given the risk of a boilover event from water in the tank being heated and evaporating.
5. Perform a SIL study on the proposed bitumen storage and processing facility to ensure the instrumented protective loops are suitably designed and are of adequate reliability for the potential hazardous events that can occur.
6. Ensure the transformer room / area is adequately designed to prevent fire propagation either from a transformer explosion / fire event, e.g. damage to the electrical switch gear, or from a switchroom fire.

## **2 SITE DESCRIPTION**

The proposed expansion is to be located on the Terminals leased land at 45 Friendship Road, Port Botany. The land is part of the Port Botany reclamation area owned by the Sydney Ports Corporation (SPC) and is devoted to port and associated activities. The nearest residents are over 1 kilometre away. See Figure 1 for details of the site location.

Port Botany is one of the major ports in New South Wales with trade including petroleum products, liquefied petroleum gas (LPG), and liquid chemicals. The majority of industries in the Port Botany industrial region are involved in the storage and distribution of these products and are located on Friendship Road in the vicinity of the site. These industries include:

*Hydrocarbons:* The terminal imports and stores ethylene, propane and butane for transport by pipeline to Botany Industrial Park manufacturing site at Botany.

*Vopak (Sites A and B):* These terminals store and distribute products similar to those at Terminals Pty Ltd.

*Origin Energy:* The site imports LPG by sea tankers and stores it for distribution by road tankers.

*Elgas Pty Ltd:* An underground storage cavern and above-ground facilities for storing and distributing LPG.

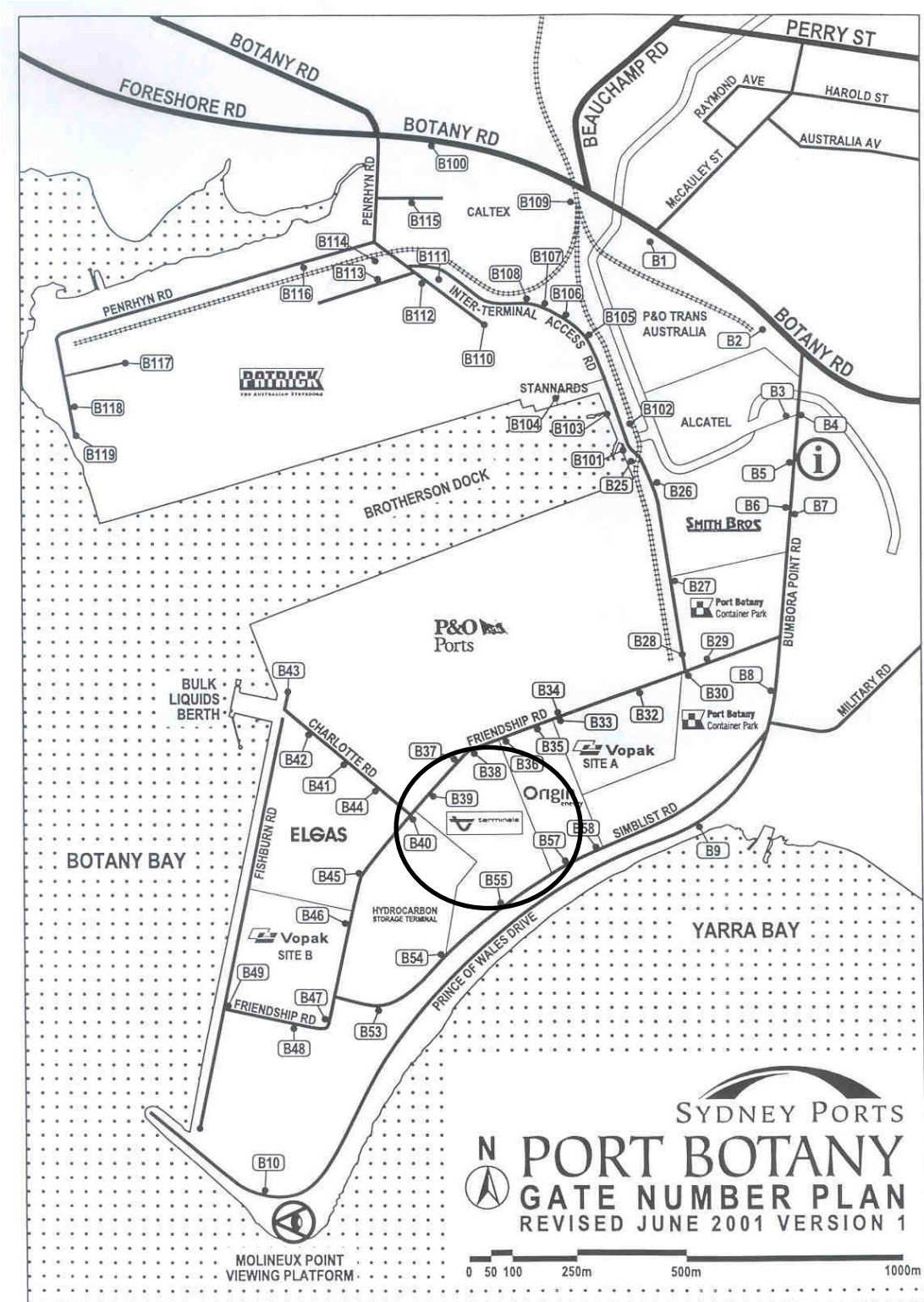
*P&O Ports, Molineaux Point:* A facility for storing and distributing shipping containers.

Construction of the Terminals site began in 1978 and has expanded in five major stages to date. The terminal has 65 tanks of various sizes with a total storage capacity of 53,000 m<sup>3</sup> of bulk liquids ranging from animal fats, vegetable oils, industrial chemicals, petrochemicals and petroleum products. These products are handled into and out of the terminal by:

- Sea-going parcel tankers from the Bulk Liquids Berth at the end of Charlotte Road;
- Road tankers;
- Drums;
- Pipeline from the Orica petrochemical complex at Botany; and
- Iso-tank containers.

The dangerous goods stored at the site are Classes 3, 6, 8 and 9. Combustibles (C1 and C2) are also stored in bulk. Liquid nitrogen is stored in a small VIE for tank blanketing etc.

Figure 1 - Site Location



The site layout, including the proposed bitumen facilities, is shown in Figure 2.

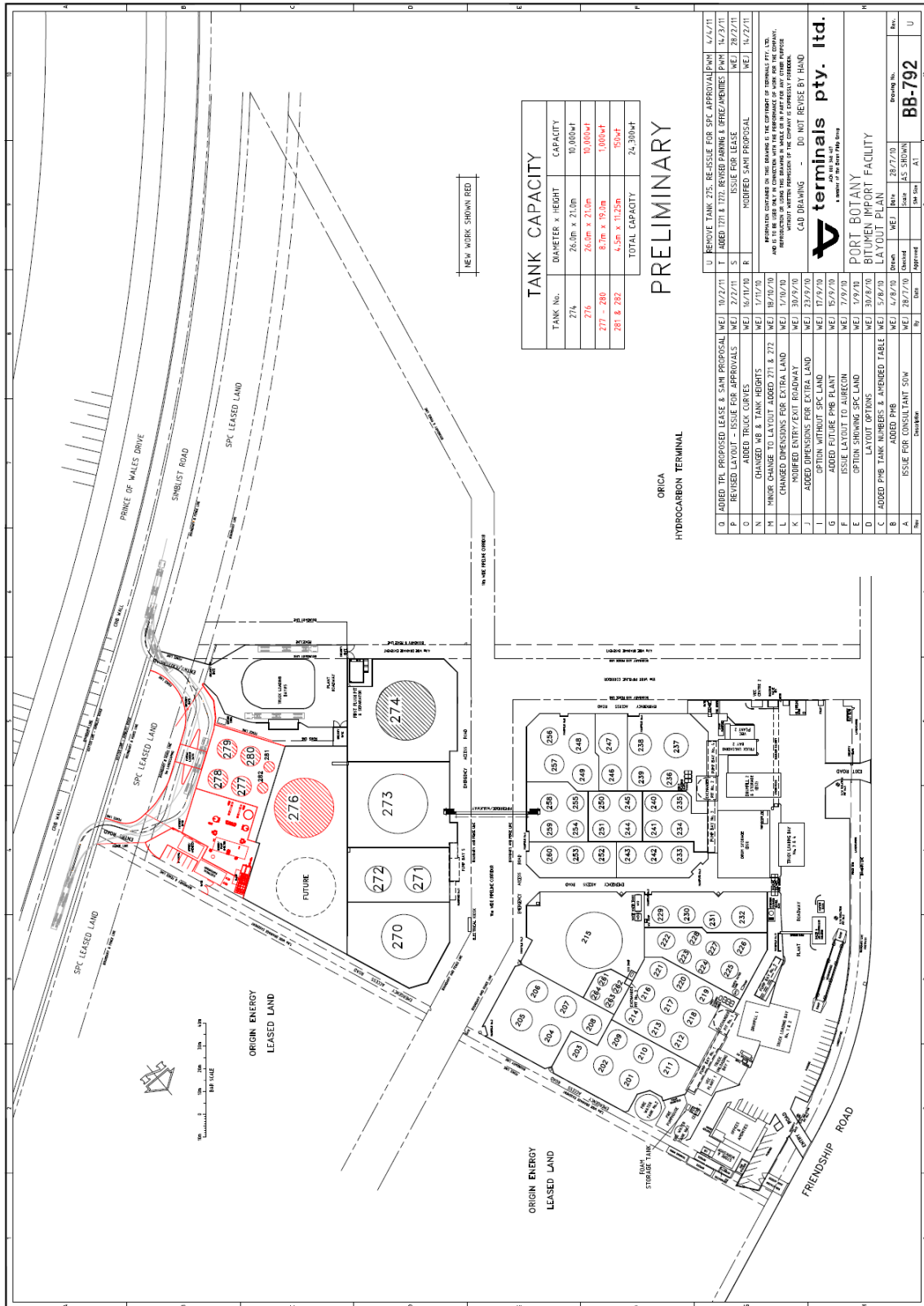
Security of the site is achieved by a number of means. This includes site personnel and security patrols by an external security company (this includes weekends and night patrols). The site normally operates 5 days per week (day shift only, depending on whether a ship is in or not). Also, the site is fully fenced (1.5 kilometres) and non-operating gates are locked (e.g. to the pipeline corridor). The main entrance and exit gates are normally closed. A security swipe card is required to open them. Security cameras (16 CCTV and four cameras in the Stage 5 area) are installed for staff to view visitors and site activities.

The bitumen road tanker loading system and tank farm will have six new CCTV cameras.

There are approximately 20 people on site (plus drivers, visitors etc) during normal working hours.

Depending on weather conditions, the site may lie under the flight path to /from Sydney Airport. There are no known natural hazards associated with this location that pose unacceptable levels of risk.

Figure 2 – Site Layout



TANK No.	DIAMETER x HEIGHT	CAPACITY
274	26.0m x 21.0m	10,000m <sup>3</sup>
276	26.0m x 21.0m	10,000m <sup>3</sup>
277 - 280	8.5m x 19.0m	1,000m <sup>3</sup>
281 & 282	4.5m x 11.25m	500m <sup>3</sup>
TOTAL CAPACITY		24,300m <sup>3</sup>

**PRELIMINARY**

ORICA  
HYDROCARBON TERMINAL

Rev.	Issue For Consultant SOW	Date	Issue For Lease	Issue For Approval	Issue For Approval
U	REVISED TANK 775 RE-USE FOR SPC APPROVAL FROM	14/2/11	WE	14/2/11	WE
T	ADDED T11 & T12S FOR APPROVALS	22/2/11	WE	22/2/11	WE
P	REVISED LAYOUT - ISSUE FOR APPROVALS	22/2/11	WE	22/2/11	WE
O	ADDED TRUCK CURVES	16/11/10	WE	16/11/10	WE
N	CHANGED W8 & TANK HEIGHTS	17/11/10	WE	17/11/10	WE
M	MINOR CHANGE TO LAYOUT ADDED 271 & 272	18/10/10	WE	18/10/10	WE
L	CHANGED DIMENSIONS FOR EXTRA LAND	17/10/10	WE	17/10/10	WE
K	ADDED DIMENSIONS FOR EXTRA LAND	30/9/10	WE	30/9/10	WE
J	ADDED DIMENSIONS FOR EXTRA LAND	17/9/10	WE	17/9/10	WE
I	OPTION WITHOUT SPC LAND	15/9/10	WE	15/9/10	WE
G	ADDED FUTURE PHE PLANT	15/9/10	WE	15/9/10	WE
F	ISSUE LAYOUT TO AURECON	15/9/10	WE	15/9/10	WE
E	OPTION SHOWING SPC LAND	15/9/10	WE	15/9/10	WE
D	LAYOUT OPTIONS	30/8/10	WE	30/8/10	WE
C	ADDED PHE TANK NUMBERS & AMENDED TABLE	15/8/10	WE	15/8/10	WE
B	ADDED PHE	15/8/10	WE	15/8/10	WE
A	ISSUE FOR CONSULTANT SOW	28/7/10	WE	28/7/10	WE
Rev.	Issue For Consultant SOW	Date	Issue For Lease	Issue For Approval	Issue For Approval

terminal's pty. ltd.  
PORT BOTANY  
BITUMEN IMPORT FACILITY  
LAYOUT PLAN

### **3 BITUMEN FACILITY DESCRIPTION**

The proposed bitumen import, processing, storage and road tanker loadout facilities are described as follows. The previous Stage 5 changes were described in Refs 1 and 2 and are not reiterated here.

From Ref 6, the proposed bitumen facility will occupy approximately 6,000 square meters at the Stage 5 area adjacent to Simblist Road. The reason for the project is the closure of the Kurnell Bitumen Refinery so Sydney's bitumen needs will need to be imported.

Projected annual throughput of the proposed new facility is 200,000 tonnes of bitumen feedstock. The project projections indicate an impact on wharf operations with an increase in shipping movements at BLB1 of approximately 33 receipts per annum. There are two imported bitumen grades; C170 and C320. Bitumen is typically stored at approximately 130 to 150 C and loaded out at approximately 190 C. Heating will be primarily done by two hot oil heaters using natural gas.

The C170 grade is transferred to two 1,000 m<sup>3</sup> day tanks for load out. The C320 grade is treated by an aeration process to generate an AR 450 multi grade bitumen to meet NSW road specifications via two 1,000 m<sup>3</sup> day tanks for load out. In addition, speciality batches are provided by a separate aeration process into two smaller 150 m<sup>3</sup> tanks. The two aeration processes vent to the combustor or the hot oil heaters for vapour treatment. Also, the two aeration processes have heating and cooling equipment and controls using the hot oil heaters and water bath plus cooling towers.

The bitumen dispatch facility will operate 24/7 365 days per annum with the entrance and exit from Simblist Rd, Port Botany. Road tanker loading is envisaged to average 15 trucks per day.

#### **3.1 PROJECT SCOPE SUMMARY**

##### **3.1.1 Tankage and Major Equipment Items**

Approximately 14,000 m<sup>3</sup> total new working volume comprising:

- One new 10 ML bitumen storage tanks for imported hot bitumen grades (existing Tank 274 will also be used to store imported bitumen);
- Four x 1 ML bitumen day tanks;
- Two x 150 kilolitre batching tanks;
- One x 100 kilolitre feed preheating tank plus heat exchangers;
- Two aeration (oxidation) towers including catalyst addition;
- Two air compressors; and

- Associated insulated piping and pumping equipment.

### **3.1.2 Heating Systems and Combustor**

Two gas fired hot oil heater systems will be used to heat and maintain the temperature of the bitumen in the storage tanks and during loading into a road tanker.

A combustor is to be located near the proposed Stage 5 bitumen road tanker loading bay for treating vapours from the two larger bitumen tanks during ship unloading operations, aeration process venting and from road tankers during filling.

### **3.1.3 Truck Loading Gantry**

- Two bay road tanker loading gantry with access to and from Simblist Road;
- Loading from the site 365/24/7 by driver self-loading; and
- Average loading of 15 trucks per day.

### **3.1.4 Wharf Shipping**

- Dedicated carbon steel heated insulated pipeline from BLB1 (250 mm diameter);
- Average unloading of 33 ships per annum; and
- Ship / shore connection by flexible hose.

## **3.2 PROPOSED BITUMEN TANKS**

It is proposed to construct one new large storage tank with a capacity of 10,000 m<sup>3</sup>. The tank is to be 26 metres diameter and have an overall height of 21 metres. With a modified Tank 274, these two tanks will be used to store two imported grades of bitumen called C170 and C320.

The four day tanks will be 8.7 m diameter and 19 m high whilst the two batching tanks will be 4.5 m diameter and 11 m high.

The tanks will be fixed roof carbon steel and fabricated to API 650 standard. The venting of these tanks will be to a combustor for the two large tanks during ship unloading operations and the day / batch / preheat tanks will be vapour balanced back to their filling tanks where possible. Overfill protection includes the installation of two independent level systems with high level alarms as well as an automatic computer driven transferring system between tanks.

Protection systems on the storage tanks will include:

- Procedures for liquid transfers, stormwater management, regular maintenance and inspection;
- Fully welded and tested carbon steel plate construction;
- Remote emergency shutdown valves on the tank outlet lines;
- Connection to a combustor for processing of the vapour emitted during filling of the two large tanks and from road tanker filling;
- Internal vapour balancing lines between tanks for tank filling;
- Structural integrity tests conducted every 10 years in accordance with AS1940;
- Non-return valves in the pipeline at the bulk liquids berth while all tanks will be filled from the top to prevent backflow;
- Containment of liquid within proposed capacity bund to meet AS1940 requirements;
- Automatic computer driven transfer systems;
- High level and redundant high high level alarm systems;
- Firewater ring main around the Stage 5 area;
- Emergency response plan including communication with site control centre; and
- Emergency alarms.

### **3.3 EXTRA BUND CAPACITY**

In compliance with AS1940, which requires a bund to be able to contain the contents of the largest tank as well as an appropriate amount of rainwater, the bitumen tanks bunded area will have extra capacity by overflowing into the existing Stage 5 bunded area as well as overflowing into the new bunds for Tanks 276 to 282. Any loss of containment from the existing tanks in the Stage 5 area (currently Tanks 270, 273 and 274) will initially fill the existing Stage 5 bund for these tanks. If the spill is larger than this volume, the overflow will be directed to the bund for Tank 276 and then to the bund for Tanks 277 to 282 (should the spill be worst case). To achieve this philosophy and remain compliant with the requirements of AS1940, Terminals have decided to store only combustible materials in all Stage 5 tanks, i.e. Tanks 270 to 274.

The bitumen facility bunded areas will have a sump for the collection of rainwater and possible spills. Water collected in the sump will be sampled and inspected prior to release. Should the water be contaminated, it will be pumped to a collection tank and transported to an approved Department of Environment,

Climate Change and Water (DECCW) waste treatment facility. If the water is not contaminated it will be released to stormwater via an oil / water separator by opening a manual valve.

### **3.4 OPERATIONAL DETAILS**

The proposal is to be integrated into the management and operational structure of the existing bulk liquid storage facility. This includes operating in compliance with the existing Safety Management System and Environmental Manual. The facility is certificated to ISO 9001 Quality Management System and ISO 14001 Environmental Management System.

It is proposed to use the management, technical and operational staff from the existing Terminals facility. The bitumen processing equipment will always have operational personnel present when it is being run.

#### **3.4.1 Road Tanker Loading / Unloading Procedures**

The loading of bitumen into road tankers will be a driver only operation.

When the driver enters the site via Simblist Road using an electric access card, this will start a timer that limits the time the driver has on site. If this time is exceeded the security monitoring company will investigate the cause of delay. Loading interlock systems are in place to ensure that the driver connects up to the vapour discharge and tanker overfill protection before loading can commence. Automatic top loading is via purpose built tanker loading arms and road tankers will load at a rate of up to 1,500 litres per minute into each road tanker.

There will be a number of protection features in operation at the loading / unloading bay (similar to the existing Stage 5 loading bay) including:

- Procedures for drivers, operator training, maintenance, training of maintenance employees, contractor safety training and emergencies;
- Specific driver training in loading / unloading operations, liquid transfers and stormwater management;
- Requirement that the driver must be present during manual loading operations;
- Automatic slow initial and final loading rates to prevent inertia pressure surges;
- Local Emergency Stop stations will be installed that initiate pump shutdowns and tank isolations;
- Roofed area to minimise the potential contamination of stormwater;

- Facilities to contain spills or contaminated rainwater and to return this material to the existing liquid effluent tank and/or alternative storage tank;
- Fire water hose points;
- Foam and dry powder fire extinguishers;
- Loading ceases if the air line breaks as the air actuated valves fail closed;
- Containment of the largest tanker compartment contents in the event of a spill;
- Continuous closed circuit television monitoring in place;
- Independent road tanker overfill protection device located with the tanker loading nozzle to prevent overflow condition by shutting down the loading system upon detecting a high level in the tanker;
- Dedicated and separate protected booth for protecting drivers while loading hot bitumen in case of splashing or leaks;
- Dead man recognition requiring the driver to press the key pad every 2.5 minutes to verify that loading is continuing safely;
- Top loading to minimise leaks and spills while connecting and disconnecting hoses;
- Recovery of displaced vapours from the road tanker head space to a combustor for treatment; and
- A first-flush and separator pit designed for spill containment along the driveway.

For safety reasons, no queuing of trucks is permitted within the site. Two road tankers can be loaded simultaneously. The envisaged average loading rate is 15 trucks per day.

The weighbridge system will be automatically set up for self service during out of normal business hours and it will be under camera surveillance to an on-site operator for safety and security reasons.

### **3.4.2 Spill Management**

Specific operating and emergency procedures exist for the management of spills at the terminal as outlined below and vary according to the magnitude of the spill as well as considering liquid bitumen will solidify.

Spills are categorised as:

1. Very Minor Spill (<20 litres);
2. Minor Spills (<500 litres); and
3. Major Spill (>500 litres):

Procedures include:

- Contain the spill within the bunded area and/or by isolation of the stormwater discharge from the site and/or local containment;
- Add appropriate absorbent; and
- Dispose of absorbent to an approved Environment Protection Authority facility.

### **3.5 FIRE PREVENTION AND CONTROL**

Portable fire extinguishers will be available in the road tanker loading bay. A firewater ring main will be located around the perimeter of the bitumen tank farm with several available firewater hydrant points and availability of hydrants near the loading area. Fire water is provided via two existing diesel operated fire water pumps in the existing site with 1,400m<sup>3</sup> of water in storage and continuous replenishment from the Sydney Water reticulation system.

At the operational areas and exit of the loading bay will be manual fire call points as well as emergency exit points at the Simblist Road fenceline for personnel.

## **4 HAZARD IDENTIFICATION**

### **4.1 HAZARDOUS MATERIALS**

The combined stage 5 equipment will handle and store the following chemicals:

1. Combustible liquids such as diesel / biodiesel;
2. Bitumen;
3. Natural gas;
4. Hot oil; and
5. Catalyst (for the bitumen oxidation towers).

A summary of the material hazards is given below.

Diesel, including biodiesel, is classified as a combustible liquid, C1. Similarly, the hot oil for the bitumen processing is a combustible liquid. However, as it will be handled at elevated temperatures, there is an increased risk of fires when losses of containment occur, e.g. spraying of the hot oil with a source of ignition.

All petroleum products are potentially injurious to humans, e.g. carcinogenic properties, and aquatic organisms.

#### ***Bitumen***

Bitumen is a complex black solid consisting of high molecular weight organic compounds with carbon numbers greater than C25 and high carbon to hydrogen ratios. It is used for road building, and industrial and civil engineering applications. It is not classified as Hazardous according to the Worksafe Australia criteria but it is combustible. Bitumen is relatively stable and unlikely to react in a hazardous manner.

Bitumen can contain hydrogen sulphide, which is a toxic and flammable gas, as well as other flammable light hydrocarbons. The latter can collect in confined spaces, e.g. within a tank, and hence pose an explosion hazard. Control of ignition sources, e.g. avoid static buildup, equipment should be earthed and hoses to be electrically continuous, is therefore required. Any confined areas where hydrogen sulphide can collect pose significant risks to humans due to its toxicity. As bitumen's normal boiling point and flash point are both above 250°C then the fire hazard is relatively low. Care is therefore required to prevent overheating.

As bitumen is a solid at ambient temperature, it is normally handled and stored at temperatures above 100°C. Therefore, contact with hot bitumen is a potential burn hazard.

In the presence of water, there is a risk of boilover, i.e. on heating of the bitumen and hence water, steam can be rapidly evolved with the potential to overpressure tanks with subsequent losses of containment. Therefore, bitumen tanks need to be as watertight as possible and any steam heating coils are regularly checked for leaks. For bulk bitumen storage, the temperature should not be allowed to fluctuate above and below 100°C due to the risk of water condensation leading to boilover.

It is possible that pyrophoric (self-heating) deposits may form inside storage tanks. These can lead to fires and/or explosions. Products of combustion include smoke, carbon dioxide, carbon monoxide, hydrogen sulphide and oxides of sulphur.

Whilst bitumen is not biodegradable, spills are unlikely to penetrate into the soil and cause significant environmental impact. As it is relatively stable, spills are also unlikely to have a long term impact on the aquatic environment.

### **Natural Gas**

Natural gas is a Class 2.1 Dangerous Good (flammable gas).

Natural gas is a colourless hydrocarbon fluid mainly composed of the following hydrocarbons:

- Methane (typically 88.5% or higher);
- Ethane (typically 8%);
- Propane (typically 0.2%);
- Carbon dioxide (typically 2%); and
- Nitrogen (typically 1.3%).

For a typical natural gas, the TLV is approximately 1,000 ppm and the STEL (short term exposure limit) is 30,000 ppm (i.e. approaching 5 vol% which is the lower explosive limit).

The hydrocarbons are not considered to represent a significant environmental threat. Their hazard potential derives solely from the fact that they are flammable materials.

To enable ready leak detection, natural gas is normally odourised with mercaptans (sulphur containing hydrocarbons).

The flammability range is typically 5% to 15% v/v in air. The vapours are lighter than air and will normally disperse safely if not confined and/or ignited.

Natural gas ignition can lead to jet fires, flash fires or vapour cloud explosions.

Products of combustion include carbon monoxide and carbon dioxide.

## **Catalyst**

The catalyst used in the bitumen oxidation towers is ferrous chloride (FeCl<sub>2</sub>).

Ferrous chloride is a non-combustible, acidic solution (DG Class 8). It can decompose on heating to emit toxic fumes such as hydrogen chloride. Therefore, if involved in a fire, fog sprays can be used to absorb any emitted hydrogen chloride. Ferrous chloride is also incompatible with ethylene oxide, potassium and sodium.

## **4.2 POTENTIAL HAZARDOUS INCIDENTS REVIEW**

In accordance with the requirements of *Guidelines for Hazard Analysis*, (Ref 3), it is necessary to identify hazardous events associated with the tank operations. As recommended in HIPAP 6, the PHA focuses on “atypical and abnormal events and conditions. It is not intended to apply to continuous or normal operating emissions to air or water”.

A search of available literature and information was conducted to review the types of historical events that can occur with bulk fuel terminals and bitumen facilities. The search included the following references:

1. Frank Lees, Loss Prevention in the Process Industries (Ref 7);
2. Australian, US and UK Departments of Transport records;
3. US National Transport Safety Board statistics;
4. US Occupational Health and Safety Administration statistics;
5. US Chemical Safety and Hazard Investigation Board statistics;
6. UK Health and Safety Executive statistics; and
7. Previous risk studies for terminals.

A review of larger reported tank fire incidents worldwide has been carried out (Ref 8). It was found that there have been no serious injury or fatality incidents to surrounding land users in advanced countries (characterised by modern technology, knowledgeable management and good emergency services) in the past 30 years.

## **4.3 HAZARDOUS EVENTS - SHIPPING**

Whilst it is not the purpose of this PHA to perform a detailed analysis of all shipping activities at or near the BLB, the following types of potential hazardous events are included for information. As previously noted in Section 1.3, the BLB is a purpose built wharf specifically for transferring hazardous cargo such as the materials stored at Port Botany and it is used by a number of companies. The proposed changes to Terminals operations are commensurate with the design intent of the BLB.

Hazardous events resulting from the release of the products include pool fires upon ignition and pollution of the local environment.

Shipping incidents which could occur that may lead to losses of containment of products include grounding, collision (ship-ship), impacts with the wharf and movement away from the wharf during transfer.

Descriptions of potential scenarios are as follows (Refs 7 and 9).

### ***Grounding***

Grounding occurs when a vessel runs onto the shore or submerged rocks and would require either loss of power and/or steering, human error or severe weather conditions.

### ***Striking***

This is where a vessel moored at the wharf is struck by another passing vessel. The risk of significant damage to the moored vessel in such an event clearly depends on the size, speed, direction and type of the vessel doing the impacting.

### ***Collision***

Collision refers to the collision of two vessels underway, either with their own power or being manoeuvred by tugs. The potential energy in such a collision may theoretically be sufficient to damage the outer and inner (if included) hulls of a vessel.

### ***Impact with Wharf***

Impact with the wharf / jetty could result from the vessel approaching the wharf too fast or attempting to dock during bad weather.

### ***Fire / Explosion***

A fire or explosion (e.g. within the engine room) on a vessel may spread to involve the cargo and/or bunker. A fire / explosion could also occur directly within the cargo.

### ***Transfer Incidents***

Losses of containment can occur while a vessel is being loaded / unloaded. Causes include water hammer from, for example, fast closing of valves, movement of the ship away from the wharf, line failures due to mechanical impact from a vehicle, corrosion, mechanical defect (e.g. poor weld), flange leaks and thermal expansion of trapped liquid causing overpressure, hose or hose coupling failures, and human error, e.g. leaving drain valves open. Overflowing of the vessel's tanks can also occur during loading.

In addition to the above events, the following events are also possible but are generally found to represent lower risks:

***Foundering / Capsize***

This occurs when a ship sinks in rough weather or a leak has occurred.

***Structural Failure***

This occurs where the cargo tank cracks due to fatigue, wave loads, vibration or adverse cargo load distribution.

***Aircraft Strike***

There exists the possibility of an aircraft or helicopter impact with the ship.

***Spontaneous Failure***

Manufacturing defects may lead to a spontaneous failure of the cargo tank.

***Domino Incident***

Where an accident on one ship either causes or is caused by an accident on a nearby ship or in a storage or process plant onshore.

***Sabotage / Terrorism***

It is possible that an act of sabotage, either from company or non-company employees or terrorism can lead to a loss of containment.

***Natural Events***

Natural events such as strong winds can lead to losses of containment.

***Other Causes***

Other causes that can lead to hazardous events include liquid sloshing in a cargo tank and overpressurisation of a cargo tank.

The accident outcomes for the above causes for a loss of containment of products could be a fire (pool fire) and/or environmental effect, including fish and bird kill. These events can also lead to injuries due to radiant heat impact and/or equipment damage. Fires will also release products of combustion such as carbon dioxide, carbon monoxide, water vapour, NOx, soot etc. These potential hazardous events can occur now at the BLB or immediate area for the bulk liquid fuels.

#### **4.4 HAZARDOUS EVENTS – TERMINAL OPERATIONS**

In keeping with the principles of risk assessments, credible, hazardous events with the potential for off-site effects have been identified. That is, “slips, trips and falls” type events are not included nor are non-credible situations such as an aircraft crash occurring at the same time as an earthquake. The large majority of the specific release scenarios are generic equipment failures, e.g. failures of tanks, pipes etc, from previous industrial incidents. These are supplemented by process incidents due to other abnormal modes of operation, control system failure and human error.

The credible, significant incidents identified for the five existing and approved bulk fuel storage tanks at Stage 5 are summarised in the first Hazard Identification Word Diagram following (Table 1).

The credible, significant incidents identified for proposed bitumen facility at Stage 5 are summarised in the second Hazard Identification Word Diagram following (Table 2). A literature search of incidents involving bitumen processing and storage facilities indicates numerous events involving bitumen. One study (Ref 10) on heated bitumen tanks shows that there were 73 significant incidents reported in the UK during the period 1971 to 1992. The results of the literature search are combined in the scenarios in Table 2.

These diagrams present the causes and consequences of the events, together with major preventative and protective features that are included as part of the design.

**Table 1 – Hazard Identification Word Diagram – Stage 5 Bulk Storage Tanks**

Event ID No.	Hazardous Event	Causes	Possible Consequences	Proposed Prevention and Mitigation Control Measures
1.	Major mechanical failure of tanks	Metal fatigue Faulty fabrication Corrosion of tank base / weld Tank explosion due to lightning strike / breach of hazardous area ignition source controls Adjacent tank on fire Blocked vent	Large spillage of combustible materials in bund. Fire if ignited For historical tank explosions, some tanks have rocketed away from the foundations Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)	Tanks designed to API 650 Regular maintenance and inspection procedures Tank and site fire protection facilities available Explosions only occur when ullage vapour is between LEL and UEL. For combustible liquids, the vapour concentration is expected to be below the LEL. Design conforms to AS1940 requirements
2.	Tank roof failure Note that Tank 272 is proposed to be a fixed roof tank and Tank 271 will have an internal floating roof	Ignition, e.g. by lightning, of atmosphere within the roof space Vents blocked during filling procedure High speed filling	Rim seal fire (floating roof tank) Tank top fire Initial explosion possible leading to a tank top fire Potential for spill into the bund with a fire if ignition occurs Boil over possible if water layer exists Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)	Internal floating roof with mechanical shoe seal Foam injection system Fire fighting system Regular maintenance and inspection procedures Level alarms, controlled tank filling Explosions prevention as per Item 1

<b>Event ID No.</b>	<b>Hazardous Event</b>	<b>Causes</b>	<b>Possible Consequences</b>	<b>Proposed Prevention and Mitigation Control Measures</b>
3.	Pipe failure (i.e. new piping within the terminal)	Corrosion Impact Maintenance work Pressure surge	Spillage of combustible material. Fire if ignited. Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)	Regular maintenance and inspection procedures Emergency isolation valves on the new tanks Fire fighting system (including foam) Pipes sometimes in banded areas Pipelines surge study The piping is designed to ASME 31.3 / AS 4041 to resist the combined effects on internal pressure due to contents, wind loads, earthquake forces and hydrostatic test loads
4.	Pipeline failure external to the terminal – note that this is existing piping	As per 3 above plus vandalism	As per 3 above	Regular maintenance and inspection procedures Emergency isolation valves Fire fighting system (including foam) Pipelines surge study Routine inspections during transfers

<b>Event ID No.</b>	<b>Hazardous Event</b>	<b>Causes</b>	<b>Possible Consequences</b>	<b>Proposed Prevention and Mitigation Control Measures</b>
5.	Spillage of combustible material to the existing or approved or proposed bunds	Tank overfilled during transfer  Tank drain valve left open or tank sampling valve left open, e.g. human error	Spill into bund  Bund fire if ignited  Possible tank fire and boil over  Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)	Fire fighting as above  Two independent level devices installed  Emergency shutdown system  Operating procedures  Sampling and inspection procedures prior to disposing of waste bund water
6.	Leak during filling of existing road tanker	Failure of loading arm  Leak from valves or fittings  Road tanker overfill	Leak of petroleum product in loading area  Fire if ignited  Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)	High level of surveillance and use of leak detection & shutdown systems  Drivers are well trained so as to minimise chance of operator error & ensure quick response to leaks  Road tanker bay to be fitted with automatic foam deluge system (if filling flammable product)  Ignition sources controlled  Scully truck overfill shutdown system and vent knock out pot level shutdown system

<b>Event ID No.</b>	<b>Hazardous Event</b>	<b>Causes</b>	<b>Possible Consequences</b>	<b>Proposed Prevention and Mitigation Control Measures</b>
7.	Road tanker drive-away incident (i.e. driver does not disconnect the hose and drives away from the loading bay)	Failure of procedures and hardware interlocks	Leak of petroleum product in loading area  Fire if ignited  Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)  Ignition source present (road tanker engine), hence fire more likely	Driver training  Driver not in cab during filling  Brakes interlocked prior to connection and until disconnection  Road tanker bays to be fitted with automatic foam deluge system  "Dry-break" hose couplings
8.	Leak at product pumps	Pump seal, shaft or casing failures	Leak of petroleum product in loading area  Fire if ignited  Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)	Double mechanical seal with seal failure trip interlock (if filling flammable product)  Condition monitoring and preventative maintenance of pumps  Fire fighting as above  Pumps in contained area
9.	Leak at vapour recovery unit	Failure of vessel due to corrosion or other cause	Potential for fires and environmental impact	Regular maintenance and inspection procedures  Gas detection system and alarm  Stoppage of road tanker filling  Fixed firewater monitors for fighting fires

<b>Event ID No.</b>	<b>Hazardous Event</b>	<b>Causes</b>	<b>Possible Consequences</b>	<b>Proposed Prevention and Mitigation Control Measures</b>
10.	Road accident (off-site)	Bad road or traffic conditions	Most likely outcome is no loss of load  Leak may occur, leading to fire  Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)	Design of road tankers to survive accident without a loss of containment - pipes and running gear designed to shear off without product loss  Driver training and choice of routes to reduce accident potential
11.	Aircraft crash	Pilot error  Bad weather  Plane fault	Propagation to tank / bund fires  Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)	As per aviation standards
12.	Strong winds, earthquakes	Strong winds cause equipment damage etc	Loss of containment leading to a fire if ignited (as above)	The tanks are designed API 650 / AS 1692 / AS 1170 to resist the combined effects on internal pressure due to contents, weight of platforms, ladders, live loads, wind loads, earthquake forces and hydrostatic test loads  Operations stopped in adverse weather conditions
13.	Breach of Security / Sabotage	Disgruntled employee or intruder	Possible release of product with consequences as per above	Security measures include fencing, CCTV, security patrols, operator / driver vigilance  Pressure tests prior to commissioning transfer  Pipe inspections prior to commissioning transfer; regularly during ship discharge and otherwise on a periodic basis

**Table 2 – Hazard Identification Word Diagram – Bitumen Facility**

Event ID No.	Hazardous Event	Causes	Possible Consequences	Proposed Prevention and Mitigation Control Measures
14.	Explosion within a bitumen tank or vessel	<p>Buildup of flammable gases from the bitumen with subsequent source of ignition.</p> <p>Welding on a tank with bitumen still present.</p> <p>Unblocking pipes or vents with direct flames.</p> <p>Low level in the bitumen tanks with exposure of the heating tubes. This can lead to temperatures above the autoignition point for the vapours in the tank.</p> <p>Overheating a tank and hence the potential for greater flammable vapour generation.</p> <p>Smouldering of deposits on the underside of the roof can lead to high enough temperatures (if sufficient oxygen is present) for the flammable vapours to autoignite</p>	<p>Damage to the tank and possible injury to people nearby, e.g. by ejected bitumen. Potential for missile generation and propagation to nearby equipment, e.g. the bulk liquid tanks in the Stage 5 area. Explosions can result in a bitumen fire.</p> <p>For historical tank explosions, some tanks have rocketed away from the foundations</p>	<p>Bitumen tanks have frangible roofs to prevent excessive explosion overpressures developing.</p> <p>Bitumen tanks have 600 mm diameter emergency vents.</p> <p>Control of ignition sources throughout the terminal.</p> <p>All equipment is to be earthed.</p> <p>Hot work permits for maintenance.</p> <p>Unblocking procedures are based on the storage and handling of bitumen products standard (DR 07435 CP; previously AIP CP 20).</p> <p>Large storage tank temperatures are automatically controlled at about 145 C and smaller day storage tanks at about 190 C.</p> <p>Heating is by coils via hot oil and no direct flame heating.</p> <p>Hot oil high temperature is limited with alarms and trips.</p> <p>Storage tanks designed to maintain minimum level above heating floor coils.</p>

Event ID No.	Hazardous Event	Causes	Possible Consequences	Proposed Prevention and Mitigation Control Measures
				Fire protection facilities available, e.g. ring main with hydrants
15.	<p>Self-ignition of bitumen.</p> <p>Note that when oxygen levels fall below 3%, the tank condition favours the formation of pyrophoric materials. Smouldering of deposits can lower the oxygen levels to below 3%</p>	<p>Bitumen heated and exposed to air.</p> <p>Deposits can build-up, e.g. under tank roofs due to the condensation of hot vapours, which can auto-ignite around 190°C or at lower temperatures if iron sulphide is present. Deposits can also self-heat if their thickness exceeds critical values. Deposit formation will increase with overheating, i.e. excessive vapour generation</p>	<p>Tank fire (typically slow burning) with toxic products of combustion and radiant heat emitted. Potential for injury to people nearby and environmental impact</p>	<p>Large storage tank temperatures are automatically controlled at about 145 C and smaller day storage tanks at about 190 C.</p> <p>Heating is by coils and no direct flame heating.</p> <p>Hot oil high temperature is limited with alarms and trips.</p> <p>Storage tanks are balanced with atmospheric air in breathing (21% oxygen).</p> <p>Storage tank roofs are not heated but they are insulated.</p> <p>Deposits within tanks are to be removed during ten year tank shutdowns when the tank is cool and high pressure water jetting or mechanical cutting tools are used</p>
16.	<p>Burns or exposure to hydrogen sulphide. Note that these events will not contribute to off-site risk but are included for completeness</p>	<p>People exposed to hot bitumen from losses of containment.</p> <p>People exposed to hydrogen sulphide from losses of containment or entering confined spaces</p>	<p>Burn injuries.</p> <p>Potential for toxic impact from hydrogen sulphide. This may result in fatality if the dose is high enough. Note that people may suffer loss of smell at high concentrations of hydrogen sulphide, e.g. 300 ppm</p>	<p>The piping design is to comply with existing Terminals and Australian Standards, e.g. AS4041, to minimise the likelihood of losses of containment.</p> <p>Trained first aiders on site for elevated temperature bitumen burns.</p> <p>Safety showers are to be located throughout the bitumen processing facility for quick</p>

Event ID No.	Hazardous Event	Causes	Possible Consequences	Proposed Prevention and Mitigation Control Measures
				<p>quenching of any hot bitumen that may be stuck on people's skin or for cooling of any burns.</p> <p>Road tanker loading is enabled by driver being in a protected booth and fumes extracted from area.</p> <p>Confined space entries, risk assessments and permits are included in the Terminals safety management system.</p> <p>The bitumen will not be heated above 200°C in the storage tanks nor road tankers to avoid generating too much fumes.</p> <p>Fumes / vapours are handled by extracting / treating or returned to source tanks and are not free vented to limit exposure potential.</p> <p>Emergency response including ringing 000 to get an ambulance for the affected people to get to hospitals for further treatment</p>
17.	Tank boilover	Water entering a tank and being heated	Steam will be generated with the potential to overpressure the tank, causing failure, and resulting in a loss of containment	<p>All tanks to be kept above 100°C to prevent water condensation.</p> <p>Tanks have 600 mm diameter emergency vents as well as open goose neck vents</p>

<b>Event ID No.</b>	<b>Hazardous Event</b>	<b>Causes</b>	<b>Possible Consequences</b>	<b>Proposed Prevention and Mitigation Control Measures</b>
18.	Overflowing a bitumen tank	<p>Incorrect conversion factors for changes in bitumen temperature.</p> <p>Failure of the level instruments</p>	<p>Potential for burns.</p> <p>Potential for a fire if exposed to source of ignition with injury to people, damage to equipment and environmental impact from products of combustion</p>	<p>Bitumen tanks safefill level to be nominated and included in the level monitoring and alarming system. Internal transfers to be done through a computer driven checking and monitoring system; in effect doubles the level gauging.</p> <p>Level instrumentation to be included in the existing Terminals preventative maintenance systems.</p> <p>Redundant independent level systems on all tanks with additional alarms.</p> <p>Tanks are bunded.</p> <p>Control of ignition sources in the bunded areas</p>
19.	Major mechanical failure of tanks	<p>Metal fatigue</p> <p>Faulty fabrication</p> <p>Corrosion of tank base / weld</p> <p>Adjacent tank on fire</p> <p>Blocked vent</p>	<p>Large spillage of bitumen in bund. Fire if ignited.</p> <p>Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)</p>	<p>Tanks designed to API 650.</p> <p>Bitumen solidifies quickly when heating removed.</p> <p>Regular maintenance and inspection procedures.</p> <p>Tank and site fire protection facilities available</p>

Event ID No.	Hazardous Event	Causes	Possible Consequences	Proposed Prevention and Mitigation Control Measures
20.	Loss of containment from piping systems	Pipe failures, e.g. due to corrosion, valves left open, hose failures, pump seal, shaft or casing failures	<p>Potential for burns.</p> <p>Potential for a fire if exposed to source of ignition with injury to people, damage to equipment and environmental impact from products of combustion</p>	<p>Regular maintenance and inspection procedures.</p> <p>Emergency isolation valves on the outlet lines of the new tanks.</p> <p>Fire fighting system.</p> <p>Most pipes in banded areas; all pumps are banded.</p> <p>Pipelines surge study.</p> <p>The piping is designed to ASME 31.3 / AS 4041 to resist the combined effects on internal pressure due to contents, wind loads, earthquake forces and hydrostatic test loads.</p> <p>Trained first aiders on site for elevated temperature bitumen burns.</p> <p>Safety showers are to be located throughout the bitumen processing facility for quick quenching of any hot bitumen that may be stuck on people's skin or for cooling of any burns.</p> <p>Operators to wear additional appropriate PPE for handling bitumen if they have potential for exposure; i.e. heat resistant gauntlet gloves, face shield and hood (all skin protected).</p> <p>Bitumen hoses to be included in the existing</p>

Event ID No.	Hazardous Event	Causes	Possible Consequences	Proposed Prevention and Mitigation Control Measures
				Terminals Hose Register with routine inspection, testing and replacement
21.	Loss of containment at the berth	Pipe failures, e.g. due to corrosion, valves left open, hose failures	<p>Potential for burns.</p> <p>Potential for a fire if exposed to source of ignition with injury to people, damage to equipment and environmental impact from products of combustion.</p> <p>Potential for bitumen to enter the water and hence environmental impact</p>	<p>The piping design is to comply with existing Terminals and Australian Standards, e.g. AS4041, to minimise the likelihood of losses of containment.</p> <p>Operators to wear additional appropriate PPE for handling bitumen if they have potential for exposure; i.e. heat resistant gauntlet gloves, face shield and hood (all skin protected).</p> <p>Safety showers are located at the BLB for quick quenching of any hot bitumen that may be stuck on people's skin or for cooling of any burns.</p> <p>Trained first aiders on site for elevated temperature bitumen burns.</p> <p>Bitumen hoses to be included in the existing Terminals Hose Register with routine inspection, testing and replacement.</p> <p>The main processing areas are bunded</p>

<b>Event ID No.</b>	<b>Hazardous Event</b>	<b>Causes</b>	<b>Possible Consequences</b>	<b>Proposed Prevention and Mitigation Control Measures</b>
22.	Loss of containment in the Pipeline Corridor	Pipe failures, e.g. due to corrosion, thermal overpressure or third party activity / malicious act	<p>Most likely outcome is a spill onto the ground with subsequent cooling and solidification. Few sources of ignition exist in the Pipeline Corridor.</p> <p>Note, however, when solid deposits are heated, there is the risk of flammable vapours being evolved with subsequent ignition and burning of the bitumen</p>	<p>Regular maintenance and inspection procedures.</p> <p>Emergency isolation valves.</p> <p>Fire fighting system.</p> <p>Pipelines surge study.</p> <p>Routine inspections during transfers</p>
23.	Insulation fires	Loss of containment of bitumen into the piping, tank or vessel insulation	Potential for fires, i.e. from burning of the bitumen and/or flammable vapours, and hence propagation to the adjoining system	<p>Small amount of bitumen adsorbed as limited to about 50 mm thick insulation around tanks.</p> <p>Flammable vapours are limited and H<sub>2</sub>S is readily noticeable at low odour levels of 0.005 ppm well before LEL.</p> <p>Combustible product.</p> <p>Fire fighting systems</p>
24.	Failure of a hot oil heater coil	High temperature induced failure, cycling of the metal temperature, corrosion, material of construction failure	Potential for bitumen and flammable vapours to enter the heating circuit. The flammable vapours could ignite, e.g. when exiting the hot oil head tank	<p>Hot oil piping designed to suit conditions.</p> <p>Hot oil piping system is higher pressure (usually 5 to 10 bar) than bitumen storage so leaks are into bitumen system. Top of bitumen tanks are designed for Zone 1 so no immediate ignition sources.</p> <p>Regular testing and monitoring of hot oil for degradation and in turn contamination.</p> <p>Fire fighting systems</p>

Event ID No.	Hazardous Event	Causes	Possible Consequences	Proposed Prevention and Mitigation Control Measures
25.	Hot oil fires	Loss of containment of hot oil with subsequent ignition, e.g. pump seal failures	<p>Hot oil fire with the potential to burn people and/or damage nearby equipment. Products of combustion, e.g. smoke, will have an environmental impact.</p> <p>Any fire in the bitumen processing area also has the potential to involve the oxidation catalyst (ferrous chloride). In this case, there is the potential for toxic products to be emitted, e.g. hydrogen chloride</p>	<p>Hot oil is combustible product at maximum temperature.</p> <p>Fire fighting systems</p>
26.	Loss of containment of natural gas	<p>Pipe failure, e.g. corrosion, flange failure or impact.</p> <p>Valve left open</p>	<p>Potential for a jet fire, flash fire or vapour cloud explosion (particularly if some degree of confinement exists), if ignited. These events can lead to injury and/or radiant heat / explosion overpressure damage to equipment. In the absence of confinement, most probable outcome will be jet or flash fires if ignited</p>	<p>Piping is copper and at low pressure.</p> <p>Piping is designed and constructed to AS 2885, Gas Pipelines code.</p> <p>Fully welded pipeline with no flanges in the natural gas pipeline except at regulator; metering and control valve stations / areas.</p> <p>All drain and vent valves are plugged.</p> <p>Annual pipeline inspection as part of the regular maintenance and inspection procedures.</p> <p>Piping is located in open areas promoting good dispersion of buoyant gas.</p> <p>Gas is odorous and periodically patrolling enables easy detection if leaking.</p> <p>Emergency Plan of isolation procedures when fire fighting</p>

<b>Event ID No.</b>	<b>Hazardous Event</b>	<b>Causes</b>	<b>Possible Consequences</b>	<b>Proposed Prevention and Mitigation Control Measures</b>
27.	Internal explosion within the oil heaters	Passing natural gas isolation valves during a shutdown and the heaters are not adequately purged at startup	Potential for an internal explosion within the heater which can result in injuries to nearby personnel and/or damage to equipment. Historically, the effects of these types of incidents are generally local to the heaters	Double isolation valves as automatic shutdown.  Pre-purge before start up sequence.  Testing of shutdown and pre-purge sequence on a regular basis to AS 3788 as part of regular maintenance and inspection procedures
28.	Internal explosion within the combustor	Gas mixture is in the flammable region, e.g. during a startup, and a source of ignition is present, e.g. flame igniter	Potential for an internal explosion within the combustor which can result in injuries to nearby personnel and/or damage to equipment. Historically, the effects of these types of incidents are generally local to the combustors (the combustor is an open ended burner in a vertical chamber)	No flame shutdown of double isolation valves.  Pre-purge before start up sequence.  Testing of shutdown and pre-purge sequence on a regular basis to AS 3788 as part of regular maintenance and inspection procedures
29.	Transformer fires	Short circuiting, build-up of flammable gas (hydrogen) in the oil with subsequent ignition, loss of containment of oil with subsequent ignition	Potential for an initial explosion followed by a fire involving the transformer oil. Potential to damage nearby equipment and/or injure people	Low load, sealed 11KV transformer.  Testing schedule for transformers and oil degradation.  Separated from plant and people activity areas.  Emergency Response Plan includes fire events
30.	Bacterial growth in the cooling tower	Dead-legs, inadequate chemical dosing	Potential for Legionella bacteria to grow which can cause sickness in humans	Routine chemical dosing by a specialist company with on-going testing

<b>Event ID No.</b>	<b>Hazardous Event</b>	<b>Causes</b>	<b>Possible Consequences</b>	<b>Proposed Prevention and Mitigation Control Measures</b>
31.	Cooling tower fire	During a shutdown, the cooling tower could dry out	Any dried timber, if ignited (e.g. by hot work), can result in immediate ignition and loss of the cooling tower	Control of ignition sources during a shutdown, e.g. hot work permit.  Wetting of the tower during shutdowns.  Fire fighting systems
32.	Loss of containment of cooling tower dosing chemicals or catalyst (ferrous chloride)	Hose failure, pipe failure, valve left open	Potential for people to be exposed to corrosive liquids.  Potential for environmental impact if the spilt liquids are released via the stormwater system	All dosing chemicals / systems are located within the process area bunded compound, i.e. secondary containment provided for all dosing chemicals
33.	Leak during filling of road tanker	Failure of loading arm.  Leak from valves or fittings.  Road tanker overfill	Leak of bitumen in loading area.  Fire if ignited.  Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)	High level of surveillance and immediate access button to shutdown systems.  Drivers are well trained so as to minimise chance of operator error and ensure quick response to leaks.  Ignition sources controlled at top of road tanker.  Road tanker overfill shutdown system and vent knock out pot level shutdown system  Fire fighting systems

<b>Event ID No.</b>	<b>Hazardous Event</b>	<b>Causes</b>	<b>Possible Consequences</b>	<b>Proposed Prevention and Mitigation Control Measures</b>
34.	Road tanker drive-away incident (i.e. driver does not disconnect the hose and drives away from the loading bay)	Failure of procedures and hardware interlocks	<p>Leak of bitumen in loading area.</p> <p>Fire if ignited.</p> <p>Impact to people (radiant heat and/or exposure to products), property and the environment (products of combustion)</p>	<p>Driver training.</p> <p>Driver not in cab during filling but monitoring at same elevation as loading arm.</p> <p>Automatic loading system instructs driver on actions required.</p> <p>Ignition sources controlled at top of road tanker.</p> <p>Fire fighting systems</p>

## **4.5 SAFETY MANAGEMENT SYSTEMS**

Safety management systems are intended to minimise the risk from potentially hazardous installations by a combination of hardware (i.e. design) and software factors (managements systems such as procedures, policies, plans, training etc). To ensure safe operation of the terminal, both the hardware and the software systems must be of high standard.

The proposed terminal modifications will necessitate changes to the existing safety management system.

Terminals' operations and safety management systems at Port Botany have been previously reviewed during hazard audits by Pinnacle Risk Management (Refs 11, 12 and 13). These hazard audits have found that the safety management systems in use at the time of the audits are generally adequate for the nature of the hazards present.

### **Emergency Response**

An audible alarm alerts plant operators if an emergency occurs. Emergency procedures exist for the site and are routinely tested via simulated emergencies. This includes joint Port Botany exercises. The emergency response procedure will require updating as a result of the proposed changes.

#### **4.5.1 Safety Software in Risk Assessment**

In risk assessments, incidents are assessed in terms of consequences and frequencies (where necessary), leading to a measure of risk. Where possible, frequency data comes from actual experience. However, in many cases, the frequencies used are generic, based on historical information from a variety of plants and processes with different standards and designs.

The quality of the management systems (known as "safety software") in place in these historical plants will vary. Some will have little or no software, such as work permits and modification procedures, in place. Others will have exemplary systems covering all issues of safe operation. Clearly, the generic frequencies derived from a wide sample represent the failure rates of an "average plant". This hypothetical average plant would have average hardware and software safety systems in place.

If an installation with below average safety software is assessed using generic frequencies, it is likely that risk will be underestimated. Conversely, if a plant is above average, the risk will probably be overestimated. However, it is extremely difficult to quantify the effect of software on plant safety.

Therefore, Pinnacle Risk Management adopts a policy which does not attempt to quantitatively account for the presence of and quality of software safety systems. It is assumed that the generic failure frequencies used apply to installations which have safety software corresponding to accepted industry practice. It is believed that this assumption will be conservative in that it will

overstate the risk from well managed installations such as the Terminals' site. Therefore, any quantitative approach is valid (i.e. conservative) only if safety management within the operation being assessed is of a high standard.

## **5 RISK ANALYSIS**

The assessment of risks to both the public as well as to operating personnel around this industrial development requires the application of the basic steps outlined in Section 1. As per HIPAP 6 (Ref 3), the chosen analysis technique should be commensurate with the nature of the risks involved.

The typical risk analysis methodology attempts to take account of all credible hazardous situations that may arise from the operation of processing plants etc. For quantitative risk analysis (QRA), this is done by first taking a probabilistic approach to vessel and pipe failures for all vessels containing hazardous materials. Specific incidents, identified by a variety of techniques, are then added and the combined data used to generate composite risk contours which can be used for both the public and plant personnel.

Having assembled data on possible incidents, risk analysis requires the following general approach for individual incidents (which are then summated for all potential recognised incidents to get cumulative risk):

$$\text{Risk} = \text{Likelihood} \times \text{Consequence}$$

For QRA and hazard analysis, the consequences of an incident are calculated using standard correlations and probit-type methods which assess the effect of fire radiation, explosion overpressure and toxicity to an individual, depending on the type of hazard.

In this PHA, however, the approach adopted to assess the risk of the identified hazardous events is scenario based risk assessment. The reasons for this approach are:

1. The distance to residential and other sensitive land users is large for the Port Botany area and hence it is unlikely that any significant consequential impacts, e.g. due to radiant heat from fires, from the Stage 5 equipment will have any significant contribution to off-site risk; and
2. The distance between the on-site tanks and other equipment to the neighbouring industrial facilities is relatively large, hence, the consequential impacts may not have any significant contribution to off-site industrial risk.

Therefore, appropriate analysis of credible scenarios is performed in this PHA. Initially, the consequences of the potential events with off-site impact are assessed. For the events which do not contribute to off-site risk (as determined by the risk criteria in HIPAP No. 4 (Ref 4) then no further risk analysis is warranted. When the consequence of an event does contribute to off-site, the likelihood and hence risk is then analysed as required.

The risk criteria applying to developments in NSW are summarised in Table 3 below (from Ref 4).

**Table 3 - Risk Criteria, New Plants**

<b>Description</b>	<b>Risk Criteria</b>
Fatality risk to sensitive uses, including hospitals, schools, aged care	$0.5 \times 10^{-6}$ per year
Fatality risk to residential and hotels	$1 \times 10^{-6}$ per year
Fatality risk to commercial areas, including offices, retail centres, warehouses	$5 \times 10^{-6}$ per year
Fatality risk to sporting complexes and active open spaces	$10 \times 10^{-6}$ per year
Fatality risk to be contained within the boundary of an industrial site	$50 \times 10^{-6}$ per year
Injury risk – incident heat flux radiation at residential areas should not exceed $4.7 \text{ kW/m}^2$ at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year	$50 \times 10^{-6}$ per year
Toxic exposure - Toxic concentrations in residential areas which would be seriously injurious to sensitive members of the community following a relatively short period of exposure	$10 \times 10^{-6}$ per year
Toxic exposure - Toxic concentrations in residential areas which should cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community	$50 \times 10^{-6}$ per year
Propagation due to Fire and Explosion – exceed radiant heat levels of $23 \text{ kW/m}^2$ or explosion overpressures of 14 kPa in adjacent industrial facilities	$50 \times 10^{-6}$ per year

As discussed above, the consequences of the potential hazardous events are initially analysed to determine if any events have the potential to contribute to the above-listed criteria and hence worthy of further analysis.

## 5.1 POOL FIRE MODELLING

The credible hazardous events associated with the Stage 5 terminal and bitumen operations are largely pool fires due to potential losses of containment being ignited. The potential fire events associated with all the Stage 5 area tanks and bunds are detailed in Table 5 (all events are included for cumulative risk assessment purposes). This data is used in the fire modelling. A discussion on burndown rates and surface emissive powers is given below.

### ***Burndown Rates:***

For burning liquid pools (Ref 14), heat is transferred to the liquid via conduction, radiation and from the pool rim. For pool fires less than 1 m diameter, the radiative heat transfer and the resulting burning rate increases with pool diameter. For pool diameters greater than 1 m, radiative heat transfer dominates, thus a constant burning rate is expected.

Wind can affect the burning rate (experiments have shown both an increase and decrease in burning rates due to the effects wind) but also can affect flame stability (and hence average flame emissive power) (Ref 15). Therefore, average reported values for burndown rates are used in this study.

For very large pool fires with diameters greater than 5 to 10 m, there is some evidence of a slight decrease in burning rate. This is believed to be due to poor mixing with air and is unlikely to reduce the burning rate by more than 20%.

Typical burndown rates for diesel are 4 to 6 mm/min (Refs 7 and 16). Therefore, an average value of 5 mm/min is taken as the fire scenarios typically involve large diameters for these materials. Due to the heavy nature of bitumen, the burndown rate is taken to be 2 mm/min (Ref 7).

The burning rate is used in the determination of flame height. Normally, the higher the burning rate, the higher the estimated flame height.

### ***Surface Emissive Power:***

Surface emissive power can be either derived by calculation or by experimentation. Unfortunately, experimental values for surface emissive powers are limited.

When calculated, the results can be overly conservative, particularly for large diameter fires, as it is assumed that the entire flame is at the same surface emissive power. This is not the case for large diameter fires as air entrainment to the centre of the flame is limited and hence inefficient combustion occurs.

A surface emissive power correlation that fits experimental data well for products that produce smokey flames (as is the case for diesel in tanks 270 to 273 as well as bitumen) is as follows (Ref 14):

$$\text{SEP (average)} = 140 \times e^{(-0.12 \times D)} + 20 \times (1 - e^{(-0.12 \times D)})$$

Where D = the pool fire diameter.

The constant, 140 kW/m<sup>2</sup>, is the maximum emissive power of luminous spots and the constant, 20 kW/m<sup>2</sup>, is the emissive power of smoke.

The values in the following table are derived from this equation.

**Table 4 – Predicted SEP**

Diameter, m	SEP Average, kW/m <sup>2</sup>
1	126
5	86
10	56
15	40
20	31
25	26
30	23
35	22
40	21
45	21
50	20

Note that materials such as propane, ethane, LNG, ethanol and other low molecular weight materials do not produce sooty flames.

The distances to specified radiant heat levels for the potential fire scenarios are shown in Table 5. The distances were calculated using the View Factor model for pool fires (Refs 7 and 16). This model was used as it better approximates the square / rectangular shapes of the potential bund fires. It will be slightly conservative for the tank top fires. Graphical representations of the estimated radiant heat contours are shown in Appendix 2.

Table 5 – Fire Scenarios Calculation Data and Results

Note that “Eq. D” is the equivalent diameter of the fire (4 x the fire area / the fire perimeter) and “SEP” is the surface emissive power (i.e. the radiant heat level of the flames). Where bund fires width is significantly different to the length, the top row results corresponds to the radiant heat predicted for an object perpendicular to the width and the bottom row results corresponds to the radiant heat predicted for an object perpendicular to the length.

Item No.	Item Description	Width, m	Length, m	Eq. D, m	Tank Height, m	Liquid Density, kg/m <sup>3</sup>	SEP, kW/m <sup>2</sup>	Distance to Specified Radiant Heat Level, m (from base of flame)				
								35 kW/m <sup>2</sup>	23 kW/m <sup>2</sup>	12.6 kW/m <sup>2</sup>	4.7 kW/m <sup>2</sup>	2.1 kW/m <sup>2</sup>
1	Tank 270 bund fire (diesel)	31	45	37	-	840	21	- -	- -	4 4	23 29	44 55
2	Tanks 271 and 272 bund fire (diesel)	24	45	31	-	840	23	- -	- -	5 7	20 30	39 57
3	Tank 273 bund fire (diesel)	38	45	41	-	840	21	- -	- -	4 5	27 30	52 58
4	Tank 274 bund fire (bitumen)	45	45	45	-	970	21	-	-	5	26	49
5	Pit Fire, i.e. larger banded area for tanks 270 to 282 (diesel / bitumen)	76	137	78	-	840	20	- -	- -	4 5	45 62	88 121
6	Pump bund, i.e. for the pumps associated with tanks 270 to 273	3	13	3	-	840	104	2	3	5	11	17
7	Existing Stage 5 road tanker bay fire	8	8	8	-	840	66	3	5	8	18	29
8	Tank 270 – tank top fire	-	-	19.6	17	840	31	-	<1	8	21	38

Item No.	Item Description	Width, m	Length, m	Eq. D, m	Tank Height, m	Liquid Density, kg/m <sup>3</sup>	SEP, kW/m <sup>2</sup>	Distance to Specified Radiant Heat Level, m (from base of flame)				
								35 kW/m <sup>2</sup>	23 kW/m <sup>2</sup>	12.6 kW/m <sup>2</sup>	4.7 kW/m <sup>2</sup>	2.1 kW/m <sup>2</sup>
9	Tanks 271 and 272 – tank top fire	-	-	11.8	17	840	49	<1	4	9	20	33
10	Tank 273 – tank top fire	-	-	26.5	20	840	25	-	<1	7	23	43
11	Tank 276 bund fire (bitumen)	35	84	48		970	20	- -	- -	3 4	22 34	42 66
12	Tanks 277 to 282 bund fire (bitumen)	26	32	29		970	24	- -	- -	5 6	19 22	36 40
13	Bitumen road tanker bay fire	8	8	8	-	970	66	3	5	8	15	24
14	Tanks 274 and 276 – tank top fire	-	-	26	21	970	25	-	<1	6	20	35
15	Tanks 277 to 280 – tank top fire	-	-	8.7	19	970	62	2	5	8	16	25
16	Tanks 281 and 282 – tank top fire	-	-	4.5	11	970	90	3	4	6	11	18

Notes for Table 5:

1. The individual tank bund fires are for moderate releases, including piping leaks which ignite. If a large loss of containment occurs, e.g. 10,000 m<sup>3</sup> of diesel, then the individual bunds for Tanks 270, 273 and 274 will fill as well as the additional capacity from the bitumen tanks banded areas. This scenario results in a large pit fire if the product is ignited.
2. Note that Scenario Number 6 is modelled as a channel fire, i.e. the equivalent diameter is taken as the width (to estimate the flame height) along the entire length of the channel.

3. The fire dimensions for a road tanker bay fire are based on typical conditions expected once the fire is established.
4. Fires in the bitumen processing bunded area, e.g. hot oil pump fire, will be comparatively smaller than the corresponding tank and bund fires and equivalent to Scenario Number 6. Given the results in Table 5, off-site impact is not expected. Therefore, these cases are not modelled.

The maximum **ground level** radiant heat values for the tank top fires are typically much lower due to the angle from the base of the flames (approximately the tank top height) to the ground. Representative ground level radiant heat levels are as follows.

- 1 Tank 270, 19.6 m diameter, tank height being approximately 17 metres - a maximum ground level radiant heat value of 5.2 kW/m<sup>2</sup> at 9 metres from the tank wall is estimated.
- 2 Tanks 271 and 272, 11.8 m diameter, tank height being approximately 17 metres - a maximum ground level radiant heat value of 5.8 kW/m<sup>2</sup> at 7 metres from the tank wall is estimated.
- 3 Tank 273, 26.5 m diameter, tank height being approximately 20 metres - a maximum ground level radiant heat value of 4.5 kW/m<sup>2</sup> at 12 metres from the tank wall is estimated.
- 4 Tanks 274 and 276, 26 m diameter, tank height being approximately 21 metres - a maximum ground level radiant heat value of 4.0 kW/m<sup>2</sup> at 10 metres from the tank wall is estimated.
- 5 Tanks 277 to 280, 8.7 m diameter, tank height being approximately 19 metres - a maximum ground level radiant heat value of 5.3 kW/m<sup>2</sup> at 5 metres from the tank wall is estimated.
- 6 Tanks 281 and 282, 4.5 m diameter, tank height being approximately 11 metres - a maximum ground level radiant heat value of 7.1 kW/m<sup>2</sup> at 3 metres from the tank wall is estimated.

The values of interest for radiant heat (DoP, HIPAP No. 4 and ICI HAZAN Course notes) are shown in Table 6.

**Table 6 - Radiant Heat Impact**

HEAT FLUX (kW/m <sup>2</sup> )	EFFECT
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-30 seconds and second degree burns after 30 seconds. Glass breaks
12.6	30% chance of fatality for continuous exposure. High chance of injury Wood can be ignited by a naked flame after long exposure
23	100% chance of fatality for continuous exposure to people and 10% chance of fatality for instantaneous exposure Spontaneous ignition of wood after long exposure Unprotected steel will reach thermal stress temperatures to cause failure
35	25% chance of fatality if people are exposed instantaneously. Storage tanks fail
60	100% chance of fatality for instantaneous exposure

For information, further data on tolerable radiant heat levels is shown in Table 7.

**Table 7 – Layout Considerations – Tolerable Radiant Heat Levels**

<b>Plant Item</b>	<b>Tolerable Radiant Heat Level, kW/m<sup>2</sup></b>	<b>Source</b>
Drenched Storage Tanks	38	Ref 7
Special Buildings (Protected)	25	Ref 7
Cable Insulation Degrades	18-20	Ref 7
Normal Buildings	14	Ref 7
Vegetation	12	Ref 7
Plastic Melts	12	Ref 7
Escape Routes	6	Ref 7
Glass Breakage	4	Ref 17
Personnel in Emergencies	3	Ref 7
Plastic Cables	2	Ref 7
Stationary Personnel	1.5	Ref 7

The results in Table 5 are analysed as follows to check compliance with HIPAP 4 (Ref 4) risk criteria.

For assessment of the effects of radiant heat, it is generally assumed that if a person is subjected to 4.7 kW/m<sup>2</sup> of radiant heat and they can take cover within approximately 20 seconds then no serious injury, and hence fatality, is expected. However, exposure to a radiant heat level of 12.6 kW/m<sup>2</sup> can result in fatality for some people for limited exposure durations. Therefore, for the larger spills, appropriate emergency response actions are required to minimise the potential for harm to people. This should include moving people away from such releases to a safe distance.

Given the large distance to the nearest residential area (approximately 1 km to the east) and the estimated radiant heat levels from the potential fire events shown in Table 5 then there is no credible risk of injury or fatality in residential areas or to other sensitive land users.

*Correspondingly, the risk criteria for fatality and injury (Table 3) in residential areas are satisfied for radiant heat from fires.*

Whilst some of the estimated levels of radiant heat at neighbouring industrial areas are approximately 12.6 kW/m<sup>2</sup> or slightly lower (events numbers 1, 4, 5 and 6) and hence theoretically can lead to fatality, it is more probable that should a pool fire occur, people within the pipeline corridor (rare event) or in the nearest corner of the Origin Energy site (also a rare event as this area does not have installed equipment) will be either evacuated as per the established Port Botany emergency response procedures or escape before a fully developed pool fire occurs.

Fortunately the likelihood of these potential fire events is low (approximately  $6 \times 10^{-6}$  per year for large bund fires, Ref 18).

Given that the radiant heat is approximately  $12.6 \text{ kW/m}^2$  or lower, it is unlikely that fatality at these industrial neighbouring areas will result from these events.

The risk of propagation due to fires to neighbouring industrial areas (i.e. exceeding  $23 \text{ kW/m}^2$ ) is not expected given the predicted results in Table 5.

*Therefore, the criterion of  $50 \times 10^{-6}$ /year for industrial propagation risk for exceeding  $23 \text{ kW/m}^2$  (Table 3) is satisfied for fire events.*

Hence, propagation to neighbouring industrial facilities is unlikely due to radiant heat from pool fires.

For the same reasons above for off-site propagation not being expected, propagation within the Terminals' site, i.e. across the pipeline corridor, is not expected given the predicted results in Table 5 (i.e. the  $23 \text{ kW/m}^2$  contours do not impact existing plant areas). However, should a large loss of containment occur from the tanks and be ignited then, as per the current bund design, the other intact tanks in the larger pit are at risk of failure. This is a common business risk for pit designs where the intermediate bund walls within the pit are lower than the outer bund walls. It is also possible for a road tanker fire at the bitumen loading bay could propagate to the nearby tanks (i.e. Scenario 13 could lead to scenarios 12 and 15). The results shown in Appendix 2 show the significant levels of radiant heat will still be contained on-site.

Given the limited radiant heat impact as above, no further risk analysis of the identified pool fire scenarios is warranted in this study as compliance with the DoP criteria (Table 3) has been shown.

## **5.2 PRODUCTS OF COMBUSTION**

There is a potential risk to those attending a fire emergency (and possibly off-site) of effects from toxic products of combustion, e.g. carbon oxides and smoke, as well as vaporised product (i.e. not combusted).

Impact from toxic products of combustion will only be significant, generally, local to the fire. As stated in Lees (Ref 7):

“The hot products of combustion rising from a fire typically have a temperature in the range  $800\text{-}1200^\circ\text{C}$  and a density a quarter that of air.”

Hence, a buoyant plume is formed (as seen when smoke is emitted from a chimney) and the combustion products rise and are dispersed as per the prevailing wind / weather conditions. Several runs of the Brigg's Plume Model (Ref 15) for various combinations of weather / wind conditions and fire temperatures show that the plume rises from a 26.5 m diameter tank fire to at least 80 metres and then disperses via passive dispersion in the down wind direction. Momentum effects continue to cause the plume to rise whilst it is dispersing. The results are shown in Table 8. The results also show that plume

rise is insensitive to fire temperature variations of 800°C +/- 100°C (not shown). An efflux velocity of 5 m/s for the products of combustion is taken for the fire event.

**Table 8 – Fire Plume Rise Modelling**

Wind (m/s) / Weather	Initial Height of Plume, m
5 D	80
3 E	130
2 F	200

Therefore, unless a temperature inversion exists where reverse atmospheric currents can occur (i.e. air slumps to the ground as opposed to air eddies that rise), no effect at ground level is expected. Note that dispersion models best account for temperature inversions by using F class stability (i.e. typically when the adiabatic lapse rate is positive). The models, however, do not include the provision for air slumping to ground.

### **5.3 VAPOUR EXPLOSIONS**

Whilst it is proposed to only store and handle combustible liquids in the Stage 5 area, it is noted that explosions involving the vapours from petroleum products are possible and are acknowledged in Table 1. There are two notable incidents involving releases of *flammable* liquids that have resulted in unconfined vapour explosions. Given that Terminals proposed to only store and handle combustible liquids in the Stage 5 Area, the risk of the following events will be even lower than that for flammable liquids.

The most recent incident occurred at the fuel storage facility at Buncefield, UK. In the early hours of Sunday 11th December 2005, a number of explosions occurred at Buncefield Oil Storage Depot, Hemel Hempstead, Hertfordshire. At least one of the initial explosions was of massive proportions and there was a large fire, which engulfed a high proportion of the site. Over 40 people were injured; fortunately there were no fatalities. The explosion was the result of a large loss of containment of flammable liquid.

Another similar incident occurred at the Texaco Newark storage facility, January 7 (i.e. during winter again), 1983. The tanks involved here had little level protective instrumentation; tank level was primarily achieved via frequent dipping with subsequent checklist completion. The material was super unleaded gasoline. During a transfer operation, one tank overflowed at approximately midnight and a vapour cloud formed. It travelled approximately 300 metres towards an incinerator (most likely source of ignition given eye-witness reports) and then exploded. There was one fatality and twenty four people injured.

Issues in common with two events are:

- Overflow from height, spraying of the flammable liquid causing a mist;
- Cold ambient temperatures (Buncefield approximately -2 deg Cel, similarly for Newark);
- Low wind speeds (e.g. Buncefield - Pasquill stability class F);
- Rolling mist (e.g. Buncefield - 5 to 7 metres high mist with confinement, i.e. between buildings);
- Delayed ignition; and
- Large amounts lost - Buncefield approximately 300 tes and Newark approximately 450 tes.

The following, summarised recommendations are from the Buncefield Safety Task Group's investigation. Comment is included on their applicability to the Terminals site at Port Botany.

- The overall systems for tank filling control need to be of high integrity, with sufficient independence to ensure timely and safe shutdown to prevent tank overflow and the overall systems for tank filling control meet AS 61511. *This is achieved via tank radar level monitoring and an independent high level switch on the new tanks which are linked to the operators radios.*
- Management systems for maintenance of equipment and systems to ensure their continuing integrity in operation. *Terminals have an established safety management system which includes equipment item maintenance, including instrumentation testing, requirements.*
- Fire-safe shut-off valves should be used and remotely operated shut-off valves (ROSOVs) should be installed on tank outlets. *Terminals plan to use fire-safe valves and install ROSOVs on the new tanks outlet lines and overhead or non-return valves on the inlet lines.*
- Safe management of fuel transfer. *Terminals have established procedures for product transfers including compliance with the International Shipping Guide for Oil Tankers and Terminals.*
- Bunds are to be leak tight, bund wall joints are to be fire resistant and the bund capacity is to be at least 110% of the maximum tank capacity. *These recommendations are consistent with the Terminals bund designs.*
- Site-specific planning of firewater management and control measures should be undertaken. *Firewater containment is afforded by the tank bunds, the ability to transfer water from bund-to-bund and on-site waste water containment facilities. Beyond these measures, further emergency response is required.*

- Procedures exist for defining roles, responsibilities and competence, staffing and shift work arrangements (e.g. managing fatigue), shift handover, organisational change and management of contractors, performance evaluation and process safety performance measurement including procedures for investigation of incidents and near misses, and auditing. *Terminals have an established safety management system which includes these requirements.*
- Emergency procedures exist inclusive of fire fighting requirements. *Terminals have an existing site emergency response plan which includes actions to take in a fire event. This is planned to be updated for the current project.*

In summary, unconfined vapour cloud explosions resulting from the spillage of a hydrocarbon at ambient temperature and below its boiling point are rare (Ref 19). If enough hydrocarbon is spilt, particularly from height with low wind speeds to minimise dilution, then a vapour cloud is possible.

Given the measures employed at the Terminals site and that only combustible liquids are to be stored in the Stage 5, the expected likelihoods for these types of events are still rare and therefore do not pose significant off-site risks.

Therefore, given the historically low frequency of petroleum products vapour explosions associated with these types of tanks then the risk to people off-site or adjacent industrial facilities is not considered intolerable.

As identified in Table 2, it is also possible to have confined explosions within the bitumen tanks. These events have occurred, however, the anecdotal evidence indicates the impacts are confined to the plant area around the tanks. In these cases, the energy of the explosions is largely spent in causing damage to the tanks. Therefore, propagation to other nearby tanks and equipment is possible with a potential outcome of pool fires. As per the preceding pool fire analyses, the risk of adverse consequential impacts from pool fires in the Stage 5 area is deemed acceptable and no further safeguarding is recommended.

## **5.4 NATURAL GAS FIRES AND EXPLOSIONS**

Failures associated with the natural gas feed line to the hot oil heaters or combustor will release the natural gas to atmosphere and, if ignited, it can form a jet fire, a flash fire and/or an explosion.

The natural gas line is proposed to be installed aboveground in the pipeline corridor from Friendship Road. The mains supply pressure is 10.5 barg and will be let down to 2.75 barg at the terminal boundary. The gas pipe will be either 80 or 50 mm nominal diameter as it runs through the pipeline corridor for a distance of about 500m. The pipe will have welded joints where possible. All flanged joints will have a hazardous atmosphere zone around them.

The analysis of the potential jet fires from the natural gas feed line to the hot oil heaters / combustor is shown in Table 9. From above, the natural gas pressure is taken as 2.75 barg (at ambient temperature).

**Table 9 –Natural Gas Jet Fires**

Stream	Estimated Release Rate, kg/s	Estimated Length of Jet, m
Full bore failure (80 mm used)	0.71	9
50 mm hole	0.55	8
13 mm hole	0.053	3

Notes: Jet flames modelled using methane.

As expected for these size jet fires, no adverse radiant heat levels will be imposed off-site.

Potential vapour cloud explosions and flash fires can occur from the natural gas line failures, i.e. delayed ignition.

The effects from explosion overpressures (Ref 4) are summarised in Table 10.

**Table 10 – Effects of Explosion Overpressure**

OVERPRESSURE, kPa	PHYSICAL EFFECT
3.5	90% glass breakage No fatality, very low probability of injury
7	Damage to internal partitions & Joinery 10% probability of injury, no fatality
14	Houses uninhabitable and badly cracked
21	Reinforced structures distort, storage tanks fail 20% chance of fatality to person in building
35	Houses uninhabitable, rail wagons & plant items overturned. Threshold of eardrum damage, 50% chance of fatality for a person in a building, 15% in the open
70	Complete demolition of houses Threshold of lung damage, 100% chance of fatality for a person in a building or in the open

For flash fires, any person inside the flash fire cloud is assumed to be fatally injured. As flash fires are of limited duration (typically burning velocity is 1 m/s, Ref 20) then those outside the flash fire cloud have a high probability of survival without serious injury.

The analysis of the potential vapour cloud explosions and flash fires from the natural gas pipe failures is shown in Table 11. The mass calculated in the flammable range is assumed to be 100% confined, i.e. all this gas is involved in the explosion calculations. As methane is not a high reactive flammable gas and the quantities involved are relatively small then a weak deflagration is assumed in the explosion calculations (multi-energy method – TNO).

**Table 11 – Natural Gas Vapour Cloud Explosions and Flash Fires**

<b>Stream</b>	<b>Mass of Natural Gas in the Flammable Range, kg</b>	<b>Radius of Flash Fire, m</b>	<b>Distance (m) to 14 kPa Explosion Overpressure</b>	<b>Distance (m) to 7 kPa Explosion Overpressure</b>
Full bore failure (80 mm)	7.5	36 m	< 10 m	16 m
50 mm hole	5	30 m	< 10 m	14 m

Notes: 1. Pipeline failures assumed to be isolated within 30 minutes.

2. Radius of flash fires calculated to be the distance to LEL at F weather stability and 2 m/s wind speed.

3. 13 mm holes not modelled as they are too small to generate gas clouds of any significant size.

For these releases of natural gas, choked flow exists and rapid jet mixing with air occurs. The result is a relatively small vapour cloud size with limited consequential impacts if ignited. The 30 minute release duration also has no significant impact on the release. Steady state conditions are reached soon after the release occurs (i.e. after approximately 4 minutes, the distance to the LEL does not change at steady state dispersion conditions).

Given these results for the natural gas vapour cloud explosions and flash fires, no adverse consequential impacts will be imposed off-site. The low likelihoods for these events are supported by the following data.

For piping failures, frequencies have been estimated either from data compiled and published by ICI (Ref 21) or from frequency estimates published by the Institution of Chemical Engineers (Ref 22).

**Table 12 - Piping Failure Frequencies**

Type of Failure	Failure Rate per year
<b>Pipelines</b>	
13 mm hole	$3 \times 10^{-6} / \text{m}$
50 mm hole	$0.3 \times 10^{-6} / \text{m}$
3 mm gasket (13 mm hole equivalent)	$5 \times 10^{-6} / \text{joint}$
Guillotine fracture (full bore):	
< 50 mm	$0.6 \times 10^{-6} / \text{m}$
> 50 mm but < 100 mm	$0.3 \times 10^{-6} / \text{m}$
> 100 mm	$0.1 \times 10^{-6} / \text{m}$

For example, the frequency of catastrophic pipe failure for an 80 mm pipe is  $3 \times 10^{-7} / \text{m}$ . This is a low level of risk and not considered intolerable.

## 5.5 AIRCRAFT IMPACT AND OTHER EXTERNAL EVENTS

The Airport study by ACARRE (Australian Centre for Advanced Risk and Reliability Engineering) examined the likely frequency of aircraft crashing onto various sites within the Port Botany region. The frequency is related to the area of the site in question, its distance from Sydney Airport and its orientation to the runways. For completeness, and to allow the crash frequencies of the various types of aircraft to be determined, the size of the impact zones determined by ACARRE for aircraft crashes on land are presented in Table 13.

**Table 13 – Aircraft Crash Data for Sydney Airport**

AIRCRAFT TYPE	DISTANCE TO INJURY POTENTIAL (12.5 kW/m <sup>2</sup> ) FROM CENTRE OF CRASH	
	WORST CREDIBLE CASE Fireball, 5% of crashes	PROBABLE CASE Pool Fire, 95% of crashes
	Scheduled Aircraft (e.g. commercial)	450 m
Unscheduled Aircraft (e.g. private)	120 m	25 m

On the basis of both the distance from the airport and the site area, the ACARRE report was able to determine the frequency of crash per unit area based on both scheduled aircraft (major passenger or courier style aircraft) and the much smaller unscheduled aircraft. For the site at Port Botany, which is around 5.5 km from Sydney Airport, a crash frequency of  $2 \times 10^{-7}$  pa for scheduled aircraft was reported. From the summary in Table 13, the 450 metre affect distance would be expected to result on only 5% of occasions. Thus, the frequency at which this event would be expected to occur would be approximately  $1 \times 10^{-8}$  pa. This worst case scenario is extremely unlikely and therefore would be expected to make a negligible contribution to the overall risk.

A crash frequency for unscheduled aircraft is around 20 times more probable than a scheduled aircraft at this location (based on an equivalent area). However, the area of impact of small aircraft (i.e. less than 10 te in total mass) is considerably less than that of a scheduled passenger aircraft. The area which the aircraft would need to hit is reduced to the immediate location of the storage vessels. Hence the likelihood of a "direct hit" by a small aircraft is conservatively mitigated by an approximate factor of 10. The frequency of a small aircraft hitting any of the storage tanks and bitumen facility is around  $4 \times 10^{-6}$ /yr for the site. It is thus more like  $4 \times 10^{-7}$ /yr for a tank affected incident.

Thus in summary, frequencies associated with aircraft crashes are:

- Scheduled aircraft  $1 \times 10^{-8}$ /year; and
- Unscheduled aircraft  $4 \times 10^{-7}$ /year.

The outcomes of any aircraft crash on this site will be dominated by larger hazardous events in other storage and handling areas as well as the ensuing fire from the plane wreckage. This is an existing risk for the site and the proposed changes to the site have negligible effect. The likelihood of this type of event is acceptably low for a site of this size and location.

Other external events that may lead to propagation of incidents on any site include:

Subsidence	Landslide
Burst Dam	Vermin/insect infestation
Storm and high winds	Forest fire
Storm surge	Rising water courses
Flood	Storm water runoff
Breach of security	Lightning
Tidal waves	Earthquake

These events were reviewed and none of them were found to pose any significant risk to the new bitumen facility given the proposed safeguards.

## **5.6 CUMULATIVE RISK**

Cumulative risk for the Port Botany area was considered by the Department of Urban Affairs and Planning (now the DoP) in 1996 (Ref 5). The estimated risk contours extended well beyond the Terminal's site and largely over the water. As shown in this PHA, the proposed changes to the Terminals site will have negligible impact on the cumulative risk results for the Port Botany area as the significant radiant heat levels are retained on the site.

Therefore it is reasonable to conclude that the modified development does not make a significant contribution to the existing cumulative Port Botany risk.

The recommendations from the 1996 study have been reviewed to determine if the proposed changes are consistent with the intent of these recommendations. In summary, all current proposed changes to the Terminals site have been found to be consistent with the intent of the recommendations and do not contribute to unacceptable cumulative risk in the Port Botany area.

## **5.7 RISK FROM NEIGHBOURING CONTAINER STORAGE**

This assessment was performed in Ref 2 and is reproduced here.

Sydney Ports Corporation (SPC) requested an assessment of the risk of freight containers in the adjacent Tyne storage area being blown or possibly dropped into Terminals property and hence the risk of propagation, i.e. causing a release of stored material and a fire if ignited. Tyne sub-lease the land adjacent to Terminals and to the south of Hydrocarbons.

Pinnacle Risk Management understands that the freight containers can be located as close as 5 metres from the Terminals fenceline. On the Terminals side of the boundary fence is a 6.1 m roadway. The freight containers are stacked with their ends facing towards Terminals (rather than side on). The maximum stack height is 6 high which complies with the SPC's maximum stacking height for containers.

A review of container incidents indicates that falling containers is a credible event in high winds. Some best practice techniques include the following to prevent such incidents propagating to adjacent industry:

- Aligning the longitudinal axis of the shipping containers with the predominant wind direction (in this case, aligning with Terminals is preferred as the containers are more likely to be blown side-ways rather than end-over-end);
- Providing adequate separation distances between shipping container stacks and vehicle access lanes, residential properties, on-site offices, amenities and work areas, and work areas on adjoining sites (note that no practical recommendations to comply with this requirement have yet to be found); and
- Stacking shipping containers in a pyramid formation where practicable.

Other than the containers being stacked in the most appropriate alignment to minimise the likelihood of propagation to Terminals, the following point is made:

Should a container impact a Terminals tank or part of the Bitumen processing facility in the Stage 5 area and ignition occur, the results of this PHA indicate that the potential fires will have negligible impact on the cumulative risk results for the Port Botany area (as determined by the DoP – see Section 5.6) as the significant radiant heat levels are retained on the site. Hence, whilst this event

is undesirable, the resulting risk lies within the Port Botany acceptable risk contours.

## **5.8 SOCIETAL RISK**

The above criteria for individual risk do not necessarily reflect the overall risk associated with any proposal. In some cases for instance, where the 1 pmpy contour approaches closely to residential areas or sensitive land uses, the potential may exist for multiple fatalities as the result of a single accident. One attempt to make comparative assessments of such cases involves the calculation of societal risk.

Societal risk results are usually presented as F-N curves, which show the frequency of events (F) resulting in N or more fatalities. To determine societal risk, it is necessary to quantify the population within each zone of risk surrounding a facility. By combining the results for different risk levels, a societal risk curve can be produced.

In this study of the modified Terminals site at Port Botany, the risk of fatality does not extend significantly off the site and is therefore well away from the residential areas. In fact, the nearest house is approximately 1 kilometre away. The concept of societal risk applying to residential population is therefore not applicable for the terminal.

## **5.9 RISK TO THE BIOPHYSICAL ENVIRONMENT**

The main concern for risk to the biophysical environment is generally with effects on whole systems or populations. For the expanded terminal, it is suitably located away from residential areas. However, due to the nature of the activities, there are operations, e.g. ship transfers and road tanker filling, where losses of containment can potentially impact the environment. Major fires can also effect the environment (combustion products).

Whereas any adverse effect on the environment is obviously undesirable, the results of this study show that the risk of losses of containment is broadly acceptable.

For completeness, risks to the biophysical environment due to loss of containment events are summarised below.

### **5.9.1 Escape of Materials to Atmosphere**

Combustion of the stored products, caused by ignition following a spillage or leak, will release products of combustion (e.g. carbon dioxide, carbon monoxide, soot, vaporised product [unburnt] and water vapour). As shown in Section 5.2, for typical wind / weather conditions, the products of combustion from a fire will rise due to momentum and buoyancy. Local impact can be expected for very still conditions only (in which case, emergency response is required for evacuation). The products of combustion are unlikely to include any materials which present a long-term risk to the biosphere.

Hydrocarbons vapour emissions whilst tanker filling are, as previously discussed, controlled via a combustor unit.

## **5.9.2 Escape of Materials to Soil or Waterways**

### ***Products Stored in Bunded Areas***

Spillages of products from the tanks, vessels and adjacent piping are contained in the bunds. The bunded areas are sized to contain the entire contents of the single tank so that a total loss of contents does not spill over the bund, plus an allowance for rainwater, fire water, hosing down etc. The bitumen processing equipment is also located within a bunded area.

### ***Drainage Systems and Site Grades***

These have been designed so that in the event of fire, fire water run off containing any materials is held on site. All open areas are paved.

On spillage or other loss of containment on paved areas associated with the new tanks and equipment, e.g. at the bitumen road tanker loading bay, the products will be captured in the site's existing waste water pit and disposed of off-site via a licensed contractor (as per current procedure).

If a spill was to occur on a general paved site area then equipment such as absorbents and booms are available for use to minimise the spread of the liquid. As bitumen readily cools, most spills will solidify and then be removed manually.

### ***Bulk Liquids Berth***

For small spills at the Bulk Liquids Berth, containment is provided by catchment trays. Terminals have installed further matting to help prevent any potential spills flowing into the bay. Larger releases are designed to be contained by a bunded wharf with a collection sump providing 100,000 litres containment. Any liquid spills entering the sea water involve emergency response from personnel from Terminals, SPC and the ship's crew. Again, for bitumen, recovery of solid bitumen will be required as it will solidify on entering the water (if a loss of containment is not held by the BLB catchment systems).

## **5.9.3 Solid Wastes**

There will be minimal solid wastes from the new equipment and are low consequence hazards. The dedicated bitumen dockline will be heavily purged with air to the relevant storage tank and left with residual bitumen. This material will solidify as the heat tracing is turned off between ship unloading operations; removing the need to completely empty the pipeline.

Any maintenance of equipment will require purging to remove residual liquid after using the positive displacement pumps to operate backwards to clear lines of liquid bitumen. These pumps are designed for forwards and backwards

operations. Any residual solidified product will be recycled to stakeholder facilities, where practicable, or sent off site for disposal.

From the analysis in this report, no incident scenarios were identified where the risk of whole systems or populations being affected by a release to the atmosphere, waterways or soil is intolerable.

## **6 CONCLUSION AND RECOMMENDATIONS**

The risks associated with the Stage 5 tanks, associated equipment and bitumen facilities at the Terminals site, Port Botany, have been assessed and compared against the DoP risk criteria.

In summary:

### 1. Fires:

- No risk of injury or fatality at residential areas or other sensitive land uses as the separation distance is large, i.e. 1 km or larger to residential areas;
- As the estimated radiant heat levels from potential fire events are approximately 12.6 kW/m<sup>2</sup> or lower at neighbouring industrial facilities, the likelihood of fatality at these locations is acceptably low and there exists a high probability of escape; and
- Propagation to neighbouring industrial facilities is not expected given that the significant levels of radiant heat are largely contained on-site.

### 2. Vapour explosions:

- These are considered rare events for these types of facilities and materials, and hence the risk of injury, fatality and/or propagation at residential areas or other sensitive land uses (i.e. more than 1 km away) or at neighbouring facilities is not considered intolerable.

3. The shipping and road transport activities associated with this project are commensurate with the zoning for the Port Botany area and are not considered intolerable.

### 4. Societal risk is qualitatively concluded to be acceptable given:

- Few events analysed in the study have the potential for off-site impact and, for the ones that do, their likelihood is acceptably low; and
- The population density in the Port Botany area is relatively low.

Therefore, the results of this PHA show that the risks associated with the proposed changes comply with the DoP guidelines for tolerable fatality, injury, irritation, propagation and societal risk. Also, risks to the biophysical environment from potential hazardous events are broadly acceptable.

Additionally, the proposed bitumen handling and storage equipment have no significant impact to the cumulative individual risk contours (for future development planning) as presented in the Port Botany Land Use Safety Study by DUAP in 1996.

The primary reason for the low risk levels from the proposed changes is that significant consequential impacts from potential hazardous events (mainly radiant heat from fires) do not extend far from the relevant processing areas.

It is assumed that the proposed changes will be reviewed via the HAZOP methodology, a fire safety study will be performed and the existing safety management systems and emergency response plans will be updated to reflect the proposed changes.

The following recommendations are made from this review:

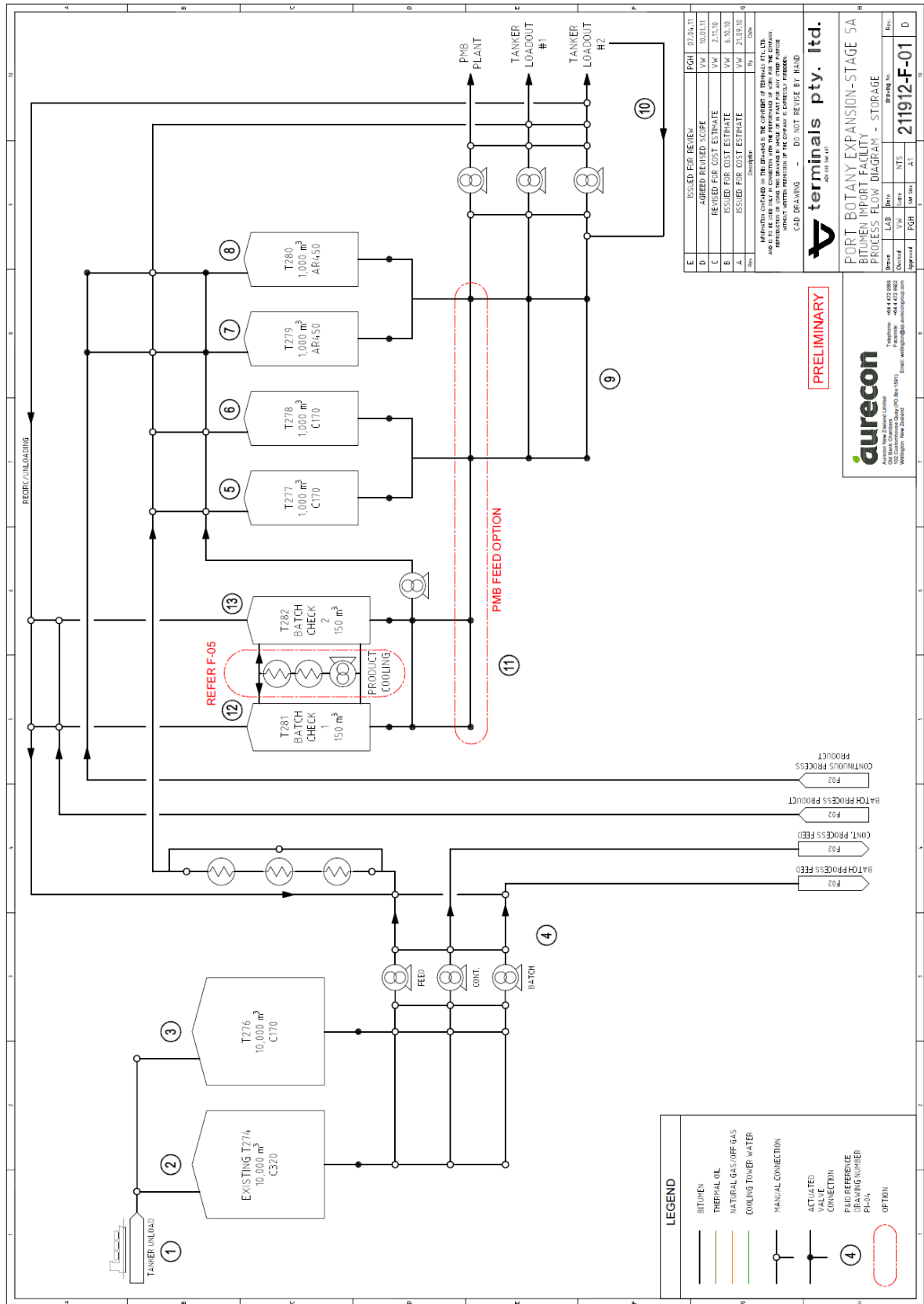
1. Include in the existing Terminals safety management system procedures for safely emptying and opening a bitumen tank or vessel given the risk of fires on contact with air.
2. Procedures need to be developed to routinely handle and remove carbonaceous deposits (possibly with iron sulphides which can result in a pyrophoric material) inside the bitumen tanks and vessels. If not routinely removed, the carbonaceous deposits may provide an ignition hazard when they are exposed to a sudden increase in temperature or oxygen supply. Also, solid deposits can float on the bitumen surface and these can interfere with level instruments.
3. Develop procedures to control the risk of hydrogen sulphide exposure to personnel in the vicinity of the bitumen handling equipment or those who are required to enter confined spaces associated with the bitumen equipment.
4. Develop procedures for heating a tank from cold given the risk of a boilover event from water in the tank being heated and evaporating.
5. Perform a SIL study on the proposed bitumen storage and processing facility to ensure the instrumented protective loops are suitably designed and are of adequate reliability for the potential hazardous events that can occur.
6. Ensure the transformer room / area is adequately designed to prevent fire propagation either from a transformer explosion / fire event, e.g. damage to the electrical switch gear, or from a switchroom fire.

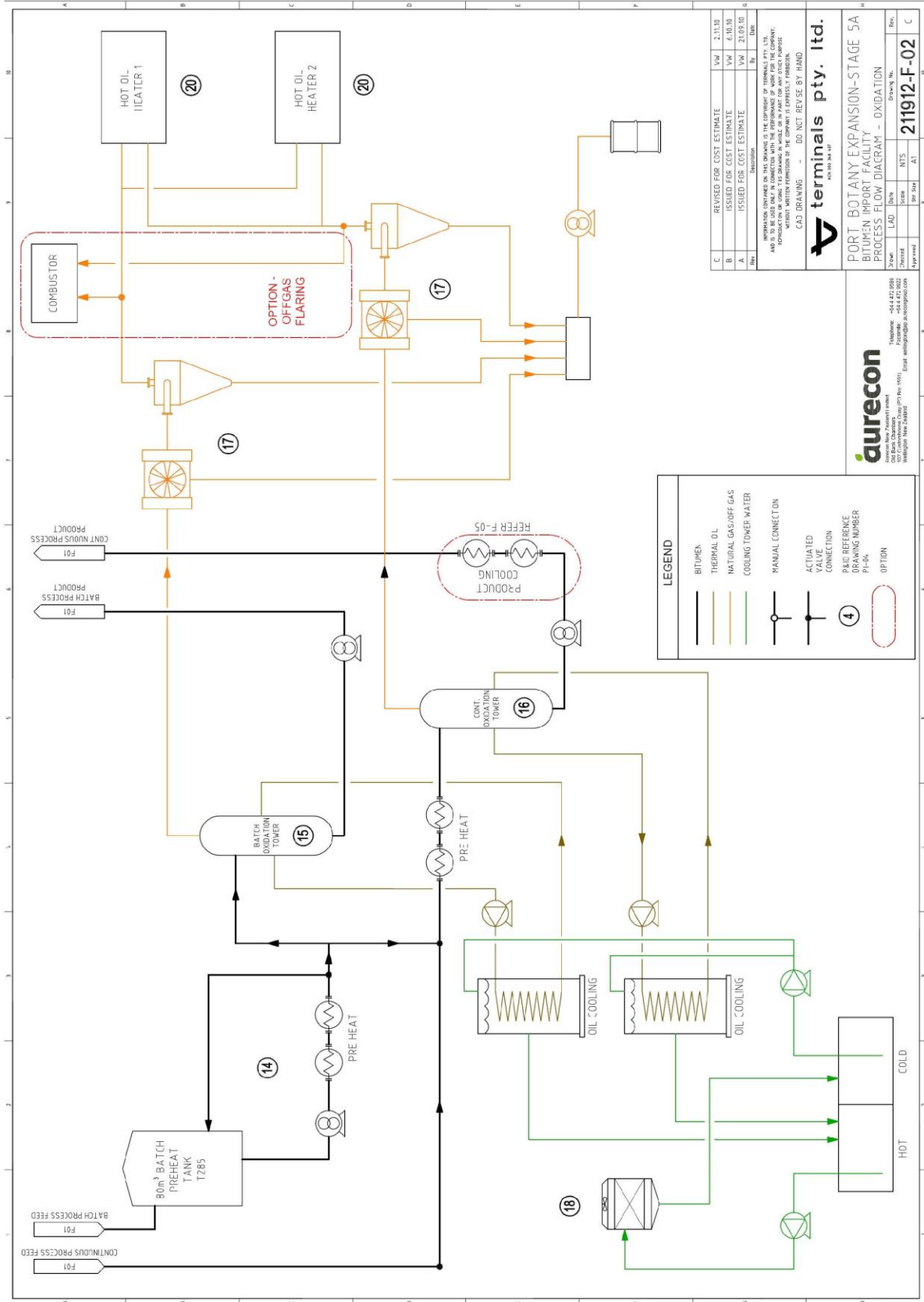
## **Appendix 1**

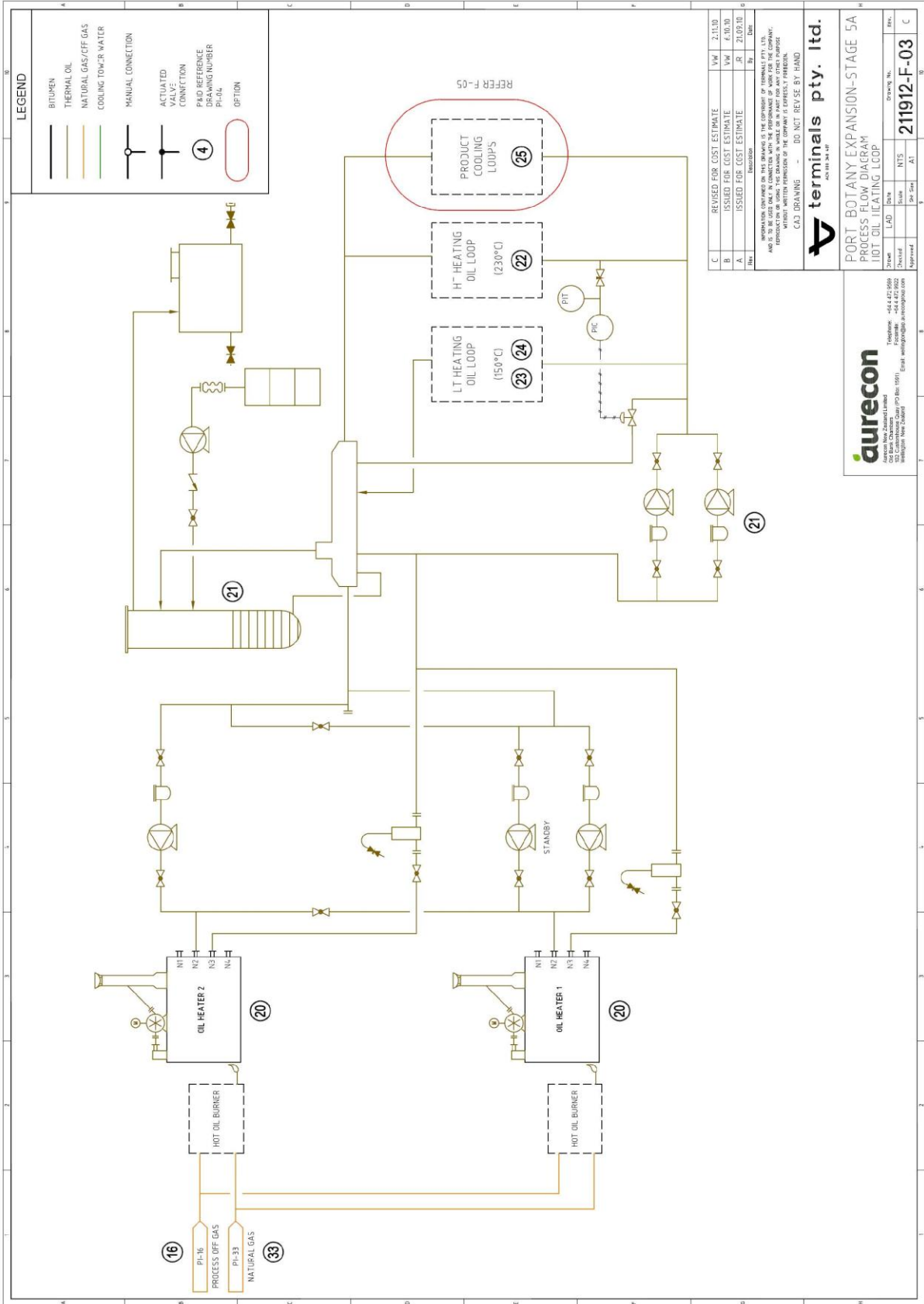
# **Drawings**

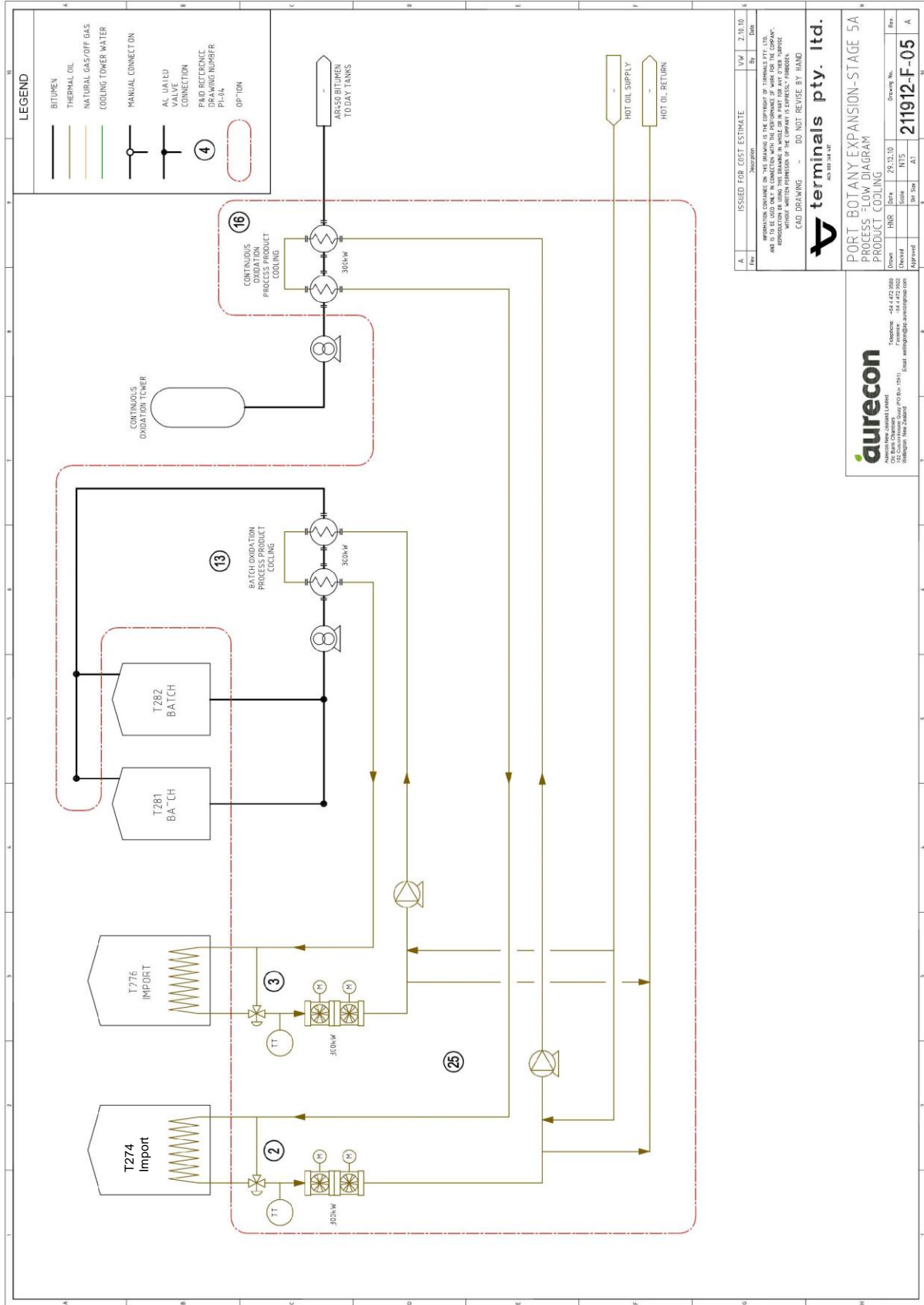
### **Preliminary Hazard Analysis, Terminals Pty Ltd, Stage 5 Modifications - Bitumen**

Appendix 1 – Drawings.









Rev.	Description	By	Date
A	ISSUED FOR COST ESTIMATE	VJK	2.16.10

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**terminals pty. ltd.**  
 100 BOTANY ROAD

**PORT BOTANY EXPANSION-STAGE 5A**  
 PROCESS FLOW DIAGRAM  
 PRODUCT COOLING

Drawn	Check	Scale	NTS	Drawing No.	Rev.
HRH	JGK	1:1	NTS	211912-F-05	A

Approved: JGK Date: 29.10.10

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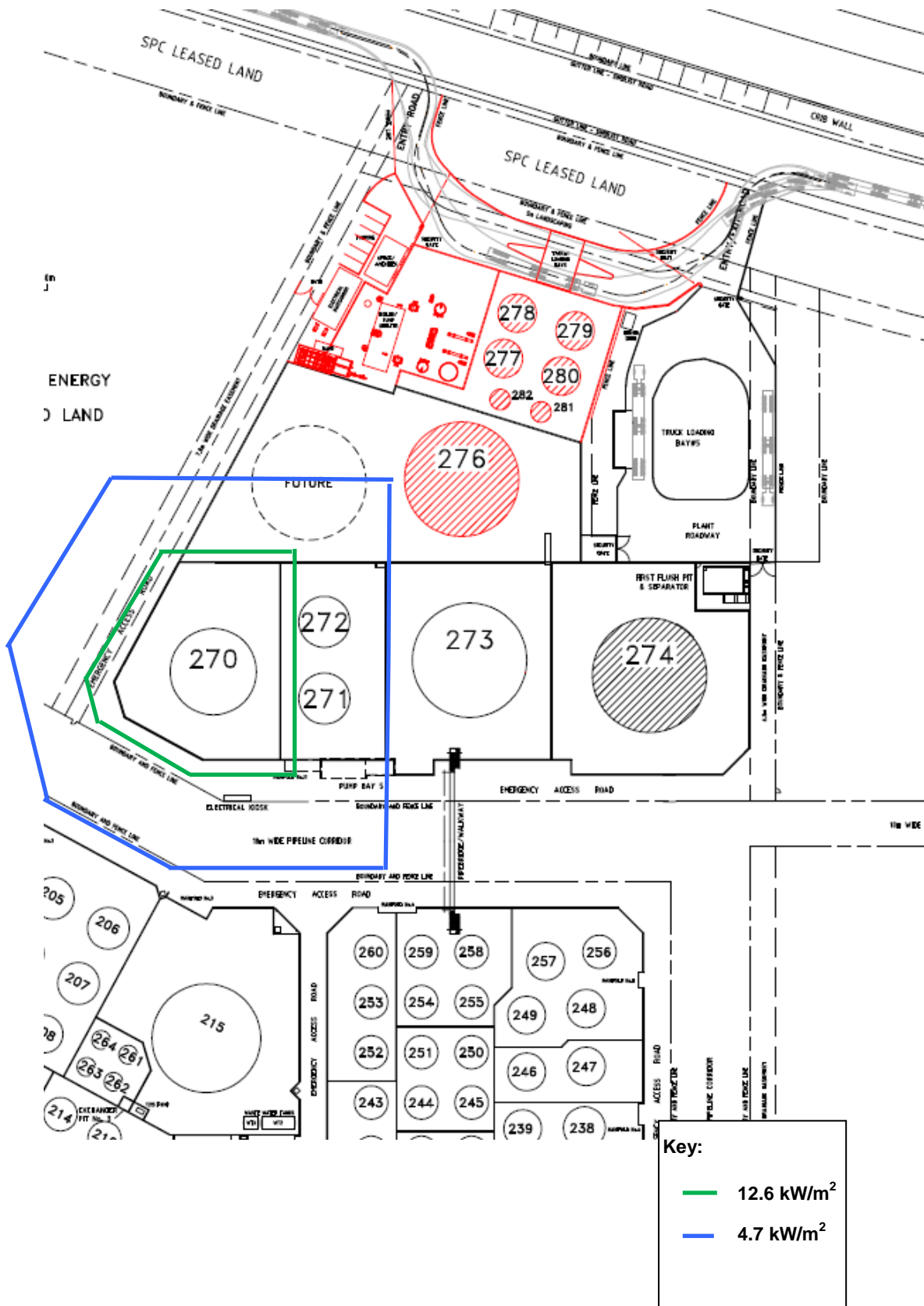
## **Appendix 2**

# **Radiant Heat Contours**

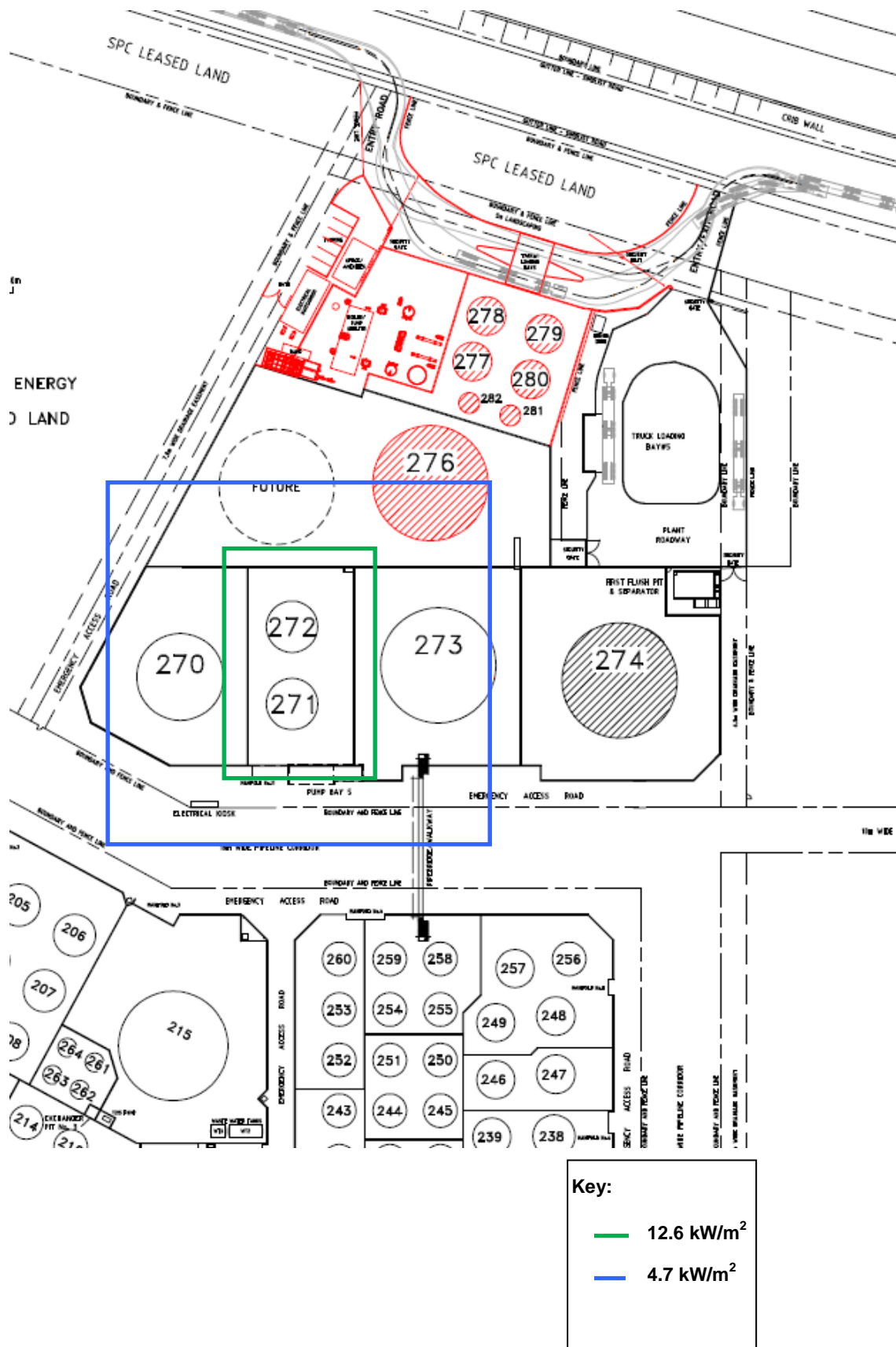
**Preliminary Hazard Analysis, Terminals Pty Ltd,  
Stage 5 Modifications - Bitumen**

Appendix 2 – Radiant Heat Contours.

Scenario 1 – Tank 270 Bund Fire (diesel)



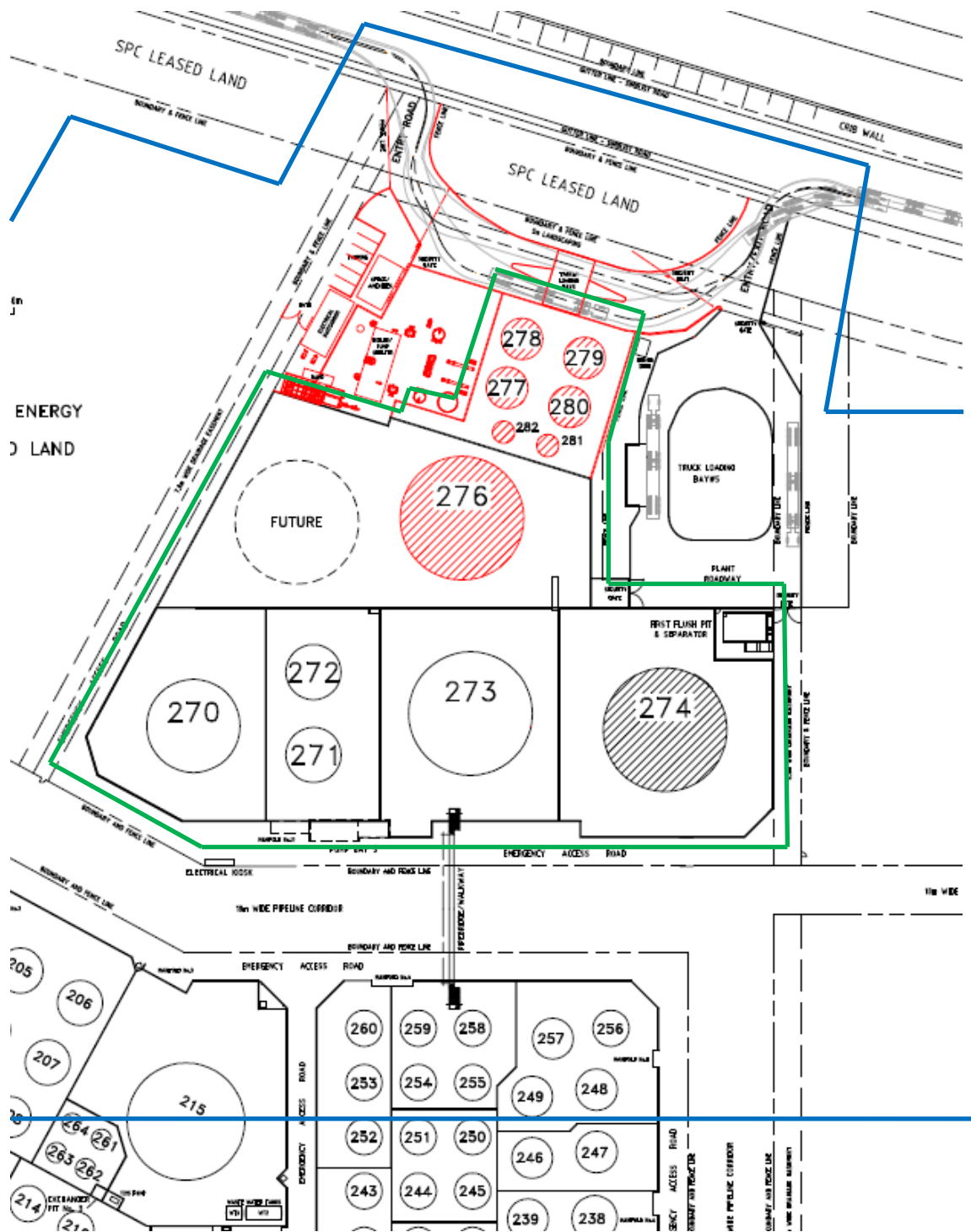
Scenario 2 – Tanks 271 and 272 Bund Fire (diesel)









Scenario 5 – Pit Fire

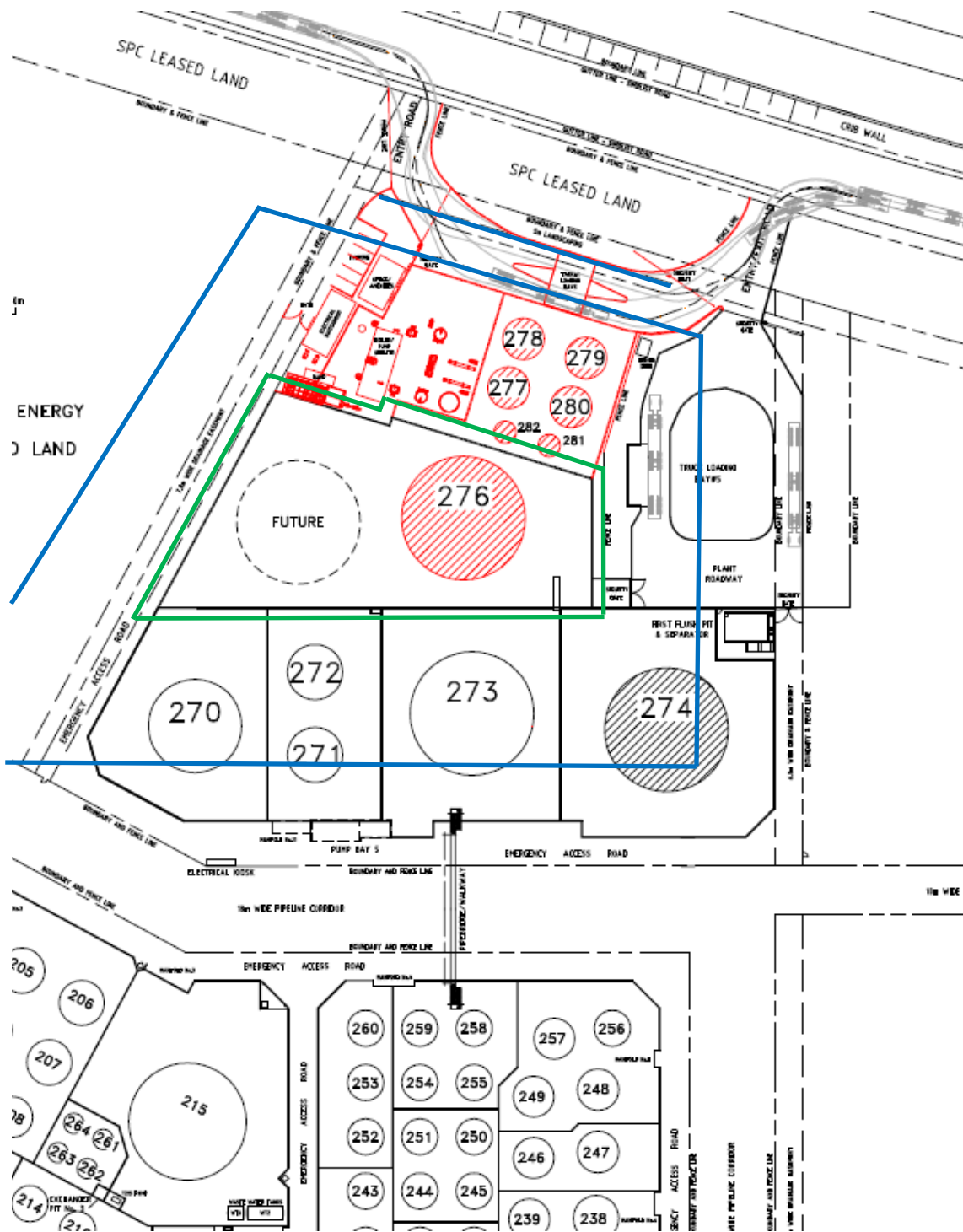


Note: Contours are an approximation given the irregular shape of the pit.

Key:	
	12.6 kW/m <sup>2</sup>
	4.7 kW/m <sup>2</sup>



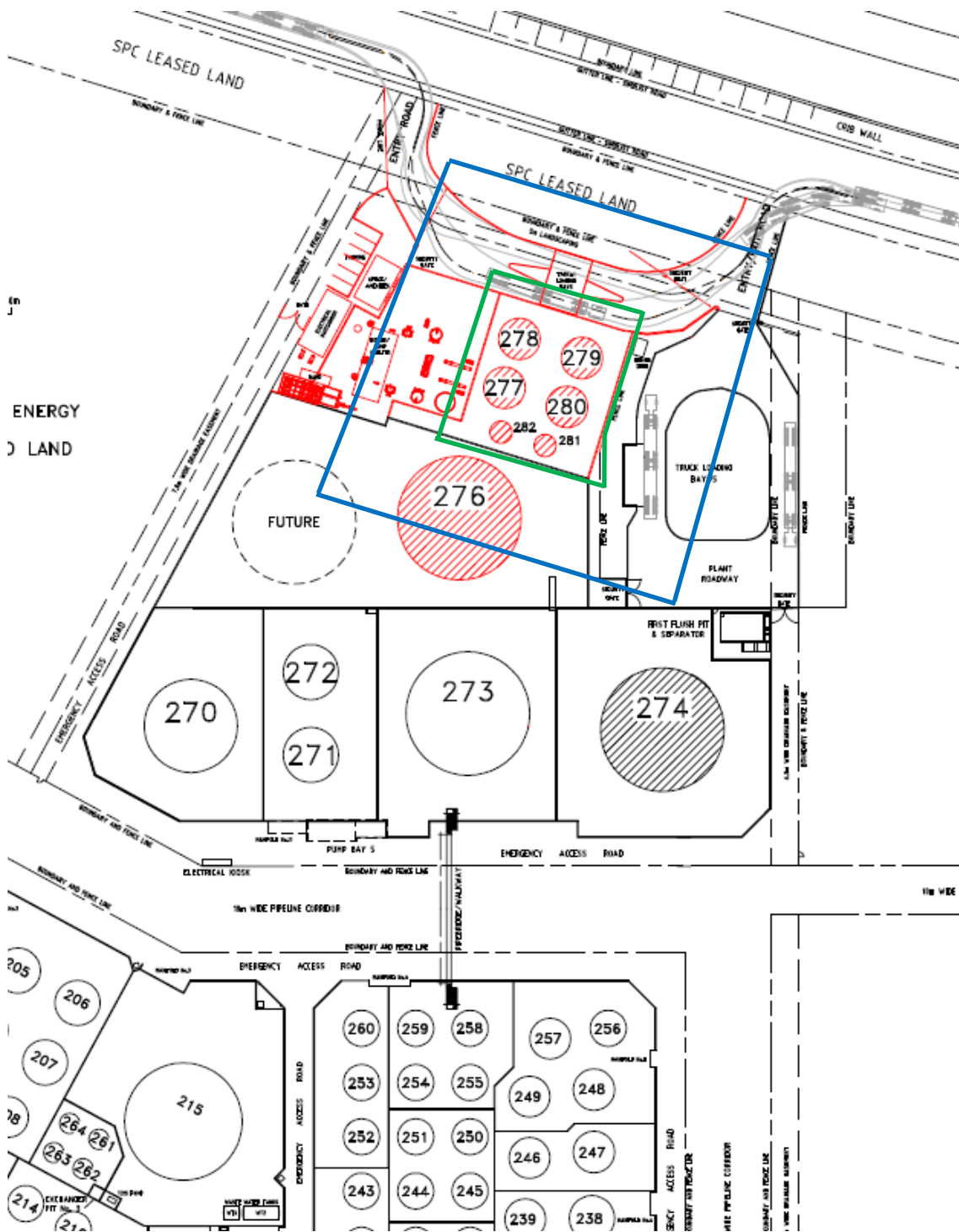
Scenario 11 – Tank 276 Bund Fire



**Key:**

- 12.6 kW/m<sup>2</sup>
- 4.7 kW/m<sup>2</sup>

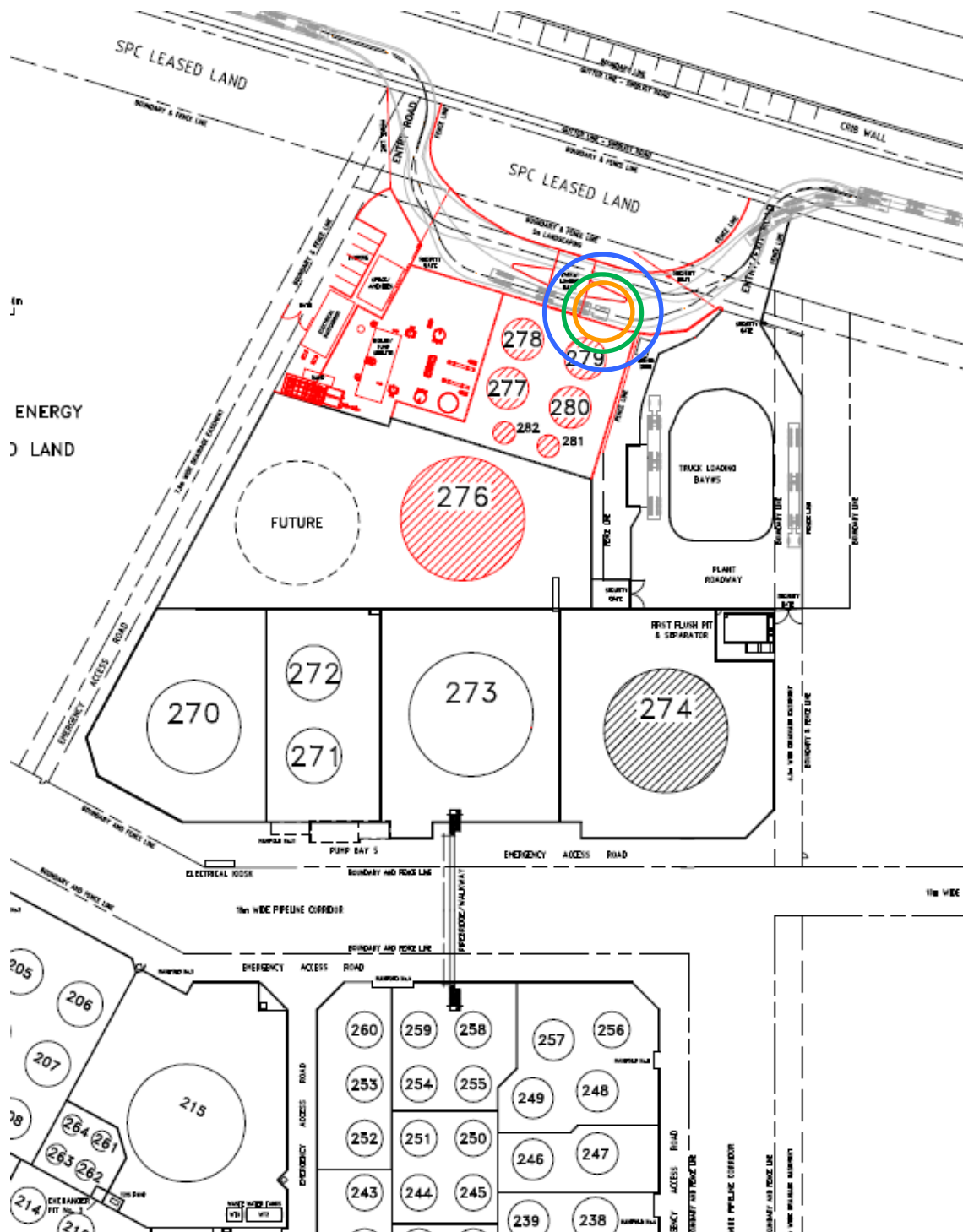
Scenario 12 – Tanks 277 to 282 Bund Fire (bitumen)



**Key:**

- 12.6 kW/m<sup>2</sup>
- 4.7 kW/m<sup>2</sup>

Scenario 13 – Bitumen Road Tanker Loading Fire



**Key:**

<span style="color: orange;">—</span>	23 kW/m <sup>2</sup>
<span style="color: green;">—</span>	12.6 kW/m <sup>2</sup>
<span style="color: blue;">—</span>	4.7 kW/m <sup>2</sup>

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