Quantitative Risk Assessment of

Bulk Liquid Storage Facilities

At Coode Island

Prepared for WorkCover

By

DNV Consultancy Services
December, 1977

EXECUTIVE SUMMARY

1. Background

Coode Island is a commonly used name for the area of land within the Melbourne City Council which is bounded by Footscray Road, the Yarra River and Maribyrnong River. The area comprises the international container terminal at Swanson Dock, a range of transport depots and warehouses and a number of bulk liquid storage terminals. Coode Island is Victorian Government owned land which is vested in the Melbourne Port Corporation. There are significant bulk liquid storage facilities on the island which are classified as dangerous goods storage. These facilities are currently operated by 9 private sector companies who-lease land from the Melbourne P9rt Corporation (MPC). These facilities are used for the import and export of bulk liquid materials necessary to service Victoria's manufacturing industry.

In 1991 the Terminals Pty Ltd's "A" site at Coode Island was involved in a serious fire which essentially destroyed the facility. This fire received widespread media and public attention. During the course of the fire serious concerns were raised regarding the potential for toxic smoke generation and the adverse effects this might have on downwind populations. However, there were no reported serious injuries as a direct result of the fire, either directly from the fire or from the smoke.

In response to the fire the Government of Victoria established the Coode Island Review Panel to investigate the incident, to develop an action plan to improve safety at the Coode Island facilities and to make recommendations on the longer term storage of hazardous chemicals at port facilities. The Review Panel's final report was issued March 1992. The Review Panel recommended establishing a new facility at West Point Wilson (subsequently moved to Pt Lillias) for the storage of bulk liquid hazardous chemicals currently stored at Coode Is1and, with non-hazardous materials such as tallow and vegetable oils remaining at Coode Island. However, the cost of establishing a new facility was estimated to be significantly higher than the alternate option of upgrading the Coode Island facilities.

Following the 1991 fire many experts were commissioned by the various interested parties to review both the bulk storage facilities and the associated safety management systems. The Review Panel commissioned Arthur D. Little International Inc. to perform a review of Coode Island bulk storage and associated facilities. The report from this review "Safety Audit of the Bulk Liquid Storage Terminals at Coode Island" recommended a number of changes to the hardware and operation of the facilities, most of which have been implemented by the operators of the facilities, resulting in a substantial upgrade of safety at the Coode Island facilities.

The Victorian WorkCover Authority is responsible for the licensing of hazardous chemical bulk storage facilities in Victoria and is involved in the controlling of hazards associated with the operation of Coode Island bulk storage facilities.

In order to more fully assess the risks associated with the Coode Island facilities (following an extensive safety upgrade) the Victorian WorkCover Authority commissioned DNV Consultancy Services to conduct a Quantitative Risk Assessment (QRA) of these facilities. A Quantitative Risk Assessment can be defined as the numerical evaluation of the likelihood of harm occurring together with the value judgments made concerning the significance of the results.

2. Study Scope & Methodology

The QRA assessed the full set of risk to the public from the hazardous materials stored at the bulk liquid storage sites/operational areas at Coode Island. The individual facilities assessed were as follows:

- P&O Ports Limited.
- Terminals Pty Ltd's "B" and "C" sites.
- Mobil Oil (Australia) Ltd.
- Bentley Chemplax Pty Ltd (occupying part of Mobil site).
- Gordon Brandon Victoria Pty Ltd.
- EMCO (Australia) Pty Ltd.
- Pacific Terminals Pty Ltd's "A", "B", "C" and "B" sites.
- MPC's Maribyrnong Wharf Berth No.1.
- Intertek Testing Services Caleb Brett (on Pacific Terminals' "C" site).
- King Transport Pty Ltd (occupying former BP Oil site).

The analysis involved a comprehensive assessment of the risk from the facilities via classical risk assessment techniques and was conducted using the internationally accepted risk assessment software SAFETI (**S**oftware for the **A**ssessment of **F**ire, **E**xplosion and **T**oxic **I**mpact) which is capable of analysing all the potentially hazardous impacts for the study. A conservative best estimate approach was utilised throughout the analysis, that is every attempt was made to utilised realistic fully justified data. Where this was not practicable some overestimation was built into the analysis. This approach assures that the risk is not underestimated and helps offset any uncertainties arising from the possibility of abnormal human behavior and other minor unquantified items.

3. Study Results

The results of the analysis were compared against Victorian, national and international criteria and included both individual and societal risk results.

Both types of result were utilised since individual risk assessment is designed to assess if any one individual has an unduly high risk exposure, while societal risk assessment is intended to ensure that the community as a whole is not exposed to an extent inconsistent with the benefits derived.

The results from the study show that the levels of individual and societal risk arising from the operation of the Coode Island storage facilities and the container terminal facilities are within the accepted limits, as defined by Victorian, national and international criteria. The current operation of these facilities is therefore compatible with surrounding land uses in terms of risk to the public.

The individual risk contours (normal method for reporting individual risk) for risk to the public is shown in Figure A. As can be seen from Figure A the 1 x 1 0~ per year risk contour (target criteria for residential land use) stays 300 metres clear of Whitehall Street which is the closest residential area (to the west). Therefore the individual risk is well within the acceptable limits. It should be noted that the acceptable boundary risk criteria (both Nationally and Internationally) normally 1 x 1 0~ per year contour is nearly entirely contained within the area controlled by the terminal operators. Further, it should be noted that the 1×10^{-5} per year risk contour due to storage terminal operations (while limited to the Coode Island facilities) extend into the P & 0 Ports operational area. Similarly the 1×10^{-7} per year risk contour due to the container terminal operations extends into the storage terminal areas. Therefore, it would be appropriate that suitable emergency plans be prepared and implemented by the container terminal operator and the storage terminal operator to deal with offsite risks due to their respective facilities.

The societal risk to the public due to the operations of Coode Island bulk liquid storage facilities and P&0 Ports Ltd's operations as expressed in an FN curve (the standard method for representing societal risk) is shown in Figure B. Figure B shows that the societal risk to the public is well within the acceptable criteria for Victoria.

The primary finding of the study is that the major risk issues arising from these facilities relates to personnel employed at other industrial sites at Coode Island rather than the broad public. The study also showed that although toxic combustion products are formed in potentially hazardous concentrations during fires, they are not a source of off-site fatality risk as they rise in the thermal plume created by the fire and disperse to non fatal and non injurious concentrations, without returning to ground level.

It should be stressed that since 1991 very substantial improvements have been made to safety at the Coode Island bulk liquid storage facilities by the operators in collaboration with the Government of Victoria. The facilities as they stand today meet the acceptable risk criteria applicable in Victoria and internationally. A number of additional recommendations for improving the level of safety at the facilities are made in the main report (DNY Consultancy Services A2843, December 1997) and their implementation would further reduce the risk below the currently acceptable levels. The risk profile from Coode Island should be regularly assessed and revised as changes occur within the operation of the facilities (i.e. materials stored change, new safety improvements are instigated, storage types change). To this end the SAFETI risk model of Coode Island will be provided to the Government of Victoria in a format it can utilise to address these issues. This will assure that the relevant authorities are aware of and can manage (in conjunction with the operators) the risk related issues arising from the storage and handling of Dangerous Goods in the Coode Island storage terminals and at P & 0 Ports Ltd.

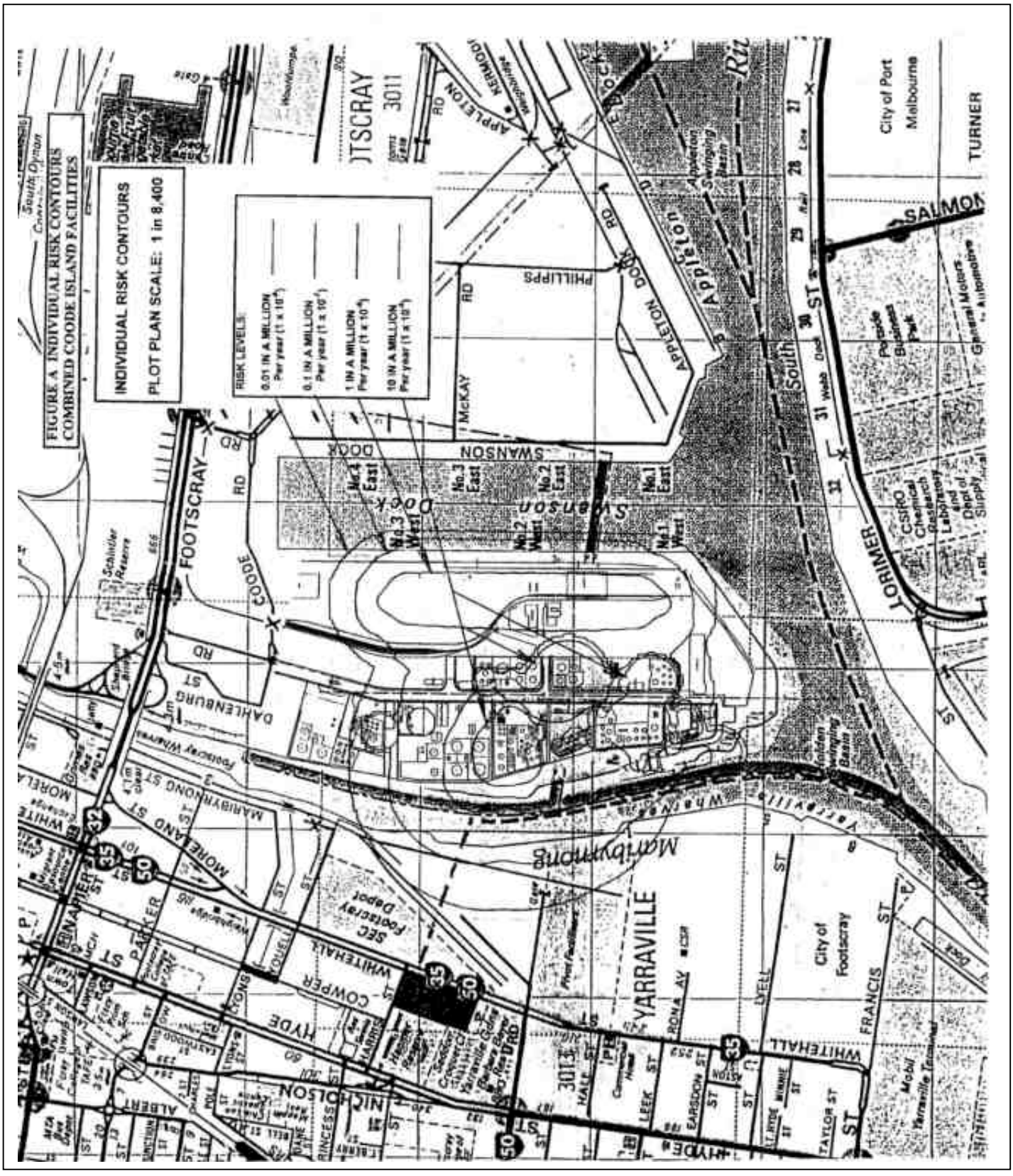
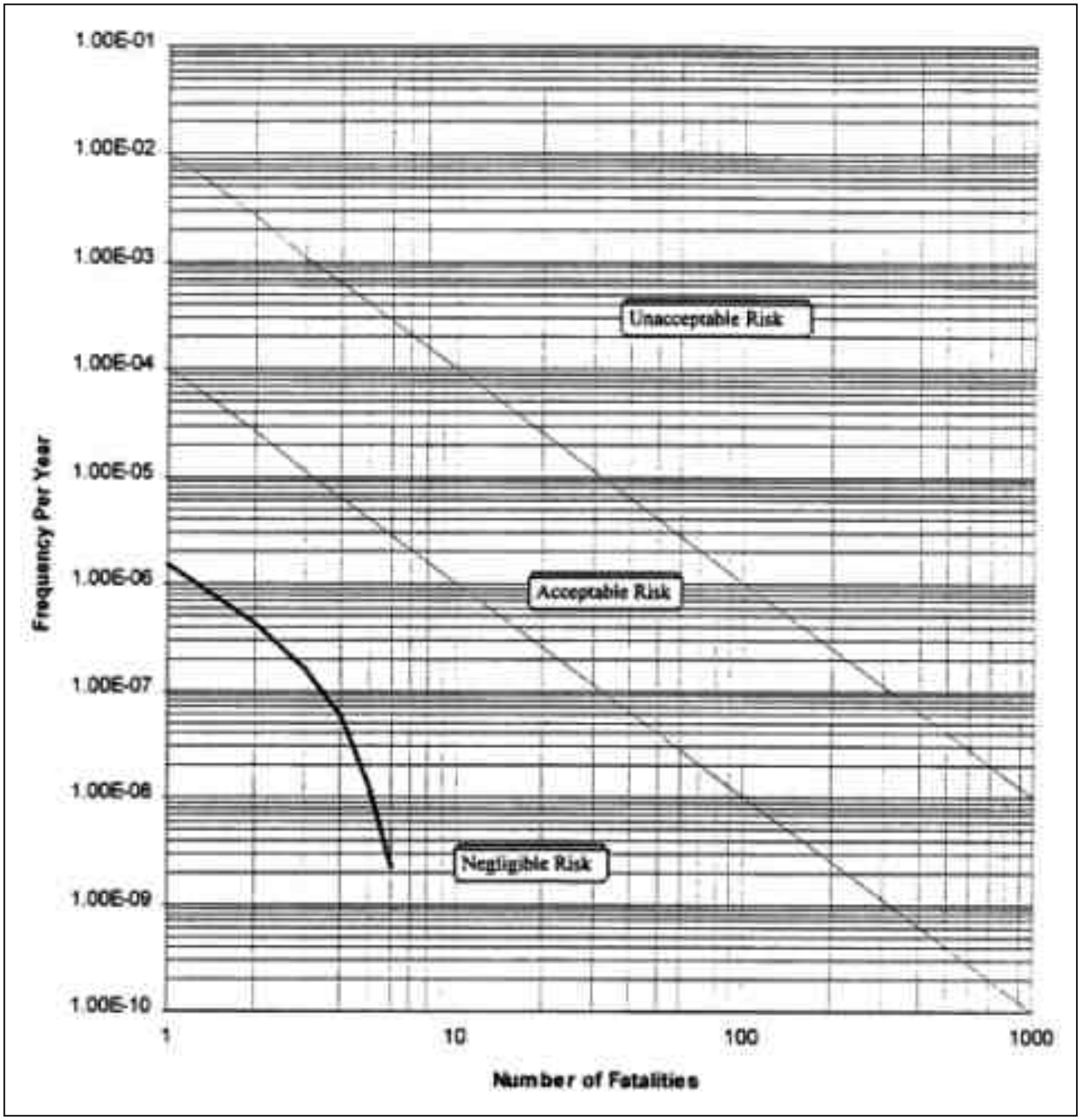


FIGURE A INDIVIDUAL RISK CONTOURS
COMBINED COODE ISLAND FACILITIES
INDIVIDUAL RISK CONTOURS
PLOT PLAN SCALE: 1 in 8,400
RISK LEVELS:
0.01 IN A MILLION Per year (1 x 10⁻⁸)
0.1 IN A MILLION Per year (1 x 10⁻⁷)
1 IN A MILLION Per year (1 x 10⁻⁶)
10 IN A MILLION Per year (1 x 10⁻⁵)
FOOTSCRAY
COODE
RD
SWANSON
DOCK
No.4 East
No.3 East
No.2 East
No.1 East
No.3 West
No.2 West
No.1 West
Swanson Dock
APPLETON
McKAY
PHILLIPPS
Appleton Dock
Appleton Swinging Basin
City of Port Melbourne
SALMON
TURNER
LORIMER
South
ST
DAHLENBURG
MARIBYRNONG ST
MORELAND
NAPIER
PARKER
COWPER
HYDE
WHITEHALL
NICHOLSON
ALBERT
YARRAVILLE
Maribyrnong
City of Footscray
FRANCIS
LYELL
EARSDON ST
LEEK ST
HALE ST
RONALD AY
Footscray Depot
SEC
Footscray Wharves
Yarraville Gardens
Yarraville Golden Swinging Basin
Schindler Reserve
CSIRO Chemical Research Laboratory
Dept of Supply
Melbourne Powder Business Park
General Motors Automotive
Mobil
Yarraville Terminal
3011

FIGURE B SOCIETAL RISK DUE TO THE OPERATION OF THE COODE ISLAND BULK LIQUID STORAGE FACILITIES AND DUE TO OPERATIONS AT P&O PORTS LTD



Note: The above societal risk curve was generated based on the offsite industrial population in the areas surrounding Coode Island. This excluded the workplace at P&O Ports Ltd.

4. Conclusions

The primary conclusions of the study are as follows, while other conclusions have been drawn throughout the report these conclusions are the most significant in terms of impact on the on-going control of risk at Coode Island:

1. The levels of individual and societal risks arising from the operation of the Coode Island bulk liquid storage facilities and container operations are acceptable in accordance with the various national and international risk criteria as well as the criteria, applicable to existing installations in Victoria.

2. The risks arising from these facilities predominantly concern people employed on the facilities themselves and at neighboring industrial sites at Coode Island. The levels of risk for all residential areas and 'other' offsite populations are below acceptance criteria levels.

3. The offsite risks arising from P&0 Ports Limited's operations are predominantly due to the storage and handling of Glass 2.1 flammable gases and Glass 2.3 toxic gases in containers and isotainers.

4. For tank farm operations the main contributors to the off-site risk is due to the operation of the acrylonitrile and propylene oxide storage and handling facilities.

5. The near field risk (i.e. within 100 metres of the source) is generally dominated by Glass 3 area fires, arising from all potential sources of a flammable liquid spill. Large area fires are the main source of onsite fatality risk, which may impact on neighbouring facilities at Coode Island, including West Swanson Dock.

6. Toxic combustion products, though formed in hazardous concentrations during a fire, can be concluded not to be a source of offsite fatality risk as they rise in the thermal plume and disperse to non fatal concentrations before returning to ground level.

7. While the hoses and transfer manifold Maribyrnong Wharf No. 1 berth present a significant potential for product leak, given the current controls the levels of risk generated by the operation of the berth are currently low.

8. In many locations tank farm piping is routed from bund to bund to common facilities such as production manifolds or pump slabs (this is quite common in tank farm design). A spill fire inside such a 'high density pipe band' bunded area (due to line leaks, tank leaks or hose rupture) could lead to multiple line damage. This is particularly relevant to Class 3 storage (Terminals Pty Ltd's "B" and "C" sites), but is (at least partially) addressed by the current procedure to keep all tank valves closed unless the tank is used for transfers.

9. The materials used in expansion joints of most concrete bund walls at Coode Island were mostly found to be PVC, neoprene or some other type of plastic.

Though these are commonly used materials in bund wall construction, it is uncertain if such materials are product or UV resistant which could lead to a gradual deterioration of the expansion joint seals. Plastic expansion joint seals are not fire resistant. If during a fire scenario the liquid spill level in bunded areas rises, this can lead to ignited product spills seeping through deteriorated and/or fire damaged expansion joints to outside (some of) the bunded areas.

Some instances were noted where concrete bund walls and clay bund walls were butted, without a concrete key being provided at their interface. In such cases an easy leakage flow path may be provided, as adequate clay compaction against a concrete wall interface would be very hard to achieve.

Some (low) intermediate bund walls were found to be in a poor state of repair and would not provide effective spill containment, even against moderate spills, although some repairs have been made in this area since 1994. Inadequate intermediate bunds can lead to larger spill and fire areas, reducing the chance of successful control and extinguishment.

5. Follow up on Previous Recommendations

5.1 Follow up on ADL Recommendations

The following provides comment on the adequacy and effectiveness of the 'alternatives' to the Arthur D Little (ADL) 1991 recommendations, or for which exemption were granted by the Victorian WorkCover Authority.

Maribyrnong No.1 Wharf, ADL No 2: *"A crane or hoist needs to be provided to handle hoses when making up, changing or disconnecting the ship to shore unloading lines"*. MPG were given an exemption. The requirement is now with the operating companies to ensure that ships have cranes.

DNV Comment: Provided either the MPC or the ships visiting have a suitable crane (as Terminals currently require) the intent of the recommendation is met. MPC to monitor for compliance. Refer recommendation R8 in this summary report.

Maribyrnong No.1 Wharf, ADL No 9: *"Boom stations should be located upstream and downstream of the wharf to enable quick isolation of a major spill from the wharf or a tanker. Location of a boom deployment boat and training of the PMA* (MPC) *and terminal facility personnel in its use would make waiting for a PMA* (MPC) *vessel to arrive unnecessary and hopefully minimise the spread of the spilled materials"*. Matter resolved between EPA and MPG. Boom facilities at Holden Dock would be towed across to Maribyrnong Wharf in case of an emergency.

DNV Comment: Neither the 1994 QRA report nor the 1997 QRA update report took booms into account in the spill modelling at the wharf. The individual and societal risk results are acceptable, regardless of boom deployment. DNV considers the recommendation made by ADL to be of limited value, in view of the relatively rapid spread of spills due to tidal and rain runoff induced current in Maribyrnong River and the likely delay between a potential spill and boom deployment, regardless where the booms are located. In a previous Hazard Identification study conducted with the MPG, the deployment of booms as a preventative measure was considered not feasible, due to excess current in the river.

Mobil – ADL No. 1, 18, 22 and 27 An exemption was granted on the basis that the facility is effectively closed down.

DNV Comment: The two TEL storage tanks still contain a small quantity of toxic TEL sludge (1 to 2 tons). The tanks will be cleaned and decommissioned during 1998.
Mobil's facilities were excluded from the 1997 Update QRA as a fire in the sludge tanks would have no offsite impact neither would it impact on the current Bentley Chemplax facilities on the site.

Terminals "C" (ex Powell Duffryn), ADL No. 29: *"Flame arresters should be installed in the environmental system at strategic points to minimise the danger of flash backs to the tank during afire. A HAZOP on this system should be conducted and its recommendations implemented".* Nitrogen blanketing of flammable liquid tanks (with a potentially explosive vapour space) was accepted by the Victorian WorkCover Authority as an equivalent mitigation measure to the ADL recommendation.

DNV Comment: Nitrogen blanketing of tanks is actually a more reliable and positive means then flame arresters to prevent an explosion in the vapour space of storage tanks.

Terminals "C" (ex Powell Duffryn), ADL No. 32: *"Normal best practice for tanks handling materials of this type* (class 3) *is to provide nitrogen padding of the vapour space to prevent formation of an explosive vapour. The terminal should develop its own policies on this regardless of customer requirements".* All class 3 tanks except the acrylate and styrene (polymerisable liquid) tanks are now protected by nitrogen blanketing systems. (For polymerisable liquid tanks a minimum of *5* percent oxygen is required to maintain inhibitor activity).

DNV Comment: Nitrogen blanketing of tanks is a reliable means to prevent an explosion in the vapour space of class 3 storage tanks. However, too low an oxygen content may affect inhibitor activity in monomer tanks, actually increasing the risk of a fire. The need for nitrogen blanketing of monomer tanks should be decided based on best international practice/experience and chemical specific specialist advice. Note that a tank fire or bunded area fire involving monomer liquids does not pose a risk to

residential population areas and hence the question of nitrogen blanketing may be considered discretionary. Refer recommendation 6 in this summary report.

Terminals "C" (ex Powell Duffryn), ADL No. *44: "Rohm and Haas in its bulletin on the Handling and Storage of Acrylic Monomers recommends isolating the monomer tanks so they can not be surrounded by flammable or combustible liquids from other tanks and providing a source of water for cooling the monomer storage tanks, in case of fire or explosion from another tank or building. Means that could be utilised to put these recommendations in to place should be investigated".* Fixed cooling water protection has been provided for all flammable liquid tanks including all polymerisable liquid storage tanks. Terminals agreed to reproof the bund floors to direct spills away from tanks containing monomers. An exemption has been granted for isolating the monomer tanks from other storage.

DNV Comment: As demonstrated in the 1991 fire a 'run-away' reaction in polymerisable liquid storage tank is likely to present only a very localised risk, confined to the bunded area concerned.

Individual bunding by itself is not an adequate precaution. To limit heat input into monomer tanks to less than run-away reaction temperature (100º to 150º C) leads to excessive spacing requirements.

The use of fixed fire water sprays (as now provided) and/or fire proofing of monomer tanks reduces safe spacing requirements. Regardless of such measures, individual bunding requires significantly more space and is unlikely to be practicable for the existing facilities and the risk results do not support the likely level of expenditure required. The fixed water spray systems currently provided would limit heat input, as does the re-grading of bund floors to direct spills further away from the monomer tanks. Refer recommendations R7 and R9.

Terminals "C" (ex Powell Duffryn), ADL No. 48: *"The terminal needs to survey each bunded area and consider* ***one or more*** *of the following options:*

1. *Provide fixedfire protection for the entire bunded area.*
2. *Improve drainage around tanks to assure spills collect away from tanks.*
3. *Use additional bunding and/or intermediate bunding to assure that spill areas are minimised in size and that exposures to adjacent tanks are minimised.*

In addition, portable or fixed monitors for fighting bund fires should be provided". An exemption for item 1 was granted, based on completion of item 2 and 3 (2 out of 3 option requirements).

DNV Comment: Item 1 above is not an AS code requirement nor common best practice. Further improvements concerning item 2 and 3 are desirable. Refer recommendation 7 in this summary report.

Terminals "B"-site, ADL No. 33: *"Two significant potential hazards exist in this system (vapour control system), i.e..*

- *Violent reaction between two (or more) incompatible materials and*
- *Potential fire or explosion in the system with the possibility of propagating the fire to other areas of the terminal.*

To identify the hazards present in the system, a hazard identification study (such as a hazard and operability study (HAZOP) should be undertaken promptly. All hazards identified should be examined and appropriate mitigating measures developed and implemented. It is understood that there are plans to perform a HAZOP on this system". WorkCover accepted that nitrogen blanketing of tanks is an effective means to reduce explosive vapour space risks in tanks, which addresses the second bullet point.

DNV Comment: Based on the a review of the product tanks lined up to the vapour handling system, no violent reactions are possible due to incompatible vapours. Nitrogen blanketing of tanks is a reliable means to prevent an explosion in the vapour space of storage tanks. Refer recommendation 6 in this summary report.

Terminals "B"-site, ADL No. 37: *"Tanks containing polymerisabk liquids should be in separate bund areas* - Fixed cooling water protection has been provided for all flammable liquid tanks including all polymerisable liquid storage tanks. Terminals agreed to regrade the bund floors to direct spills away from tanks containing monomers. An exemption has been granted for isolating the monomer tanks from other storage.

DNV Comment: As demonstrated in the 1991 fire a 'run-away' reaction in polymerisable liquid storage tank is likely to present only a very localised risk, confined to the bunded area concerned.

Individual bunding by itself is not an adequate precaution. To limit heat input into monomer tanks to less than run-away reaction temperature (100º to 150º C) leads to excessive spacing requirements.

The use of fixed fire water sprays (as now provided) and/or fire proofing of monomer tanks reduces safe spacing requirements. Regardless of such measures, individual bunding requires significantly more space and is unlikely to be practicable for the existing facilities and the risk results do not support the likely level of expenditure required. The fixed water spray systems currently provided would limit heat input, as does the re-grading of bund floors to direct spills further away from the monomer tanks. Refer recommendations R7 and R9.

5.2 Follow up on 1994 QRA Report Recommendations

The following provides comment on the status with regard to each of the 1994 QRA Report recommendations. It should be noted that a number of the recommendations were modified following discussions between DNV, Terminals and WorkCover to take into account the limited tenure of Terminals' operations at Coode Island.

1994 Recommendation 1: *"To prevent back flow from tank inlet lines during filling operations consider fitting a non return valve against the inlet valve to all class 3 tanks where inlet and outlet lines are segregated".*

DNV Comment: This item was not implemented and most class 3 tanks inlet lines (where the inlet and outlet line are segregated) are not fitted with a non return valve. Refer recommendation R3 in this summary report.

1994 Recommendation 2: *"To provide a remote operable fail closed type valve (ROV) on all class 3 tank outlet lines and on all class 3 tanks with a common inlet/outlet. To provide the ROVs with limit switches to provide remote status indication".*

DNV Comment: No new tanks were fitted with ROVs. The propylene oxide, toluene diisocyanate, phenol and the 2 benzene import tanks are fitted with ROVs. None are fitted with status indication. Refer recommendations R3 and R4 in this summary report.

1994 Recommendation 3: *"Remote operable valves (ROVs) should ideally be operable locally, from the respective road tanker (un)loading station and from the control room, with status indication in all locations. Provide a fusible link to cause the ROVs to automatically close in the event of a spill fire near the tank".*

DNV Comment: None of the current ROVs are fitted with limit switches to provide remote status indication. Current ROVs are operable from (un)loading stations. Refer recommendation R4 in this summary report.

1994 Recommendation 4: *"Revise operating procedures to close all tank (remote and/or manual) valves when the tanks are not in use for transfers".*

DNV Comment: This recommendation concerns class 3 tanks in particular. Terminals is the only operator with class 3 tanks. They have revised their operating procedures and close the tank valves, when not in use. They have manually updated status boards at road tanker loading stations. This constitutes an improvement. However, ROVs and an automatic status information update is a more reliable system. Refer recommendation R4 in this summary report.

1994 Recommendation 5: *"To eliminate all hose exchange pit manifolds associated with class 3 tanks".*

DNV Comment: Terminals replaced the benzene tank hose exchange pit manifold with hard piping ("C" site, east of MacKenzie Road). Some other hose exchange pits still remain for class 3 tanks. Refer recommendation R5 in this summary report.

1994 Recommendation 6: *"If feasible, develop a blanketing suitable for polymerisable liquid tanks, that does not adversely affect inhibitor activity*

DNV Comment: Item has not been addressed to date. Refer recommendation R6 in this summary report.

1994 Recommendation 7: *"Facilities should be provided to monitor the residual oxygen content on nitrogen blanketed tanks on a regular basis. Until historical data have been acquired this may be required before and after each significant product movement".*

DNV Comment: Terminals is the only company with nitrogen blanketed tanks. They have amended their operating procedures to perform a monthly check. For polymerisable liquid tanks (when blanketed) more frequent check would be desirable, in particular after each significant product movement.

1994 Recommendation 8: *"Provide blanketed (class 3) tanks with pressure sensors and a low and high pressure alarm (or other suitable instrumentation) to provide warning of a blanketing system ma~/unction. Regularly test alarm functions".*

DM/ Comment: Tenninals have amended their operating procedures to perform a monthly manual check on blanketed tanks. For polymerisable liquid tanks (when blanketed) oxygen monitoring equipment and alarms may be essential. The acrylonitrile tank is nitrogen blanketed, no monitoring equipment or alanns are installed. Refer recommendation R6 in this summary report.

1994 Recommendation 9: *"For class 3 product storage and handling areas (in consultation with the MFB) review the adequacy of the mobile response fire fighting equipment and manpower resources to provide effective initial response to potential spill fires".*

DNV Comment: In particular this concerns higher risk spill areas such as hose exchange pits, pump slabs, road tanker loading areas and drum loading facilities. Where manpower resources are lacking, fixed systems may be required. Terminals has provided a fixed water spay systems on the propylene oxide road tanker loading area (p.o. is water soluble, foam is ineffective) and un-aspirated AFFF foam spray systems on all other

class 3 road tanker loading and drum filling areas. All systems are automatically actuated (by I.R. detection). For spill fire risks in other areas, the Terminals "B" site is protected by a foam solution main and mobile response equipment, the Terminals "C" site by foam trailers and other mobile response fire fighting equipment. The current level of fire fighting facilities for dealing with spill fires (at the Terminals sites) is in line with good practice. Class 3 hose exchange pits should be eliminated, refer recommendation R5.

1994 Recommendation 10: *"Review bund wall design and maintenance problems highlighted under conclusion 12".*

DNV Comment: The original recommendation made related in particular to the Terminals' sites, but may also apply to other operators, where some bund discrepancies were noted. Refer recommendation R7 in this summary report.

1994 Recommendation 11: *"Review first aid equipment and manpower resources to deal with emergencies, in consultation with emergency services*

DNV Comment: The intent of the recommendation was to review equipment and resources available by the operators to effect the rescue of any personnel, trapped or immobilised by an accident scenario. DNV has not ascertained the extent of emergency rescue facilities, as such information is not pertinent to the QRA study results (in line with guideline criteria, all exposed people were modelled as incapable of escape). In line with good management practice to regularly review emergency preparedness (and regularly update the emergency response manual), this general recommendation was made. Refer recommendation R10 in this summary report.

1994 Recommendation 12: *"To consider the integration/interconnection of Terminals' fire water and foam compound resources with the facilities operated by MPC at Maribyrnong No.1 wharf to provide more effective mutual aid. To develop a mutual aid plan".*

DNV Comment: This recommendation has not been implemented in terms of hardware. The MPC fire water pumps at Maribyrnong wharf take suction from the river and are sensitive to spill fires on water and hence may not operate in a ship/berth spill fire emergency (though radiant heat shields have now been provided to protect the fire water pumps). The Terminals facilities are less susceptible to total failure due to the extensive interlinking of the "B" and "C" site facilities. Terminals has the following principal fire fighting facilities for supplying cooling water, fire water and foam solution to the individual user areas:

- 2 diesel driven, 15,000 l.p.m auto start fire water pumps near Maribyrnong River, taking suction from two 1,000 m3 water storage tanks. This system is intended for cooling water supply to all areas, and to supply the fire mains at both the "B"

and the "C" site. Make up to the water tanks is via a 150mm city water supply line and an interconnection to the MPG dry hydrant line along the wharf.

- 1 diesel + 1 electric auto start fire water pumps for foam generation at BOTH the "B" and the "C" site, taking suction from a local fire water tank in each location. Normal make up to these tanks is via city water; an interconnection exist to allow make up from the wharf tanks.

- 1 diesel + 1 electric foam compound pump at BOTH the "B" and "C" site.

- Bulk AFFF-ATC foam compound supplies at both foam generation stations.

The foam systems and fire water systems at the "B" and "C" sites are interconnected. Foam solution making facilities are located indoors to reduce potential exposure risks. Refer recommendation Rl1 in this summary report.

1994 Recommendation 13: *"MPC to provide a crane at Maribyrnong Berth No.1 for hose handling and support."* MPC were given an exemption. The requirement is now with the operating companies to ensure that ships have cranes.

DNV Comment: Provided either the MPC or the ships visiting have a suitable crane the intent of the ADL recommendation No. 2 is met. MPC to monitor for compliance. Refer recommendation R8 in this summary report

1994 Recommendation 14: *"MPC to review ship checklist/procedures to minimise the likelihood of leaks on ships during transfer operations".*

DNV Comment: Historical accident/incident experience is that leaks have been of short duration. Upon review DNV considers that site operator, ships crew and MPG precautions and procedures have resulted in minimal risk.

6. 1997 Recommendations

The following provides a summary of all previous recommendations with outstanding actions plus any new recommendations made, based on the analysis and results of the 1997 QRA study. It should be stressed that the facilities as they stand today meet the various national and international risk criteria as well as the acceptable risk criteria applicable in Victoria and most measures that would lead to an appreciable reduction in risk have already been implemented. The following recommendations should be viewed as 'reasonable practicable' additional measures to consider for implementation.

R1 That the aluminum cladding on the propylene oxide tanks 368 and 370 be replaced with SS sheeting and that water sprays be provided on the holding down bolts and that the bunding associate with these tanks be upgraded.

R2 That the type, quantity and container size of dangerous goods handled by P&O Ports Limited be closely monitored (particularly class 2.1 & 2.3 materials) and if changes occur, that the effects of these changes on the overall acceptability of the risk profile of Coode Island be reassessed. If the change to the risk profile is unacceptable then additional controls/restrictions over container/isotainer operations will be required.

R3 That for all Class 3 tanks where inlet and outlet lines are segregated, an NRV be provided on the inlet lines and an ROV be provided on the product outlet lines. Further on tanks where there is a single in/outlet line, an ROV (or an equivalent design to allow isolation of the tank from the line in an emergency) should be provided.

R4 That the remote operable tank isolation valves should be operable locally, from the road tanker (un)loading station and from the control room. The ROVs should be provided with limit switches. Valve status indication (based on limit switch output) and an emergency shutdown button should be provided in the following locations:

- At the respective road tanker loading points, to close the relevant tank valves, also stopping all pumps associated with that loading station (refer conclusion No. 8).

- In the control room.

R5 That the hose manifolds associated with the shipping lines for the Class 3 product storage of the Terminals “B” site areas should be eliminated and replaced by hard piped production manifolds or dedicated lines.

R6 That a nitrogen (or equivalent inert gas i.e. oxygen reduce) blanketing system be developed and installed (if feasible) that does not adversely affect inhibitor activity on the polymerisable liquid storage tanks (i.e. acrylates and styrene) which are not currently fitted with nitrogen blanketing. Monitoring equipment and alarms may be required to monitor residual oxygen content.

R7 That a chartered civil engineer be commissioned to survey and certify the status of current bundwalls for all tank farm areas, and any remedial work required be implemented. Further the materials used in expansion joints should be replaced with non combustible, product inert materials or protected from fire/product exposure. The area around all monomer tanks that are not individually bunded should be so graded as to maximise the distance between these tanks and potential spills in the bunds.

R8 That regular checks be made to ensure the practice of utilising only ships with adequate hose handling cranes for dangerous goods is met or, the MPG provide a crane or hoist.

R9 To better 'spread' the risk, that the current polymerisable tank selection practice be continued. Ensure that tanks for polymerisable liquid service are selected based on the following criteria:

- Minimising the spill containment area, the smaller the bunded area containing polymerisable liquid tanks the better.
- Minimising the number of tanks, sharing the same bunded area.
- Assign less hazardous products (e.g. Cl or C2 products) to 'other' tanks sharing the same bunded area.
- Maximise the distance from monomer tanks to high risk tanks which can cause far field fire related risks (propylene oxide storage BLEVEs).

Consider fire proofing of monomer storage tanks, when not individually bunded.

R10 That all sites handling dangerous goods at Coode Island implement and maintain appropriate safety management systems to control the managerial and organisational factors that can impact on the overall risk associated with the dangerous goods.

R11 Consider linking foam and firewater systems between the MPC at Maribyrnong berth No.1 and Terminals' sites to provide mutual aid. Consideration should be given to directly inject AFFF-ATC foam compound into the respective fire mains (at 6 percent strength), which can act as a 'vehicle' to transport foam solution to user points on either site for mobile response foam branches/cannons.