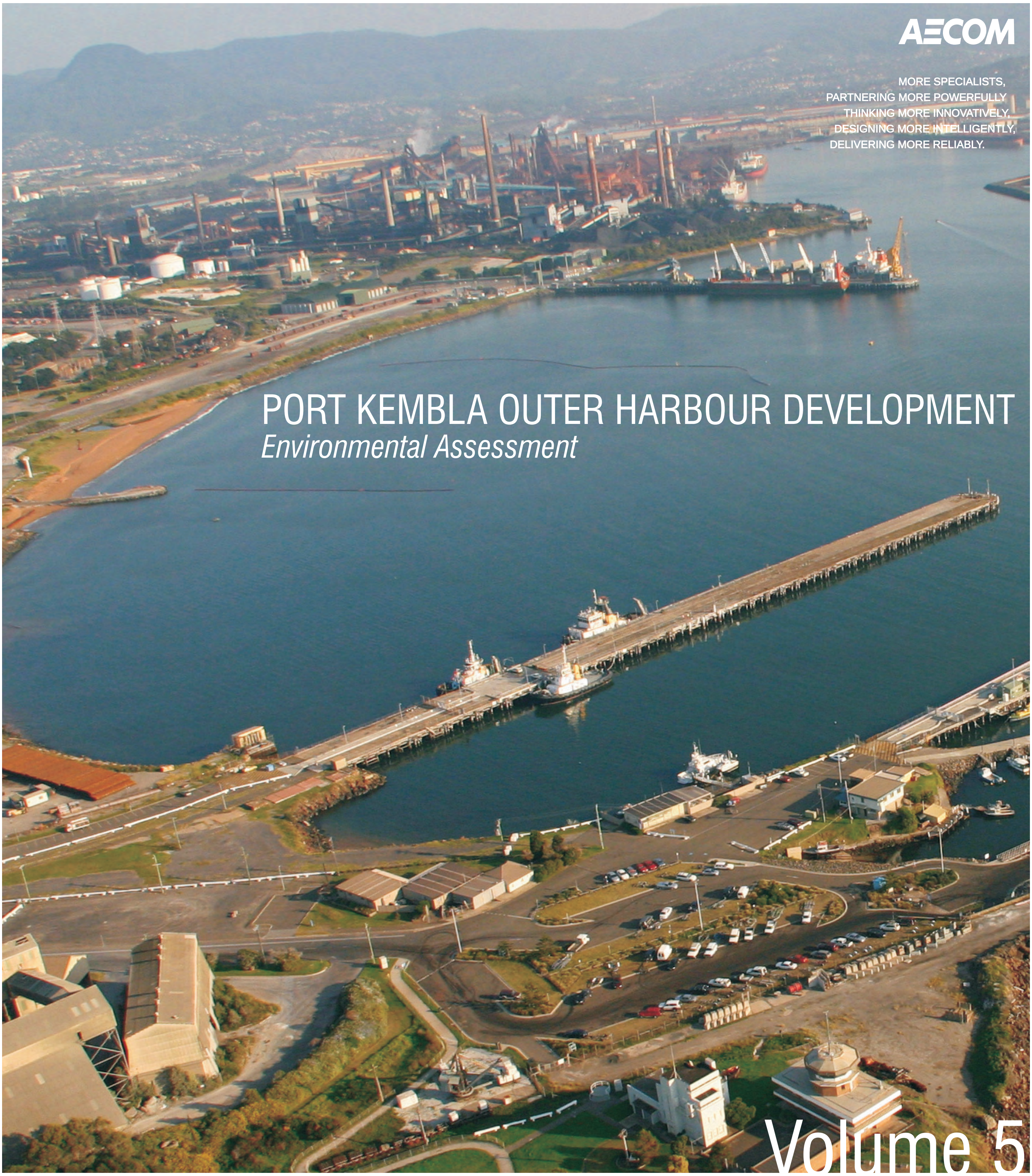


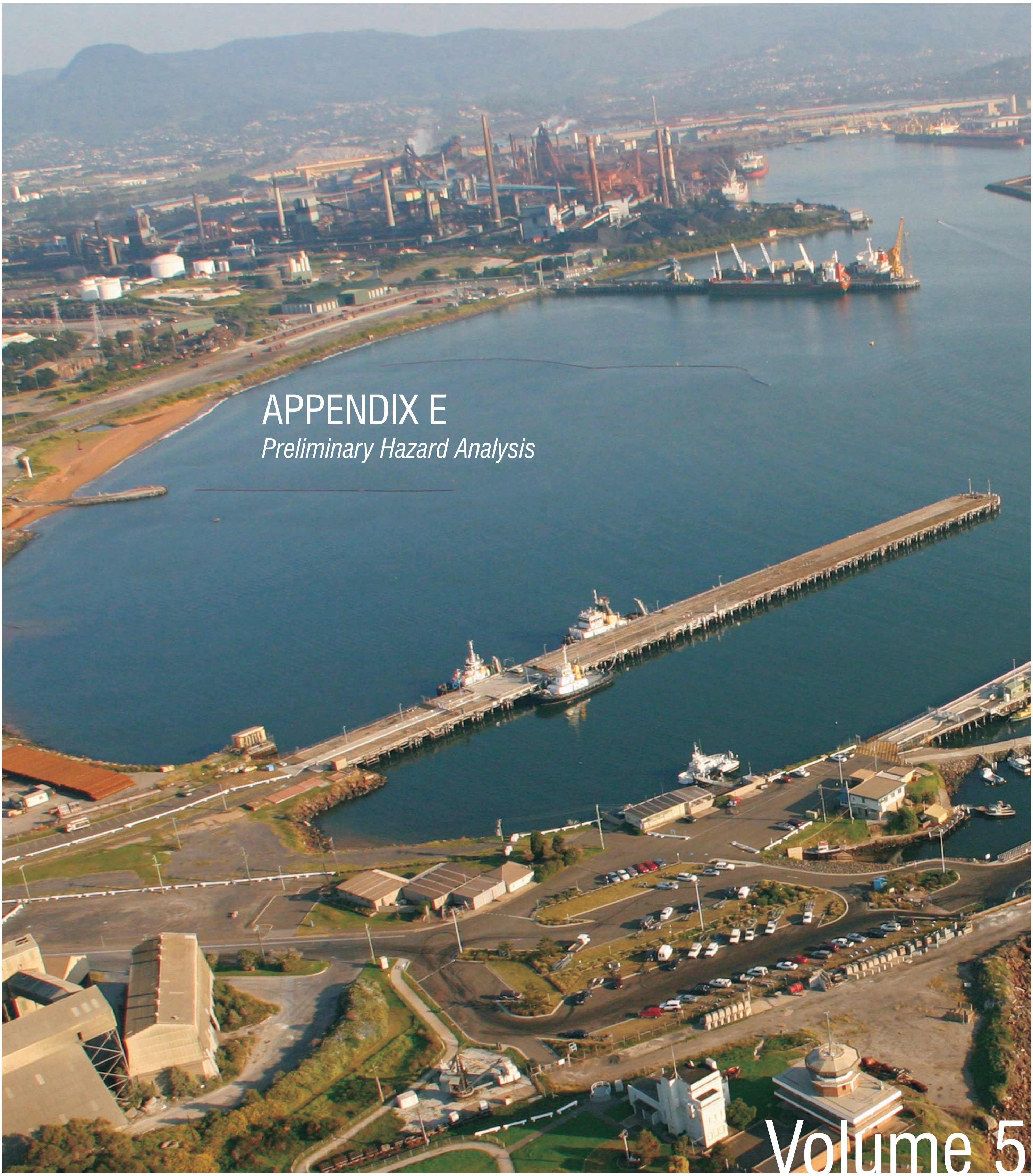
PORT KEMBLA OUTER HARBOUR DEVELOPMENT

Appendix E: Preliminary Hazard Analysis
Appendix F: Coastal Hydrodynamic Processes
Appendix G: Aquatic Ecology

Prepared for
Port Kembla Port Corporation

March 2010

PORT KEMBLA PORT CORPORATION


APPENDIX E
Preliminary Hazard Analysis
Volume 5

FINAL

Port Kembla Port Corporation
4 March 2010

Port Kembla Outer Harbour Development

Preliminary Hazard Analysis

Port Kembla Outer Harbour Development

Preliminary Hazard Analysis

Prepared for

Port Kembla Port Corporation

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Abbreviations

Abbreviation	Description
ALARP	As Low As Reasonably Practicable
AN	Ammonium Nitrate
DECC	Department of Environment and Climate Change
DG	Dangerous Goods
DoP	Department of Planning
HCFC	Hydro-chloro-fluoro-carbon
HIPAP	Hazardous Industry Planning Advisory Paper
IBC	Intermediate Bulk Container
kg	kilograms
kPa	kilo Pascals
kW/m^2	kilo Watts per square metre
L	Litres
LEL	Lower Flammable Limit
LEP	Local Environmental Plan
m	metres
mg/s	milligrams per second
mm	millimetres
mtpa	million tonnes per annum
OHD	Outer Harbour Development
PHA	Preliminary Hazard Analysis
PKPC	Port Kembla Port Corporation
ppm	parts per million
QRA	Quantitative Risk Assessment
SEPP	State Environmental Planning Policy
TEU	Equivalent unit 20 foot
UEL	Upper Flammable Limit
V	Volts

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Executive Summary

Introduction

Port Kembla Port Corporation (PKPC) proposes to develop the Port Kembla Outer Harbour area to provide berths for containers handling, bulk trades and general cargo. General cargo may include Dangerous Goods (DGs) that enter the port in containers or bulk products in portable tanks or Intermediate Bulk Containers (IBCs).
As part of the development project, the Department of Planning has requested PKPC to conduct a Preliminary Hazard Analysis, the objective of which is to demonstrate that the Concept Plan will not present a Hazardous Facility and that the proposed safeguards and operations will ensure the facility is only potentially hazardous.

As the Concept Plan is in the early states of planning, it is difficult to determine the exact list of DGs that may enter the Port. Hence, the scope of the assessment is to review typical DGs that may be transported and stored at the Outer Harbour Development (OHD) during transit to owners' premises.

Methodology

The requirement for the assessment arises as the result of the potential to exceed the Dangerous Goods (DGs) threshold levels listed in State Environmental Planning Policy No.33, Hazardous and Offensive Developments. This policy requires proponent to assess the hazards associated with the storage of DGs and whether these hazards have the potential to impact offsite land uses. The policy is supported by a number of Hazardous Industry Planning Advisory Papers (HIPAPs), that provide guidance on the assessment of hazards and risks and provide acceptable hazard and risk criteria.

The methodology used for the assessment has been based on HIPAP No.6, Hazard Analysis Guidelines. Each DG Class and representative product, selected for assessment, was subjected to a detailed hazard analysis and consequence assessment. The results of this component of the study was used to recommend considerations that should be given to the detailed design of the Concept Plan, including separation distances and DG storage design areas.

Existing Conditions

The development would be located in Port Kembla Outer Harbour. The surrounding area is zoned industrial including heavy industries such as Bluescope Steel, former Port Kembla Copper Smelter and a brick manufacturing industry. The closest residential area is located over 600 metres to the south west of the site across Five Islands Road.

The Outer Harbour Development

The OHD will consist of dry bulk and general cargo terminals, container terminals and associated ship berthing facilities. The Concept Plan development would proceed in a staged manner over a number of years. The operation of the Concept Plan would involve ships arriving and departing with goods that would be loaded and unloaded at the various wharves. Bulk goods would be unloaded using ship mounted equipment or loaded to ships using wharf mounted equipment.

The bulk goods transferred between the ships and the Port would include products such as woodchips, gypsum, sand, coke, fertiliser, clinker, slag, steel making materials, construction materials, bulk liquids, timber, steel, newsprint but would not contain Dangerous Goods and hence, risks to offsite facilities from operation in this area are negligible.

Ships would also arrive and depart with containers, that would be lifted from the ships or to the ships using ship or wharf mounted cranes. The containers would be transferred to and from the ships by wharf vehicles (e.g. forklifts) and may be stored on site prior to loading or after unloading, the latter being the more likely case as fumigation for quarantine purposes would be required for some of containers arriving from overseas.

The containers delivered to the port may hold DGs, and hence, during the storage period there is a potential for incident that could impact offsite areas.

Hazard Analysis

As the OHD is in the early stages of planning, it was difficult to identify the exact list and quantities of DGs that would pass through the Port. Hence, the types of DGs that generally pass through Ports was reviewed and a representative list developed. Based on this list a detailed hazard analysis was conducted for the proposed operations and temporary DG storages at the site. It is recognised that detailed analysis will be conducted as part of Major Project developments for the various container terminals in the OHD, hence, the analysis conducted in this study is aimed at providing guidance on whether the concept plan is feasible. A hazard identification table was developed (**Appendix A**) the results of which indicated what DGs required review and assessment. The following hazards were assessed:

- **Flammable Gas Cylinders (Class 2.1)** – gas release, delayed ignition and explosion in the shipping container;
- **Toxic Gas Cylinders/Drums (Class 2.3)** – gas release and dispersion downwind resulting in the potential for toxic impact to people offsite;
- **Flammable/Combustible Liquids (Class 3)** – release of flammable/combustible liquid, ignition and pool fire;
- **Flammable Solids (Class 4.1)** – ignition of flammable solid and localised fire;
- **Solids that Emit Flammable/Toxic Gas when Wet (Class 4.3) –** potential for goods to become wet releasing flammable or toxic gas;
- **Oxidising Agents (Class 5.1) –** the storage of (for example) ammonium nitrate that could be impacted from external events causing explosion;
- **Toxic Substances (Class 6) –** release of toxic solids or liquids with potential impact to the environment and people;
- **Corrosive Substances -** release of corrosive solids or liquids (such as sulphuric acid from the proposed transfer pipeline between the bulk goods area and the ICI facility) with potential impact to the environment and people; and
- **Environmentally Active Substances –** release of environmentally active material with the potential to impact the biophysical environment (e.g. harbour).

The hazard analysis identified a number of hazards that have the potential to impact offsite and, hence, were carried forward for consequence analysis. As a result of the hazard analysis a number of recommendations were made to ensure the risks would be maintained in the As Low As Reasonably Practicable (ALARP) range. These are detailed in the recommendations section of this report.

Consequence Assessment

The hazards identified to have a potential to impact offsite were:

- Flammable gas leak into a container, from a gas cylinder, delayed ignition and explosion;
- Flammable liquids release, ignition and pool fire;
- Toxic gas release and dispersion downwind towards sensitive land uses (off-site); and
- Fire in the AN storage area leading to explosion with the potential to impact adjacent sites;

Each hazard was subjected to a consequence analysis to determine the severity of impact at the site boundary. The results of the analysis are presented below:

Flammable Gas Leak and Explosion – in the event of a release of gas within the container, the gas would form a flammable mixture and, if ignited, explode. The distance to an overpressure level of 7kPa (the maximum permissible level at the site boundary above which further risk assessment is required) is 78m. Hence, there is sufficient space at the proposed container terminal area to store the containers holding flammable gas well clear of the site boundary.

Flammable Liquid Release, Ignition and Pool Fire – in the event of a flammable liquid release, the liquid would be contained within the bund. Ignition of the liquid would result in a bund fire, radiating heat to the surrounding area. The heat radiation impact at 4.7kW/m^2 (the maximum permissible level at the site boundary above which further risk assessment is required) is 30.1m. Hence, there is sufficient space at the container terminal to store the containers holding flammable gas well clear of the site boundary.

Toxic Gas Release and Downwind Impact – in the event of release of a toxic gas (e.g. ammonia or chlorine), the gas would disperse downwind until it reached a concentration which was not harmful. The study identified that in the worst case a release of chlorine from a storage drum could result in a fatality impact to a distance of 558m. Hence, if the containers holding the drums were stored at the north west corner of the container terminal (i.e. at the northern end of the container development), there would be no fatality impact offsite (i.e. at Foreshore Road or the Boat Harbour). However, it was identified that the concentration beyond the site boundary may reach levels that would result in injuries and, hence, it would be necessary to review the final design safeguards and conduct a detailed risk assessment as part of the environmental assessment for the container terminal operation, which will be subject to a separate Project Application.

Explosion of Stored Ammonium Nitrate (AN) – in the event of a fire that may impact an AN storage, the fire could initiate an explosion within the stored AN. The maximum quantity stored in each stack would not exceed 300 tonnes, as specified by the relevant Australian Standard. The impact distance to 7kPa (the maximum permissible level at the site boundary above which further risk assessment is required) is 584m. There is adequate area available within the container terminal (north west corner) to meet this requirement so that there would be no impact above acceptable levels beyond the site boundary (Foreshore Road and the Boat Harbour).

Mitigation Measures

A number of recommendations for mitigation have been made to ensure the risks are maintained within the permissible levels of SEPP33 and also within the ALARP range. These are:

1. It was identified that Methyl Bromide would be used as a fumigation product for a percentage of the containers at the container terminal. As Methyl Bromide is a HCFC gas, there is a potential for this gas to impact the environment and, to some extent, operators close to the fumigation process. It is therefore recommended that the container terminal be designed and operated with Methyl Bromide dosing and capture systems to minimise the risk of harmful gas release to the atmosphere.
2. Flammable (Class 3), corrosive (Class 8), toxic (Class 6) and environmentally active (Class 9) liquids may be delivered to site in 20,000 L isotainers. Leaks from tanks may impact the environment and, in the case of flammable liquids, ignite causing fires that may spread to other container storage areas. It is therefore recommended that containers holding flammable, corrosive, toxic or environmentally active materials be located within bunded areas with a capacity of 20,000 L per bund.
3. It was identified that in the event of a fire (e.g. in the flammable liquids container storage area), the fire may impact the flammable solids containers, initiating combustion in this area. The analysis identified that the heat radiation from a flammable liquids storage fire at distances below 35m may initiate combustion in the flammable solids area. Hence, it is recommended that the flammable solids storage area be separated from the flammable liquids storage area by a minimum of 35m.
4. It was identified that the relevant Australian Standard for the storage of AN, a product that may be delivered to the Port in containers, limits storage quantities to a maximum of 300 tonnes. An assessment conducted in this study identified that an explosion of 300 tonnes of AN would result in an overpressure of 7kPa at a distance of 584m from the explosion. There is sufficient site area available at the container terminal to accommodate this separation distance (i.e. from AN storage to Foreshore Road and the Boat Harbour). Hence, it is recommended that AN storages at the container terminal be sited and designed to comply with the relevant Australian Standards in respect to both storage quantities and siting (distance separation). This issue can be assessed in more detail at the subsequent Project Application stage.
5. It was identified that in the event chlorine is delivered to the site in drums, a drum leak could result in injury impacts to people beyond the OHD boundary. The current status of the project design is preliminary and detailed operations with respect to storage and handling of chemicals (i.e. deliveries, detailed safeguards, etc.) are not available. Hence, it is difficult to assess the risks associated with an injurious level of chlorine at the site boundary. It is therefore recommended that the risks associated with the storage of toxic gases be included in the Environmental Assessments prepared for the subsequent Project Application for the container terminal and that risk reduction measures determined as a result the assessment be included in the terminal design and operation.
6. It was identified that Dangerous Goods would be transported to and from the proposed OHD. However, at this stage of the project details about the likely transport routes, number and type of vehicles, etc. are not available for Dangerous Goods transport and therefore it is difficult to conduct a transport risk assessment. Therefore, it is recommended that the Environmental Assessment, conducted as part of the subsequent Project Application for the container terminal operation, includes an assessment of the transport requirements and risks associated with the transport of DGs in accordance with relevant guidelines (The Australian Dangerous Goods Code).
7. Whilst it is recognised that as part of Conditions of Consent it is likely that an Emergency Response Plan (ERP) will be required, it is recommended that an ERP be prepared for each of the multi-purpose terminal and the container terminal. The ERP should be prepared in accordance with the HIPAP No.1 Emergency Planning Guidelines.

Conclusions

The proposed terminal facilities are located in an established port and industrial setting and some distance (in excess of 600 metres) from the closest residential areas to the south west across Five Islands Road. Industrial development is located within this buffer area.

The Concept Plan will consist of multi-purpose terminals and container terminals with associated ship berthing facilities. The multi-purpose terminals are not likely to contain DG storage, however, a sulphuric acid transfer pipeline will be installed from the multi-purpose terminal to the existing Orica facility in Port Kembla. It is noted that the sulphuric acid pipeline will be installed to replace an existing line from the demolished No.4 Jetty to the Orica site. The analysis conducted for the proposed sulphuric acid pipeline concluded that the hazards and risks would be effectively managed by the proposed safeguards.

The type of DGs that are likely to be stored and handled at the container terminals are not known in detail at this stage, however, it can reasonably be assumed that the DGs would be representative of those typically found at similar terminal facilities across a range of ports in NSW and Australia.

Based on the analysis outlined above, it is considered that the proposed PKPC Concept Plan development would not exceed the requirements of SEPP33, Hazardous and Offensive Developments. Hence, the facility would be classified only as potentially hazardous and therefore would be permissible in the proposed location provided that the recommendations made above are implemented.

1.0 Introduction

1.1 Background

Port Kembla Port Corporation (PKPC) proposes to develop the Port Kembla Outer Harbour area to provide berths for containers handling, bulk trades and general cargo. General cargo may include dangerous goods that enter the port in containers or bulk products in portable tanks or Intermediate Bulk Containers (IBCs).
As part of the development, it may be necessary to store dangerous goods, that are listed in the Australian Dangerous Goods Code (Ref.1), that enter the port and are stored until these goods can be transported to the owner's premises. Whilst the goods may only be stored temporarily, there is a potential for incident at the port whilst the goods are stored. Hence, in the Director Generals requirements for this project the NSW Department of Planning (DoP) has requested that a Preliminary Hazard Analysis (PHA) be conducted for the proposed development.

PKPC has commissioned AECOM to prepare the PHA study for the proposed port development. This document reports on the results of the PHA study for the proposed PKPC OHD.

1.2 Objectives

The objectives of the study are to:

- Conduct a PHA study of the proposed PKPC OHD in accordance with the requirements of the NSW DoP Hazardous Industry Planning Advisory Paper (HIPAP) No.6, Hazard Analysis Guidelines (Ref.1); and
- Prepare a report on the results of the PHA study for inclusion in the environmental assessment conducted for the Port Kembla OHD.

1.3 Scope of Work

The scope of work is for a PHA of the Port Kembla OHD. At this stage of the development it is difficult to determine the exact quantity and type of Dangerous Goods (DGs) that may enter the harbour and, hence, be stored in the harbour precinct. The scope of the PHA is therefore difficult to define as the exact quantity of DGs is not available for assessment. The scope of the study is therefore to review the general principles of storage at the proposed facility and to identify any issues that may arise as a result of the OHD.

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2.0 Methodology

2.1 Multi Level Risk Assessment

The Multi Level Risk Assessment (Ref.3) approach was used to assist in developing a methodology that may be used for the PKPC OHD, considering the stage of the project and the difficulty in identifying the exact quantity of DGs that may enter the port and in any given cargo.

The methodology used in this study was based on estimated quantities that may be stored at the PKPC OHD project in context of the location of the site and to the surrounding land uses and the nature of the DGs that may be stored. The Multi Level Risk Assessment Guidelines are intended to assist industry, consultants and the consent authorities to carry out and evaluate risk assessments at an appropriate level for the facility being studied, in this case a concept design.

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

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

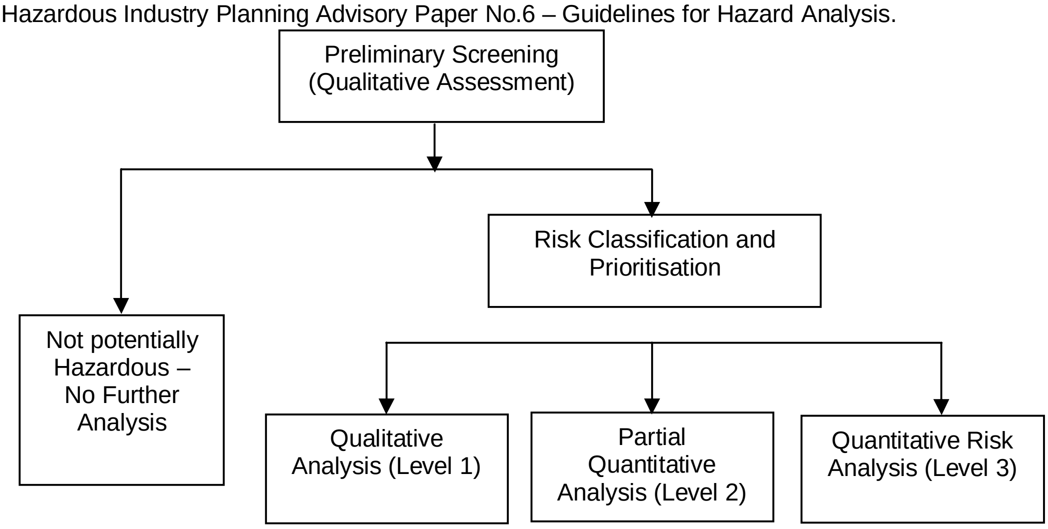


Figure 2.1: The Multi Level Risk Assessment Approach

The “Applying SEPP 33” (Ref.4) guideline may also be used to assist in the selection of the appropriate level of assessment. This guideline states the following:

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

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

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

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

"*A sound qualitative PHA which addresses the above matters could, for some proposals, provide the consent authority with sufficient information to form a judgement about the level of risk involved in a particular proposal*"(Ref.4). It is noted that, apart from Stage 1 which involves dredging, reclamation works and operation of one berth at the multi-purpose terminal, the proposed PKPC OHD is in the concept stage and therefore details of the development are not finalised. Under these circumstances, qualitative assessment with some quantitative analysis has been used, following the general principles detailed in HIPAP No.6 (Ref.2).

Hence, based on the concept nature of the proposed development and the fact that the nature and quantity of the DGs is uncertain, a Level 1 assessment has been selected for this PHA, supported by selected quantitative studies (Level 2). This analysis will permit a qualitative assessment of the general DG storage area with a more detailed assessment of higher potential hazard materials (e.g. toxic gases, flammable liquids, etc.). It is noted that subsequent Protect Applications will be prepared for the container terminals, each requiring Environmental Assessment including preliminary hazard analyses of the Dangerous Goods storages. At this stage of the development, more detailed information regarding Dangerous Goods storage quantities and storage designs will be available.

The analysis generally followed the approach below:

- **Hazard Analysis** - A hazard identification was conducted for the range of DGs that could be stored at the port. Where an incident was identified to have potential off site impact, it was included in the recorded hazard identification word diagram (**Appendix A**). The hazard identification word diagram lists incident type, causes, consequences and safeguards. This was performed using the word diagram format suggested in HIPAP No.6 (Ref.2). Each postulated hazardous incident was assessed qualitatively in light of proposed safeguards (technical and management controls). Where a potential offsite impact was identified, the incident was carried into the main report for further analysis. Where the qualitative review in the main report determined that the safeguards were adequate to control the hazard, or that the consequence would obviously have no offsite impact, no further analysis was performed.
- Consequence **Analysis** - For those incidents qualitatively identified in the hazard analysis to have a potential offsite impact, a detailed consequence analysis was conducted. The analysis modelled the various postulated hazardous incidents and determined impact distances from the incident source. The results were compared to the criteria listed in HIPAP No.4 (Ref.5). Where an incident was identified to have an offsite effect, and a simple solution was evident (i.e. move the proposed equipment further away from the site boundary), the solution was recommended and no further analysis was performed. Where an incident was identified to result in offsite effect, and no immediate solution was evident, it was reviewed qualitatively and recommendations made for risk reduction. The quantitative assessment of risk is difficult to perform at this stage of the development as detailed storage quantities and delivery frequencies are unavailable. Hence, assessment of risk performed for the overall concept impacts were reviewed in light of the potential location of Dangerous Goods and the site boundaries.

On completion of the assessment a report detailing the study outcomes, conclusions and recommendations was developed in support of the Environmental Assessment for submission to the regulatory authority.

3.0 Brief Description of the Proposed PKPC Outer Harbour Development

3.1 Development Location

The proposed PKPC Outer Harbour Development (the OHD) would be located within the existing Port Kembla Harbour precinct and inside the northern and eastern harbour breakwaters. **Figure 3.1** shows the regional location of the proposed development.

The land use surrounding the Port Kembla Harbour is predominantly industrial, with a residential area located directly to the south. The land use surrounding the harbour area is zoned 5(a) (special uses-port) under the Wollongong LEP. The closest residential area, from the boundary of the proposed OHD, is located over 600m to the south west on Wentworth Road.

Figure 3.1: Regional Location of the Proposed PKPC Outer Harbour Development

Figure 3.2 shows the final layout of the proposed OHD.

Figure 3.2: PKPC Outer Harbour Development Final Layout

The surrounding land uses can be seen on **Figure 3.2**.The areas surrounding the site are:

- North – Outer Harbour open water, northern breakwater incorporating a flammable liquids berth (520m from the closest OHD terminal);
- East – Eastern Breakwater and Pacific Ocean,
- South – Heavy Industrial areas including open areas on the foreshore currently used for steel pipe storage, PKPC Training facilities, Brick and Block Company, Morgan Cement, Orica and the former PKC Copper Smelter;
- West – Heavy industrial areas including BHP Billiton Steelworks, bulk liquids terminals and rail yards.

The nearest residential area is located to the south west of the proposed OHD and is located at a distance of approximately 600m.

3.2 Brief Description of the Proposed PKPC Outer Harbour Development

3.2.1 Approval Framework

Port Kembla Port Corporation is seeking concurrent Concept Plan approval for the total development and Major Project approval for Stage 1 of the development. The Major Project sits within, and is part of, the overarching Concept Plan framework. A brief description of the Concept Plan and Major Project is provided in the following sections of this report. Further discussion on the framework of the Concept Plan and Major Project is presented in Sections 5 and 6 of the Environmental Assessment report

3.2.2 Concept Plan Description

Figure 3.3 shows an artist's impression of the OHD footprint and it's component parts, which is to be constructed in three discrete stages over the next 30 years with an anticipated completion date of 2037. Concept Plan approval is being sought for the total development. Construction of the Concept Plan would be staged to meet the needs of prospective customers, to cater for growing port needs and regional development, and to increase the potential to address the needs of new industry for 30 plus years into the future.

The Concept Plan provides a framework for the progressive completion of the Outer Harbour development and comprises creation of land dedicated to port activity. The reclaimed land would be divided into two main areas, one devoted to the import and export of dry bulk, break bulk and bulk liquid cargoes (multi-purpose terminals) and one devoted to container trade (container terminals).

Once the Concept Plan is completed, the reclamation footprint of the development would extend from the existing Port Kembla Gateway jetty in the north to Foreshore Road in the south, the boat harbour to the east and existing rail sidings to the west.

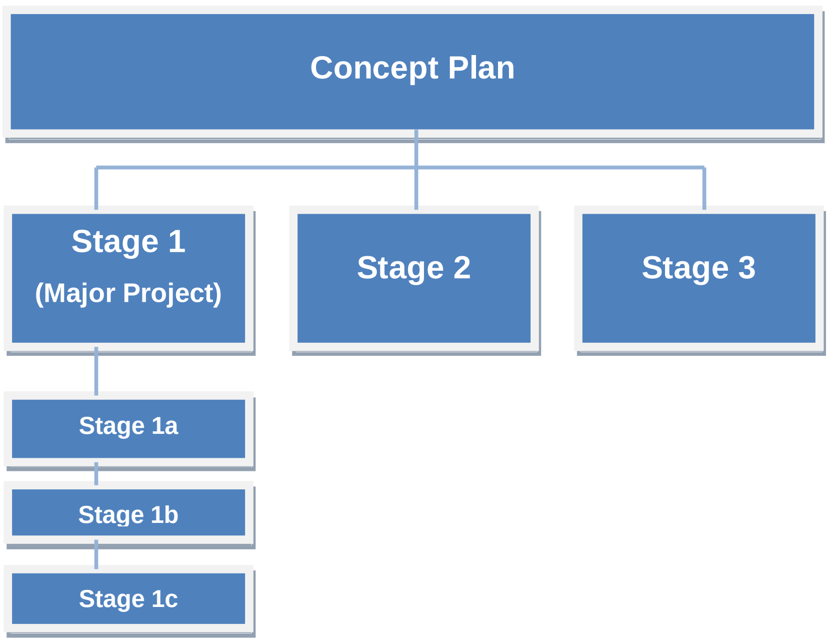
Physical features of the Concept Plan include the following:

- At least 42 hectares of hard stand, to accommodate new multi-purpose terminals and new container terminals
- Dredging would be completed over a series of dredging campaigns for:
  - Berth boxes and basins between multi-purpose terminals and container terminals.
  - Basins east of the container terminals.
  - Container berth boxes and approach channels.
- 1770 metres total new berth length.
- A total of seven new berths, including:
  - Four container berths with a total length of 1,150 metres.
  - Two multi-purpose berths designed to handle dry bulk, break bulk and bulk liquid with a total berth length of 620m.
  - A multi-purpose berth at the site of the existing No. 6 Jetty.
- Retention of the existing oil berth on the northern breakwater of the Outer Harbour.
- Berthing basins and approaches with up to -16.5 metres water depth below Port Kembla Harbour Datum for new berths.
- Road and rail infrastructure to support the expansion, including:

- New road link from Christy Drive to the multi-purpose and container terminals.
- Rail infrastructure upgrade in the South Yard.
- A new road link connecting Darcy Road.
- An extension of existing sidings to connect to a rail siding on the container terminals.

PKPC is seeking Concept Plan Approval for the total development of the Outer Harbour with the understanding that separate Major Project applications would be made for approval to construct and operate facilities on the site. PKPC would construct the reclamation, road and rail infrastructure and basic services for the site as a whole. Development of specific facilities may be undertaken by PKPC or third party operators who would lease part of the site from PKPC for a specific purpose. It is initially intended that the first stage of the multi-purpose terminals, including utilities and amenities, would be developed, operated and maintained by PKPC as a common user facility.

The relationship between Concept Plan and Major Project is illustrated in the Figure below.



Stage 1 would be constructed between 2010 and 2018, Stage 2 between 2014 and 2025 and Stage 3 between 2026 and 2037.

Stage 1 is programmed to commence in 2010. Project timing for activities as part of Stages 2 and 3 of the Concept Plan has been determined based on current market projections, outlined in the Master Plan, and are anticipated to be completed by 2037.

Figure 3.3: Concept Plan – Artists Impression

3.2.3 Major Project Description

Figure 3.4 shows the activities to be undertaken as part of the Major Project Approval, which is being sought to construct and operate Stage 1 of the Concept Plan. Construction of the Major Project would be divided into three sub-stages, identified as Stage 1a, Stage 1b and Stage 1c. Construction elements of Stage 1 comprise demolition of No.3 and No.4 Jetties, and reclamation and dredging for the footprint of the total development, with the following exceptions:

- An area in the vicinity of the Port Kembla Gateway.
- Expansion of the current swing basin area (ship turning circle).

At the completion of Stage 1 the central portion of the multi-purpose terminals would be operational. Road and rail infrastructure to support the first multi-purpose berth would also be constructed, and would comprise:

- Upgrade of rail infrastructure in the South Yard.
- A new road link from Christy Drive to the central portion of the multi-purpose terminals.
- A temporary road to facilitate construction of the container terminals.

The Major Project application sits within, and is part of, the overarching Concept Plan. Stage 1 is proposed to be constructed between 2010 and 2018. Major Project Approval would allow PKPC to commence reclamation and dredging for the multi-purpose and container terminals and construct and commence operations for the first multi-purpose berth. Major Project Approval for Stages 2 and 3 of the Concept Plan would be subject to separate applications for Project Approval made at a later date.

The required capacity of the development has been estimated based on PKPC trade forecasts and likely demand into the future. **Table 3.1** lists the capacity estimate for the Major Project Approval and the Concept Plan. Project capacity has been calculated using the following throughputs:

- Dry bulk products assumed at 4.25 Mtpa per berth
- General cargo assumed at 1 Mtpa per berth
- Containers assumed at 300,000 TEU pa per berth

Table 3.1: Estimated Capacity for Major Project And Concept Plan Approval

Approval	Dry Bulk / Multi-purpose Terminal		Container Terminal		Total number of berths in Outer Harbour
	No. of operational Berths	Capacity (Mtpa)	No. of operational Berths	Capacity ('000 TEU)	
Major Project	1	4.25	0	0	4 (one new berth plus three existing berths; two at Gateway and oil berth)
Concept Plan	3	6.25	4	1,200	8 (seven new berths plus retained oil berth)

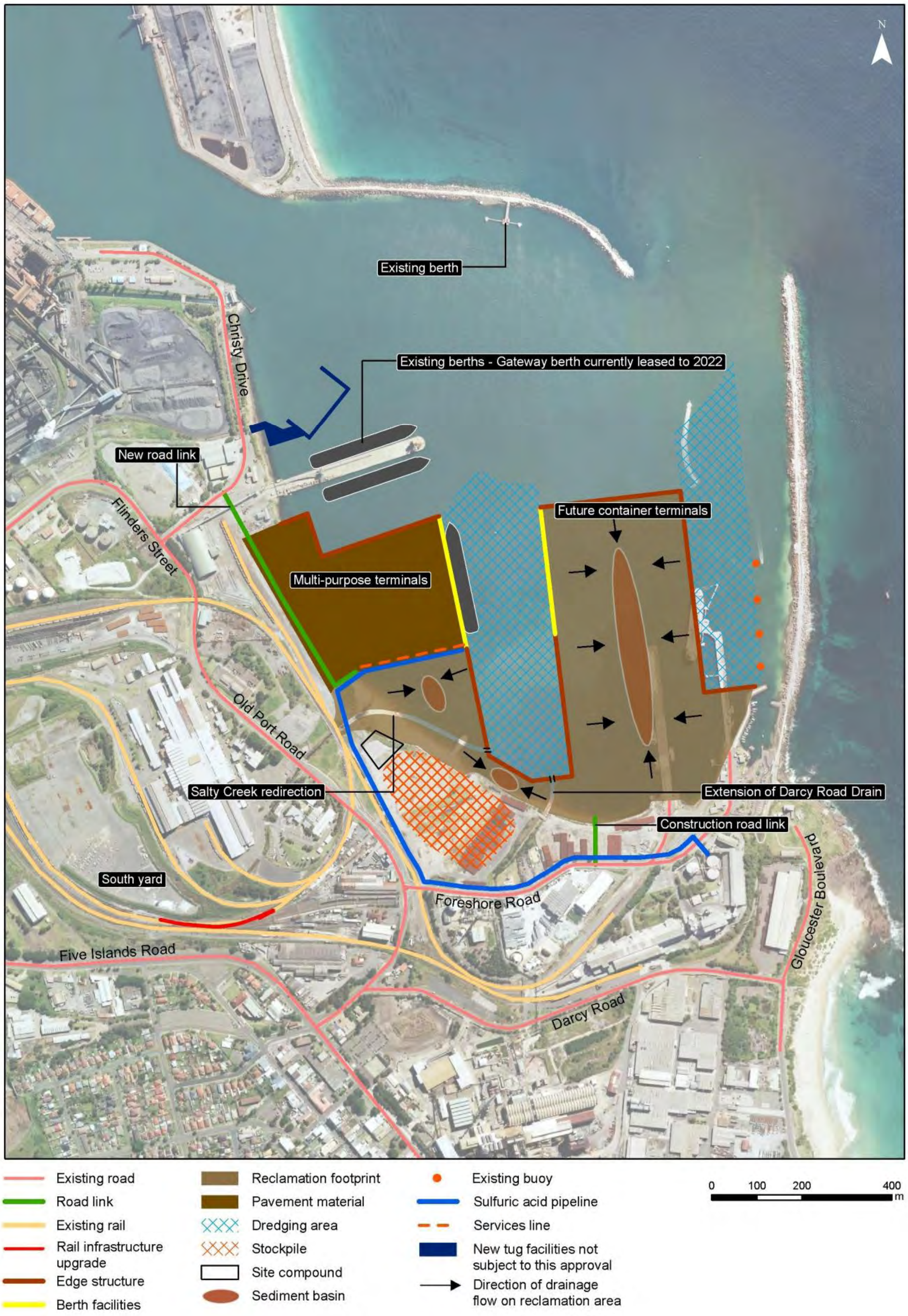


Figure 3.4: Activities to be Undertaken as Part of Major Project Application

3.3 Brief Description of the Concept Plan Operation

The new port facilities associated with the Concept Plan would be used for the transit of goods arriving/departing via ship to and from overseas ports. The facility would be designed to cater for a wide range of goods including dry bulk and containerised products. The multipurpose terminal would be used for the loading/unloading of sulphuric acid, which is currently transferred at Jetty No.4 (to be demolished). However it would not be used to for the loading/unloading or storage of other bulk liquids (e.g. fuels, chemicals, etc.).

Ships would arrive via the entry to the harbour (i.e. between the north and east breakwaters) and would be directed to the wharf where loading/unloading would occur. The loading/unloading operation would depend upon the cargo carried by the ship (i.e. bulk goods, containers or sulphuric acid).

- **Bulk Goods Cargo** – ships would tie up at the dry bulk/multi-purpose terminal area and goods would be unloaded using ship mounted equipment. For bulk goods this could be a variety of equipment including crane mounted grabs, lifting the bulk materials from the ship hold and depositing it into a hopper where it is transferred by conveyor to stockpiles. Unloading may also be via pneumatic conveyance, where dry products are carried in an air stream in ducts to stockpiles. Loading ships may occur using ship loader gantries, that convey the materials by belt conveyor and deliver them to the cargo holds via spouts. Details of bulk loading/unloading are not finalised at this stage of the project, however, the bulk goods area would not handle bulk Dangerous Goods transferred by conveyor/pneumatic operation.
- **Containers Cargo** - Once tied up, the ships would unload the cargo using ship mounted lifting equipment which lowers the containers to the dock where they are transported to the container storage area. A percentage of these containers are fumigated, which consists of the dosing of the containers with a charge of methyl bromide (about 100kg per container). Once fumigation has been completed, the fumigated containers are transferred to temporary storage, with the non-fumigated containers, where they remain until cleared by customs. Once cleared, the containers are then transferred to the owner's premises off-site.
- **Sulphuric Acid** – an existing sulphuric acid pipeline and transfer berth is located at Jetty No.4. This jetty will be demolished and the pipeline removed. A new pipeline will be installed from the multi-purpose terminal to the existing Orica sulphuric acid storage tanks at the Orica facility. There will be no storage of acid at the multi-purpose terminal as part of the development. Bulk acid ships will tie-up alongside the transfer point and flexible hoses installed between the ship and shore connections. Acid will then be transferred, using ship mounted pumps, to the Orica tanks. The acid pipeline will be installed underground within a dedicated pipeline corridor wholly within the PKPC OHD. The pipeline will be clearly marked both below and above ground, inventory records of transfer and storage will be maintained to detect any discrepancies (identifying leaks), the pipeline will be constructed from corrosion resistant materials and regular inspections and pipeline testing will be conducted.
- Safeguards during construction and operation of the sulphuric acid pipeline would be implemented to ensure risks are minimised and maintained within the ALARP range. A range of safeguards may include:
  - Locating the pipeline within the dedicated services corridor.
  - Use of underground marker tape to highlight the presence of the pipeline as well as above-ground service indicator sign posts.
  - Construction from corrosion-resistant materials.
  - Maintenance of inventory records and pipeline inspections

3.4 Dangerous Goods Transit at the Proposed PKPC Outer Harbour Facility

Dangerous Goods (DGs) will not be transported in bulk via the multi-purpose terminal. However, containers that transport DGs may enter the Port and require temporary storage at the container terminal until clearance from customs and prior to transfer to the owner's premises.
At this stage of the development, the type and quantity of DGs that may enter the harbour has not been defined and therefore it is difficult to provide a list of the exact quantities of DGs that may be stored at the Port. However, it is not anticipated that explosives would be transported through the Port at this stage. To ensure appropriate hazard management is provided for the areas where DGs may be stored, the protection systems proposed for inclusion at the Port, for each DG Class, are listed in **Table 3.2**.

Table 3.2: List of DG Protection Systems Proposed for Inclusion at the PKPC Port Facility

DG Class	DG Properties	Proposed Protection
Class 1	Explosives	Not intended to be stored at this stage
Class 2.1	Flammable Gas (Cylinders)	Separation, ventilation, placed clear of other areas on and offsite.
Class 2.3	Toxic Gas (cylinders/drums)	Separation, ventilation, placed clear of other areas on and off-site.
Class 3	Flammable Liquids (Drums)	Bunding surrounding the storage area and separation from other areas on and off-site.
Class 4	Flammable Solids (Drums)	Separation, ventilation, placed clear of other areas on and off-site
Class 5	Oxidising Agents (Drums, 1000kg and 25kg bags)	Placed clear of other areas on site, ammonium nitrate stored in container stacks no larger than 100 tonnes
Class 6	Toxic Substances (Drums, 1000kg and 25kg bags)	Bunding surrounding the storage area. Separated from other temporary DG stores
Class 7	Radioactive	Not stored
Class 8	Corrosive Substances (Drums, Isotainers, 1000kg and 25kg bags)	Bunding surrounding the storage area and separation from other DG areas.
Class 9	Environmentally Active Substance (Drums, Isotainers, 1000kg and 25kg bags)	Bunding surrounding the storage area and separation from other DG areas

3.5 Proposed Safeguards at the Port

In addition to the safety management of the Port temporary DG storages (i.e. transit storages), and the safeguards listed above, a number of additional safeguards will be provided, these include:

- Fire hydrants located throughout the facility;
- Fire pumps that draw water from the harbour (unlimited water supply);
- Fire hose reels located throughout the buildings in the facility;
- Fire extinguishers located throughout the buildings in the facility and on each vehicle used within the Port (e.g. forklifts, trucks, etc.);
- Port Emergency Response Plan, with a dedicated Port Emergency Response Team; and
- Spill retention equipment (spill kits, booms, etc.) for quick response and deployment (including training of personnel at the Port).

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4.0 Hazard Analysis

4.1 General Hazard Identification

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

Table 4.1 lists the type and quantity of DGs that may be stored and handled at the proposed OHD. It is noted that not all goods listed in **Table 4.1** are flammable or combustible liquids and therefore the hazard characteristics will be different for each type of DG stored and handled. It is also noted that the quantity of combustible liquids that are likely to be stored at the facility, albeit temporary storage, would trigger the requirements for compliance with the NSW Occupational Health and Safety (Dangerous Goods Amendment) Regulation 2005 (the Regulation). The facility, under this regulation, will be classified as a 'Manifest' site. It is understood that PKPC will develop the appropriate safety management systems to comply with the requirements of the Regulation. **Table 4.1** lists the characteristics of the DGs that are likely to be stored at the site.

Table 4.1: Properties of the Dangerous Goods Proposed for Storage at the OHD Container Terminal

Material Name	Class/ PG	Hazardous Properties
Flammable Gas (e.g. LPG, Acetylene)	2.1	Flammable gases may be heavier than air or lighter than air, depending on the gas stored. LPG/acetylene are heavier than air gases and can tend to accumulate in low lying areas, Ignition of a larger cloud of gas may result in flash fire or explosion.
Toxic Gas (e.g. Chlorine, Ammonia, Methyl Bromide)	2.3	Toxic gases are generally heavier than air and if release tend to accumulate on low lying areas being dispersed as they are carried downwind. The gases are toxic to people and usually affect the mucus membranes and breathing functions, causing involuntary coughing and eventual restriction of airways. Continued exposure to high concentrations of the gas may lead to fatality.
Flammable (alcohols based liquid) and Combustible (Diesel) Liquid	3 - II and III	Flammable liquids have a flash point below 60.5^{o}C. In the event of spill, the liquid may vaporise creating a vapour cloud that if ignited results in a flash fire and pool fire at the spill source. Pool fires may impact adjacent areas causing fire growth.
	C1	Combustible liquid with a flash point greater than 60.5^{o}C but less than 150^{o}C are classified as C1. Diesel fuel has a flash point of around 90-100^{o}C, hence, is classified as a combustible liquid. Under these circumstances, the liquid does not flash (vaporise) readily at ambient temperature, hence, vapour clouds do not form and flash fires, at ambient temperature do not occur. Localised heating and minor vapour generation may result in ignition and pool fire which may escalate to larger incidents
Flammable Solid (matches, metal powders, firelighters, naphthalene)	4.1 - II and III	Flammable solids may be ignited and catch fire causing intense local burning in the containers. The spread of fire is limited as the flammable materials would generally burn in-situ and would not spread much beyond the immediate storage.
Flammable Solid (generates flammable gas when wet) e.g. Dross or Aluminium Smelting by Products or Aluminium Remelting by Products	4.3 – III	Dross is a waste product from the aluminium smelting industry. It contains a number of compounds such as aluminium carbide, aluminium nitride and compounds of fluoride. In the event these products mix with water, there is a potential for a reaction that could release ammonia (NH_3), acetylene (C_2H_2) and methane (CH_4). With significant water contact with a large volume of dross, sufficient quantity of gas could be generated such that ammonia could reach harmful levels and acetylene and methane could reach the lower explosive limit.

Material Name	Class/ PG	Hazardous Properties
Oxidising Agents Ammonium Nitrate (with not more than 0.2% combustible substances, including any organic substance calculated as carbon, to the exclusion of any other added substance)	5.1 – III	Ammonium Nitrate (AN) is a stable solid, molten or in solution. It can become less resistant to detonation/ initiation due to the presence of contaminants or on exposure to high temperatures (e.g. fire or radiant heat). Other factors may also cause AN to become less stable and a greater risk of detonation, these are: - exposure to chlorides or metals such as chromium, copper and nickel - a decrease in pH (i.e. more acidic) - formation of bubbles in the molten AN or solutions of AN Explosion may occur due to string shocks (shockwaves from nearby explosions, high temperatures from adjacent fires, a smaller detonation can trigger a larger explosion.
Toxic Substances (herbicides, pesticides)	6 - II and III	Toxic substances may be stored in solid or liquid form. In the event of release there is a potential for the substance to reach escape off-site causing damage to the biophysical environment. The damage severity is dependent on the release quantity and location.
Corrosive Substances (acids and alkalis)	8 - II and III	Corrosive substances, such as sulphuric acid, may be stored in solid or liquid form. Like the toxic materials, In the event of release there is a potential for the substance to reach escape off-site causing damage to the biophysical environment. The damage severity is dependent on the release quantity and location. In some cases, release of corrosive chemicals (e.g. sulphuric acid) may lead to dangerous reactions with other substances (e.g. water, caustic) causing heating and violent reactions.
Environmentally Active Substances (battery powered vehicles, ammonium nitrate fertiliser not classified as 5.1)	9 - III	Environmentally active substances may be stored in solid or liquid form. In the event of release, there is a potential for the substance to reach the harbour with potential detrimental effects to the marine species in the harbour.

4.2 Detailed Hazard Identification

4.2.1 Flammable Gas (Cylinders)

Flammable gases may be delivered to the Port in cylinders. In the unlikely event of a gas release, there is a potential for the gas to accumulate within the container resulting in a flammable gas mixture that could be ignited causing flash fire or explosion. The release of gas from more than a single cylinder would be highly unlikely, due to the cylinder caps installed to protect the valves from damage. However, a single cylinder release from a valve or thread failure is more likely.

In the event of a release, the quantity of gas in a single cylinder (maximum cylinder water capacity of 500 L) would escape and if immediately ignited would result in a jet fire at the leak point. This may impact adjacent cylinders causing cylinder explosion. In the event of delayed ignition, the released gas would mix with the air in the container. This would, at some point, reach flammable levels (i.e. lower flammable limit) and if ignited would result in an explosion. In the event of immediate ignition, the explosive force may cause overpressure impact off-site, hence, this incident has been carried forward for consequence analysis.

4.2.2 Toxic Gas Drums/Cylinders

Toxic gas may be delivered to the Port in drums and cylinders. In the unlikely event of a gas release, there is a potential for the gas to accumulate in the container and escape via minor holes and seal leaks at the doors. As the gas escapes, it will disperse with the wind and be carried down wind potentially impacting on and off-site areas in the wind direction. People off-site, in the direction of the wind, may be impacted by the toxic gas, resulting in injury and, in the worst case, fatality. This incident has therefore been carried forward for consequence analysis.

In addition to the storage of toxic gases that may enter the Port in containers, it is necessary to provide fumigation services for a percentage of the containers that arrive from overseas, in order to kill potential harmful insects and wildlife that could be in the containers. To fumigate containers, methyl bromide is dosed to the container over a 24 hour period and then released to the atmosphere. Methyl Bromide is a HCFC gas and has the potential to add to the depletion of the ozone layer if released. Continued releases of this gas could have significant impacts on the environment and safety of personnel within the fumigation area. Whilst it is recognised that Methyl Bromide dosing is currently performed in all Ports within Australia where overseas containers are received, and that in many cases the gas is released directly to atmosphere, this practice is not recommended. There are a number of fumigation recycling systems available whereby Methyl Bromide is dosed to the containers and recycled through a "clip-on" front to the container door. Once the recycling process is complete the gas can be captured and scrubbed out of the exhaust stream prior to release to atmosphere. This system minimises the risk to people and the environment.

It is therefore recommended that the container terminal be designed and operated with Methyl Bromide dosing and capture systems to minimise the risk of harmful gas release to the atmosphere.

4.2.3 Flammable/Combustible Liquid

Flammable and combustible liquids may be delivered to the Port in drums or isotainers (20,000 L tanks in a container sized frame). A leak of liquid from a drum would initially be contained within the container itself, gradually leaking from the container into the area surrounding the storage. The container terminal will be constructed with a DG storage area for the location of specific DGs. The area would be constructed with a bund to contain any spills that may occur. A minor spill from a drum would not result in a significant spread of the liquid, however, a leak from an isotainer could result in 20,000 litres being released to the bund. The simultaneous leak of isotainers is unlikely, hence, the containment of a single isotainer would be required within the bunded area. It is therefore recommended that the bund constructed for the storage of flammable liquids be designed to contain a minimum of 20,000 L.

In the event of a release of flammable liquid, the bund would contain the liquid, preventing spill to the environment. However, in the event of ignition of the flammable liquid, a pool fire would form radiating heat to the surrounding area. There is a potential for the heat radiation to impact offsite, hence, this incident has been carried forward for consequence analysis.

4.2.4 Flammable Solids

Flammable solids will be stored within the containers and ignition/fire would be highly unlikely as there are no ignition sources within the containers themselves. However, fire impact to the exterior of the container could result in container heating and eventual ignition of the flammable solids inside.
To ensure the potential for heating of flammable solids containers is minimised, it is recommended that the flammable solids storage be separated from the flammable liquids store by a minimum of 35m (see Table 5.1). This will ensure the containers are not exposed to heat radiation levels exceeding 12.5kW/m^2, which would provide adequate heating over an extended period to cause spontaneous ignition of flammable solids (e.g. matches) inside the container (Ref.5). See **Appendix B** for the flammable liquids analysis results and the distance to a heat radiation level of 12.5kW/m^2.

4.2.5 Solids that Emit Flammable Gas when Wet

As an example, dross has been used to demonstrate the potential gas development from Class 4.3 becoming wet whilst stored at the Port. The dross or Class 4.3 solids would be stored at the container terminal in bulk bags in containers and located in a dedicated container storage area at the site. Whilst the dross (Class 4.3) remains dry, there is little or no risk, hence, the prevention of contact between water and dross is important in managing the potential hazards of storage of this material.

There is a potential for rainwater to leak into containers resulting in contact between dross and water. Dross, however, will be stored in bulk bags (plastic) inside shipping containers to ensure there is no contact between water and dross in the event of water ingress to the container. Whilst it is recognised that small amounts of dross dust may accumulate inside the container (between the container and bulk-bags) the quantity of dust would be insufficient to generate harmful quantities of ammonia (i.e. at levels that would exceed Lc50 concentrations, about 5,000ppm, Ref.6) or methane/acetylene (i.e. at levels that would reach LEL). As a check, the following analysis has been performed to identify the quantity of gas that may be generated.

Chemical Reactions

The mixing of water and dross results in a reaction that takes place according to the equation:

$AlN + 3(H_2O) \rightarrow NH_3 + Al(OH)_3$.

This calculation assumes that all water mixing with dross is available for reaction. However, this is not usually the case in water dross mixes. In reality, other reactions take place in conjunction with the aluminium nitride/water reaction above. One important reaction is:

$2\ AlN + 3\ (H_2O) \rightarrow 2NH_3 + Al_2O_3$

This reaction creates significant heat, liberating water in the form of vapour and steam, limiting the water that is available for reaction.

Ammonia Release Calculation

To estimate the quantity of ammonia released as a result of water ingress to the container, it is assumed that the dust within the container would accumulate to about 1kg in total quantity. It is conservatively assumed that as the water gradually leaks into the container, it will contact all the dross, mix stoichiometrically and release the maximum quantity of ammonia available.

A stoichiometric mixture of 1 mole of AlN (41kg) and 3 moles of H2O (54kg) gives 1 mole of NH3 (17kg). Proportionally, for 1kg of AIN, H2O = 1.32kg and NH3 = 0.42kg. In previous studies conducted for the storage and handling of aluminium dross, it was identified that dross materials from smelters in Australia contain around 10% aluminium nitride and 1% aluminium carbides. Hence, the quantity of ammonia released is 10% of that estimated above for 1kg of AIN, NH3 release = 0.1 x 0.42 = 0.042kg.

Assuming the leak occurs over an hour (i.e. a gradual leak into the container through a small hole and contact is made with the dross over this period (liberating the full extent of the ammonia over 1 hour), then the ammonia release rate would be 0.042/3600 = 0.014grams/second or 14mg/s. This would not cause a significant impact in and around the container, even if the ammonia accumulated within the container. Once the container doors were opened, the gas would disperse rapidly and would not reach harmful levels at the site boundary (noting that there would be no continued gas generation once the dross dust in the container had reacted with the water).

Other Chemical Reactions

Two other important chemical reactions that may occur as a result of water and dross mixing are:

Al2C6 = 1kg of water mixed with 2.33kg of carbide leads to 1.44kg of acetylene

Al4C3 = 1kg of water mixed with 1.33kg carbide leads to 0.44kg of methane.

Hence, by proportion, 1kg of carbide stochiometrically mixed with water may generate 0.62kg of acetylene and 1kg of carbide stochiometrically mixed with water may generate 0.33kg of methane. Based on the premise that dross from Australian smelters contains around 1% carbide, and assuming the carbide evenly distributes to form acetylene and methane, the quantity of acetylene and methane generated from 1kg of dross is:

Acetylene = 0.05 x 0.62 = 0.031kg or 31 grams
Methane = 0.05 x 0.33 = 0.017kg or 17 grams

Similar to the ammonia scenario above, assuming the water leaks into the container over an hour period, the release rate would be:

Acetylene = 0.031/3600 = 0.0086 grams or 8.6mg
Methane = 0.017/3600 = 0.0047 grams or 4.7mg

These quantities of gas are very small and would not result in the development of a flammable mixture within the container (noting that there would be no continued gas generation once the dross dust in the container had reacted with the water).

Summary of Dross Storage Analysis

Based on the analysis conducted above, the storage of dross (Class 4.3) is considered to be adequately managed with respect to the prevention of dross (Class 4.3) and water mixing. In the event of container damage or leak (i.e. water ingress from rain), there would be insufficient gas generated to result in the accumulation of toxic or flammable gas that would impact offsite areas. Hence, this incident has not been carried forward for further analysis.

4.2.6 Oxidising Agents

The most likely oxidising agent that would be stored at the port would Ammonium Nitrate (AN). This material is a Class 5.1 (oxidising) solid with a packaging group III classification.
AN is a hygroscopic colourless crystalline solid, which is very soluble in water. In the dry state it is non-corrosive, but, when moist, it reacts with various metals forming a variety of compounds, some of which are highly unstable (e.g. copper nitrate tetramine). The main decomposition product when AN is heated above 200°C is N_2O, but above 250°C other oxides of nitrogen can be formed.

The most common form of AN is fertiliser, which exists in a variety of forms but these are classified into two groups according to the nitrogen content. All fertilisers with a nitrogen content of more than 28% are assumed to have the same hazard potential, although it is known that low density material and compounds containing potassium are more likely to detonate. It has been assumed that the AN will be in a relatively pure form with little if any potassium as this is the more common product used for feritliser. Hence, the likelihood of detonation is diminished.

Pure AN is not shock or friction sensitive and cannot be induced to detonate under normal storage conditions; however, the following characteristics increase its sensitivity:

- High temperature;
- Confinement; and
- Contamination with organic substances.

There is some confusion and uncertainty in the literature and in safety reports about the explosive power of AN and whether it detonates or only deflagrates (detonation results in shock compression or explosion, deflagration is rapid burning and gas expansion). Experiments have shown (Ref.7) that, to all intents and purpose, AN is incapable of deflagration or detonation unless at least some of the stack is heated above its melting point. Detonation, which is characterised by a supersonic pressure wave moving through the material, can occur only if the dimensions of the explosive are greater than some particular value, known as the critical charge diameter. For solid AN this diameter is about 3m which implies that a stack of less than 300 tonnes is unlikely to detonate. The corresponding diameter for molten AN (i.e. heated by fire) is only about 100mm.

Deflagration is not constrained by dimensions and occurs when a subsonic combustion generated pressure wave moves through the material. Under certain conditions the energy released and the damage caused by the two processes (detonation and deflagration) in a sample of AN can be different, but, in hazard analysis, it is not usual to distinguish between them and therefore to refer to these only as an explosion.

In the event of a large fire at an AN store, a pool of liquid AN will be formed at the side of the stack that is nearest to the fire. If this pool is struck by a high speed projectile (e.g. something falling from the roof or part of a drum that has exploded) then a local explosion will occur sending a shock wave into the main AN stack that has not melted. If this stack contains just less than 300 tonnes it will not support a detonation but will deflagrate and, in doing so, will release an amount of energy equivalent to 41 tonnes of TNT (Ref.12).

Based on this analysis, it is recommended that storages of AN at the Port be limited to quantities not exceeding 300 tonnes.

Whilst the discussion above indicates that hazards related to the storage of AN may result in explosion, this is related to the impact on an AN stack by fire. It is clear that a stack of AN will not explode without both heat (fire) and shock (impact). Hence, as the AN would be stored in containers, the likelihood of heat impact is low and the potential for impact from external sources greatly diminished. Assuming the total storage quantity in any AN storage would be less than 300 tonnes, the maximum quantity of TNT that would represent the AN is 41 tonnes.

Whilst it is indicated that the risk of AN explosion at the Port is low, due to the storage in containers and the low likelihood of fire impacting the AN, it cannot be discounted and, hence, it has been carried forward for further analysis.

4.2.7 Toxic Substances

Toxic substances may be delivered to the Port in liquid and solid form. In solid form, spills and releases would be localised and retained within the container, resulting in no impact outside the container itself. However, liquids may be delivered to site in drums or isotainers (20,000 L tanks in a containers sized frame). A leak of liquid from a drum would initially be contained within the container itself, gradually leaking from the container into the area surrounding the storage. The container terminal will be constructed with a Toxic Substances storage area for the location of containers and isotainers holding toxic materials. The area would be constructed with a bund to contain any spills that may occur. A minor spill from a drum would not result in a significant spread of the liquid, however, a leak from an isotainer could result in 20,000 Litres being released to the bund. The simultaneous leak of isotainers is unlikely, hence, the containment of a single isontainer would be required within the bunded area.

It is therefore recommended that the Toxic Substances bund be constructed to retain a minimum of 20,000 L.

In the event of a release of Toxic Substance, there is also a potential for impact to people, however, the site will be operated with an Emergency Response Plan, that will contain a response procedure to spills of chemicals. The procedure will include the wearing of the appropriate personal protective equipment (PPE) to minimise the risk of impact to people involved with spill clean up. As spill kits and other spill response equipment will be available at the Port, along with trained Emergency Response Team, the risk of impact to people is low.

Construction of the bund would minimise the potential for impact to the environment and the risk of environmental damage would be low. The trained emergency response team, along with a dedicated emergency response plan would minimise the potential for impact to people. Assuming the bund for Toxic Substances is constructed, and the emergency response plan for the Port is effective, the risk of impact is considered to be low. Hence, this incident has not been carried forward for further assessment.

4.2.8 Corrosive Substances

Like Toxic Substances, Corrosive Substances may be delivered to the Port in liquid and solid form. Hence, releases of solids would be retained within the containers and there would be little if any impact beyond the container itself. Potential leaks of Corrosive Liquids delivered to site in drums or isotainers, would be essentially contained within the container and there would be no impact beyond the immediate container area. However, a leak from an isotainer could result in 20,000 L of liquid being released to the environment. Like the Toxic Liquids, the Corrosive Liquids storage area will be bunded and larger spills would be retained within the confines of the bund and there would be no release offsite.

It is therefore recommended that the Corrosive Substances bund be constructed to retain a minimum of 20,000 L.

The existing sulphuric acid operations at Jetty No.4 will be transferred to the multi-purpose terminal, as Jetty No.4 will be demolished as part of the OHD. Sulphuric acid would be transferred from ships at the multi-purpose terminal via a newly constructed pipeline, to the Orica storage facility southeast of the site adjacent to Foreshore Road. There is a low potential for undetected leaks of sulphuric acid from the new pipeline, as the pipeline would be installed based on the Australian Standard for pipelines (AS2885) and would be constructed according to a series of stringent safeguards contained therein. Transfers of sulphuric acid the wharf would be conducted by Orica using flexible lines and using the principals of ISGOTT (International Safety Guide for Oil Tankers and Terminals), the IMDG (International Maritime Dangerous Goods code) and the Australian Dangerous Goods Code. These standards require the implementation of significant safeguards in relation to the transfer of Dangerous Goods from ship to shore and vice versa.

It is important to note that the AS2885 series of standards relate to gas and petroleum pipelines, however, the principles of installation using this set of standards is important in minimising and maintaining the risk within the ALARP range. Based on the use of AS2885 as a guide, the following safeguards would be installed:

- The pipeline will be located in a dedicated services corridor, with clearly marked pipelines;
- The service corridor will be marked above ground with sign posts indicating services pipelines underground, the markers located at distances of 50m apart;
- Marker tape will be used above the acid pipeline indicating that an acid pipeline is located under the tape, the tape will be located at 300mm depth below grade (i.e. in the event of external interference or excavation, the marker tape will be struck first, highlighting the presence of the pipeline);
- An inventory record will be kept by the operator for all transfers, reconciling the quantity of acid transferred from the ship and received at the tanks (discrepancies will indicate potential pipeline leaks, alerting operators who can respond as required);
- The pipeline will be constructed from corrosion resistant materials, minimising the potential for development of leaks in the pipeline; and
- Regular pipeline inspections will be conducted by the operator, including inspection (random locations) and testing of the pipeline (pressure).

Based on the above safeguards, the potential for undetected leaks from the pipeline would be low. In addition, impacts from external sources (i.e. excavation impacts on the pipeline) would also be low as most of the pipeline length is located within the proposed Outer Harbour site, the risk of impact beyond the site boundary would be negligible. Notwithstanding this, it is recommended that the detailed pipeline design be reviewed and the risks assessed as part of the final hazard analysis (FHA) for the site.

In addition to the above pipeline safeguards, transfers at the wharf will be conducted by the operator (Orica) using flexible lines. The transfers will be conducted using the principles of ISGOTT (International Safety Guide for Oil Tankers and Terminals), the International Marine Dangerous Goods Code and the Australian Dangerous Goods Code. These standards require the implementation of significant safeguards in relation to the transfer of Dangerous Goods from ship to shore and vice versa. As an example, transfers under these standards require the following (but are not limited to these examples):

- Annual testing of transfer hoses (including pressure tests);
- Full documented inspection of the flexible connections prior to commencement of transfer and after transfer commences;
- Fully attended transfer operations, both at the wharf and receival bulk storage;
- Emergency Response Plans available and ready for implementation in the event of an incident;
- Spill response equipment available and ready for implementation (both ship and wharf);
- Isolation of the wharf in the transfer area (preventing access to the transfer points) using barricades; and
- Safety Management Plans compliant with the standards requirements.

Based on these safeguards, the risks associated with the proposed transfer operation are considered to be low. However, as the final details of acid transfer are not currently complete, it is recommended that the transfer risks be reviewed in the final hazard analysis when the transfer operation design is completed.

Assuming that an emergency response plan and implemented safeguards would be effective in managing the clean up of corrosive liquid spills, the risk of release to the environment or impact to people is considered to be low and therefore this incident has not been carried forward for further assessment.

4.2.9 Environmentally Active Substances

Similar to the Toxic and Corrosive Substances, the environmentally active substances may be delivered in solid or liquids form in bags, drums or isotainers. Releases of solids (i.e. broken bags) would be retained within the confines of the container and there would be no release to the environment. However, liquid releases, particularly isotainer leaks, may escape beyond the immediate area of the storage causing damage to the biophysical environment. To minimise the potential for this incident to occur, the Environmentally Active Substances storage will be bunded to contain spills and prevent damage to the environment.

As environmentally active materials may be delivered in isotainers, it is recommended that the environmentally active substances bund be constructed to retain a minimum of 20,000 L.

Assuming that the emergency response plan would be effective in managing the spill clean up, the risk of release to the environment or impact to people is considered to be low and therefore this incident has not been carried forward for further assessment.

4.3 Transport

In the document “Applying SEPP33” (Ref.4), reference is made only to road transport consideration with respect to of vehicles arriving and leaving the site. No reference is made to rail vehicle movements. Whilst hazard associated with the loading and unloading of trains would be included in a detailed PHA study for the individual operators, rail movements offsite are not generally considered within the SEPP33 concept.

With respect to vehicle (truck) movements, at this stage of the development it is difficult to determine the exact number of vehicles that would access the Port for the transport of DGs, however, it is likely only to be a small number in comparison to the total number of vehicles that access the Port for all transport activities. Notwithstanding this, the transport of DGs may result in vehicle accidents and incidents that could result in the release of DGs on the transport routes.

The main safeguards that would be employed by transport vehicles are as follows:

- **Emergency Plans** – each vehicle would have an emergency plan carried in the vehicle that would be specific to the DG that is transported. Hence, in the event of an incident, the correct emergency response could be implemented.

- **Trained Drivers** – all drivers transporting DGs would be trained and licensed by the Department of Environment Climate Change (DECC) to ensure that each driver has a full understanding of the material being transported as well as an effective knowledge of emergency response implementation.
- **Dedicated Vehicles** – only dedicated DG vehicles will be used for the transport of DGs in accordance with the ADG (Ref.1). Trucks transporting DGs will not carry general loads, minimising the potential for incident from mixed loads.
- **Selected Routes** – routes will be selected from the site to the main industrial centres in Wollongong and Sydney so that in the event of incident there would be minimum impact to potentially sensitive land uses en-route.

Whilst the risk of an incident involving DGs is considered to be low, and effectively managed, an incident with vehicle transport cannot be discounted.

It is recommended that future Environmental Assessment for the container terminal operation (Stage 2 and 3 the Concept Plan) include an assessment of the transport requirements and risks associated with the transport of DGs at each facility at the Port.

5.0 Consequence Analysis

5.1 Incidents Carried Forward for Consequence Analysis

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

- Flammable gas leak into a container, from a gas cylinder, delayed ignition and explosion;
- Flammable liquids release, ignition and pool fire;
- Toxic gas release and dispersion downwind towards sensitive land uses (off-site); and
- Fire in the AN storage area leading to explosion with the potential to impact adjacent sites.

Each incident has been assessed in detail in **Appendix B**. All incidents assessed were for impacts at specific heat radiation levels (fire), overpressure (explosion) and toxic gas impact (toxic gas release). The distances to the specific levels of consequence impact were calculated to determine whether the impact at the OHD boundary exceeded the acceptable impact criteria (Ref.5).

5.2 Flammable Gas Explosion

In the event of a flammable gas release (e.g. LPG) from a cylinder into a container, the gas would mix with air resulting in a flammable mixture that if ignited may result in explosion. A detailed gas release and explosion analysis was conducted in **Appendix B**. This analysis identified that the distance to an explosion overpressure of 7kPa was estimated to be 78m.

It is therefore recommended that in the detailed design phase that containers holding flammable gas be stored no closer to the container terminal boundary than 78m.

5.3 Flammable Liquids Pool Fire

In the unlikely event of a release of flammable liquid from an isotainer into the flammable liquids bunded area, there is a potential for the liquid to ignite resulting in a pool fire. The fire would radiate heat to the surrounding area with the potential to impact offsite. The maximum permissible heat radiation level at the site boundary, before risk assessment is required, is 4.7kW/m^2 (Ref.5). A detailed heat radiation impact analysis was conducted and is shown in **Appendix B**. The results of the analysis, showing the distance to various heat radiation levels is presented in **Table 5.1**.

It can be seen from **Table 5.1** that the distance to a heat radiation level of 4.7kW/m^2 is 30.1m.

Hence, it is recommended that the isotainer and flammable liquids storage areas be located a minimum of 35m from the OHD boundary. It is also recommended that the assessment conducted in this study for the heat radiation impact from flammable liquids fires be reviewed during the detailed design of each facility.

Table 5.1: Distance to Selected Heat Radiation Impactsisotainer Storage Area Bund Fire

Heat Radiation Level (kW/m^2)	Isotainer Storage Distance (m)
35	15.4
23	17.2
15	19.6
12.5	20.8
8	24.4
6	27.3
4.7	30.1
2	42.7

5.4 Toxic Gas Release

5.4.1 Ammonia

Ammonia would be transported in cylinders (1,000kg) and possibly horizontal tanks (2,000kg). Cylinders would be stored in the container in the upright position, with the valves at the top. Horizontal tanks would also be stored with the valves at the top. Valve caps and covers are installed on the cylinders and tanks, and damage to valves is highly unlikely, however, as a worst case incident a broken valve has been assumed.

In the event of a broken valve, the gas would be released via the hole remaining where the valve is fitted to the cylinder. Whilst it is recognised that excess flow valves are fitted to cylinders and tanks, this has not been included in the assessment for the sake of conservatism. A leak and dispersion analysis was conducted and is detailed in **Appendix B**. The results of the analysis identified that there is a potential for fatality from ammonia gas at distances of up to 320m from the ammonia storage area in the container terminal.

The location of the storage of toxic gases would depend on the results of the assessment of the gas of highest toxicity. For example, chlorine incidents may result in a longer downwind distance for potential fatality/injury incidents. Hence, the recommended placement of the toxic gas storage area would depend on the results of the chlorine assessment. The recommendation relating to the location of the storage of toxic gases is made in the chlorine consequence analysis (**Section 5.4.2**).

5.4.2 Chlorine

Chlorine would be transported in 70kg cylinders and 900kg drums. Chlorine cylinders and drums have an extremely robust cap fitting and drums have concave dished ends with the valves set back inside the concave section of the end. The potential for damage to valves in chlorine cylinders and drums is negligible, and anecdotal evidence indicates that such incidents have not occurred in the industry. However, leaks at valve connection and through valve seats is possible. A detailed chlorine leak and dispersion analysis has been conducted in **Appendix B**. The results of this analysis indicates that there is a potential for fatality from chlorine gas release at distances up to 558m from the chlorine storage area at the container terminal. The study also identified that there is a potential for injury as a result of chlorine release up to a distance of 1,558m from the chlorine storage area at the container terminal.

The potential fatality and injury distances are higher than those for ammonia, hence, the location of the toxic gas storage area would be governed by the chlorine analysis. A review of the proposed container terminal layout indicates that the storage for toxic gases could be located well clear of adjacent properties. The location of the storage in the north west corner of the container terminal would provide the maximum distance from the site boundary, about 600m to the closest boundary to the south west. This would ensure that fatality risks would be eliminated at offsite areas as a result of the storage of toxic gases (chlorine/ammonia) at the terminal. However, injury impacts as a result of a chlorine release may still occur up to 1,558 metres, which would impact offsite areas to the south.

At this stage of the study, information on the delivery of chemicals is not available as the terminals have not been constructed and let to shipping companies. Hence, it is difficult to assess the risks associated with the potential for injuries. Further, additional safeguards that may be developed for the storage of chemicals have not been finalised and therefore risk mitigation cannot be effectively assessed.

It is therefore recommended that the risks associated with the storage of toxic gases be included in the specific Environmental Assessments for the container terminal operations (Stages 2 & 3 of the Concept Plan) and that any risks reduction measures determined as a result of the assessment be included in the terminal design and operation.

5.5 Ammonium Nitrate (AN) Storage Explosion

In the unlikely event of an AN storage explosion, there is a potential for overpressure at the site boundary that could adversely impact people. HIPAP No.4 (Ref.5) indicates that for incidents that cause overpressure values of 7kPa, the risk would be acceptable. Hence, a detailed analysis was conducted (**Appendix B**) to determine the potential impact overpressure from the storage of 300 tonnes of AN. The results of the analysis indicate that as a result of an explosion of 300 tonnes of AN an overpressure of 7kPa would be reached at 584m from the AN storage.

A review of the proposed container terminal layout indicates that the storage for AN could be located well clear of adjacent properties. The location of the storage in the north west corner of the container terminal would provide the maximum distance from the site boundary, about 600m to the closest boundary to the south west. Hence, the location of the AN in the north western area of the terminal would minimise the risk at the site boundary.

It is recommended that the storage of oxidising agents (in particular AN) be located in the north west corner of the container terminal a minimum of 600m from the closest site boundary.

5.6 Emergency Response

The analysis conducted in this study has identified a number of incidents that may occur with the potential to impact offsite. In many cases, the development of these incidents can be mitigated by early response (i.e. local fire fighting, evacuation, etc.). Whilst it is recognised that the proposed port development would be subject to the DoP seven stage process (Ref.4), it is reiterated that an effective emergency plan would provide for a significant impact reduction in the event of an incident occurring.

Hence, it is recommended that an emergency plan be developed for each of the facilities in the PKPC project using HIPAP No.1, Emergency Planning Guidelines for Industry.

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6.0 References

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Appendix A

Hazard Identification Table

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Area/Section	Hazard Cause	Hazard Consequence	Proposed Safeguards
Class 2.1 Gas (e.g. LPG, acetylene)	Release from gas cylinder	Ignition and explosion followed by localised jet fire at the cylinder head	Single cylinder release only, limited release quantity Cylinders will be sealed and capped (damage prevention) No ignition sources in the storage area Separation between the storage and surrounding land uses
Class 2.3 Gas (e.g. chlorine, ammonia)	Release from gas cylinder	Accumulation of gas inside containers and around the container, impact to people near the container and downwind of the release.	Single cylinder/drum release only, limit release quantity Cylinders will be sealed and caped (damage prevention) Container limits direct release to atmosphere Separation between the storage and surrounding land uses
Class 3 Flammable Liquids (e.g. alcohols, paints) C1/C2 Combustible Liquids (e.g. diesel, oil, etc.)	Release from drum or isotainer	Ignition and pool fire	Drums protected by container storage (i.e. unlikely impact damage to drums) Bunding provided around the flammable liquid storage area Fire fighting equipment provided (fire hydrants, extinguishers and hose reels); Site Emergency Response Plan and dedicated emergency response team Site is attended 24 hours, 7 days per week (i.e. personnel on hand to raise alarms)
Class 4.1 Flammable Solids (e.g. matches, metal powders)	Solids heated by external source	Ignition of solids and fire in container	Fire contained within the container, localised due to nature of product Fire fighting equipment provided (fire hydrants, extinguishers and hose reels); Site Emergency Response Plan and dedicated emergency response team

Area/Section	Hazard Cause	Hazard Consequence	Proposed Safeguards
			Site is attended 24 hours, 7 days per week (i.e. personnel on hand to raise alarms)
Class 4.3 Solids that emit flammable gas when wet (e.g. Dross)	Leak of water into the dross storage container	Potential generation of ammonia and methane/acetylene	Fire safety systems, fire main, sprinklers, onsite pumping system Solids would be stored in bulk bags within containers (minimal potential for contact with water from leaking container) Small quantities of water and solid mix (low gas generation potential) Containers provide protection from rainwater
Class 5.1 (e.g. Ammonium Nitrate)	Fire in the packaging materials (bulk bags within containers)	Potential heating of ammonium nitrate, external impact, explosion	Fire safety systems including, fire main, hydrants, extinguishers, hose reels, onsite pumping system Containers minimise the potential for impact and explosion initiator Regular inspections of storage Storage is onsite for minimal period only Minimal combustible materials in the storage area, low potential for external fire source
Class 6 Toxic Substances (e.g. pesticides, herbicides)	Leaking drum/Isontainer	Potential for release off-site, impact to the biophysical environment Acute Impact to people	Limited release quantity from drum, minor release inside container Drums protected from impact damage by containers Bunded area around containers (spill retention on site) Regular inspection of storage area and containers to identify leaks Product Quarantine area set aside for damage materials

Area/Section	Hazard Cause	Hazard Consequence	Proposed Safeguards
Class 8 Corrosive Substance (e.g. acid, alkali)	Leaking drum/Isontainer/sulphuric acid pipeline	Potential for release off-site, impact to the biophysical environment Acute Impact to people	Limited release quantity from drum, minor release inside container Drums protected from impact damage by containers Bunded area around containers (spill retention on site) Regular inspection of storage area, containers and pipelines to identify leaks Product Quarantine area set aside for damage materials
Class 9 Environmentally Hazardous Substance (e.g. ammonium nitrate fertiliser not classified as Class 5.1, battery powered equipment, air-bag inflator)	Leaking containers	Potential for release off-site, impact to the biophysical environment	Limited release quantity from drum, minor release inside container Drums protected from impact damage by containers Bunded area around containers (spill retention on site) Regular inspection of storage area and containers to identify leaks Product Quarantine area set aside for damage materials
Truck and Rail Loading/Unloading Areas	Dropped bags, containers	Potential for spill of dangerous goods, contamination of ground and rainwater and release offsite	Operator present when incident occurs Operator can implement emergency spill response Spill kits available around the site All materials are transported in shipping containers (dropped container will retain minor spills) Damaged container quarantine area

Area/Section	Hazard Cause	Hazard Consequence	Proposed Safeguards
Transport of Dangerous Goods	Truck accident	Potential for spill of dangerous goods and impact to the environment Potential for release of flammable liquid/gas ignition and fire Potential for release of toxic liquid/gas impact to environment or people close to the container	All DGs are transported in shipping containers Incidents involving shipping containers would result in minimal impact (spills retained within the container) Drivers transporting dangerous goods will all be licensed under the DECC requirements All dangerous goods transport vehicles will carry emergency response plans Materials proposed for transport are currently transported on roads within the Port area

Appendix B

Consequence Analysis

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B Consequence Analysis

B1. Flammable Gas Explosion

The analysis conducted in **Section 4.2.1** identified that in the event of a gas release within a container there is a potential for the gas to mix with air and form a flammable mixture that of ignited would explode causing explosion overpressure that could impact at the beyond the OHD boundary.

To estimate the quantity of gas within the container that could explode, the mixture of LPG in air at the Upper Flammable Limit (UFL) has been used. This will provide a conservative estimate as the quantity of gas at the lower flammable limit will be considerably less and the explosion less powerful. The volume of the container is estimated to be 2.4m x 2.2m x 6m = 31.7m^3. The container will hold a number of gas cylinders that will take up volume within the container reducing the free space such that there is less gas air mixture available. An estimate of 40% reduction in space has been made. Hence, the space available for gas/air is 31.7x0.6 = 19m^3.

The mass of LPG (propane), at UEL, within 19m^3 of is calculated as follows:

1 mole of gas is contained within each 22.4Litres of volume. Hence, for 19,000 L of gas the number of moles = 19,000/22.4 = 850 mole

At UEL there is a 10% mixture of propane gas in air. Hence, the total number of mole of propane = 850 x 0.1 = 85 mole. The molecular weight of propane is 44.1. Hence, the total mass of propane in the enclosure is 3,748kg. Whilst the UFL would require 3,748kg, it is noted that only one cylinder would leak, hence, based on a single 500 L water capacity cylinder (the largest cylinder that would be transported), the maximum mass of gas released at a density of 580kg/m^3 = 580 x 0.5 = 265kg. Hence,

The equivalent mass of TNT is calculated by:

$$W_{TNT} = \alpha\left(\frac{W.H_c}{H_{TNT}}\right) \qquad \text{------------- B1}$$

Where: W = mass of fuel in the cloud (265 kg in the container)

H_c = heat of combustion of the fuel (50,000 kj/kg for propane)

H_{TNT} = TNT blast energy (5420 kj/kg)

α = explosion efficiency (0.04 for propane, Ref.15)

Hence,

W_{TNT} = 0.04 (265x50,000/5420) = 97 kg TNT

Overpressure is now calculated using a scaled distance curve, based on actual distance from the blast and the TNT equivalent, this is given by:

$$z = \frac{R}{(W_{TNT})^{1/3}} \qquad \text{---------------------------B2}$$

Where: R = distance from the blast (m)

W_{TNT} = kg equivalent of TNT

The maximum permissible overpressure at the boundary of a site is 7kPa. Overpressure values exceeding this must be subjected to risk assessment. Form **Figure B1**, for 7kPa, the scaled distance is 17. From **Formula B2**:

$17 = \xi/(97)^{0.333}$

ξ = 17 x (97)0.333 = 78m

The distance to an overpressure of 7kPa from an explosion in a container is 78m.

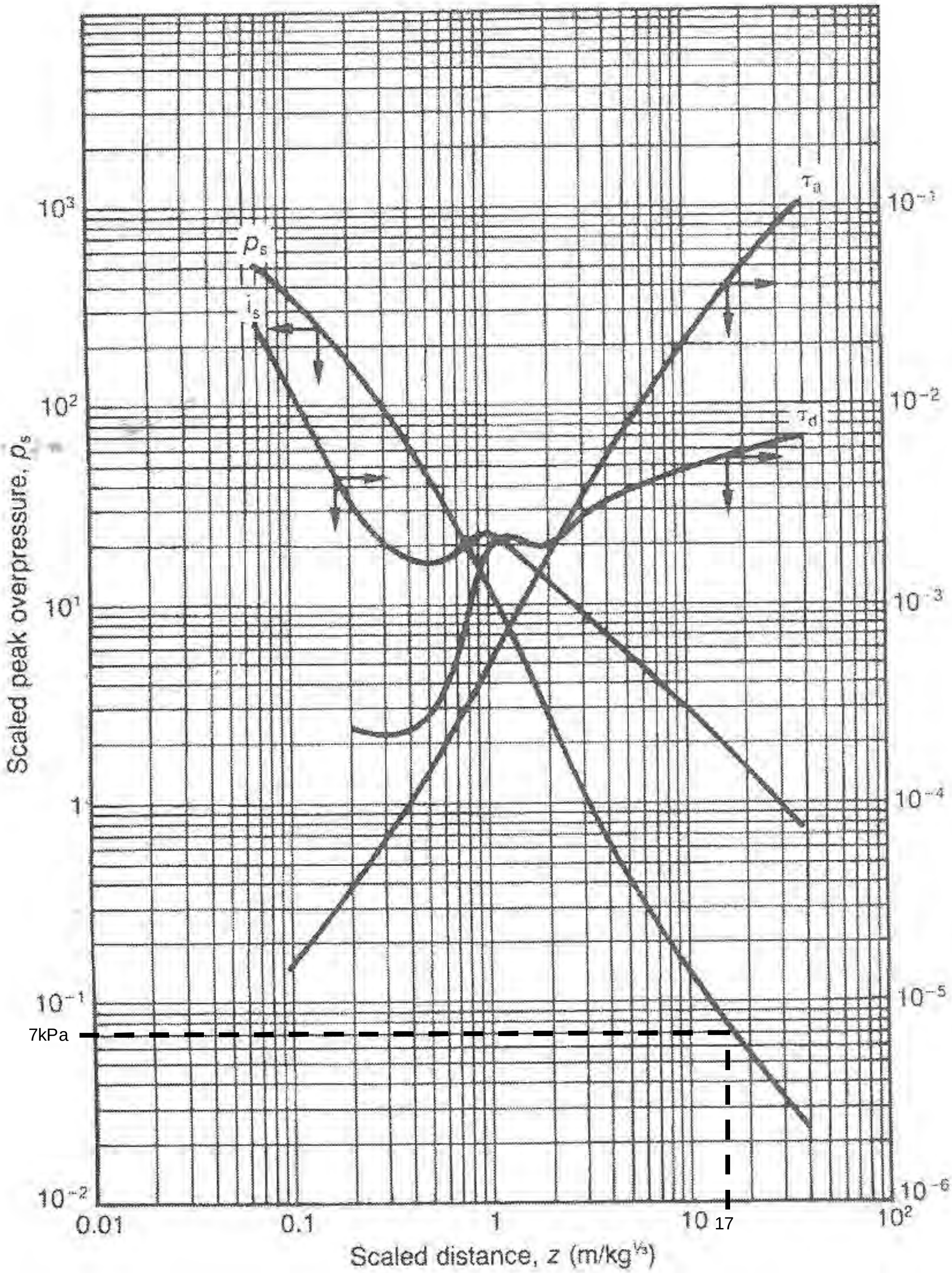

Figure B1: Scaled Parameter Plots For TNT Explosions(ref.8)

B2. Flammable Liquids Pool Fire

Flammable liquids may be transported in drums or isotainers. The storage area in which these containers would be located would be bunded. For this analysis, an area containing around 8 isotainers has been used. The isotainer is 2.2m wide x 6m long. Hence the area in which the isotainers would be stored would be around 16m long x 10m wide. In the event of a continuing leak from an isotainer, the bund would fill with flammable liquid and if ignited would result in a full bind fire.

Whilst unlikely, a spill scenario at the isotainer storage bund would result in a pool fire which would radiate heat to the areas surrounding the storage. The isotainer storage bund is 16m x 10m.

Pool Equivalent Diameter: $\pi/4 \times D^2 = 16m \times 10m$

$D = (160 \times 4/\pi)^{0.5}$

$D = 14.3m$

B2.1 Fire Modelling

Figure B2 shows an illustration of a typical pool fire in a fuel transfer location. It can be seen from this illustration that the flame tilts with the wind directions.

Figure B2: Example of Typical Fire in a Bund

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

$Q = E F \tau$

Where: Q = incident heat flux at the receiver (kW/m^2)

E = surface emissive power of the flame (kW/m^2)

F = view factor between the flame and the receiver

τ = atmospheric transmissivity

Figure B3 shows the heat radiation path for the fire. It can be seen from this figure that flame tilt and height above ground level will have impacts on the amount of heat flux received by the target.

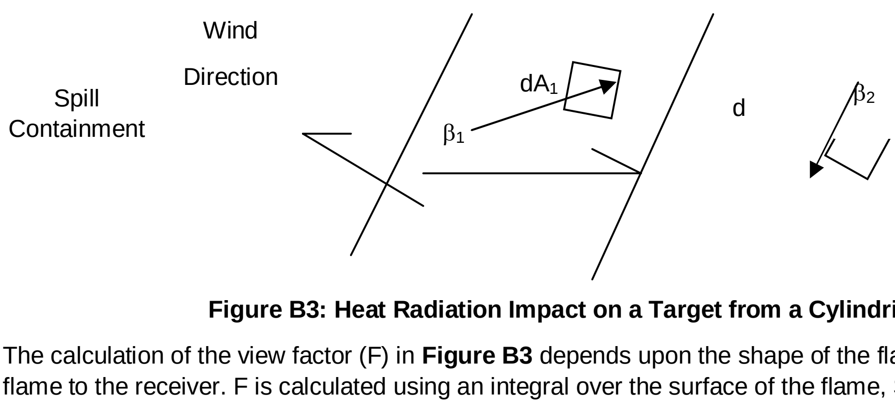

Figure B3: Heat Radiation Impact on a Target from a Cylindrical Flame

The calculation of the view factor (F) in **Figure B3** depends upon the shape of the flame and the location of the flame to the receiver. F is calculated using an integral over the surface of the flame, S. The formula can be shown as:

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

The above formula may be solved using the double integral or using a numerical integration method in spread sheet form. This is explained in **Section B3**.

B2.2 Development of the Numerical Integration Model

B2.2.1 Introduction

The spreadsheet calculator (SSC) determines the radiation flux experienced at a “target” originating from a cylindrical fire. It is intended typically for fires of flammable liquids (Class 3) though it can be used with any material so long as the “emissivity” of the flame is known. This is the heat flux at the surface of the flame and is given in kilo Watts per square metre (kW/m2). The other parameters needed are: diameter of the fire, height of the fire walls, distance to target, height of flame, tilt of flame caused by wind. It is assumed that the walls have some height although there is no reason not to use the calculator for pool fires at ground level by entering a zero height.

B2.2.2 Design Basis

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

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

Formula B1 (Ref.8)

where: L= mean flame height (m)
D= pool diameter (m)
ρ_o= ambient air density (typically 1.2 kg/m^3)
m= mass burning rate (kg/m^{2}s) = 0.0667, based on 5mm/min burn down rate (Ref.9)
g= acceleration due to gravity (9.81 m/s^2)

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

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

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

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

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

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

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

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

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

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

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

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

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

B1.3.4 Analysis Results

Prior to the development of the model, parameters were developed (e.g. pool equivalent diameter, flame height, SEP, wind tilt, etc.). Pool equivalent diameter has been estimated as 14.3m (see Section B2.1).

Flame Height:

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

where: L= mean flame height (m)
D= pool diameter (m)
ρo= ambient air density (typically 1.2 kg/m^3)
m= mass burning rate (kg/m^{2}s) = 0.0667, based on 5mm/min burn down rate (Ref.9)
g= acceleration due to gravity (9.81 m/s^2)

Using a diameter of 14.3m, the flame height is 22.8m.

Wind Tilt has been estimated to be 30oC.

Surface Emissive Power (SEP)

SEP is a function of the fire magnitude (i.e. diameter and height), which governs the amount of heat at the surface of the fire. Larger fires tend to generate larger quantities of soot or smoke, which shields the more luminous components of the flame. Large diameter pool fires average an SEP of about 20kW/m2. The average SEP of an 80m kerosene fire is about 10kW/m2, suggesting the correlation is conservative (Ref.9).

From the correlation of Mudan (Ref.9) the following formula may be developed for calculating the SEP of a flame:

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

Where: SEP = the total surface emissive power of the flame
SEPm = the maximum surface emissive power of luminous spots on a large hydrocarbon fuel flame (140kW/m^2)
SEPs = the surface emissive power of a smokey flame (20kW/m^2)
S = 0.12m-1 (an experimentally determined parameter)
D = diameter of the pool

Based on the above formula, the calculated SEP for the diesel fire is 41.6kW/m^2.

Transmissivity

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

Transmissivity = $1.006 - 0.01171(\log10X(H_2O) - 0.02368(\log_{10}X(H_2O)))^2 - 0.03188(\log_{10}X(CO_2) + 0.001164(\log_{10}X(CO_2)))^2$

Where: $X(H_2O)$ = (RH x L x Smm x 2.88651 x 102)/T

$X(CO_2)$ = L x 273/T

RH = relative humidity

L = path length in metres

Smm = saturated water vapour pressure in mm mercury (= 17.535 @ 293K)

T = temperature in degrees Kelvin (293K)

The distance to a heat radiation level of 4.7kW/m2 from the flame (isotainer bund) is about 30.1m, relative humidity is selected as 70% (0.7). Using these values and the values listed above, the transmissivity parameter is calculated to be 0.77.

Summary of Inputs to the SCC Model

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

Fire Diameter 14.3m

Fire height22.81m

Flame tilt 30 degrees

SEP 41.6 kW/m^2

Transmissivity 0.77 (at 30.1m)

B.1.5 Consequence Analysis (SCC Model Results)

The SCC model was entered into a Microsoft Excel spread sheet and the data above input to the model. A heat radiation level of 4.7kW/m2 was selected and the distance to this level of hat radiation was estimated to be 30.1m. **Table B1** shows the distances to selected values of heat radiation.

Table B1: Distance to Selected Heat Radiation Impact Isotainer Storage Area Bund Fire

Heat Radiation Level (kW/m^2)	Isotainer Storage Distance (m)
35	15.4
23	17.2
15	19.6
12.5	20.8
8	24.4
6	27.3
4.7	30.1
2	42.7

B3. Toxic Gas Release

B3.1 Ammonia

Ammonia would be transported in cylinders (1,000kg) and possibly horizontal tanks (2,000kg), Cylinders would be stored in the container in the upright position, with the valves at the top. Horizontal tanks would also be stored with the valves at the top. Valve caps and covers are installed on the cylinders and tanks, and damage to valves is highly unlikely, however, as a worst case incident a broken valve has been assumed. The valve fitted to the cylinder has been assumed to be 20mm NPT, with a 3mm wall thickness on the valve threaded section where the valve screws into the top of the cylinder. In the event of a broken valve, the diameter of the discharge hole would be 20-(2x3) = 14mm.

Release rate from a 14mm hole is estimated as follows.

Liquid Release rate $G_L = C_d A(2.\rho.\delta P)^{0.5}$

Where: C_d = Co-efficient of discharge (0.6)

A = cross sectional area of the release hole (m^2)

ρ = density of the liquid (kg/m^3)

δP= pressure difference across the hole (Pa)

Hence, for a 14mm hole, the cross sectional area = $1.54 \times 10^{-4} m^2$

Density of anhydrous ammonia = 682kg/m^3

Pressure differential = 8.8 bar (or 8.8×10^5 Pa)

$G_L = 0.6 \times 1.45 \times 10^{-4} \times (2 \times 682 \times 8.8 \times 10^5)^{0.5}$ = 3kg/s

To calculate the adiabatic flash rate (i.e. the quantity of vapour formed from a liquid release), the following formula is used:

$V = (W.C_{p(mean)}.(T_1-T_2))/H_v$

Where: V = weight of the flash vapour produced (kg/s)

W = weight of liquid spilled (3 kg/s)

$C_{p(mean)}$ = geometric mean of the specific heats over a range between T_1 and T_2 (1.37)

T_1 = Temperature of the liquid in the process (21^oC)

T_2= Atmospheric pressure boiling temperature of the liquid (-33^oC)

H_v = Latent Heat of Vaporisation (287.84kJ/kg)

V = 3 x 1.37 x (21 – (-33))/287.84

Vapour Release Rate = 0.77 kg/s

A dispersion analysis was conducted using the gas release rate estimated above. When a gas is released, the downwind dispersion is a function of wind speed and weather conditions. In bright sunny conditions, with high wind, the gas disperses readily, but in light wind and overcast conditions the cloud tends to disperse slowly. To model such releases dispersion analysis analyse weather conditions in 6 classes:

A – Bright sunny conditions, highly unstable air streams;

B – Bright sunny conditions, moderately stable air streams;

C – Partial cloud, moderately stable air streams;

D – Mostly cloudy, some patches of sun, moderately stable air;

E – Full cloud cover, very light to stable air streams;

F – Full cloud, virtually no wind, very stable air streams.

To the values above, a wind speed is added to estimate the dispersion at the selected wind weather condition. For example, D5 represents partial cloud with moderate air stream and a wind speed of 5m per second. The selected values are input to a computer model that assesses the dispersion of the release and estimates the downwind concentration of the gas over a range of distances from the release source. The results are read in parts per million (ppm) of gas content in air.

The model used for the analysis was SLAB. This model was developed by the University of California (Lawrence Livermore Laboratories) for the US Department of Energy. This model is also used as the basis for the EFFECTS© consequence analysis program used by the TNO organisation in the Netherlands. The model was applied for each of the release scenario detailed above.

For ammonia, the concentration levels of interest are:

- Lowest reported lethal concentrations for any species for 30 minutes exposure (Ref.6) – 5000 ppm
- Injuriuos (50% of lowest reported lethal concentrations) – 2500 ppm

For conservatism, the SLAB model was run using a concentration level of interest of 1000 ppm to determine the impact distance at the lower level of concentration. Further conservatism was applied by assuming the cylinder released in the open, whereas the release occurs inside the container providing some “hold-up” of dispersion and reducing the downwind impacts. Model simulations were undertaken for time averaging periods of 1 second and 900 seconds to represent peak and typical short term (STEL) exposures. The source and meteorological parameters used in the model are presented in **Table B2** and **B3**.t

Table B2: Source Parameters

Parameter	Ammonia
Spill source type	Stack
Source duration (seconds)	3600
Source height (metres)	0.3
Storage temperature (K)	288
Source Area (m^2)	0.000028
Averaging Time (seconds)	1 and 900
Emission Rate (kg/s)	0.77
Analysis level of interest (ppm)	1000

Table B3: Meteorological Parameters

Parameter	Value
Surface Roughness (metres)	0.05
Temperature (K)	288
Relative Humidity (%)	40
Wind Speed and Stability Scenarios (PG stab, m/s)	B3, B5, D3, D5, D9, E1.5, F1

The result of the analysis is shown in **Tables B4** and **B5**.

Table B4: Ammonia 1000 Ppm Maximum Distance Form Source (Metres) – 1 Second Averaging Period

Met Condition	Height (m) Above Ground Level			
	0.01	1.5	1.8	2.5
B3	88	87	87	86
B5	75	74	74	73
D3	167	163	161	155
D5	148	145	144	139
D9	121	119	118	113
E1.5	223	213	210	199
F1	320	300	291	260

Table B5: Ammonia 1000 Ppm Maximum Distance Form Source (Metres) 900 Second Averaging Period

Met Condition	Height (m) Above Ground Level			
	0.01	1.5	1.8	2.5
B3	73	72	72	71
B5	57	56	55	54
D3	146	143	141	135
D5	120	117	115	110
D9	89	86	85	80
E1.5	212	206	202	191
F1	314	294	286	256

It can be seen from **Tables B4** and **B5** that the maximum downwind distance for a concentration level of ammonia of 1000 ppm is 320 m. This occurs using a 1 second averaging period, at 0.01 m above ground level, and under F class stability 1 m/s conditions (i.e. postulated worst case conditions).

B3.2 Chlorine

The chlorine would be transported in cylinders and 900kg drums. Chlorine cylinders and drums have an extremely robust cap fitting and drums have concave dished ends with the valves set back inside the concave section of the end. The potential for damage to valves in chlorine cylinders and drums is negligible, and anecdotal evidence indicates that such incidents have not occurred in the industry. However, leaks at valve connection and through valve seats is possible. A leak at a valve has been assumed to be 6mm, as this is a common leak scenario where chlorine cylinders and drums are used (i.e. broken “pigtail” pipe connection). This would be conservative, as a leak across a valve or through damaged threads on the valve to cylinder/drum connection would be expected to be much smaller. The release rate is estimated as follows:

Liquid Release rate $G_L = C_d A(2.\rho.\delta P)^{0.5}$

Where: C_d = Co-efficient of discharge (0.6)
A = cross sectional area of the release hole (m^2)
ρ = density of the liquid (kg/m^3)
δP= pressure difference across the hole (Pa)

Hence, for a 6mm hole, the cross sectional area = $2.83 \times 10^{-5} m^2$

Density of chlorine = $1.56 kg/m^3$

Pressure differential = 6.95 bar (or 6.95×10^5 Pa)

$G_L = 0.6 \times 2.83 \times 10^{-5} \times (2 \times 1560 \times 6.95 \times 10^5)^{0.5} = 0.79$ kg/s

To calculate the adiabatic flash rate (i.e. the quantity of vapour formed from a liquid release, the following formula is used:

$V = (W.C_{p(mean)}.(T_1 - T_2))/H_v$

Where:
V = weight of the flash vapour produced (kg/s)
W = weight of liquid spilled (0.79 kg/s)
$C_{p(mean)}$ = geometric mean of the specific heats over a range between T_1 and T_2 (1.3)
T_1 = Temperature of the liquid in the process (21°C)
T_2= Atmospheric pressure boiling temperature of the liquid (-34.6°C)
H_v = Latent Heat of Vaporisation (1,370.84kJ/kg)

V = 0.79 x 1.3 x (21 –(-34.6))/1370.84
Vapour Release Rate = 0.041kg/s

The model used for the analysis was SLAB (see details listed in **Section B3.1**). This model was developed by the University of California (Lawrence Livermore Laboratories) for the US Department of Energy. The model was applied for the release scenarios detailed above.

For chlorine, the concentration levels of interest are:

- Fatality potential (Ref.10) – 20 ppm
- Injuriuos (50% of lowest reported lethal concentrations) – 5 ppm

The SLAB model was run using the two concentration levels above (20 and 5 ppm) to determine the impact distance at these levels of concentration. Model simulations were undertaken for time averaging periods of 1 second and 900 seconds to represent peak and typical short term (STEL) exposures. The source and meteorological parameters used in the model are presented in **Table B6** and **B7**.

Table B6: Source Parameters

Parameter	Chlorine
Spill source type	Stack
Source duration (seconds)	3600
Source height (metres)	0.3
Storage temperature (K)	288
Source Area (m^2)	0.000028
Averaging Time (seconds)	1s and 900s
Emission Rate (kg/s)	0.041
Analysis level of interest (ppm)	5 and 20

Table B7: Meteorological Parameters

Parameter	Value
Surface Roughness (metres)	0.05
Temperature (K)	288
Relative Humidity (%)	40
Wind Speed and Stability Scenarios (PG stab, m/s)	B3, B5, D3, D5, D9, E1.5, F1

The result of the analysis is shown in **Tables B8** and **B9**, for 5ppm and **B10** and **B11** for 20ppm.

Table B9: Chlorine 5 Ppm Maximum Distance Form Source (Metres) 1 Second Averaging Period

Met Condition	Height (m)			
	0.01	1.5	1.8	2.5
B3	175	175	175	174
B5	136	136	136	135
D3	402	401	400	389
D5	308	307	307	305
D9	225	225	224	223
E1.5	786	783	782	778
F1	1570	1561	1558	1546

Table B10: Chlorine 5 Ppm Maximum Distance Form Source (Metres) 900 Second Averaging Period

Met Condition	Height (m)			
	0.01	1.5	1.8	2.5
B3	115	114	114	113
B5	90	90	89	89
D3	261	260	259	258
D5	197	196	195	192
D9	143	141	140	137
E1.5	536	533	531	526
F1	1135	1127	1124	1111

It can be seen from Tables B9 and B10 that the maximum downwind distance for a concentration level of chlorine of 5 ppm is 1,558m. This occurs using a 1 second averaging period, at 1.8m above ground level, and under F class stability 1 m/s conditions.

Table B11: Chlorine 20 Ppm Maximum Distance Form Source (Metres) 1 Second Averaging Period

Met Condition	Height (m)			
	0.01	1.5	1.8	2.5
B3	84	83	83	83
B5	68	67	67	66
D3	182	180	179	176
D5	142	140	138	136
D9	106	104	103	100
E1.5	326	321	319	313
F1	576	563	558	540

Table 12: Chlorine 20 Ppm Maximum Distance Form Source (Metres) – 900 Second Averaging Period

Met Condition	Height (m)			
	0.01	1.5	1.8	2.5
B3	58	57	57	56
B5	46	45	45	43
D3	124	121	120	117
D5	94	92	91	87
D9	69	66	65	61
E1.5	243	239	237	230
F1	464	453	446	432

It can be seen from **Tables B11** and **B12** that the maximum downwind distance for a concentration level of chlorine of 20 ppm is 558m. This occurs using a 1 second averaging period, at 1.8m above ground level, and under F class stability 1 m/s conditions.

B4. AN Storage Explosion

Section 4.2.6 of the main report indicates that the quantity of TNT equivalent for 300 tonnes of ammonium nitrate is 41 tonnes.

The distance to an overpressure of 7kPa (the maximum permissible value before risk assessment is required, Ref.5) is estimated as:

Scaled Distance (Ŕ) = $R/(Mass_{TNT})^{0.333}$, where R = distance to the target and $Mass_{TNT}$ in kg

Scaled distance for 7kPa, from **Figure B1** is 17. Hence:

$17 = \xi /(41{,}000)^{0.333}$

$\xi = 17 \times (41{,}000)^{0.333} = 584m$

Hence, the impact criteria listed in HIPAP No.4 (Ref.5) would not be exceeded if the storage is located more than 584m from the boundary.

Worldwide Locations

Australia	+61-2-8484-8999
Azerbaijan	+994 12 4975881
Belgium	+32-3-540-95-86
Bolivia	+591-3-354-8564
Brazil	+55-21-3526-8160
China	+86-20-8130-3737
England	+44 1928-726006
France	+33(0)1 48 42 59 53
Germany	+49-631-341-13-62
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Japan	+813-3541 5926
Malaysia	+603-7725-0380
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Philippines	+632 910 6226
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Australian Locations

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23 February 2010

Attention: Mr. Jahangir Alam

Dear Jahangir,

Re: PORT KEMBLA PORT CORPORATION – SUPPLEMENTARY INFORMATION – PHA

Please find the attached supplementary information in relation to the Port Kembla Outer Harbour Development Preliminary Hazard Analysis. I have included the additional information requested in relation to ship collision hazards and bunkering operational risks.

If you have any further queries or require any additional information, please contact me on the mobile (0411 659 309).

Yours sincerely,

for

Steve Sylvester, Principal – Risk & Safety Engineering
AECOM
P: (02) 8484 8945 F: (02) 8484 8989 M: 0411 659 309

Enclosures:

Preliminary Hazard Analysis Supplementary Information

1.0 INTRODUCTION

Port Kembla Port Corporation (PKPC) proposes to develop the Port Kembla Outer Harbour area to provide berths for containers handling, bulk trades and general cargo. There is potential for Dangerous Goods (DGs) to enter the port in containers or bulk products in portable tanks or Intermediate Bulk Containers (IBCs).

As part of the development an Environmental Assessment (EA), containing a Preliminary Hazard Analysis (PHA) was submitted to the NSW Department of Planning (DoP) in February 2010. DoP has requested additional information relating to ship collision hazards and fuel bunkering operational risks. This document has been prepared to present this supplementary information and should be read in conjunction with the PHA included within the EA.

2.0 OBJECTIVES

The objectives of the supplementary study include the following:

- identify the hazards associated with the movement of ships in the PKPC harbour;
- identify the hazards associated with fuel bunkering operations; and
- determine the risks to "offsite" facilities and, if required recommend risk reduction measures.

3.0 SCOPE OF WORK

The scope of work for the supplementary analysis is only for the assessment of hazards and risks associated with:

- Ship movements in the harbour and the potential for collision; and
- Fuel bunkering operations of ships in the harbour.

All other hazards with the potential for offsite impact have been included in the PHA study within the EA.

4.0 METHODOLOGY

The Multi-Level Risk Assessment (DUAP, 1997) was used as a guide to the level of risk assessment required for the Port Kembla Outer Harbour development. The review of the MLRA identified that a level 2 analysis was most appropriate for the development. This approach used the following methodology:

- Identification and analysis of the hazards;
- Qualitative assessment of the identified hazard to determine potential offsite risk impacts;
- Where the results of the hazard analysis are considered to have an offsite impact, the incident is carried forward for further analysis; and
- Where hazard analysis identifies that the proposed safeguards are sufficient to ensure the risks are maintained in the as low as reasonably practicable range, no further assessment is performed.

This approach was also used in this supplementary information study.

5.0 BRIEF DESCRIPTION OF THE SHIP MOVEMENTS AND BUNKERING OPERATIONS

5.1 Ship Movements

The Port of Port Kembla currently operates as a regulated port under the *Marine Safety Act 1998* (MSA) with ships moving to and from the berths under the direction and control of the Harbour Master who is an employee of PKPC. Vessels entering, leaving or moving within the port must take on board a marine pilot to conduct the vessel during such movement unless the vessel or its master is specifically exempted under the MSA from this requirement. Pilotage is provided in Port Kembla by marine pilots who are appropriately trained and licensed in accordance with the *Marine Pilotage Licensing Regulations*. PKPC is responsible for exercising port safety functions in accordance with the terms of the Port Safety Operating Licence (PSOL) issued by the Minister for Ports. These functions include:

- the installation and maintenance of navigation aids;
- vessel traffic control;
- pilotage services;
- the dredging and maintenance of navigation channels;
- hydrographic services; and
- emergency environment protection services for dealing with pollution incidents in relevant waters.

Port safety functions are exercised in accordance with clear performance standards set out in the PSOL. Procedures and records relevant to port safety functions are documented and maintained within a quality management system that is independently audited and subject to continual improvement. The existing regulatory functions and operating practices of PKPC will continue to apply to operations associated with the Outer Harbour Development.

Ships arriving offshore will contact PKPC's Vessel Traffic Information Centre and either be directed immediately to a berth or anchor and await further directions. Once directed to enter the harbour, a marine pilot will travel to the ship in a small craft and board the ship while offshore. The marine pilot will provide local knowledge and shiphandling advice to guide the vessel on its course into the harbour and to the berth. The pilot operations will be conducted under constant radio contact with the port facilities.

Tugs will be used within the PKPC port area to assist the berthing operations. Tugs will meet ships as they enter the harbour and, where required, assist the vessels into the berth to which they were directed. In some cases, ships will be fitted with shiphandling aids, such as bow and stern thrusters, which may, at the discretion of the marine pilot allow un-assisted berthing (i.e. without the use of tugs). Notwithstanding this, tugs will be available to assist all berthing operations as required. The pilot will remain with the ship until it is securely berthed alongside the wharf to which it was directed. The master of the vessel and the marine pilot will ensure that it is operated in accordance with the International Regulations for Preventing Collisions at Sea including the provision for safe speed, maintaining a look-out and avoiding collisions. Pilots will have full control of the ships when entering the harbour, hence, the potential for excessive speed in the port is negligible.

Once the cargo has been loaded/unloaded, the reverse operation will occur. A pilot will board the ship at the berth and guide the vessel's departure. Where required, tugs will assist vessels to move into the main channel prior to leaving the port. Once in the main channel, the pilot will direct sailing operations until the vessel is clear of the port and at sea. The pilot will then disembark the ship and return to the port via a small craft.

At present the Port has approximately 900 vessel visits per year in an average year. This comprises approximately 800 vessel visits to the Inner Harbour and up to 100 vessel visits to the Outer Harbour. This equates on average to approximately 2.5 vessel visits per day.

The proposed development (comprising three multi-purpose berths and four container berths) could generate up to 1,500 vessel visits per year in the Outer Harbour once fully operational. With long term growth, projected total vessel visits per year for the Inner and Outer Harbours combined could be up to 2,600, which equates to seven vessel visits per day on average.

As trade increases, PKPC would review resources to service the additional vessel movements and introduce measures, such as additional tug and pilotage resources over time, as required.

5.2 Bunkering Operations

In some cases it will be necessary to refuel ships alongside the berths and wharves at the port. The berths will not be fitted with fuel pipelines, hence where ships are required to be refuelled, it will be necessary to refuel using road tankers. This operation is currently performed at the existing ports around Australia and consists of the following:

- Road tankers will be loaded at local terminals (e.g. Manildra Park Facility on Flinders St.);
- The tankers will the drive to the wharf where the ship is located and park alongside the ship at the wharf;
- A flexible hose is connected to the tanker discharge point and to the ship receival manifold, fuel is then pumped to the ships tanks using a tanker mounted pump;
- On completion of the transfer, the transfer hose is drained back to the tanker until empty, the valves on the ship and tanker isolated and the line disconnected from the ship and tanker (the hose is then stowed on the tanker for future use); and
- The tanker then drives away from the wharf and returns to the terminal.

The following safeguards are employed as part of the refuelling operations:

- Transfer hoses will be tested annually as per the requirements of the regulations and standards;
- Transfers will be fully monitored by tanker driver and ships staff (the tanker driver will be located at the tanker on the wharf and a ship's crew member will be on the deck of the ship at the refuelling manifold);
- The ship's engineering staff will monitor the refuelling operations from the ships control room, monitoring the tank levels and transfer systems (e.g. pipework) during the refuelling operation;
- Refuelling will only occur with bunker fuel or diesel, both fuels are combustible liquids and are not classified as flammable (i.e. inherently safer products);
- Trucks are fitted with a drive-away protection to prevent the trucks being moved whilst connected to the ship by flexible hose;
- Spill containment equipment will be stored on the wharf ready for immediate deployment in the unlikely event of a spill (i.e. containment booms); and
- Fire fighting equipment installed at the wharf and on the truck (e.g. hydrants, hose reels, extinguishers, fire pumps and ring main).

6.0 HAZARD IDENTIFICATION

6.1 Ship Movements – Hazard Analysis

During the movements of ships in the Port Kembla harbour there is a potential for collision between ships moving in and out of the harbour or between ships moving to or from berths and stationary vessels alongside wharves.

Ship collision is highly unlikely due to a number of factors including the following:

- Vessel scheduling, tracking and communication systems as managed by PKPC's Vessel Traffic Information Centre;
- Maritime rules and regulations for ship movements (i.e. direction of passing, rules for right of way, etc.);
- PKPC Port Parameters and Berthing Priority Code (PPBPC);
- Tugs available to assist movement and berthing operations; and
- Use of marine pilots for all ship movements in and out of the harbour.

The key component in the port operation is the use of marine pilots for all ship movements in the harbour. The use of marine pilots prevents ship's Masters, who may be unfamiliar with the port, making errors of judgement resulting in serious consequences such as collisions or grounding. Marine pilots undergo a comprehensive program of training and examination before obtaining a license to operate in the port. Pilotage activities are supported by sophisticated systems including:

- Vessel booking and scheduling system, including information about the vessel such as its dimensions, draft, weight and the forms of propulsion available;
- Continuous automated monitoring of weather and sea state conditions with data available in real time;
- Dynamic Under-Keel Clearance system to predict the distance between the keel of the vessel and the bed of the harbour based on vessel parameters, hydrographic data and current tide, weather and sea state information; and
- Portable Pilot Units – portable computer system with global positioning system that is carried on-board by pilots and used to track vessel movements during the pilotage against planned pathways.
- Navigation Aids such as lead lights and channel markers.

The use of these systems is supported by the guidance contained within the PPBPC, quality management system and standard operating procedures.

As part of Stage 1 only one bulk dangerous good will be transported into the harbour, sulphuric acid, which will be transported in a tanker vessel. Sulphuric acid cargoes are already delivered to the Outer Harbour and transferred at the existing Berth 206. When No 4 Jetty (and Berth 206) is demolished during Stage 1, facilities to enable the import of sulphuric acid will be relocated to the first multi-purpose berth. Hence, there will be no new bulk Dangerous Goods transported to the port as part of Stage 1. In addition, the sulphuric acid vessel is constructed with a double bottom system, which allows a space between the external hull and the sulphuric acid tank wall. In the event of a collision or grounding, the risk of tank failure from impact is negligible.

In Stages 2 and 3, four container berths will be operational. Containers are secured to the ship's deck and to each other by "cams" located on the deck and in the corners of the container. It is highly unlikely that a container would be dislodged by a ship collision in the harbour, hence, there would be a negligible risk of release of product as the result of collision between vessels.

PKPC maintains a Marine Oil and Chemical Spill Contingency Plan to deal with any spills of oil or chemicals which may enter the harbour. The plan is integrated with the Wollongong Local Disaster Plan and covers all aspects of spill response including planning, notification, containment and clean-up techniques.

A review of the potential impacts as a result of collisions indicates that the consequences of a release of Dangerous Goods would be negligible, due to the safeguards used at the port. This is supported by the existing incident record at the port showing no collisions between ships in the past 10 years. Based on this assessment, no further analysis has been conducted.

6.2 Bunkering Operations – Hazard Analysis

The transport of fuel by road tanker to the wharves at the PKPC port area will involve the same operations and transport methods as is currently used in the port area. The current history of incidents during transport of the fuel at the port indicates that there have been no serious spills or fires that have resulted in impacts beyond the immediate area of an incident (i.e. large spill to the environment or major fire on the way to or at the wharf). The fuel transfer operations, proposed for the Outer Harbour development are the same as those currently operating at the port and surrounding facilities. The current and proposed safeguards meet the requirements of the regulations and standards. Based on the history and safe operations using the existing safeguards, the risks associated with the transport of fuel to the port are considered low as the same operations and safeguards will be used.

Once the tanker truck reaches the fuel transfer point, it will be located adjacent to the ship and the park brakes applied by the driver. The driver will then lay out the hoses and join these together for connection to the tanker transfer manifold and ship manifold. On the tanker, a drive-away protection system will prevent accident movement of the tanker whilst the hoses are connected. A bar is located across the front of the hose connection point, such that when the bar is moved to connect the hose, the park brakes are applied to the truck. The truck cannot be moved unless the hose is disconnected and the bar lifted (i.e. the hose connection prevents the bar from being lifted and the brakes released). Hence, the risk of truck drive-away whilst connected is negligible.

Once connected, the tanker driver and ships operator will prove the connections and ensure the hoses are secure. Fuel will then be transferred initially at low pressure to ensure the connection does not leak and the hose integrity is satisfactory. The tanker driver and ships operator will be in attendance during the entire transfer operation. During transfer of the fuel oil, the tank levels in the ship will be continually monitored by the ships staff and continually relayed to the truck driver. Hence, the potential for tank overfill is very low, also noting that the ships tanks would be considerably larger than the truck capacity. Once the ships transfer of fuel oil is complete, the remaining liquid in the flexible transfer lines will be drained back to the tanker and the isolation valves on the tanker and ship closed. The flexible hose will then be disconnected and stowed on the truck ready for the next operation.

During fuel transfer there is a potential for flexible hose failure resulting in release of fuel oil and spill to the environment (i.e. the area surrounding the truck/ship). To minimise the potential for this incident, containment booms will be located on the wharf at strategic locations such that these may be deployed to contain any spills that may occur between the wharf and ship. Releases and spills on the wharf or ship's deck will be contained by the wharf contour and deck bunding. All "scuppers" on the ship's deck will be blocked during the transfer to ensure no minor spillage reaches the harbour.

In the event of a spill and fuel oil ignition, there is a potential for fire on the wharf of deck of the ship. However, it is noted that the fuelling operation will be conducted in a clear area of the wharf, separated from storages and, in particular, Dangerous Goods transit areas. Further, the fuelling operations will be staffed by the tanker driver and ship's crews during the full transfer providing immediate response in the event of an incident (noting that tanker driver and ship's crews will be trained in spill and fire response). The tanker driver will have access to an emergency shut-down button on the tanker to permit immediate isolation of the fuel transfer and pump shut-down. Fire fighting equipment will also be installed on the wharf and carried on the tanker, in readiness, adjacent to the refuelling operations (i.e. hoses attached to hydrants).

In the event of a release, the tanker driver and ships operator can deploy the emergency shut down and spill containment systems, minimising impact to the environment. It is noted that the fuel transferred to the ships will be combustible liquid and not flammable liquids, hence, the probability of ignition is very low, considering the area is continually monitored by the ships staff and tanker driver. In the unlikely event of an ignition of a fuel oil spill, a pool fire could occur in the area surrounding the truck or on the ship's deck. The spill area would be less than that detailed in the analysis presented in the EA as the tanker driver would detect the spill and isolate the release, minimising the quantity to less than 200L (i.e. the quantity in the hose). This would spread to an area of about 7.5m diameter on the wharf or ship's deck. The area of the spill analysed in the EA is 14.3m, nearly twice the size of a spill on the wharf. The heat radiation to 4.7kW/m^2 from the analysis of a flammable liquid fire in the EA (14.3m diameter) is 30m. A review of the location of the wharves at the port indicates that ships would not be located within 30m of a public area or boundary. Hence, there would be no impact offsite.

It is re-iterated that fuel transfer operations are currently performed within the Port and that there will be no change between the current refuelling operations and those that will be performed for the new Outer Harbour development. Based on the analysis conducted above, and the safeguards installed and used, the risk of incidents as a result of bunkering operations is considered to be low and therefore no further analysis is conducted.

7.0 SUMMARY AND CONCLUSIONS

The analysis conducted in this study has identified that during ship movements in the harbour for the Concept Plan, there is a potential for ship collision that could result in breach of a ships hull during sulphuric acid imports to the multi-purpose terminalor the dislodging of a container holding Dangerous Goods.

Hazards associated with Stage 1 will be limited to ship collisions during import of sulphuric acid only.The safeguards installed and applied at the port were considered to maintain the risks in the ALARP range.

In addition, ship refuelling operations in the harbour were identified to have the potential to result in fuel releases that could impact the environment or be ignited causing fire. However, the operational safeguards installed and used during the refuelling operations were considered to maintain the risks in the ALARP range. Further, the location of the re-fuelling operations results in sufficient separation between the site boundary and refuelling points such that no impact beyond acceptable criteria (Ref.2) would occur offsite.

Based on the assessment conducted in this supplementary information study, it is concluded that the risks associated with collision and refuelling operations are currently effectively controlled and will continue to be effectively controlled in the new port facilities constructed and operational as part of the Outer Harbour development.

8.0 REFERENCES

1. Department of Urban Affairs and Planning (1997). Multi-Level Risk Assessment.
2. Department of Planning (1992). Hazardous Industry Planning Advisory Paper No.4, Risk Criteria for Land Use Safety Planning.