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APPENDIXES

1. INTRODUCTION

1.1 Background

In March 1980 the New South Wales Department of Environment and Planning initiated an investigation into the risk to people living in and around the Botany/Randwick industrial complex and Port Botany from the combined impact of potentially hazardous industrial and storage installations, existing and proposed, in that area.

The investigation was initiated in response to the concern expressed by community groups and by Randwick and Botany Councils in relation to the intensification of such potentially hazardous installations and processes in the area and their risk implications on nearby residential land uses. In some cases, opposition was also expressed to the continuation of operations of existing installations.

The hazard issue was also identified by the Department of Environment and Planning during the course of preparing the Draft Sydney Regional Environmental Plan (Botany Bay) currently on public exhibition and through the environmental impact assessment of relevant development applications, particularly in the Port Botany area. The Department's concern is in relation to the cumulative risk effect of industrial developments in the area and the need for the formulation and implementation of technical and land use planning criteria and guidelines related to industrial hazards accounting for such cumulative impact.

This report documents the outcome of the Department's investigations; defines the issues involved; describes the surveys, studies and analysis conducted to investigate those issues; presents the results; and discusses their implications. Specific recommendations are also presented in an attempt to mitigate existing identified impacts and hopefully resolve the issues.

1.2 Study objectives

The main objectives of this assessment study are as follows:

- to examine whether public safety, property or normal community activity are at risk from industrial operations in the study area;
- if such risks are found, to quantify the hazard impact and identify the major contributing causes; and
- to outline broad options available to ensure satisfactory public, property and community safety.

The study therefore attempts to quantify and assess the degree of risk which exists in the areas around the Botany/Randwick industrial complex and at Port Botany.

This report emphasises the overall combined hazard impact from all installations in the area and their resultant overall risk levels on adjacent land uses, mainly residential.

It is important to acknowledge the limitations associated with a hazard study such as the one in hand. These are detailed in the body of the report as applicable and include assumptions on the nature and behaviour of various postulated hazardous events and limitations in the quantification of the human factor in safety assessment. Theoretically, the potential for serious mishaps exists to various degrees. In practice, few such mishaps occur worldwide.

It is because of such limitations that this report has accounted for the probability (credibility) of various hazardous accidents occurring in practice, rather than relying entirely on theoretical consequence estimations. Overall, the results of this study represent a balanced discussion of the existing safety situation in this area.

2. DESCRIPTION OF THE STUDY AREA

This section defines the area subject to this study and the surrounding land uses (mostly residential) as the basis for assessment.

2.1 The study area

Figure 1 indicates the general locality of the study area within the Sydney Region. Figure 2 specifically delineates the area subject to the current investigations and presents a generalised land use map.

The area can be broadly divided into:

(a) the industrial complex referred to as the Randwick/Botany industrial complex and Port Botany; and

(b) land surrounding the industrial complex, mainly residential developments.

The total resident population (as at the 1981 census) within 1 kilometre of the boundary of the industrial area (see Figure 3) was 8,000 with some 4,500 of these within 300 metres of the complex.

2.2 The Botany/Randwick industrial complex and Port Botany (Figure 3)

The Botany/Randwick industrial complex and Port Botany occupy an area of some 600 hectares, the largest area of industrial land in the Sydney Region. Most of this land (500 hectares) is located in the Municipality of Botany. The industrial complex is one of the oldest established industrial areas in the State and is being continuously encouraged to expand. Its role has been strongly reinforced by the reclamation and development of Port Botany.

The complex accommodates a relatively large number of industrial installations and storage terminals, grouped adjacent to each other and in many cases sharing the same boundaries. Table 1 lists all the companies surveyed within the study area. The nature of industry currently operating in that area is mostly that of chemical, petrochemical and petroleum products (processing and storage). The ICI petrochemical complex is one of the largest in Australia and major petroleum storage terminals of State significance are included. Industry in the area is potentially hazardous in nature.

Table 2 lists the establishment dates of the major industries in the area. The Table indicates that most potentially hazardous installations have located and developed in the area in the early to mid-1950s.

It is noted that from a statutory planning viewpoint, a substantial proportion of the industrial area and all of Port Botany are covered by a s.101 Direction under the Environmental Planning and Assessment Act, 1979. This requires development applications to be referred by Councils to the Department for the Minister's determination.

2.3 Surrounding land uses

Land uses surrounding the industrial complex and Port Botany to within a general distance of 2 kilometres are mostly residential (Figures 2 and 3).

2.3.1 Residential

(a) Randwick

The surrounding residential zoning under the prescribed environmental planning instrument, Randwick Planning Scheme, gazetted in April 1978 is 2(a1) and 2(a2) allowing single dwellings on 325 square metre and 460 square metre lots respectively. The residential zones are fully developed with single dwellings and some semidetached cottages. The residential areas to the north-west of Bunnerong Road contains cottages ranging from pre-World War I weatherboard in the Harold Street Australia Avenue area to 1930s brick cottage development.

Generally, the area is wellmaintained even in closest proximity to major industry. The Shirley Crescent area to the east of Bunnerong Road is a 1970s brick cottage development on the site of an old market garden and is meticulously maintained.

Residential development to the west of the industrial complex betwen Wassell Street and Macquarie Street is post-depression housing built by the Unemployed Homes Trust. Residential development south of Macquarie Street to Little Bay Road is mostly post-World War II Housing Commission development. Houses in both of these areas are mostly brick with some high quality brick infill development. The 2(a2) La Perouse residential development contains some cottages dating from the early 1900s but is mostly post-World War II development. Much of the housing fronting Yarra Road appears to be neglected and rundown. The undeveloped 2(d) Crown land area adjacent to La Perouse public school in Keroo Avenue (an unmade road) is low-lying and its aspect towards the cemetery and the Total refinery is unattractive.

(b) Botany

The Botany Industrial Area is approximately 473 hectares, the largest area of industrial land in Sydney except for South Sydney. Surrounding development to the north-east is all 2(a) Residential in the prescribed environmental planning instrument, Interim Development Order No. 19 gazetted in September 1977.

The 2(a) zoning allows single dwellings on 500 square metre allotments although there are many cottages erected on smaller allotments that predate planning controls. The area is fully developed with 1920s-30s brick, weatherboard, and fibro cottages with some pockets of newer brick development.

The 2(a) zone in northern Hillsdale is developed with well-maintained 1920s brick cottages. The large 2(c1) area which covers most of Hillsdale allows medium density development of 175 persons per hectare. This area is fully developed with three floor walk-up flats with the exception of development fronting the southern end of Rhodes Street which is single dwellings. A small strip development of 2(b) zoning allowing a density of 125 persons per hectare lies east of Nilsen Street and is fully developed with semi-detached town houses. A strip of 2(a) zoning with a frontage to Denison Street opposite ICI contains old cottages of various materials, many in disrepair. This area has a very low amenity, being directly opposite a major petro-chemical complex and on a major industrial artery carrying container trucks and heavy vehicles, including dangerous goods transportation.

2.3.2 Other land uses

The study area includes a number of passive and active open space areas, the most important of which are the Yarra Recreation Reserve, Woonera Road Reserve and the Women's Athletic Field (within 500 metres the Total oil refinery), Heffron Park (700 metres from ICI), Mutch Park (200 metres from Total/B.P. storage). The Hensley Athletic Field extensively used for active sporting events, is located some 50 metres from ICI's boundaries.

The La Perouse Public School is located some 500 metres from the Total oil refinery processing units. Within 100 metres from the boundaries of the industrial complex in the Botany Municipality, Matraville Public School and Botany Public School are also located.

2.4 Other relevant information

Appendix C presents an outline of relevant statutory planning controls applicable to the study area while Appendix D details the safety standards, codes and applicable N.S.W. legislations in that regard.

Appendix E presents a description of the existing physical, social and economic environment relevant to this assessment.

3. METHODOLOGY AND ASSESSMENT PRINCIPLES/ASSESSMENT CRITERIA

3.1 Principles of assessment

Two options are available for the quantification and assessment of hazard impact.

In one option, the type of hazardous events (e.g. fire, explosion, release of toxic materials) and the causes and sources of their occurrence (e.g. vessel failure, pipeline fracture, leaks) are identified and quantified in terms of their consequences (heat radiation, explosion overpressure and/or toxicity) using relatively well established techniques. The consequences of these hazardous events are then related to the number of people that would be injured or killed and/or the numbers of plants and buildings that would be damaged and the extent of damage.

This method of assessment emphasises the consequences of mishaps associated with the presence of potentially hazardous processes and materials with little acknowledgment being given to the various safety controls available to limit the probability of a hazardous event occurring in practice.

The second option for assessment consists of accounting for the design, operational and organisational safety controls implemented at various installations by assigning probability factors to each potential mishap. These probability factors are related to the consequences of each mishap as applicable and the results presented in probabilistic terms for fatality or injury to people and/or damage to buildings and plants. An application of this approach is found in the Canvey Island Study conducted by the U.K. Health and Safety Executive.

The Department's principles of risk assessment adopted for this study are based on a combination of both options outlined above. The assessment is based on the notion that risk is inevitable and cannot be totally eliminated, particularly in a heavy industrial area such as the Botany/Randwick industrial complex, but that there is a need to limit the probabilities of impacts from "credible" mishaps to technically and economically practicable levels accounting for the nature of surrounding landuses.

The Department's assessment assigns probability factors to various possible mishaps in recognition that safety controls must play a role in hazard assessment. The assessment is not however solely based on probability estimations but also on consequences which are given high consideration for major potential mishaps particularly as they affect residential areas. The assessment criteria in that regard are based on the need to control the causes and sources of incidents with large consequences to an almost negligible likelihood of occurrence.

3.2 Methodology of assessment

The procedures adopted for assessing hazard impact in this study basically involves:

(i) hazard identification;

(ii) hazard analysis (consequences and probabilities estimations); and

(iii) risk evaluation and assessment.

These are outlined below.

3.2.1 Hazard identification

This is the first step in any risk assessment and involves the definition of all theoretically possible hazardous materials, processes and incidents as the basis for further quantification and analysis. It also indicates the possible causes of initiating hazardous events and possible impacts associated with such events.

It must be noted, however, that hazard identification does not in any way imply that the hazard identified or its theoretically possible impact will occur in practice. Rather, it pinpoints the type and nature of hazards to be further evaluated in order to quantify resultant risks.

In order to identify the type of hazards applicable to this area, a survey was undertaken of more than 50 industrial installations. Information sought by the survey included the type, nature and quantities of materials handled, processed and stored, the nature of operations, the type of vessels and the safety controls (design, operational and organisational) implemented at each installation. Section 4 of this report deals with that matter.

3.2.2 Hazard analysis

(i) Consequence estimations

This includes the analysis and quantification of the type and magnitude of various potential mishaps associated with the area. They mainly include fire, explosion and the release of toxic material and their potential to injure or kill people and/or damage properties.

Appendix F presents the methods and techniques adopted for: the quantification of heat radiation associated with fires; explosion overpressures associated with explosions, specifically unconfined vapour cloud explosions; and toxicity levels resulting from the release of toxic materials both directly and indirectly.

Figures 4(a) to 4(f) inclusive should also be consulted in that regard.

(ii) Probability estimations

The likelihood of mishaps quantified in (i) above were determined by adopting probability factors derived by reference to similar operating installations elsewhere, from worldwide published data and from the results of detailed risk analysis studies undertaken both in the local area and in some overseas countries.

Table 3 presents the failure rate probabilities adopted in this assessment together with relevant assumptions. It is noted that, while some factors are more reliable than others, the general approach adopted in this assessment is of a comparative nature rather than entirely relying on absolute values. For example, it was assumed that a pump/pipe system has a higher probability of failure than a complete storage tank failure given the nature of operations and available controls.

In addition, a thorough examination of each installation in the study area and its associated design, organisational and operational safety controls was undertaken. This examination assisted in the determination of applicable probability factors.

The failure rates adopted for this study (see Table 3) are generally based on good engineering operation and safety practices and account for safety requirements of the relevant standards. Individual companies would have to demonstrate through detailed hazard and operability studies that significantly better failure probabilities could be achieved.

3.2.3 Risk evaluation and assessment

The consequences and probabilities of postulated hazardous events were combined cumulatively, using a hazard computer model based on the methods discussed in Appendix F, to estimate risk contours at various distances from each installation.

The risk contours are presented in terms of:

- the probability (or chance) that any person would be fatally affected, i.e. the risk of fatality per person per year;
- the probability of exceeding a certain heat flux at various distances from the plant;
- the probability of exceeding a certain explosion overpressure at various distances from the plant;
- the probability of exceeding a certain toxic gas concentration at various distances from the plant.

Consideration was also given to the possibility of the "domino" effect occurring between adjacent plants. Risk contours were also cumulatively combined to produce overall risk levels for the whole of the study area.

The risk contours estimated as per the above were then analysed and assessed in terms of the criteria discussed in Section 3.3 following.

3.3 Assessment criteria

Appendix G presents an overall discussion on the question of criteria for risk assessment and of risk acceptability with relevant limitations.

An assessment of public safety relies heavily on public perception of what is an acceptable risk level. In order to gain some insight into risk perception by the local population in the study area, a risk perception survey was conducted through household interviews by random sampling. The results of this survey are available in a separate document to this report and have been used as a guide to this assessment.

3.3.1 Fatality risks

People in general are willing to voluntarily take great individual risks by, for example, smoking, driving, or private aviation. On the other hand society is offering growing resistance to risks imposed involuntarily on one group of people for the benefit of others such as by the presence of hazardous industries close to neighbourhoods, or the transport of dangerous substances.

One approach to formulating a criterion for determining the fatality risk acceptable for people is to ensure that the risks imposed by a hazardous industry are well below all known voluntary and involuntary day-to-day risks. Statistical considerations (see Table G1) indicate that a fatality risk level of less than one chance in a million per person per year can be taken as a guide for assessment purposes subject to further refinement. It is noted that this level has been applied as only one component of total risk evaluation. Risk of injury (but not fatality) to people and damage to property was also accounted for.

The level of less than one in a million per person per year is considered applicable to residential areas where people are normally present for extended durations. For other land uses such as open space, commercial and public roads, the chance of any one member of the public being present during the mishap is lower than for those living in of a residential area. On that basis, the following assessment criteria are suggested.

Fatality risk criteria for various landuses

Land use	Fatality Risk Criteria per million per person per year
Residential	Up to 1
Open space	
- Passive	Up to 10
- Active	Up to 5
Commercial	Up to 5
Public roads	Up to 20
Industrial	Up to 50 (per employee)

3.3.2 Heat flux and explosion overpressure

Tables 4 and 5 indicate the effect of various levels of resultant heat radiation and explosion overpressure on people, buildings, plant and equipment as applicable. The tables have been compiled by reference to a number of research data and published information.

In formulating the relevant assessment criteria, the important consequence levels indicated in these tables were not allowed to occur at significant probability levels. On that basis, the following criteria are suggested (the criteria apply to this particular assessment and do not in any way imply uniform criteria for risk acceptability):

(i) Incident heat flux radiation and explosion overpressure (as applicable) at residential areas should not exceed 4.7 kW/m^2 and/or 7kPa at frequencies of more than 50 chances in a million per year.

(ii) Incident heat flux radiation and explosion overpressure (as applicable) at residential areas should not exceed 12.6 kW/m^2 and/or 14 kPa at frequencies of more than 10 chances in a million per year.

(iii) Incident heat flux radiation and explosion overpressure (as applicable) at neighbouring potentially hazardous installations should not exceed 23kW/m^2 and/or 14 kPa at maximum frequencies of 50 in a million per year; and

(iv) whenever applicable, in-plant accident propagation potential estimated in terms of 25 kW/m^2 and/or 35 kPa should not exceed 50 in a million per year.

The basis for the criteria outlined above is provided in Appendix G.

3.3.3 Toxicity

Toxic gases are generally hazardous from a personal rather than a property damage viewpoint. Depending on the concentration, the nature of the material and the periods and mode of exposure (i.e.via the respiratory tract, lungs, skin or ingestion), the effects vary from fatality, injury (e.g. damage to lungs and respiratory system, damage to the nervous system, emphysema, etc.) to irritation of eyes, throat or skin and nuisance. These effects are generally classified as acute, chronic or delayed.

Available assessment criteria for toxicity include LC_{50} (defined as the toxic concentration at which half of the exposed population would be fatally affected), TLV (defined as the continuous level of exposure to which a worker inside a plant exposed throughout his working life) or relevant ambient air quality standards and goals adopted by State, National or International organisations.

These criteria were found not to be applicable for this assessment in view of the following facts:

(i) Toxic concentrations which can cause fatality to <u>any</u> member of the general public (LC_{50} principle) are not acceptable in this assessment.

(ii) TLV and ambient air quality standards and goals are more applicable to continuous levels of exposure (long duration with an inbuilt safety margin). In the context of this study, it is more appropriate to formulate a criterion for a relatively short exposure time (up to one hour) since it is likely that emergency and remedial action would be taken within that time.

The implications of the above statements are that:

(i) Each toxic chemical should be considered on its own merit from a toxicology point of view.

(ii) The assessment criteria should be directed towards limiting the probability of exposure to short time duration within injury and irritation limits. The criteria should account for low probabilities of injuries and relatively higher probabilities of irritation or nuisance where emergency action should be taken.

Table 6 indicates the effects of different concentrations of toxic gases as published by Lees (1980), Sax (1979) and others. Based on the principles discussed in this Section the following criteria have been adopted for assessment purposes:-

(i) Toxic gas concentrations should not exceed a level which would be injurious to any member of the community for a relatively short period of exposure (up to one hour) at a maximum frequency of 10 in a million per year;

(ii) Toxic gas concentrations should not cause irritation to eyes or throat, coughing or other acute physiological responses over a maximum frequency of 50 in a million per year to any member of the general public.

4. HAZARD IDENTIFICATION

As previously indicated (Section 3), identification of hazards is the first step in any risk assessment and involves the definition of all "theoretically" possible hazardous materials, processes and incidents as the basis for further quantification and analysis. It also indicates the possible causes of initiating hazardous events and possible impacts.

For example, if a storage terminal contains vessels and drums of flammable liquid, such as petrol, then one of the theoretical hazards must be fire. Similarly, if a plant processes and stores large quantities of liquefied flammable gases then a vapour cloud explosion must be at least a theoretical possibility. An assessment of the safety controls and of the likelihood and consequences of these types of hazards must however be further undertaken to determine whether they impose a high risk level to people and property.

Identification of hazards was basically carried out by carefully examining the materials and processes used in the study area and by review of the local and worldwide history of incidents in similar facilities. This drew attention to types of events which could, perhaps occur.

4.1 Hazard audit survey

A hazard audit survey was undertaken in order to:

- comprehensively examine the nature, type and quantities of materials handled, stored and processed within the industrial complex;
- obtain general information on applicable safety controls and practices adopted by industry in this area; and
- obtain an appreciation of past hazardous incidents in the area, their causes and resultant impacts.

This survey was in the form of a questionnaire (a sample questionnaire form is included as Appendix L) sent to some 50 companies in the area requesting their response as to:

- type of toxic substances in storage or process exceeding 2 tonnes;
- type of highly reactive substances in storage or process exceeding given quantities which range from 1 tonne for ethylene oxide to 500 tonnes for sodium chlorate and ammonium nitrate;
- type of flammable gases in storage or process exceeding 2 tonnes;

- type of liquified flammable gases (e.g. L.P.G., ethylene) in storage or process exceeding 20 tonnes;

- type of flammable liquids in storage or process exceeding 10,000 tonnes;

- total quantities of any of the above materials, in storage or in process on the site;

- description of the nature of manufacturing or storage activities on the site and specific information related to the process, number of vessels, number, diameter and length of transfer pipelines, pumps, etc.;

- overall layout of the facility and locations of hazardous materials and processes;

- specific information on operational and organisational safety controls, e.g. emergency isolation valves, safety procedures and emergency plans, qualification and experience of safety personnel, etc.; and

- history and causes of any mishap at the plant and resultant impact.

In addition, relevant information was compiled from records kept by the Dangerous Goods Branch in order to supplement companies' responses. Such information was particularly useful for assessing those companies who did not respond to the questionnaire.

The cut-off quantities adopted for the survey were largely based on the requirements of the U.K. Health and Safety Executive (H.S.E.) as stated in their first and second reports on Major Hazards. However, in several cases, lower quantities than those specified by H.S.E., were adopted, in order to account for the relatively high concentration of industry present in the local area.

Table 7 indicates the levels selected by the Department as the basis for assessment. The corresponding quantities recommended by H.S.E. are also presented in this table for comparison.

Generalised layouts of most installations surveyed are presented in Figures 5(a) to 5(v).

4.2 Identification of major hazards in the study area

4.2.1 Type and quantitites of hazardous materials identified

From the results of the survey, the nature of the hazardous materials being handled, processed, stored or transferred in the Botany/Randwick industrial complex and at Port Botany can be broadly classified as:

- flammable and combustible liquids, including petroleum and petrochemical related raw materials and products used at refineries, chemical and petrochemical processing plants, blending facilities and in distribution terminals;
- liquified flammable gases mainly propane, butane and ethylene, in storage and process;
- flammable gases in minor quantities, mainly in process;
- toxic materials, mainly chlorine, acrylonitrile, anhydrous ammonia, pesticides, vinyl chlorides, etc. in storage;
- reactive substances mainly organic peroxides and oxides of ethylene and propylene in storage and process;
- combustible solids mainly papers, cardboard, etc., at warehouses, container terminals and freight depots.

Table 8 presents estimated quantities of each hazardous material per company surveyed, and indicates that the whole study area accommodates some 432,395 tonnes of flammable liquids, mainly petroleum products in storage, 28,365 tonnes of liquefied flammable gases, 21,870 tonnes of toxic material and 290 tonnes of highly reactive substances. Major potentially hazardous plants that accommodate the largest inventory include the ICI Botany plant storage terminals, the Total oil refinery and bulk storage facilities in the Port area.

4.2.2 Types of hazardous incidents identified

The nature and quantities of hazardous material identified in the study area, in storage, transfer or process could, theoretically, result in a number of hazardous events as indicated in Table 9. Table 10 further identifies the possible hazardous consequences of incidents which could be associated with each installation being surveyed. These generally include:

(i) fires from storage and processing units mainly handling or storing flammable liquids and gases;

(ii) in the case of major L.P.G. storage/processing units, fireballs and explosions including (Boiling Liquid Expanding Vapour Explosion);

(iii) explosions, including unconfined vapour cloud explosions from loss of containment of liquified flammable gases in storage and processing;

(iv) release of toxic gases upon loss of containment;

(v) release of toxic fumes generated from fires engulfing toxic material;

(vi) general fires from containers, warehouses, small-medium industrial operations;

(vii) fires and possible explosions from transportation accidents;

(viii) pipeline hazards including fires and explosions.

From such an investigation, the type of hazards specifically identified for analysis are fires, explosions and release of toxic material.

4.2.3 Initiating events and resultant consequences

Part of the hazard identification investigation includes an examination of the possible initiating events which could lead to hazardous incidents and their possible implications. This is carried out in order to determine which events and incidents should be considered in detail and to highlight the contributing causes of such incidents and where controls are to be maximised.

Figures 6(a) and 6(b) present examples of such investigations which were undertaken for each installation in the complex (in generalised forms). For example, in Figure 6(a) it is indicated that the main contributing causes for a transfer pipeline failure in the Port area could include corrosion 'or' third party damage 'or' abnormal pressure/temperature effects in the line, etc., which could result in loss of containment 'and' in the presence of a source of ignition would lead to a fire and/or explosion.

The following hazard identification word diagram is the result of such initial investigation.

TYPE OF FACILITY	POSSIBLE INITIATING EVENTS	POSSIBLE RESULTS & COMMENTS
*Flammable liquids (e.g. oils, petrol, etc.) Storage	Rupture of tank roof (or failure of floating roof system) followed by ignition	Fire of entire tank roof surface. Unless cooling is applied to adjacent tanks, potential for fire to spread to them if very close. (rare event)
	Leak into bund followed by ignition in bund.	Large bund fire. Very rare event. Because of large surface area, the height of the flame is greater than for a tank fire, so radius of effect on surroundings would be greater.
*Flammable liquid processing	Leak from process vessels or piping, followed by ignition.	Fire Such a fire may be very damaging to the plant involved and, if interplant spacing is inadequate may spread to neighbouring plant. However, the radius of damage to surroundings is usually very limited.
		Blast and vapour cloud explosion. Only possible if the flammable liquid is processed at a temperature significantly above its normal point.

TYPE OF FACILITY	POSSIBLE INITIATING EVENTS	POSSIBLE RESULTS & COMMENTS
*Flammable Liquids Transportation		
- Tanker loading bays	Tanker driving off while still coupled, or other leak, followed by ignition.	Fire. Mostly local effect on loading bay.
- Road transport	Vehicle collision or other cause resulting in a leak, followed by ignition.	Fire. The area of effect of the fire is largely determined by where the liquid drains to, and the time taken till fire fighting can start.
- Drum stores containing flammable liquids, etc.	Leak and ignition.	Fire. Local effect mostly.
	Fire engulfing intact drums.	Drums bursting, sheets of flame of short duration. Possibly drums rocketing. Can place immediately adjacent property at risk.
*Liquified flammable gas		
- Pressurised storage	Leak, igniting promptly.	Fire. Potential to cause blast, otherwise of local effect.
	Fire (e.g. from leak) heating and weakening containment vessel until it ruptures and contents escape and ignite almost instantaneously.	Blast (fireball). Radius of serious effect up to hundreds of metres.

TYPE OF FACILITY	POSSIBLE INITIATING EVENTS	POSSIBLE RESULTS & COMMENTS
	Leak, mixing with air before delayed ignition.	Vapour cloud explosion (only if vapour cloud before) or flash fire. Radius of blast damage can be very large with severe damage up to hundreds of metres.
		Main damage confined to area covered by cloud at time of ignition.
- Refrigerated storage at atmospheric pressure.	Leak from plant pipework.	Fire. If suitably designed, such leaks should be small and quickly isolated.
	Release of vapour from relief valves, followed by ignition.	Fire.
	Overpressure in tank or underpressure in tank followed by rupture of tank roof.	Large fire confined to area of tank.
	Tank liquid leak to the surrounding area.	Large fire. Extremely unlikely because of secondary containment.
- Processing Plant	Leak followed by ignition.	Fire or blast or vapour cloud explosion or Plant fire. As for liquified flammable gas pressurised storage, with the following differences: lower potential consequences as inventories in process are generally less

TYPE OF FACILITY	POSSIBLE INITIATING EVENTS	POSSIBLE RESULTS & COMMENTS
		and higher potential likelihood owing to the extra complexity of pipework and so opportunity for mechanical damage and/or failure leading to leaks.
*Toxic gas manufacture or storage	Leak.	Toxic gas cloud. Significant inventories of toxic gases are normally protected to prevent leaks and to enable rapid isolation.
*Storage or processing of materials with toxic combustion products.	If engulfed in fire, would result in smoke containing toxic combustion products.	Toxic effects.
*Highly reactive materials - processing or Storage.	Process or storage conditions deviating from standard, with the result of reaction run-away or decomposition.	Fire and explosion - toxic fumes. Dependent on the nature of the highly reactive material. Most of the quantities processed at any time are sufficiently small to ensure that the effect of reaction run-away would be mostly local.
*Flammable powder processing	Ignition of dust-filled air.	Dust explosion. Mostly localised to the dust-filled buildings or plant.

TYPE OF FACILITY	POSSIBLE INITIATING EVENTS	POSSIBLE RESULTS & COMMENTS
*Transfer pipelines		
- Liquified flammable gas.	Leak, mostly due to one of the following causes :	Fire.
	- mechanical damage due to accidental excavation, soil subsidence.	Flash fire. Vapour cloud explosion. The effect of any incident depends on the diameter and process conditions in the pipeline, the speed of leak detection and isolation and the delay before any ignition.
	- Corrosion	
	followed by ignition	
- Flammable liquid	Leak, due to causes such as above, followed by ignition	Fire. The extent of the effect of any such incident depends on factors listed above, plus the area covered by the leaked material when ignited.
*Port operations involving flammable liquids or liquified flammable gas.	Ship collision with other ship or fixed object, rupture of tanks, leakage, ignition.	Fire, possibly explosion.
	Shipboard pipework or plant leakage, and fire.	Fire, possibly explosion.
	Wharf incident - leak from loading/ unloading line	Fire, possibly explosion. The nature and severity of the result depends on the nature of the material leaking and the delay before ignition.

4.3 Overview past incidents in the study area

As part of the overall survey of hazards within the study area, companies were requested to supply details of any hazardous incidents which had occurred on their premises. Responses to this question were generally poor or vague.

A number of government departments were also approached with a view to collecting addditional information in that regard. Communications with the Police Department, the Board of Fire Commissioners and the Dangerous Goods Branch clearly indicated that there is no centralised mechanism for recording past incidents or mishaps which could have provided valuable information for this study. Indeed, retrieval of information on past mishaps in the area was most difficult and in many cases information was not available. Total oil refineries, for example, indicated that in 30 years of operation some 20 incidents had occurred involving fire and/or explosion in which on one occasion (in 1957) three operators were killed. The company reported that on each occasion the local fire brigade attended yet the Board of Fire Commissioners could only report one incident at the refinery.

Figure 31 documents the type of incidents that have occurred in the area over the past thirty years, as generally reported by the companies and relevant authorities. The nature of incidents experienced can be broadly classified as general leakages, fires, explosions and release of toxic gases or fumes. No fatality or injury to any member of the public outside plant boundaries have been reported, although some operators have been killed and injured. It is estimated that some 40 to 50 mishaps have occurred over the past 30 years. No records could be found as to emergency/evacuation procedures adopted nor of remedial action implemented to avoid recurrence. It is however estimated that most incidents were of limited scale and impact.

Table H-1 in Appendix H presents a listing of past incidents in the area by installation, as reported. No verification of such incidents could be comprehensively undertaken.

More recently, a series of mishaps in the area occurred on a frequent basis. A general summary of these incidents is tabulated in Table (13).

4.4 Preliminary consequence analysis

The main types of hazards identified in the previous section, namely fires, explosions and toxic gas releases, were quantified in terms of their consequences in order to pinpoint those incidents which should be considered in more detail and to formulate the basis of a detailed hazard analysis as applicable.

The methods adopted for consequence analysis are those outlined in Appendix F.

The results are indicated in Tables 11(a) to 11(c) inclusive. It is emphasised that these results do not account for the credibility nor the likelihood of occurrence and are based on specific situations considered in isolation. No cumulative risk impact is considered at this stage.

The implications of the results are:

- Isolated tank fires at the Port Botany area would not affect any residential areas although adequate fire water would be essential to prevent escalation of incidents.

- Isolated tank fires in some storage terminals at the industrial complex, namely the H.C. Sleigh and AMOCO terminals could affect adjacent residential properties. In the case of the BP and Total distribution storage terminals it is theoretically possible for accident escalation to occur between those terminals should fire water not be effective.

- Unconfined vapour cloud explosion and release of explosive vapour clouds from the Port Botany area and/or the industrial complex could under certain circumstances affect residential areas.

- Fireball mishaps from LP gas storage at the Port should not affect residential areas.

- There is a need to limit releases of toxic material and related vapours from the study area in order to prevent the potential for significant toxic effects in residential areas.

The most important implication of the results indicated in Tables 11(a) to 11(c) relate to the requirements of safety standards and codes which are also shown in these tables. It is evident that such requirements are not adequate to prevent the consequences of mishaps affecting residential land uses. In addition these requirements do not account for cumulative risk impacts. The results clearly indicate the need for a formal systematic method of quantification and analysis rather than entirely relying on those standard requirements. This is particularly the case for liquefied flammable gas installations such as liquefied petroleum gas (L.P.G.).

5. RISK QUANTIFICATION- ANALYSIS OF RESULTS AND ASSESSMENT

5.1 Results and analysis for individual installations

The methodology of assessment detailed in Section (3) and Appendix (8) was applied for each installation in the study area using the data as identified in Section (4).

The results in terms of risk contour lines are presented in Figures (7) to (29) inclusive. The following section presents an analysis of those results.

5.1.1 Resultant fatality, fire and explosion risk levels

Oil storage terminals

The main type of hazard from petroleum product storage terminals as identified in Section (4) of this report is fire. Sources of such hazards include storage tank failure, transfer pumps and pipe leakages, loading facilities and in extreme cases bund fires.

While it is possible for these facilities to experience minor deflagrations within their boundaries, explosions as such are not considered credible.

(i) Caltex Oil (Australia) Pty Ltd (Figures 7(a) - 7(b))

This is a major petroleum products storage and distribution terminal of State significance. The terminal accommodates some 29 storage tanks of total capacity in excess of 39,000 tonnes, with associated transfer pumps and pipes and loading facilities for road tankers.

Figure 7(b) indicates that fatality risk levels of 10 in a million per person per year extend beyond the terminal boundaries exposing Botany Road, but not residential areas. Fatality risk levels in residential areas from this terminal in isolation are negligible (well below 0.1 per million per person per year). Significant probabilities (in excess of 10 in a million per year) of 12.6 kW/m^2 and 4.7 kW/m^2 heat flux cover sections of Botany Road, Beauchamp Road and Foreshore Road (see Figure 7a). Part of the A.P.M. land (which is currently vacant) and Fibres Pty Ltd are also exposed to such heat radiations.

The impact of the heat radiation on Beauchamp/Foreshore Road would be exacerbated by the fact that the roadway is at approximately the same height as the tanks within the terminal.

Residential areas are not however affected by any heat radiation impact from this terminal (less than 4.7 kW/m 2).

The relative contributions to total risk within the terminal are as follows:

.	Road tanker loading facility (7.00a.m. to 3p.m. shift 38.2%) (3.00p.m. to midnight shift 57.3%)	95.5% of total risk
.	Rail tanker loading facility	3.0% of total risk
.	Drum fill warehouse	1.5% of total risk
.	Storage area	Negligible
.	Total	100%

Risk levels within the terminal's boundaries are excessive.

Outside the terminal's boundaries the main contribution to total risk is from storage tank fires.

(ii) Esso Pty Ltd (Figures 8(a) - 8(b))

The Esso petroleum products storage terminal is located to the west of the main Sydenham-Botany rail line. Adjacent companies include the ICI plant, Laporte Chemicals, A.C. Hatrick, Metal Recyclers and Johnson & Johnson. The company stores approximately 25,000 tonnes of flammable liquids in 8 main tanks (some 19 small tanks are also used in transfer/blending operations).

Figure 8(b) indicates that fatality risk levels in excess of 10 in a million per person per year would be mainly contained within the terminal's boundaries except for the southern area which impacts on part of the ICI land (currently vacant). Fatality risk levels at residential areas from this terminal in isolation are however well below 0.1 per person per year considered as negligible.

Significant probabilities of heat flux of 12.6 kW/m^2 and 4.7 kW/m^2 potentially covers the whole site and extends into part of the ICI., A.C. Hatrick and Johnson & Johnson land. No heat impact at the relevant assessment criterion would occur at residential areas as the result of fires at this terminal.

(iii) BP Australia Pty Ltd (Figures 9(a) - 9(b))

The BP petroleum products storage terminal's frontage is along both Baker and Moore Streets to the north of the Botany/Randwick industrial complex. Adjacent companies include the Total distribution terminal, ICI, Liquid Air, Ready Mix Concrete and Davis Gelatine.

This terminal accommodates 5 petroleum products storage tanks with a total capacity of some 10,000 tonnes of flammable liquids.

As indicated in Figure 9(b), fatality risk levels in excess of 10 in a million extend into the northern part of the ICI plant and the adjacent Total distribution terminal. Levels of 1-10 in a million further cover the Ready Mix and Liquid Air facilities. However, no residential or open space areas are affected (fatality risk levels at residential areas from this terminal are well below 0.1 in a million per person per year considered negligible).

Significant probabilities of heat flux of 12.6 kW/m^2 cover the whole site and extend well into the neighbouring Total facility, ICI, Readymix and Liquid Air.

The heat flux impact would not extend into residential or open space areas (levels are below 4.7 kW/m^2 at the 50 in a million per year level).

(iv) <u>Total distribution terminal (Figures 10(a) - 10(b))</u>

The Total petroleum products storage and distribution terminal is similar to the adjacent BP terminal with 8 storage tanks (and 2 slop tanks) containing in excess of 35,000 tonnes of fuels.

Of the adjacent industrial facilities, BP, ACI, Continental Distillieries, Liquid Air, Davis Gelatine and ICI would experience relatively high fatality risk levels being in excess of 10 in a million per year (refer Section 3.3.1).

Due to the location and the number of tanks, the area of fire potential impact extends closer to residential areas. Frequencies of 1 in a thousand for 4.7 kW/m^2 heat flux (in excess of residential areas heat flux criteria) extend almost from Denison Street to the west and well into Wentworth Avenue to the north.

Heat flux at residential areas from this terminal in isolation is however limited to 2.1 kW/m^2. Heat flux levels well in excess of 50 in a million per year (12.6 kW/m^2 and 23 kW/m^2) affect neighbouring BP and part of the ICI plant.

(v) <u>H.C. Sleigh (previously Golden Fleece, now Caltex) (Figures 11(a) - 11(b))</u>

H.C. Sleigh is a fuel storage and distribution terminal which stores some 12,000 tonnes of fuel in 15 tanks with 19 small tanks containing oils and greases for blending and storage.

Crest Chemicals and ICI are immediately adjacent to the terminal. A number of residences (including flat and unit dwellings) are located across the road from the terminal along Beauchamp Road.

Figure 11(b) indicates that fatality risk levels in excess of 1 in a million per person per year and in some cases exceeding 10 in a million extend well into the residential areas of Denison Street, Grace Campbell Crescent, Rhodes Street, Flack Avenue and Well Street. These areas are considered to be significantly at risk from the terminal.

Significant probabilities of 12.6 kW/m^2 heat flux unacceptable for residential areas further extend into residential areas on Grace Campbell Crescent and Beauchamp Road including a number of flat and unit dwellings. Beauchamp Road, from Denison Street to Flack Avenue, is particularly exposed to excessive heat radiation and fatality risks. To the east, the 4.7 kW/m^2 heat flux could be experienced beyond residential areas on Jennings Street. Overall residential areas are significantly at risk from this terminal. The main reason is largely the terminal's proximity to residential areas.

The ICI plant to the westwould experience only minor risks and relatively lower heat impingement from fire incidents at the terminal. However adjacent installations at risk include Crest Chemical Co. and other light industrial firms to the east of the terminal. Crest Chemical is the installation most at risk

(vi) Amoco Pty Ltd (Figures 12(a) - 12(b))

The Amoco fuel storage terminal is surrounded by industrial, residential and recreational areas. To the east lies Sea Containers Pty Ltd and Laporte Chemicals, to the west residential areas and a primary school, to the north Metal Recyclers, Cubico and residential developments, and to the south the Botany Councils depot and a number of small industries.

Eight storage tanks (and one slop tank) accommodate some 27,000 tonnes of fuel on site for distribution to service stations.

Figure 12(b) indicates that resultant fatality risk levels in excess of 1 in a million per person per year, and in some areas above 10 in a million per person per year, extend well into residential areas and the public school to the west of the site.

In addition, significant probabilities of 12.6 kW/m^2 and 4.7 kW/m^2 heat flux (exceeding the assessment criteria of 50 in a million per year) expose the surrounding residential and industrial facilities. The local topography to the west of the terminal exacerbates people's exposure to heat radiation from the site.

Adjacent facilities considered at risk from this terminal in isolation (see Figure 12(b)) include Botany Council's depot, Sea Containers and Cubico.

Port Botany

(i) Powell Duffryn Oil & Chemical Storage Co. Pty Ltd. P.D. Oil (Figures 13(a) - 13(b))

P.D. Oil currently operates 61 flammable liquid storage tanks varying in size and accommodating up to 30,000 tonnes of a wide range of flammable liquids including potentially toxic material.

The terminal is located along Friendship Road on the north eastern section of the port and is surrounded by the C.T.A.L. container terminal to the north, the Womeai Reserve to the east and land leased by Boral for its proposed L.P.G. terminal to the south west. further to the south west are the I.C.I. and Terminals sites. A proposed fully mounded 1,400 tonne L.P.G. storage and distribution terminal on the site is currently pending planning consent considerations and was the subject of a detailed Environmental Impact Assessment Report published in January 1983.

The following results apply to the P.D. Oil bulk liquid storage part of the site:

- Fatality risk levels from P.D. Oil operations (in isolation) in residential areas are well below the levels of 0.1 chance in a million per person per year, implying a negligible fatality risk level.
- Heat radiation zones (Figure 13(a)) from P.D. Oil in isolation do not reach residential down to the low levels of 4.7 kW/m^2.
- Heat radiation levels of 23 kW/m^2 at 50 in a million are contained within site boundaries.
- Friendship Road is exposed to significant heat radiation levels for public road classification.

The results applicable to the proposed L.P.G. storage installation (fully mounded) are as follows:

- Figure (13(c)) indicates that no residential areas are exposed to fatality risk levels in excess of 0.1 chance in a million per person per year. Although residential areas are not affected, the probability of fatality to any member of the public along Friendship Road is in excess of 10 chances in a million per person per year.

- Figure (13(d)) presents the frequencies of exceeding heat criterion of 4.7 kW/m^2 and explosion overpressure of 7kPa (1 psi). As shown in this figure these frequencies are less than 10-50 per million per year, judged as acceptable for residential land-use purposes.

- The frequency of exceeding a heat criterion of 23 kW/m^2 and 14 kPa is particularly relevant for risk impact at adjacent facilities. At the level of 50 chances in a million, relevant contours are contained within the proposed site boundaries. No adjacent facilities are considered at risk from this proposed terminal.

It is noted that part of the C.T.A.L. container terminal is exposed to significant probabilities of 12.6 kW/m^2 and that 95 per cent of the total risk within the terminal originates from the loading/unloading bay while the remainder 5 per cent is attributable to the storage vessels.

The cumulative results fro the whole P.D. Oil terminal, including the L.P.G. proposed facilities are as follows:-

- Cumulative fatality risk levels (Figure 13(f)) consortium/P.D. Oil are still well below 0.1 chance in a million per person per year at the nearest residential areas.

- Heat radiation and explosion overpressures of 4.7 kW/m^2 and 7kPa at the relevant level of 50 in a million for injury to people and damage to properties do not reach any residences (Figure 13(g)). Friendship Road lies within this risk contour.

- Relevant results for Port land use planning purposes are those depicted in Figure 13(h) where the 50 in a million risk levels for 23 kW/m^2 and 14 kPa are contained within the total P.D. Oil storage terminal's site boundaries in accordance with the Department's assessment criteria.

(ii) Terminals Pty Ltd (Figures 14(a) - 14(b))

This terminal is located along Friendship Road on the eastern shore of Port Botany and accommodates some 62 storage tanks with an approximate total capacity of 42,000 tonne of flammable liquids and potentially toxic material.

The results indicated in Figures 14(a) - 14(b) are summarised as follows:

- Figure 14(b) presents risk contours in terms of fatality to any member of the public per million per year per person relevant to residential land uses. The figure indicates that risk levels in excess of 1 chance in a million per year per person do not reach any residence in the area: although, theoretically, it is possible for a toxic vapour cloud to reach residential areas under the most adverse meteorological conditions.

It is noted that, although residential areas are not affected, the probability of fatality to any member of the public along Friendship Road due to fire is in excess of 10 chances in a million per person per year.

- Figure 14(a) presents the frequencies of exceeding heat criterion of 2.1 kW/m^2, 4.7 kW/m^2 and 12.6 kW/m^2. This criterion is relevant for injury to people and possible damage to residential properties. As shown, these frequencies are less than 10 in a million per person per year and are judged as low when compared with other risks.

- The frequency of exceeding a heat criterion of 23 kW/m^2 is in the order of 10 in a million per year at adjacent terminals. This indicates that the operations of the terminal do not place adjacent plants at risk and more significantly, would not introduce serious constraints for any future expansions at these plants.

Overall risk distribution within the terminal is:

Area	Percentage of total risk
Wharf	0.3
Loading/unloading	98
Storage	1.7

(iii) <u>ICI Hydrocarbon Storage Terminal (Figures 15(a) - 15(b))</u>

This storage terminal consists of 1 x 4,000 tonne liquified ethylene refrigerated storage tank currently operating and 2 x 7,000 tonne L.P.G. refrigerated storage tanks under construction.

Adjacent land uses include the Terminals Pty Ltd liquid chemicals storage complex to the north-east, the C.T.A.L. container terminal to the north across Friendship Road, and vacant land designated dry bulk storage and coal loader to the south and west.

Liquified hydrocarbons are imported by ship to the site via the liquid chemical berth and transferred to the ICI Botany site by pipeline via the pipeline corridor.

Figure 15(b) indicates that all fatality risk levels in excess of 1 in a million are well contained within the boundaries of the site. There is no fatality risk to any residential areas. Heat radiation risks are also mostly contained within the site boundaries.

(iv) Proposed Boral Gas Ltd 4,500 tonne storage and distribution terminal (Figures 16(a) - 16(c))

(For detailed reference see Department's Environmental Impact Assessment Report and supplementary document for the proposal).

This proposal, for 4500 tonnes of L.P.G. Gas storage capacity with associated transfer pipes, pumps, compressors, road loading/unloading facilities has recently been granted planning consent subject to conditions that require mounding of all storage vessels.

Preliminary results indicated in Figures 16(a) - 16(c) are summarised as follows:

- Fatality risk levels in residential areas are below the one in a million per person per year suggested as an assessment criterion for residential land uses. Friendship Road is, however, exposed to levels in excess of 10 in a million per person per year.
- Although residential areas are not affected by heat flux at the 50 in a million level for 4.7 kW/m^2 and 7kPa, comprehensive hazard and operability studies are essential to ensure that adjacent facilities are not exposed to the relevant 23 kW/m^2 and 14kPa risk levels.

Processing Plants

(i) ICI Australia Ltd (Figures 17(a) - 17(c))

The ICI petrochemical complex at Botany occupies more than 40 hectares which is centrally located within the industrial complex. Major chemical and petrochemical processing operations are carried out on this site. The site is bound by Denison Street to the east with residential areas as close as 20 metres from its boundaries, and by other storage terminals and chemical plants to the north, west and south (see Figure 2).

Because of the magnitude and intensity of operating plants on this site, this complex represents the greatest single source of potential hazards in the study area. The full range of fire, explosion and toxic hazards are potentially present.

There are extensive and comprehensive safeguards implemented at the plant. However, the proximity of surrounding residential land uses offer serious constraints to risk control and limitations.

The results of the hazard analysis for this complex are indicated in Figures 17(a) - 17(c). These results indicate that the risk of fatality levels in excess of 10 in a million per person per year are contained within the boundaries of the site. However, fatality levels in the range 1-10 extend some 300-400 metres into residential areas to the east. Relatively lower risks of fatality (0.1 - 1 in a million per person per year) from the plant still persist over a large area covering most of the northern section of the study area from Botany Road to Anzac Parade, Gardeners Road in the north to Brotherson Dock in the south.

Significant levels of 4.7 kW/m^2 heat flux and 7 kPa explosion overpressure most relevant to residential land uses cover residential areas to the east of the plant including all properties fronting Nielsen and Denison Streets.

Liquid Air and the Esso terminal are the major industrial plants bordering the complex and are exposed to significant probabilities of 14 kPa overpressure.

(ii) Total oil refinery (Figures 18(a) - 18(c))

The Total oil refinery at Matraville is closely surrounded by residential developments on its northern and north eastern boundaries. To the south lies the Botany Cemetery and to the west Bunnerong Power Station. There are three vacant Crown land sites zoned residential within 600 metres from its boundaries. Figure 19(a) indicates fatality risk levels in excess of 10 in a million extending some 300 metres within residential areas. These areas are also subject to significant levels of 4.7 kW/m^2 heat flux and 7 kPa explosion overpressure in excess of this assessment criteria.

Areas exposed to fatality risk in excess of 1 in a million extend over 600 - 700 metres from the refinery and lower levels still persist up to the junction of Bunnerong Road and Anzac Parade to the south, Anzac Parade and Long Bay Prison to the east and Brotherson Dock to the west. As the figures indicate, the extent of fatality and injury risks is quite extensive.

(iii) Collie Industries (Figure 19(a) - 19(b))

Collie is a manufacturer of industrial and graphic inks many of which are solvent based. It is located in the southern sector of the industrial complex and is surrounded by La Porte Chemicals, Sea Containers, the AMOCO terminal and a number of light industries to the south.

No fatality or heat radiation impact from the plant affect residential areas.

Neighbouring facilities however are exposed to fatality risk levels in excess of 10 in a million per person per year and significant frequencies of heat radiation in excess of 4.7 kW/m^2 and in some cases 12.6 kW/m^2. A substantial part of Banksmeadow Park to the south is also subject to such risk.

(iv) A.C. Hatrick Chemicals (Figure 20(a) - 20(b))

A.C. Hatrick is a manufacturer of various resinous materials, polyvinyl acetate and some pesticides many of which are highly flammable.

Residential areas to the west on Stephens Road and Brighton Street lie directly opposite the plant. Esso, Cubico and Johnson & Johnson are all adjoining.

Fatality risks in excess of 1 in a million per person per year cover the majority of residential areas bound by Brighton Street and Stephens Road. A large proportion of this area exceeds a fatality risk of 10 in a million per person per year considered excessive. This same area could also be subject to significant levels of heat flux well in excess of 4.7 kW/m^2 and in some areas in excess of 12.6 kW/m^2 and must be considered at primary risk.

The neighbouring bulk fuel depots Esso and AMOCO are not subject to significant heat radiation from the plant. However, levels in excess of 12.6 kW/m^2 would reach Johnson & Johnson and Cubico.

(v) Catoleum (Figures 21(a) - 21(b))

Catoleum is a specialist chemical manufacturer which produces catalysts, various polymers and liquid and powder blending. Many of the materials used are solvent based.

Adjacent facilities include Davis Gelatine, ICI and some residential/open space areas at Stephens Road and Spring Street. Residential areas are not exposed to significant fatality or heat flux risk from the plant.

Heat flux levels in excess of 12.6 kW/m^2 may be experienced at CIG land (currently vacant) and at Davis Fuller Adhesives. Kellogs may experience relatively low probabilities of heat flux between 4.7 and 12.6 kW/m^2.

(vi) Bayer-Formag (Figure 22)

The Bayer plant at Botany which formulates and blends a number of powder and liquid based pesticides is located in Wilson Street and is surrounded to its immediate west and south by a number of light industries which include goods distribution, warehouse, transport terminals and engineering workshops. Across Wilson Street opposite the plant are located residential developments.

As Figure (22) indicates these residences are exposed to significant fatality risk levels in excess of 10 in a million per person per year. In addition, a number of residences to the north are also exposed to such relatively high fatality risk levels.

Light industry adjacent to the plant could experience heat flux well in excess of 12.6 kW/m^2 should a large amount of solvent used be ignited.

5.1.2 Results of analysis for toxic gas release

Some installations in the study area store, handle or process materials that are toxic in nature and, if released to the atmosphere in sufficient quantities, and under certain meteorological/dispersion conditions, could result in high concentrations at residential and other public areas. These installations have been identified in Section 4 of this report.

Appendix F details the method adopted to estimate toxic concentration levels at various distances from the source of release.

The results of analysis for the major potential sources of toxic gas release (either directly or as a result of combustion - i.e. fire engulfing toxic materials - or due to chemical reaction/decomposition) are presented hereafter.

(i) P.D. oil and chemical storage, Port Botany (Figure 23(a))

Chloroform was identified as the chemical stored and handled on site which is the most potentially toxic if released to the atmosphere. As Figure 23(a) indicates, toxic concentrations of up to 1000 p.p.m. (level considered to be immediately dangerous to life or health, 30 minute exposure without effect) could reach some 1.1 km from the site potentially exposing residences on Kooringai Avenue, Yarra Bay. However, the probability of such events was found to be relatively low (estimated at 8 chances in a million per year) independent of wind direction.

Higher concentrations could be experienced closer to the site, with ambient levels of up to 4000 p.p.m. exposing the adjacent Terminals Pty Ltd, proposed Boral and C.T.A.L. container terminals. It is noted that Figure 23(a) indicates the results for worse case situations.

Experience has also shown that toxic materials incorrectly blended or engulfed in a fire could release toxic fumes. The stronger the fire, however, the more efficient it is at completely consuming any toxic fumes. As such, a fire at this facility (estimated to be at a frequency of 1 in a thousand) is unlikely to result in adverse concentrations of toxic vapours although it is known that, under adverse meteorological conditions, odours, at less than toxic concentrations, could reach distances of up to 3 kilometres.

A number of other substances handled on site with potential toxic impact include toluene diisocyanate (TDI) and methyl ethyl ketone (MEK). These however are not as volatile as chloroform and relevant concentrations would not exceed public threshold levels. These are more applicable to occupational health considerations.

(ii) Terminals Pty Ltd (Figure 23(b))

Toxic materials identified at this site (in storage or in transfer/handling) include Formaldehyde, methylene chloride, chloroform and epichlorohydrin which on combustion decomposes to Phosgene, a gas of serious toxic effects at relatively low concentrations.

Concentrations of epichlorohydrin in excess of 100 p.p.m. could occur at distances up to 700 metres from its release point (see Figure 23(b). Although the area potentially affected does not include residential, adjacent facilities would be at risk. The probability of such an event occurring in practice was however found to be relatively low at an estimated frequency of 0.1 chance in a million. Should phosgene be released from this site (as the result of a fire engulfing epichlorohydrin) then the area of impact would be much larger and as Figure 23(b) indicates concentrations of 10 - 25 p.p.m. would reach residential areas on Yarra Road and Elaroo Avenue. Concentrations in the range of 5 - 10 p.p.m. would still persist from up to 3 kilometres away from the site. Although the probability of such an extreme event is considered low, special precautions will have to be taken to reduce the area of potential impact.

It should also be noted that chloroform concentrations considered a public health risk (1000 p.p.m.) would not reach residential areas 1.1 km away at the critical probability of assessment. Chloroform does not generally combust, so toxic byproducts are not relevant.

(iii) Bayer-Formag

Bayer formulates a number of pesticides which, if decomposed, could result in the release of toxic gases, the most significant being sulphur dioxide. For an estimated rate of release of 0.1 m^3 per second, concentrations of up to 20 p.p.m. of sulphur dioxide (detectable by odour) could spread to 500 metres from the point of release.

Although the probability of occurrence of any of these events has not been evaluated in detail in the absence of any detailed hazard and operability investigations, it is highly likely that residential areas across the road from the plant are exposed to excessive risk of toxicity.

(iv) ICI petrochemical complex - Botany (Figure 23(c))

ICI handles a number of materials which could present a toxic gas hazard. Of particular concern are chlorine and ammonia. Chlorine is the most potentially toxic and could readily spread under adverse meteorological conditions.

Upon investigation, it was found that two different chlorine release rates, at different probabilities could occur: A relatively high rate of chlorine release (3.6 m^3/second) at a low probability of about 4 in a million; and a lower release rate (1.2 m^2/second) at a significantly higher probability of about 100 in a million. Concentrations of greater than 150 p.p.m. are considered a high risk while concentrations of less than 15 p.p.m. are not likely to manifest in any way other than a strong odour with no immeidate health effect to people. A concentration of 430 p.p.m. or greater has been adopted as the lethal concentration under any conditions.

As indicated in Figure 23(c) this high concentration, even under high conditions of rate of release, would not extend beyond the Company's site boundaries under the most probable stability atmospheric conditions.

The more probable event of a low release rate should also not result in the 150 p.p.m. concentration passing beyond the plant boundary although for the higher release rate, the 150 p.p.m. concentration could extend to Rhodes Street and cover most of the Denison Street, Nilsen Avenue and Grace Campbell Crescent are immediately to the east of the facility. Situations of release rates approaching the 3.6m ^{3}/sec should not therefore be allowed.

The 15 p.p.m. concentration for the low release rate could extend some 1.1 kilometres from its source beyond Bunnerong Road, to Wentworth Avenue and down to Brotherson Dock as indicated in Figure 23(c). This includes extensive residential premises. In the case of the less probable higher release rate, the impact is limited up to Stephens Road to the west (no residential areas affected) but affect residential land uses to the east well beyond Bunnerong Road.

Container Terminals, Transport and Freight Depots

A number of facilities handle materials which could, under certain conditions, undergo chemical reactions to produce toxic gases or fumes.

These facilities have been identified in Section 4. The largest quantity of material known to be held of this nature is 12 tonnes of pool chlorine at Mayne Nickless depot, Botany. The most important aspect to consider in relation to this material is its rate of release rather than total quantity of chlorine release.

A rate of release similar to that at ICI cannot be anticipated. In fact at distances of up to 200m from each point of release, toxic concentrations would not exceed the minimum concentration required to cause any throat irritation (15 p.p.m.) The odour threshold (1 p.p.m.) could extend up to 500 m from the release source under most weather conditions.

5.2 Combined risk levels for Port Botany

Figures 25(a) and (b) presents the combined heat radiation and explosion overpressure and fatality risk levels for all current and proposed developments at Port Botany. These results have been compiled by cumulatively computing the relevant risk contours for each individual installation previously discussed.

The results indicate that:

- The 0.1-1 chance in a million per person per year fatality risk level does not affect any residential areas and is generally contained within the Port. The results reflect a relatively high level of safety control adopted at the Port to date.

- Figure 25(a) presents the probabilistic risk levels for 4.7 kW/m^2 and 7 kPa in excess of 10 in a million. No residential areas are affected and overall risk levels are generally contained within the Port boundaries.

- There is a need to reconsider the use of vacant lands at the Port, some of which in relatively high risk areas are for public use. This is further discussed in Section 10 of this report.

- Cumulative risk levels from the Port area are very sensitive to the proper location of potential risk generators within the Port. Should potentially hazardous facilties be allowed to locate in certain sensitive areas, cumulative risk levels could significantly increase. This should be accounted for in allocating remaining vacant lands on the Port (see further discussion, Section 10.3).

- Friendship Road is shown as consistently being exposed to relatively high risk levels and general public access to it should be controlled.

- Figure 25(b) could be used as the basis for formulating an overall emergency plan specific to the Port.

5.3 Combined hazard analysis results - Major components of risk

Figures (26), (27) and (28) in the appendix present overall resultant risk levels for the industrial complex and Port Botany in terms of fatality risk levels, heat flux, explosion overpressure and toxicity.

5.3.1 Combined fatality risk levels

As shown in Figure (26), areas exposed to fatality risk levels in excess of 10 chances in a million per person per year (well in excess of this assessment's criterion) are generally contained within the industrial complex and Port Botany except for:

- residential areas adjacent to the Total oil refinery at Matraville generally bounded by Macquarie, Dampier and Wassel Streets;

- residences along Beauchamp Rd, Rhodes and Solander Streets opposite H.C. Sleigh;

- residential areas west of the industrial complex particularly those opposite A.C. Hatricks and Amoco generally bounded by Brighton Street, Stephen Road and Botany Road (well in excess of 10 chances in a million per person per year);

- residential areas surrounding the Bayer plant at Botany;

- the embankment road, Womeai Reserve at Port Botany, section of Bunnerong Road opposite Total oil refinery, section of Botany Road opposite Caltex terminal, section of Beauchamp Road opposite H.C. Sleigh and Stephen Road west of the industrial complex. Vacant Crown Lands adjacent to the Total oil refinery are also included.

Fatality risk levels in the range 1-10 in a million per person per year (also in excess of this assessment's criteria) cover a wider area, generally bound by Rhodes Street opposite ICI to the east, Wentworth Avenue to the north, Brighton Street to the west and Beauchamp Road/Botany Road to the south. The 1 chance in a million fatality risk area around Port Botany and the Total oil refinery interacts to cover residential areas up to 600 metres from the Total oil refinery to the north and Yarra Road to the south.

The major sources of these resultant risk levels are the ICI Botany plant, Total oil refinery, H.C. Sleigh, AMOCO, A.C. Hatrick and Bayer. Overall fatality risk levels from Port installations (excluding shipping activities) at residential areas are below 0.1 chance in a million per person per year.

5.3.2 Combined heat flux and explosion overpressure impact

Significant probabilities of heat flux in excess of 12.6 kW/m^2 and of overpressure in excess of 14 kPa as indicated in figure (27) cover the residential areas around the Total oil refinery, H.C. Sleigh, AMOCO and A.C. Hatricks. Residents opposite the ICI plant are exposed to lower probabilities of such levels but to significant levels of 4.7 kW/m^2 and 7kPa. In addition, the risk of fatality is well in excess of 10 chances in a million within all installations in the complex and the Port area. High probabilities of 12.6 kW/m^2 and 14 kPa also exist.

Petroleum product storage terminals are significant sources of heat radiation impact while the ICI plant, Total oil refinery and the proposed L.P.G. terminals at Port Botany are major sources of heat radiation and explosion overpressure.

The ultimate combined impact down to levels of 2.1 kW/m^2 and 3.5 kPa, important for emergency planning, cover an extensive area as indicated in Figure 27 including residential and active open space land uses.

5.3.3 Combined impact of toxic gas release

The combined impact of possible releases of toxic gases is presented in figure 28. This impact has not been translated in terms of risk of fatality because of inherent difficulties associated with assumptions relating to the rate of release and duration of people's exposure. Residential areas east of the Bayer plant, particularly those along Wilson, Wiggins, Swinbourne and Trevelyan Streets, are exposed to relatively high risk of toxic gas impacts. Residences east of ICI along Denison Street, Beauchamp Road and Grace Campbell Crescent are also at relatively high risk.

The overall extent of toxic gas release impact as indicated in figure 28 covers an area extending to Bunnerong Road, well into Frenchman's Bay, to Wentworth Avenue north of the complex and residences west of the industrial complex.

Main sources of such hazards include the P.D. Oil and Terminals storage facilities at Port Botany, the ICI and Bayer plants within the industrial complex. Minor risks from some freight depots also contribute to overall toxic risk levels particularly in the proximity of Moore and Baker Streets.

5.4 Overall assessment of hazard impact risk area classification

The computed results for risk of fatality, heat radiation and explosion overpressure and toxic hazard as discussed in the previous section of this report were compared with the suggested relevant assessment criteria in order to determine the degree of risk impact and to identify problem areas. Particular emphasis is on residential areas bordering the industrial complex.

An overall risk area classification system was adopted for that purpose. Resultant risk contours for each installation and for the overall complex, were broadly grouped into two major risk areas, as follows:

(i) Primary risk areas

These areas have been found to be exposed consistently to risk levels well in excess of any reasonably acceptable criteria. Risks of fatality are well above 1 chance in a million per person per year. Heat radiation and/or explosion overpressure and toxic risks are also excessive. In short, these areas represent the most seriously affected areas.

Because it was assumed that high levels of control are being adopted by industry, it is unlikely that any additional controls at the source would significantly alter the size of these areas.

In determining these areas, due consideration was also given to the number of people exposed.

These areas must be given priority for control.

(ii) <u>Secondary risk areas</u>

These areas represent the ultimate extent of hazard impact. Residential developments within these areas could be affected by hazardous incidents within the complex, but the likelihood is relatively low. Evacuation and counter-disaster procedures are of prime importance for these areas.

The results of this assessment are summarised as follows:

RISK AREAS CLASSIFICATION/RESULTS OF ASSESSMENT

Installation	Primary risk area	Secondary risk area
AMOCO (Figure 29(a))	. Includes residential and industrial land uses. . Residential uses are located west of the plant and include a total of some 41 dwellings (11 flats, 4 semis and 26 single detached houses). . Adjacent facilities affected include Metal Recyclers, Sea Containers, Cubico, Botany Council's depot and a mixture of light industries. . Part of Banksmeadow public school is also affected.	. Includes residential, industrial and open space areas. . Extent of overall impact bounded by Wilson Street, Fremlin Road, Wiggins Street, Excell Street, . Foreshore Road (almost 100 metres north of the Brighton Street/ Stephen Road Intersection is also included. . Include all Banksmeadow Public School
A.C. Hatrick (Figure 29(b))	. Includes residential and industrial land uses. . Residential uses are located west of the plant and include some 55 single dwellings and a few small scale commercial uses. . Industrial installations include Johnson & Johnson and Cubico. . Sections of Stephens Road and Brighton Street are extensively affected.	. Includes major residential areas, industrial uses and part of Banksmeadow Public School. . The area is generally bounded by Wilson, Wiggins, Ermington, Swinbourne and Herford Streets.

H.C. Sleigh (Figure 29(c))	. Includes residential, light industries and open space. . Residential uses are located north and north west of the plant and include a minimum of 202 dwellings (151 flats and 51 detached houses). . Industrial installations include Crest Chemicals and some light industries. . Small parcels of open space lands are also included.	. Includes major residential areas, small scale light industries and limited open space. . General extent of the area is bounded by Harold Street/Raymond Avenue intersection, Baird Avenue to the east and Denison/Grace Campbell Crescent to the north.
ICI Botany Complex (Figure 29(d))	. Includes industrial, residential and open space areas. . Residential areas are mostly located to the east some 200 metres from plant boundaries. Estimated number of dwellings affected are a minimum of 260 dwellings (169 flats, 44 semidetached and 47 singles). An additional 30 flat dwellings should also be investigated. Some 90 dwellings (17 singles and 73 flats) are exposed to the combined impact of ICI and H.C. Sleigh. . Industries affected include BP, Total distribution, Liquid Air, Johnson & Johnson, CIG, Esso, Wool processors, Alfa Romeo, H.C. Sleigh, Fibre Containers and part of A.C. Hatrick.	. Includes industrial, residential, open space and Matraville Public School. . General extent of area bounded beyond Bunnerong Road, Wentworth Avenue, Brotherson Dock, Port Botany and beyond Wilson Street.

	. Open space affected includes the Hensley Athletic Field and small parcels of scattered open space.	
Total oil refinery Matraville (Figure 29(e))	. Includes residential, open space and vacant land (zoned residential), and light industries. . Residential areas affected are mostly located to the north east sector. Number of dwellings affected include some 470 dwellings (16 flats, 31 semis and 423 singles). . Botany Cemetery and part of La Perouse Public School are included. . Bunnerong Power Station site is affected. . This area also includes three vacant Crown land sites zoned residential.	. Includes major residential areas, light industries and open space. . Area extends overall from Bunnerong/ Franklin Road to the north, beyond Anzac Parade (State Penitentiary and Prince Henry Hospital to the east, Anzac Parade/Bunnerong Road to the south, and bulk liquid storage area/Foreshore Road to the west. . All of La Perouse Public School, recreational areas to the south, the State Penitentiary and Prince Henry Hospital are affected.
Total distribution terminal (Figure 29(f))	. No residential areas are affected. . Neighbouring plants affected include ACI, BP terminal, the northern area of the ICI plant and Continental Distilleries	. This area extends to some residential areas on Denison/ Smith/Boonah/Fraser and Wentworth Avenues to the east, beyond Wentworth Avenue (Mutch Park and the Golf Club) to the north and to the Knebel, CIG and Readymix installations to the west.

BP storage terminal (Figure 29(g))	. No residential areas are affected. . Neighbouring installations affected include the Total distribution terminal, ACI, Knebel, Readymix, and part of the Liquid Air plant.	. No residential areas are included. . Extent of the area is Holloway Street, Wentworth Avenue and Corish Cricle opposite the Hensley Athletic Field. . Parts of the ICI and Davis Gelatine plants are included.
Esso storage terminal (Figure 29(h))	. No residential areas are affected. . Adjacent plants affected include parts of Johnson & Johnson, A.C.Hatrick and the ICI plants.	. No residential land uses are included. . Larger areas of the adjacent ICI, Johnson & Johnson, A.C. Hatrick, Cubico, Metal Recyclers and La Porte chemicals are affected.
Caltex terminal (Figure 29(i))	. No residential land uses are included. . Relatively small areas of the adjacent A.N.L. container terminal and A.P.M. plants are affected. . High risk along Botany Road.	. Area is mostly industrial and covers Fibre Containers, A.P.M. and A.N.L. container terminal.
Bayer Australia Ltd (Figure 29(j))	. Include major residential areas - a total of 47 dwellings (2 semis and 45 single dwellings). . Surrounding eight industries are affected.	. Area extends to Joseph Banks Street, Swinbourne Street, Brighton Street, Wilson/Herford Streets.

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.ICI hydro-carbon storage (Figure 29(k))	. Contained within site boundaries.	. Part of the embankment wall and Friendship Road could be affected. Generally the area beyond immediate boundaries is limited.
.Proposed Boral Gas Ltd (Figure 29(l))	. Extensive coverage of adjacent P.D. Oils, Terminals, part of the ICI site and of C.T.A.L. container terminal. . Extends to part of Womeai Reserve, Bumborah Point. . No residential areas included.	. Extends up to Brotherson Dock, Bunnerong Power Station site and Botany Cemetery. . Bulk liquid chemical berth included. . Under certain conditions vapour cloud could reach residential.
.P.D. Oils (Figure 29(m))	. No residential land uses are affected. . Include the Boral site, Terminals Pty Ltd and C.T.A.L. container terminal. However, the main potential is from toxic gas release. Fire risk contained with site boundaries. . Proposed L.P.G. risk contained within site boundaries.	. Extends up to Botany Road/Bumborah Point Road to the north, to Baragoola Avenue - La Perouse to the east and beyond the bulk liquid berth. Main hazard is toxic gas release.

.Terminals Pty Ltd (Figure 29(n))	. No residential areas are affected. . Mostly based on potential for toxic gas release and includes the adjacent Boral site, P.D. Oils, ICI, C.T.A.L. container terminal, dry bulk area, Womeai Reserve. Fire risk contained within site boundaries.	. Generally extends to Yarra Road, La Perouse to the south and Beauchamp Road/ Foreshore/Botany Roads intersections to the north (mostly toxic effect).

5.5 Overall resultant risk

* Prime risk area:

This area covers a multitude of residential, open space and industrial land uses.

Figure 30 indicates that a total of some 985 dwellings (630 single, 274 flats and 81 semidetached) are seriously affected. Should the impact of the Total oil refinery not be accounted, the total number of dwellings affected is reduced to 515 (207 single, 50 semis and 258 flats). The majority of these residences are located on the eastern side of the complex and include extensively developed housing in most cases bordering hazardous operations of a relatively large scale. These dwellings are exposed to risk levels well in excess of any acceptable criteria.

The area also includes two schools being Banksmeadow Public (due to the risk from AMOCO) and La Perouse school (affected by the Total oil refinery).

Open space affected includes Hensley Athletic Field, Womeai Reserve, open space land on the foreshore along Yarra Bay and a number of small areas of open space.

Major public roads affected include Bunnerong Road, Denison Street, Beauchamp Road, Botany Road, Bumborah Point and Stephens Roads. The bulk liquid berth and the single buoy mooring are significantly affected.

* Secondary risk area:

This area is extensive. As indicated in Figure 30 the area covers a large number of residential uses.

The overall extent of the area is from within the Eastlakes Golf Club to the north, Anzac Parade to the east (includes parts of the State Penitentiary, Prince Henry Hospital), into Yarra Bay southward and Botany Road to the west. This area should form the basis of overall emergency planning.

6. RISK OF INTERACTION WITHIN PLANTS AND BETWEEN PLANTS

6.1 Definition

In principle, it is possible for one hazardous incident to initiate further incidents thus increasing the damage caused by the first. This has been referred to as the "domino effect" or accident propagation.

Typical examples of such events which are theoretically possible include:

- A vapour cloud explosion causes damage at an adjacent plant or storage resulting in a leak which does not ignite at once and so accumulates into a bigger flammable cloud which ultimately explodes, significantly increasing the area of impact.

- A fire at one plant causes overheating of stocktanks at an adjacent plant, resulting in a BLEVE (Boiling Liquid Expanding Vapouur Explosion) or a secondary fire.

A distinction is commonly drawn between an escalating incident at the one location and an incident which leapfrogs to a second location. Thus differentiation must be made between accident propagation within the same installation, or internal dominoes, and accident propagation from one installation to adjacent ones and so on - external dominoes.

Relatively small accidents within one installation, if not effectively controlled, could escalate into major mishaps affecting other plant items. Records of such situations could be found.

It is, however, difficult to find records of a mishap at one plant which has affected adjacent installations and increased the overall damage. In fact, the writers could not find any records of secondary explosions or fire spreading from one installation to another. (This does not mean that one has never happened, or could not happen in future. However, the likelihood is probably much less than casual observation may suggest.)

6.2 Method of assessment and relevant criteria

The general principles adopted to investigate the potential of a "domino" effect recurring are:

(i) Each plant item within one installation was examined as was the nature of neighbouring facilities in order to identify those items which handle, store or process material with a potential for generating secondary incidents.

(ii) Potential sources of fire and/or explosions in areas adjacent to each such items were examined in turn, to see whether they could expose those items to sufficient heat radiation or explosive overpressure for a secondary incident to be initiated.

(iii) Having identified the potential sources of fire and/or explosion with sufficient effect to place the selected plant item at risk, the likelihood of such exposure was assessed.

(iv) Where an item was found to be exposed to a relatively high likelihood of exposure to high levels of heat radiation or explosion overpressure, this item and the main identified causes of exposure were given a closer review to clarify whether a domino incident is a credible result of that exposure.

Incidents which result from escalation of minor mishaps within the same plant were not described as domino per se, rather as potential for accident escalation. The main criteria adopted for assessing such a potential are:

- For atmospheric/non-pressurised flammable liquids storage, process units, pumps and pipelines - heat flux not to exceed 23 kW/m^2 and explosion overpressure not to exceed 14 kPa for maximum probabilities of 1 chance in a ten thousand (1×10^{-4}) per annum.

- For pressurised vessels, process plants, pipelines, pumps, etc. - heat flux not to exceed 25 kW/m^2 and explosion overpressure of 35 kPa at maximum probabilities of 1 chance in ten thousand (1×10^{-4}) per annum.

In order to formulate appropriate criteria of assessment in the case of domino propagation from one plant to another, facilities were examined and grouped on the basis of adjoining plants. Three groups were thus identified:

Group I - Timber yards, container terminals, bulk freight depots, warehousing and chemical factories.

Group II - Atmospheric/non-pressurised vessels and process units, pumps and pipes.

Group III - Pressurised vessels and process units, pipes and pumps.

The relevant criteria for assessing each group are as follows:

Group	Heat radiation	Explosion overpressure
I	12.6 kW/m^2	35 kPa
II	23 kW/m^2	14 kPa
III	25 kW/m^2	35 kPa

A frequency exceeding 0.5 in ten thousand (0.5×10^{-4}) per annum at the relevant criterion was considered to be "at some risk", while a frequency greater than 1 in ten thousand per year (2×10^{-4}) was considered to be at "high risk".

In relation to fatality risk, levels exceeding 10 chances in a million per person per year were considerd on the borderline of acceptability, while those in excess of 40 chances per million per person per year were considered to impose a high risk on adjacent plant personel.

6.3 Results of analysis : Potential for accident propagation within each installation

The potential for accident propagation within each of the installations examined is presented in Table 12. Almost all fuel oil storage terminals in the study area were found to experience a high risk of incident propagation. Specifically, the Caltex storage terminal, Total distribution, BP andd H.C. Sleigh experience excessively high probability of propagation risk. This probability is as high as 1 in a hundred for most tanks at H.C. Sleigh and a 1 to 10 in a thousand on some 7 tanks at the Caltex installation, exposed to high levels of 38 kW/m^2. (See Table 12 for details.) Esso and AMOCO storage terminals experience relatively lower risk of accident propagation within their respective facilities.

In the process industries category, the Total oil refinery at Matraville was found to experience the highest potential for incident propagation. Processes and storage tanks in the southern and eastern areas of the refinery are particularly at risk. Stock tanks and the gas plant distillation unit are major components of total risk. Overall, there is a serious potential within the refinery for a minor incident to escalate into a major one.

The ICI petrochemical plant however has its facilities spread over a number of discreet unit plants. The potential for incident propagation from one plant to another within the complex was found to be low (in the order of 0.1 chance in ten thousand). Propagation potential within each plant is however significantly higher (ten times higher). The olefines 2, vinyl chloride monomer, propylene and polypropylene plants in particular exceed the recommended criteria for accident propagation. The ICI tanker loading/unloading areas present a relatively significant risk of interaction with adjacent plants (e.g. ethylene tanker area and VCM plant - see Table 12 for details). With the proposed use of L.P.G. as feedstock and the transfer of ethylene by pipeline from Port Botany, this interaction potential would reduce.

In the Port Botany area the mounding of the Boral L.P.G. terminal's storage vessels would provide a relatively low internal incident propagation potential.

The ICI hydrocarbon storage terminal was found to have no interaction potential because of the safety separation distances and above standard controls implemented at this terminal.

P.D. Oil and Terminals bulk liquid storage facilities could experience interaction risks depending on the nature of the material stored at any particular time. Overall most of he storage tanks are exposed to risk of interaction in excess of the criterion.

The results of this assessment clearly indicate the need for a comprehensive review of fire fighting and other control mechanisms including emergency procedures at those installations found most at risk as indicated in Section 8 of this report.

6.4 Results of analysis: Potential for do mino effect between different Installations

The criteria suggested in Section 6.2 were adopted for the various groups of installations in order to determine domino potential. In general terms, however, all those facilities located within the high risk areas of adjacent installations, as indicated in Section 5.4 of this report, are potentially exposed to risk of the d omino effect occurring (at least theoretically).

The results of the analysis are summarised below

(i) Container terminals, freight depots and general chemical factories

The following installations within this group were identified as potentially being exposed to domino risks exceeding the criterion of 12.6 kW/m^2 and/or 35 kPa at probabilities in excess of 1 chance in ten thousand per year, thus sustaining a potential domino effect.

Installation affected	Main initiating plant(s)
Cubico	A.C. Hatrick
Sea Containers	Collie, AMOCO and La Porte
Crest Chemicals	H.C. Sleigh

(ii) Flammable liquids storage/processing plants

Within this group, facilities exposed to 23 kW/m^2 and/or 14 kPa from adjacent plants at frequencies in excess of 1 chance in ten thousand per year include:

Installation affected	Main initiating plant(s)
Part of BP	Total distribution/ICI
Part of Total distribution	BP Storage
Liquid Air	BP, Total distribution and to a lesser extent ICI

No other situations were identified as significantly sustaining a domino propagation.

6.5 Implications of results on propagation potential within each installation and from one installation to another

The potential of escalation of an incident within the same installation reflects the need for additional controls (operational and organisational) to reduce the probability of accident escalation.

Facilities identified to be particularly prone to incident propagation include Caltex, BP, Total Distribution, H.C. Sleigh, the Total oil refinery and to a lesser extent individual plants within the ICI complex.

The results imply that for the installations mentioned above a comprehensive review of fire fighting facilities, monitoring and isolation systems, emergency procedures and safety separation distances is urgently needed.

Overall, the potential for accident propagation from one installation to another was however found to be low and determined as unlikely.

7. ASSESSMENT OF SPECIAL RISKS

7.1 Transfer pipelines in the study area

Figure 24 and Table 18 indicate the routes of transfer pipelines within the study area together with the nature of materials being transferred. These can be categorised as follows:

(i) gas pipelines which include liquefied flammable gases such as L.P.G. and vapours (e.g. ethylene);

(ii) crude oil transfer pipelines including proposed pipelines and those from ship to refinery pipelines; and

(iii) refined product and bulk chemicals transfer pipelines from port unloading to site storage or from storage terminal to another terminal or facility.

It was not considered feasible to undertake a detailed risk analysis of all pipelines within the study area. The investigation was limited to the causes and consequences of worst-case events.

The consequences were assessed from a review of the nature of the material being transferred, the diameter of the pipeline and its pressure, while the likelihood of such an incident was indicatively derived from worldwide experience.

7.1.1 Hazard identification

Depending on the nature of material in transfer, potential hazards associated with pipelines are fire and explosions. In all cases enough quantities of the material would have to be released for significant impact to occur.

As indicated in Figure 24, most pipelines in the area do not travel through residential land uses with the exception of an unused L.P.G. and a liquid petroleum line from the Total oil refinery to the vicinity of H.C. Sleigh at Botany.

The main causes of pipeline failure are:

- being dug up accidentally by excavators working on adjacent projects (third party damage).
- Corrosion.
- Soil subsidence causing overstressing.
- Poor quality control in pipe fabrication and laying.
- Damage where the pipeline crosses stormwater drains, passes through culverts, etc.

- Deviations from normal operating conditions (temperature or pressure) with the absence of corrective action.
- Pipelines being exposed to thermal stress (e.g. fire).

Figure 8(b) outlines the most relevant external and internal contributing causes in that regard.

The Maritime Services Board's pipeline corridor at Port Botany represent the most concentrated and potentially hazardous array of pipelines in terms of both number and nature in the study area.

7.1.2. Consequence analysis

If a cross country pipeline containing a flammable liquid develops a large leak, a variety of results could follow.

If the liquid is a material like petrol it will partly soak into the gravel and partly come to the surface and flow according to the contours of the ground. If the means of leak detection available to the owner of the pipeline are rudimentary, then such a leak may continue for many hours before being detected, identified and isolated.

Such a leak may not ignite, in which case the public impact will have been limited to evacuation of adjacent areas, barricading of roads, etc.

If ignition occurs soon after the leak starts, the result is likely to be a fire of limited area, the leaking fuel being consumed from a pool near the leak point.

Should ignition occur after the leak has spread out, the fire could be far more widespread and much more difficult to quantify.

Pipelines carrying liquefied flammable gas are potentially more hazardous in principle. The following pipelines are of particular significance:-

Company	Material aboveground -a underground -u	Rate of transfer	Average pumping time	Pressure (kPa)
ICI - Port	Ethylene (a)	250t/hr	16 hrs	800
ICI - Port	Propane/butane (a)	250t/hr	16 hrs	800
Laporte/ICI	Hydrogen (a)	300m^3/hr	168 hrs/wk	340
ICI - Factory	Ethylene vap. (u)	5t/hr	168 hrs/wk	3000
ICI - Factory	Propane/butane (u)	20t/hr	168 hrs/wk	1500

Appendix K presents estimations of the consequences of fire and explosion from 10 minute, 6 minute and 3 minute releases from the above pipelines.

The results generally indicate that for the ICI ship to shore line (transfer rate 250 t/hr) a 10 minute release would result in an impact to tanks and equipments (35 kPa) at 120m, while a 3 minute release would reduce the same area of impact to 80m. No impact to residential areas from 10 minute releases from that pipeline. The ultimate impact as determined by distances to lower flammability limits for a maximum 10 minute release is 90m. Heat flux radiation resulting from flash fires, etc. are mostly of local impact.

In relation to the pipeline corridors, 10 minute releases of liquified flammable material will also be mostly of local effect with no impact at residential areas. Explosion overpressures of 7kPa (critical to residences) at a maximum of 180m have been estimated, while plants and equipments within 55m would be seriously affected. The hazard range in terms of lower flammability limits from the pipeline corrdor would not extend above 60m for a 10 minute release.

The conclusion of this assessment is that pipeline related mishaps from the Port Botany area would not in all probability affect residential areas located more than 1000m away. The immediate impact would be to plant and equipment, particularly exposed structure. It is essential in that regard that any possible release from the area be limited to 3-5 minutes through the installation of quick response emergency isolation valves. Within the pipeline corridor itself any leak with subsequent ignition would impose a heat impact hazard on adjacent lines with the potential for accident propagation. The formulation of fire prevention and protection measures at the Port should account for such hazards. The feasibility of protecting the lines in this area using a heat fire insulation material is also warranted.

7.1.3 Probability of L.P.G. leak from pipelines

In relation to the probability of a pipeline failure the only study undertaken in the area is that conducted by ICI for the L.P.G. transfer pipelines from the ICI hydrocarbon terminal at Port Botany to the main Botany complex and the pipeline from the ship unloading to the hydrocarbon terminal (some 750 metres). This investigation indicated that the pipeline could be considered as three discrete sections, being the unloading line at the bulk liquids wharf; the pipeline in the pipeline corridor between the wharf and the terminal; and that section of the pipeline within the ICI hydrocarbon terminal. For the three sections of pipeline the overall probability of failure was found to be in the order of 3.38×10^{-4}.

The failure probability of the main pipeline from the terminal to the Botany plant was found to be in the order of 4.1×10^{-5} per annum for a leak of more than 3 tonnes of L.P.G. while the overall failure frequency was about 5×10^{-3} per year for the two pipelines.

A similar study in the U.K. by the U.K. Health and Safety Executive found a probable leak incident frequency of between 2 and 3 x 10^{-4} per km (90 per cent of which were considered to be small).

For other pipelines in the area a general indication of the probable incident frequency has been provided in Table 3.

7.1.4 Control measures

Measures which, if adopted, could greatly reduce the risk of pipeline failure include:

- careful inspection of pipe and quality control of the pipe laying operations;
- adequate depth of cover, clearly marked route and regular patrols to watch for excavation work in the vicinity of pipeline;
- waterproof coating on pipes, plus cathodic protection, to inhibit corrosion;
- physical protection of the pipe in any exposed location;
- the installation of protective devices such as emergency isolation valves cut-off valves and one-way flow valves; and
- leak detection by automatic sensing devices (either of pressure drop or hydrocarbon detectors).

These control measure either aim to reduce the frequency of the pipeline leaking or to reduce the inventory of material released should a leak occur.

Technology for detecting leaks in long pipelines is improving all the time, and some form of leak detection system may be appropriate on pipelines where the consequences of a leak are sufficiently serious to warrant it.

The most intrinsic measure for pipeline hazard control is to limit the actual amount of material being transferred at any one time. There are however operational limitations to such a measure of control.

In addition to meeting normal standard requirements on pipeline construction and operations, emergency isolationvalves are intalled at the beginning and end of the ICI transfer lines. Monitoring facilities are also being applied. There is however an urgent need to implement similar controls (non existent) on other pipelines, particularly those along the pipeline corridor. Such controls ought to be primarily determined on the basis of hazard and operability investigations.

7.2. Road transport of dangerous goods

The Botany/Randwick Industrial Complex and Port Botany is linked to the rest of the Sydney Region by a single track rail line and a number of roads, notably the Foreshore Road, Botany Road, Bunnerong Road, Gardeners Road and General Holmes Drive. Internal access to the Port is via Friendship Road.

Because of the relatively high concentration of bulk liquid chemicals and L.P.G. storage and distribution terminals (present and projected) at the Port, this area is increasingly becoming a major source of dangerous goods,* road tankers and trucks in the Sydney Region. In addition, the State Government (e.g. Sydney Outline Plan, Draft Sydney Regional Environmental Plan - Botany Bay) is promoting the development of Port Botany to accommodate bulk storage and distribution terminals, subject to stringent safety and environmental controls. This is in recognition that Port Botany is considered to be the only suitable wharf in the Sydney Region for unloading large tonnages of liquid chemicals and L.P.G. The implications are that dangerous goods generation from the port area would ultimately increase well beyond existing generation levels.

The sources and destinations of most dangerous goods handled at the Port are scattered throughout the metropolitan area. Because of such transport distribution constraints rail transport cannot be fully justified at present unless several secondary bulk distribution centres are established at strategic locations serviced by rail throughout the metropolitan area. This is not considered to be a viable proposition, at least for the foreseeable future and road transport of dangerous goods would continue to be the only viable transportation mode.

To date, the implications of road transportation of dangerous goods generated or received at the port facilities have been considered in a piecemeal unco-ordinated manner. Although the cumulative traffic impact on the existing road system was considered in the environmental impact assessment of each proposed development at Port Botany, concern was expressed by the Department and the Development Committee of the Traffic Authority of New South Wales regarding the transport of dangerous goods along main roads which pass through sensitive land uses such as residential, shopping, school frontages, etc. No formal route for vehicles carrying dangerous goods including L.P.G. has been formulated nor implemented with the general objective of minimising, within practicable limits, the movements of dangerous goods through high density areas.

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* In the context of this report dangerous goods refer to a wide range of bulk liquid chemicals with potential for spillage, fire and toxic release and to Liquefied Petroleum Gases (L.P.G.) with potential for fire and/or explosion.

Areas of prime concern are those immediately surrounding the Port where the highest concentration of movements occurs. These areas include the Municipalities of Botany, Randwick, Rockdale, Marrickville and that part of Sydney previously known as South Sydney.

Concern about the lack of a co-ordinated formalised route for the transport of dangerous goods was also expressed by local councils in the area and various community groups, who objected to the proposed developments proceeding prior to the implementation of a specific truck route network for the transport of dangerous goods.

In its submission on a recent development application for an L.P.G. storage and distribution terminal at Port Botany,the Police Department through the Development Committee of the Traffic Authority of New South Wales summed up the issue by stating: "...in view of the potential of Port Botany for the establishment of such terminals and the resultant increase in the number of vehicles carrying dangerous goods through sensitive areas, it may ultimately be necessary to restrict this type of development or devise alternative means of transport".

The main justification for the need to formulate and implement a truck route network for the transportation of dangerous goods in this area basically stems from the potentially hazardous nature of such goods and the need to mitigate potential land use conflicts.

There are advanced and generally comprehensive technical safeguards on tankers carrying dangerous goods. Despite such safety controls, mishaps do occur. It is therefore essential to formulate land use and traffic management controls to complement technical controls and be an integral component of the overall control process.

Three main considerations ought to be accounted for in the formulation of such a truck route system:-

. cumulative traffic implications including level of service of existing roads, traffic congestion if applicable, intersection capacity, etc;

. safety and land use impacts; and

. economic distribution considerations including operators' requirements for practical transportation economies.

In addition, any truck route system for the transportation of dangerous goods in this area should be capable of being implemented effectively.

The formulation and implementation of the route network would ultimately facilitate future developments at Port Botany consistent with the role of the Port (present and future) and the need of the State. This route analysis could also be used as a case study for a wider dangerous goods road tankers, route for the whole of the metropolitan area. Reference is made in that regard to comprehensive dangerous goods road tankers, routes implemented as part of licensing requirements in several European countries and in Victoria (Department of Minerals and Energy).

There are also obvious advantages in specifying a nominated route from the viewpoint of emergency planning.

As part of development application and environmental impact assessment considerations for recent proposed developments at Port Botany, and in recognition of the need to formulate and implement specific routes for the road transportation of dangerous goods and to minimise land use conflicts, the Department has suggested conditions to be imposed on developers at the Port to the effect:-

> "That the Applicant shall ensure that L.P.G. tankers should only be permitted to leave the terminal on approved, determined routes dictated by their destination and determined in co-operation with Local Government authorities having regard to the New South Wales Traffic Authority's guidelines for the development of tanker routes;" and
>
> "That within six months of the date of any consent to the proposed development, or such further period as the Director may agree, the Applicant shall in conjunction with its customers and with Randwick and Botany Municipal Councils determine routes for the movement of Dangerous Goods trucks through the respective municipalities. AND FURTHER the Applicant shall submit the recommendations to the Department, and shall take appropriate action to ensure that tanker drivers use the specified routes."

These conditions of consent are limited and do not account for an overall co-ordinated response to the issue. It is obviously more effective if a single overall co-ordinated study be undertaken in liaison with all developers in the area and local Councils under the guidance of the Traffic Authority and the Department.

To achieve this objective, the Department has initiated such a study to cover the Municipalities of Botany, Randwick, Rockdale, Marrickville and part of Sydney (South Sydney). The main participants to the study would be:-

- Department of Environment and Planning
- Traffic Authority of New South Wales
- Terminals Pty Ltd
- Boral Gas Limited
- Shell Australia, representing the consortium of Shell, BHP, CIG and Mobil

. P.D. Oil and Chemical Storage

It is proposed to appoint specialist traffic consultants to conduct the study and present recommendations. Funding of the study be shared by all of the participants who would nominate a representative or a sub-committee to oversee, on a regular basis, the conduct of the study.

The consultants would generally undertake all traffic related analysis. The Department would provide a detailed risk quantification and land use implications paper to be used as an integral part of the study. The consultants would integrate the various aspects of the analysis (traffic, safety and land use, transportation economics) to derive a set of recommendations, thus nominating the most desirable route.

Liaison with local councils, trade unions, community groups, etc., would be the responsibility of the consultants, with guidance from the Department.

The Dangerous Goods Regulation has been upgraded (24 June 1983) to effect controls in the registration and licensing of drivers of dangerous goods road transport vehicles. In addition the Dangerous Goods Regulation has incorporated the provisions of the "Australian Code for the Transport of Dangerous Goods by Road and Rail". This code covers such matters as the classification of dangerous goods, the marking of package containers and vehicles, documentation, methods for packaging dangerous goods, carriage of bulk liquids and liquefied gases, and transport procedures.

8. ASSESSMENTS OF OVERALL OPERATIONAL AND ORGANISATIONAL SAFETY CONTROLS

8.1 Rating of safety "software"

Appendix H presents an overall assessment of operational and organisational safety controls for most installations in the study area.

The adequacy of management and operator attitudes, understanding, knowledge, skills and procedures in the field of technical safety were rated very indicatively using information from the completed questionnaires, by review of emergency procedures supplied to the Department, and information from other government sources.

Points were allotted for:

- History of hazardous incidents
  - . Are hazardous incidents with a potential to place the public at risk a continuing way of life for the organisation?
  - . Do the same types of incidents recur?
  - . Is there evidence that effective corrective action is taken after an incident?
- Safety management
  - . Is there a safety officer or, if the organisation is small, does management understand its responsibility for safety?
  - . What procedures are adopted to report on accidents or unusual occurrences, and is there any evidence of follow up?
  - . What is known of the attitude of the management of the organisation to safety?
- Safety features
  - . What evidence is there of the organisation aiming for intrinsic safety as much as posible; low inventories, temperatures, pressures etc?
  - . What evidence is there of an understanding of the need for proper storage, control and engineering standards?
  - . What evidence is there of the role of automatic protective systems: alarms, automatic shutdowns, gas detectors, combustion detectors etc?
  - . Where the organisation handles flammable materials, what fire protection equipment is there?
- Emergency procedures
  - . Does the organisation have emergency procedures?
  - . Are such procedures reasonably comprehensive in view of the range of potential hazardous incidents?
  - . Are emergency procedures practiced periodically?
  - . Does the organisation have any continuing liaison with the

internal emergency services: fire brigade, police, ambulance etc. (see following section for detail assessment on emergency planning)?

After the organisations were rated numerically, they were categorised as:

- above normal industry standard;
- normal industry standard; or
- below normal industry standard.

As these judgments were determined without due consultation with the management concerned they should be regarded as indicative only.

Table H-1 in Appendix H presents the results of the assessment. It is noted that Amoco, H.C. Sleigh, Bayer, Mayne Nickless and the Total oil refinery are industries identified as major source of hazards in the area and which are also considered to be below industry standard as to their overall software safety measures.

This would qualitatively add to the overall resultant risks from these industries as derived by hazard analysis techniques. Most other installations fall within the normal industry standard. ICI is considered to be above normal industry standard in that regard.

A comprehensive analysis in that regard is provided in Appendix H.

8.2 Adequacy of organisational safety procedures and emergency planning in the area

It is considered that, in the case of major hazardous installations, the control of the plant and its hazards requires a considerable degree of formalisation of communications through written systems and procedures, and standards and codes of practice. Such practices are designed to encourage, and where appropriate enforce, collective and personal discipline by the use of operating methods which have been carefully thought out and which contain appropriate levels of checks and counter checks to obviate problems and reduce errors.

It is the duty of any organisation operating or involved with facilities, which could experience potentially hazardous situations, to draw up its own emergency response procedures. Companies experienced in dealing with the materials involved are best able to determine the most appropriate response to an accident.

However, it has been shown that, of those companies surveyed as part of this study, not all have regarded emergency planning as an essential part of their overall safe operation.

8.2.1 General principles

The goals of emergency planning should ensure the:

i) safety of people (employees, visitors, residents);

ii) protection of property, with minimum loss or damage;

iii) isolation, control and remedial action of any hazardous incident; and

iv) restoration of safe operations with minimum delay.

While it may be impossible to predict all possible emergencies, or the particular circumstances that may be confronted, it is possible to anticipate most hazards and how to cope with them. Emergency Plans must be set down in writing, it is not enough to have generalised plans, as each aspect of the emergency response must be precise and specific. Therefore priorities must be assigned for each potential risk, with greater emphasis being placed on the most probable hazards.

8.2.2 Essential elements of an emergency plan and assessment criteria

The following general criteria have been adopted for assessing emergency procedures:

i) statement of policy;

ii) description of potential hazards and risk assessment;

iii) description of the facility, including size, construction, location, access roads or other means of transportation, entry points, hours of operation, number of personnel on hand at each shift or stage of operation utility corridors and site layout plan;

iv) emergency organisation, showing the chain of command, responsibilities of each position and provisions for out-of normal operating hours emergencies;

v) emergency facilities including command centre, evacuation routes, assembly points, communication and alarm systems and their locations;

vi) emergency equipment and supplies including medical and first aid, fire fighting equipment, salvage equipment, food and water supplies and their locations;

vii) details of any mutual Aid Agreements or co-ordinated procedures with adjacent companies;

viii) list of outside agencies and emergency phone numbers;

ix) shutdown procedures;

x) physical security procedures;

xi) evacuation procedures;

xii) provisions for the regular testing, monitoring and updating of emergency procedures;

xiii) other related items applicable to the specific organisation.

The Department in consultation with the Botany Bay Hazard/Emergency Sub-committee has formulated specific guidelines to be implemented by industry in the preparation of internal emergency procedures. A copy of the recommended guidelines is presented as Appendix I to this report. A step by step organisational chart is presented in Figure 32.

8.2.3 Assessment of internal emergency plans

On the basis of recognised general principles and essential elements in emergency planning as outlined above, an assessment was made of fourteen emergency plans and procedures for industries in the study area.

Table 21 presents an overview of the general level of adequacy of the existing provisions of these industries.

Reference is also made to Appendix H in that regard.

8.2.4 Overall assessment of internal emergency plans

A review of emergency plans submitted shows that the extent to which industries are prepared to take responsibility for safety and emergency provisions varies considerably: some have seen it as a non-essential component of their operations, while others may be aware of the necessity, but have not formalised comprehensive procedures.

The majority of the plans include only generalised procedures without reference to specific incidents which would be highly probable for certain chemical installations. This factor, together with the lack of provision for the role of external emergency services in the event of an incident, have in the past hindered the co-ordinated control of an incident. Unless the company knows exactly how best to minimise or contain the incident and can provide technical expertise to assist the emergency services, only confusion and panic will result.

Many companies feel that they can provide for and contain any eventuality with internal resources and have delayed calling in outside reinforcements until more damage has been done than necessary.

Only a few industries detail safe and alternative evacuation routes and assembly areas for their employees. While it is the role of the police to evacuate all people in the emergency situation, they cannot be expected to know the safest routes within the plant boundaries.

A number of companies do have regular training sessions to test emergency provisions and involve external emergency services on occasions. However, for a few, any written emergency procedures remain entirely paper plans, with little incentive or requirements to update.

In a few situations, internal communication systems have introduced serious delay factors by reporting through hierarchical chains of command without first notifying the Emergency Services on 000 for immediate assistance.

Procedures for terminating an emergency situation and the resumption to normal operatons are often neglected. A co-ordinated approach involving company representatives and emergency service personnel needs to be formalised so that management staff and the community need not be subject to imposed restraints longer than necessary.

8.2.5 Overall emergency provisions for the industrial area

The Police "C" District Counter Disaster Plan is the only existing plan that provides for emergencies in the study area. "C" District Plan is responsible for the area within the Local Government boundaries of Woollahra, Waverley, Randwick, Botany and South Sydney as well as the whole of the waterways of Botany Bay.

The Police Plan states that the police are in complete command in all emergency and disaster situations with the exception of fire, bushfire and floods and that they have a statutory obligation at all times to protect life and property. It is therefore the responsibility of the Police Controller to take control by co-ordinating with other essential and relevant authorities and directing the entire disaster operation.

The roles and responsibilities of the Health Department, State Emergency Services, Fire Brigade, Metropolitan Water Sewerage and Drainage Board and the Maritime Services Board are briefly outlined in this Plan. There is, however, a lack of a co-ordinated response to involve all these organisations.

Specific sub-plans for potentially disastrous situations have been referred to for the following locations:

- Kingsford-Smith International and Domestic Airport
- H.M. Prison, Long Bay
- I.C.I. Chemical Manufacturing Plant at Botany Bay
- The Caltex, Amoco, Golden Fleece oil storage terminals situated at Banksmeadow, Botany, Hillsdale, respectively, and the Total Oil Refinery at Matraville

The specific sub-plans, as they relate to chemical and petro-chemical installations in the Industrial Area, deal only with the designation of emergency vehicle routes for access to the two hospitals in the area and the manning of control points at street intersections along the way. No detailed procedures are specified for dealing with causes or incidents other than fires at these plants.

In the event of a fire at any of these installations the Fire Brigade would take command. No indication is given on how differently fires in chemical/petrochemical installations would be treated from a fire in Long Bay Gaol, for example. It is presumed that the measures specified are adequate to deal with all contingencies even though leaks, spills or the release of toxic vapours would require entirely different methods of containment, specialist equipment and technical advice, not to mention the degree of urgency in the response.

Many other installations within the "C" District Plan can be regarded as potentially hazardous, for which specialised contingency and counter disaster plans would be required. If these counter emergency measures are to be at all effective then these other facilities should be included along with the appropriate specialised level of response.

As it is stated at the outset that the police would take control in all situations other than fires, it is unclear how they would deal with explosions (or potential explosions), toxic leaks or spills either of chemicals or oil, and what mechanism exists to liaise with the technical experts.

The Counter Disaster Plan for the Port Area makes no provision for dealing with an emergency which could spread from one hazardous source to another and provides no indication as to whether existing resources could combine to contain such a situation. It should be pointed out that if a situation escalated beyond the normal resources that would be employed in an emergency situation, then a state of emergency would be declared by the Governor, and the Controller, State Emergency Services would taken immediate control.

Again the question is asked - if such a situation did occur, would the State Emergency Services be able to gather the necessary technical expertise to contain such an incident and how would that be achieved with the minimum of delay? It is doubtful that the state Emergency Services Counter Disaster Plan and Sub-Plans deal with this specifically.

More importantly the Police "C" District Plan does not provide for a co-ordinated specialised counter disaster response for this area.

The only other counter disaster plan which relates to waters of Botany Bay is the Maritime Services Board's Marine Counter Disaster Plan (M.A.R.D.A.P.). The stated aim of this plan is to establish an organisational capability to combat marine disasters caused by:

(a) natural phenomenon, i.e. storms, tempest with accompanying wave action or associated with cyclonic disturbances; and

(b) human agency, i.e. explosion, stranding, collision, floundering or fire on board vessels.

Should an emergency, of any of the types listed above, occur while a tanker is berthed at Port Botany and the mishap spread to the wharf or shore establishments, then the Police "C" District counter disaster plan would be implemented. However, precise procedures for such an emergency are not detailed.

An assessment of all existing regulations and controls indicates that no legislation exists which would require industry to prepare emergency plans that could be activated in times of a major incident or emergency.

8.3 Assessment of safety regulatory controls

Traditionally, local councils have been responsible for the control of land use. Various provisions under the Environmental Planning and Assessment Act now allow for a broader State overview when considering certain hazardous industrial developments.

To date, however, no formal mechanism exists for the integration of risk assessment and quantification techniques into the land use planning process. Instead, greater emphasise has been placed on the requirements of technical safety codes and standards which do not fully account for the overall cumulative risk implications on land use allocation.

No State, regional nor local environmental policies relevant to the locational constraints associated with hazardous installations have been formulated. The need for such policies is becoming increasingly apparent.

In addition, the list of activities designated under Schedule 3 of the Environmental Planning and Assessment Regulation does not account for hazardous plants and processes. The Schedule should be amended to incorporate such activities, a listing of which is suggested in Table 14. Requirements for formal hazard analysis and operability studies should be legislated for under the Regulations as applicable.

With regard to the Dangerous Goods Act and Regulations, the provisions are more concerned with standards than with broader environmental and societal safety issues. Safety distances for the siting of tanks and vessels containing potentially hazardous material are considered in isolation with limited recognition of land use implications. Appendix D discusses the Act and relevant standard requirements.

Because industries are required to supply to the Department of Industrial Relations details of dangerous goods, namely quantities and classes both stored and handled, on an annual basis as part of the licensing requirements, the Department is in an excellent position to formulate a total picture of the safety levels for any given area. The Department, however, uses this information more as a control on individual industries to see that they do not exceed the quantities for which they are licensed. In addition, the Department's requirements do not seem to extend to processing situations, in many cases more relevant than storage facilities from a hazard viewpoint.

If the Department of Industrial Relations were able, through new legislations and an extended level of technical expertise to deal with overall safety levels for the whole site, they would be in an ideal position to request from each industry that detailed hazard and operability studies be undertaken, monitored and updated as part of annual licensing arrangements. This information could then be used to assess the combined safety and risk levels for a given area, which in turn could be used by various authorities and residents in taking appropriate action. It is not suggested that residents be given a mass of technical information to interpret or misinterpret, but that it should be translated and be made available in an understandable format from local councils, possibly as part of a section 149 certificate. The Department of Environment and Planning could assist in providing technical guidelines in that regard.

There are other uses to which this information can be put. Those emergency service organisations (e.g. Police, Police Rescue, Fire Commissioners, Ambulance and State Emergency Services) who are involved in counter-disaster planning could well be served by being familiar with the type and the extent of hazardous goods being stored and processed, as well as knowing the location, should a major incident occur. These bodies must be able to respond appropriately to the different reactions which could be caused by various incidents and be well prepared for any cumulative impact. Given this information, emergency service organisations would be in a better position to formulate more appropriate counter-disaster plans which would better serve the community than the generalised plans which are currently deemed to cover all likely outcomes from natural disasters, to mechanical, chemical and man made incidents.

Of particular relevance are inadequacies of existing safety standards to fully account for cumulative risk impacts, risk quantification and land use implications. There is a pressing need for a comprehensive review of the standards in that regard or, alternatively, for new safety standards to be formulated by an independent body.

A case in hand is that of L.P. Gas storage and distribution terminals. As indicated in Appendix D, in deciding on the safety locational aspects of such installations, the Australian L.P. Gas Code (referred to as AS 1596-1979) is usually applied without due consideration to the extent and nature of surrounding land uses nor to the cumulative risk implications of the installation in question.

For installations with any number of storage vessels, each not exceeding 3-5 tonnes (typical of local service station), the separation distance specified by the code is in the range 8-10m (could be smaller in certain circumstances) to "protected works" which include residential and public institutions land uses. For larger distribution centres, with storage vessels each not exceeding 250 tonnes, the relevant separation distance is 45m.

Table 15 compares the hazard range to people from fire mishap at any one storage vessel with equivalent code requirements. Hazard distances indicated in the table have been extensively researched and calibrated to "actual" mishap conditions by several overseas organisations and are based on well established deterministic methods. At the distances of some 800m (for 250 tonne vessels) and 150m (for 5 tonne vessels), extensive injury and possible fatality to people would occur should a fire mishap take place. Should a release of full storage vessel contents occur where unconfined vapour cloud explosion hazard is a possibility, then the hazard range to people and buildings could extend to more than 1,000m for tanks in excess of 200 tonnes, and 300m for smaller vessels. These distances of impact are to be compared with the 45m and less than 10m as indicated by the code.

It is also relevant to emphasise that the abovementioned distances apply to one storage vessel in isolation. Most storage and distribution terminals include a number of such vessels and a consideration of the cumulative risk implications would result in larger safety separation distances.

WHICH SEPARATION DISTANCES SHOULD ONE ADOPT?

The basis for the distances specified by the code are not clear. Certainly a risk quantification approach does not apply. It is now generally recognised that for large installations, the L.P. Gas Code is not adequate for land use planning purposes. For smaller installations, a revision of the code's requirements is certainly warranted.

A comprehensive systematic hazard analysis for the whole installation would determine quantitatively the most appropriate separation distances to be implemented.

According to the European approach (mainly U.K. and The Netherlands), population densities within 1,000m (200 tonne vessels) and 150m (small service station centres) would be significantly restricted. Table 16 indicates separation distances implemented in The Netherlands and applicable population density limitations. The main emphasis is on consequences of mishaps.

In European countries, hazard analysis techniques have been fully integrated into the land use planning process. The U.K. Health and Safety Executive, for example, have established formalised procedures for consultation by local authorities when housing developments within 2,000m from a range of hazardous installations (and vice versa) are being proposed. Similar organisational procedures apply in The Netherlands, with the exception that safety distance requirements are much longer in view of past incidents experienced in that country, particularly for L.P. Gas installation.

By comparison, Australian standards do not recognise hazard analysis nor hazard and operability principles. An overall review of these standards should be initiated or alternatively new standards should be developed as a matter of urgency.

In addition to standard requirements, local councils should refer to hazard quantiication techniques in evaluating proposals for L.P.G. facilities, including installations for general retail purposes (e.g. service station outlets). The Department of Environment and Planning is currently formulating appropriate guidelines in that regard.

9. FIRE PREVENTION AND PROTECTION AT PORT BOTANY

This section examines fire prevention and protection control measures at Port Botany.

A similar assessment for the overall study area is a complex matter currently under further examination. Port Botany was considered to be a priority area in view of the extensive current developments occurring at the Port, where detailed assessment should be directed in the first instance.

9.1 Existing provisions for fire fighting

A generalised layout for the water main supply system servicing Port Botany and its surrounds is shown in Figure 33(a).

This reticulation water system originates from the Potts Hill Reservoir. The network reduces to a dual mains system in Botany Road and as far as Penrhyn Road. As indicated in the figure, the system includes a single 600mm main along Botany Road and a dead-end 150mm main which runs to the end of Military Road (from Bunnerong Road).

Facilities at the Port are serviced by a single dead-end 375mm water main along Friendship Road. The Metropolitan Water Sewerage and Drainage Board advised that a maximum water rate of some 120-140 l/sec could be obtained from that main under peak demand conditions for fire fighting purposes.

Existing fire water and other major appliances at the existing Port facilities include:-

I.C.I. Hydrocarbon Terminal

The terminal accommodates:-

- 3,000 cubic metres on-site water storage (2 tanks)
- Fire pumps with delivery capability of 400l/sec at 690 kPa
- A ring main system, tank water deluge, monitors and hoses
- Dry powder extinguishers for LP gas spill fires

Terminals Pty Ltd

This terminal emphasises foam as the main fire fighting medium. No water deluge on storage tanks is provided. Water is mainly used for foam generation and for cooling via hand held hoses.

Facilities provided include:-

- 400 cubic metres on-site static water storage (for foam application)
- fire pumps with a supply pressure capability of 860 kPa

- on-site foam supply of 3,500 litre bulk storage concentrate, 200 litre foam cart and 20 x 20 foam concentrate drums for hydrant usage

- hoses and pipe connectors for Fire Brigade access

P.D. Oil and Chemical Storage Co. Pty Ltd

In addition to foam generation capability, this facility provides for water cooling of all tanks via a deluge system. Fire fighting appliances at the facility include:-

- a 470 cubic metre on-site static water tank

- on-site foam storage and generation capability

- monitors and hand held hoses with provisions for connections to Fire Brigade appliances.

The company is currently negotiating with the Board of Fire Commissioners concerning fire appliances and other requirements regarding its proposed L.P. gas storage terminal. Facilities proposed, in principle, include a deluge system on the loading bay, monitors and hoses. Dry powder media would also be provided.

Boral Gas Ltd

Although provisions for fire fighting at this proposed L.P. Gas terminal have not been finalised, it is anticipated that facilities would include on-site water storage (3,400 cubic metres preliminary), deluge system on all storage tanks and loading bay, ring main, monitors, hoses and dry powder.

9.2 Requirements of codes and safety standards regarding fire, water and other media

Appendix C outlines the requirements of the relevant standards in relation to fire prevention and protection measures. The most relevant aspects include:-

(i) AS 1940 - SAA Flammable and Combustible Liquids Code

Cooling water should be used where a distance of less than 1.5 tank diameters between storage vessels occurs. At least 3 hydrants should be provided per installation with a minimum flow rate of 8.3 l/sec at 500 kPa pressure when cooling or foam are operating.

Water supply needs to be adequate for 1-1/2 hours, for the largest foam supply requirements.

(ii) The L.P.G. Code

In relation to L.P.G. storage facilities in excess of 250t storage capacity a static supply of 3 hours duration should be provided should town's mains be insufficient and for 1.5 hours duration if the town's main supply can provide adequate replenishment.

The basis of water supply calculation according to the standard is:

- 10 L/m ^{2}/min to cover the surface area of the tank;
- 3 storage tanks coverage in the case of multiple tank installations.
- Fixed water sprays and/or fixed monitors.

(iii) NFPA codes

The NFPA codes for L.P.G. and flammable and combustible liquids (NFPA 58 and NFPA 30 respectively) provide general guidelines but do not specify a particular methodology for fire water requirements. The codes indicate that fire water requirements should be based on "hazards of operation or exposure" on a case by case basis.

9.3 Assessment

For the purpose of this assessment, standard requirements were adopted as a guide only. Reliance was primarily placed on the results of hazard analysis considerations in relation to heat flux as presented in sections (4) and (5) of this report.

The following minimum fire water requirements, on a company by company basis, has been estimated:

* (i) ICI - Hydrocarbons Storage Terminal

Plant item	System	Required water rate (l/s)
Propane tank	Deluge	130
Butane tank	Deluge	63
Ethylene tank	Deluge	47
Process area	Deluge	40
Pipe intersection	Monitor/hoses	40
Other	Monitor/hoses	80
	Total	400

Time water available at maximum replenishment rate of 120 l/s (static water storage is 3,000m 3) = 3 hours and thereafter only 120 l/s available.

* (ii) Terminals Pty. Ltd.

Plant item	System	Required water rate (l/s)
Storage tank (largest)	Foam	33
Storage tanks affected (6)	Hoses (8)	112
Loading bay, other plant areas	Foam/hoses	40
	Total	185 l/s

Time water available at maximum replenishment rate of 120 l/s (static water storage is 400m 3) = 1.7 hours and thereafter only 120 l/s available.

*(iii) P.D. Oil and Chemical Storage (including proposed L.P.G. terminal)

Plant item	System	Water rate required (l/s)
Loading bays	Deluge	42
Storage tanks	Deluge	130
Storage tank	Foam	10.4
Loading bay/pipes	Monitor/hoses	60-120
Other plant areas	Hoses (4)	64
	Total	300-360

Time available for fire water supply at maximum replenishment rate of 120 l/s (static water storage is 470m 3) = 3/4 hr to 1/2 hr and htereafter only 120 l/s available.

Note: Discussions are still proceeding as to the final on-site fire water storage capacity at this terminal.

*(iv) Proposed Boral L.P.G. Terminal

The following assessment is based on the proposed 4500 t terminal as described in the company's EIS.

Plant item	System	Water rate required (l/s)
Storage vessels (6)	Deluge	555
Loading bay/pipeline/ other plant areas	Deluge/monitors/ hoses	126
	Total	681

Time available for fire water supply at maximum replenishment rate of 120 l/s (proposed static on site water storage is 3400m ^{3}) = 1.68 hrs.

The following table summarises the duration of fire water available at each installation at the Port when considered in isolation (i.e. no concurrent water demand). The estimations are based on the existing water supply rate of 120 l/s and existing (or proposed) static on site water storage available at each installation.

Installation	Time water is available at the required rate
ICI Hydrocarbons storage	3 hrs
Terminals	1.5
PD Oil and Chemical storage	0.5 to 0.75
Boral	1.7 hrs.

The time periods indicated above would significantly reduce should concurrent demand occur at two or more installations, likely situation should a fire occur. The results of this assessment indicate that for presently operating facilities fire water main supply is on the borderline of acceptability. For any additional facilities of the type proposed at the Port, the water supply system is certainly inadequate to provide acceptable protection.

A combination of adequate on-site fire water storage and of reliable main supply in enough quantity is considered essential prior to any additional installations at the Port becoming operational. A doubling of the existing water rate of supply, say to 220 l/s - 240 l/s, together with on site water storage to ensure a minimum of 3 hours coverage should be an adequate protection, given high levels of safety controls.

Amplification of the existing supply system has been under consideration for some time by the Maritime Services Board (MSB) and the Metropolitan Water Sewerage and Drainage Board (MWS & DB). Proposals under investigation include a 450mm diameter main to be constructed from the intersection of Botany Road and Penrhyn Road to the intersection of Friendship and Charlotte Roads (see Figure 33(b) in the appendix). In addition, a 375mm watermain extension would be required in Friendship Road from Charlotte Road to Simblist Road. The length of mains proposed would approximate 3000 metres and would roughly double the existing water capacity.

Although the proposed scheme would significantly improve fire water provision in the Port area, it is suggested that consideration be given to the alternative system indicated in figure (33(b). The network suggested presents a loop ring main network. In addition to significant reliability advantages over duplicating the existing main along Friendship Road (dead-end), the proposed network would also improve fire water requirements in the Total Oil Refinery area.

9.4 Organisational prevention and protection measures

Adequate provisions for fire water and other media must be complemented by comprehensive organisational procedures by relevant authorities.

The Board of Fire Commissioners plays a dual role in regard to counter-emergencies and fire emergency situations, firstly, in prescribing preventive measures and fire fighting requirements under consultation procedures (Ordinance 70 of the Local Government Act) at the building application stage and secondly in the direct containment and fire fighting once a fire incident has occurred.

The role of the Board at the early stages of development applications is, however, limited and entirely relies on the Department's forwarding to it details of applications and ensuring that the Board's requirements are met as condition of planning consent. It could be argued in that regard that formal procedures are urgently needed for the Board to be directly involved with developers at the early stage of development application in order to ensure that fire protection and prevention measures are adequately considered as an integral part of design. The need for update legislation on this matter ought to be considered.

In most cases, fire water and other prevention and protection measures are determined solely on the basis of standards and codes, requirements. As previously indicated, in many instances standard requirements do not fully acknowledge cumulative risk impacts nor specialised control techniques implemented as the result of formal risk quantification. For a situation such as the study area, it is essential that, in all cases, fire fighting protection and prevention measures be determined on the basis of detailed fire studies as an integral part of hazard and operability investigations. Fire studies, rather than complete reliance on the requirements of codes, are standard procedures adopted in most overseas countries. This principle has been established for all facilities at Port Botany and it is essential that a comprehensive review of all fire fighting measures for all installations in the Botany/Randwick industrial complex be undertaken on the basis of quantified studies determined from hazard and operability considerations.

Should an emergency situation occur at any facility in the area, various fire brigades are called in depending on the magnitude of the event and assistance required. Table 17 documents order of response of brigade vehicles and manning to an emergency situation at Port Botany. It could be argued in that regard that incidents at the Port or at the industrial complex necessitate specialised fire fighting techniques and material to efficiently and rapidly contain the mishap and protect life and property.

The provision of a specialised fire fighting station in the area should be considered. This station would be specifically equiped to handle all types of incidents identified in this study.

Of particular concern is the lack of a centralised storage facility in the area for other fire fighting media such as dry powder. Water is mostly used for cooling purposes to prevent further escalation of accidents. However, specialised powder and foam is the direct fire fighting media in most cases. Each company stores its own requirements, which are supplied from the 3M St Marys facilities. Should more be needed, say as the result of an extended duration fire, then supply has to await transport from St Marys. The establishment of a centralised storage facility for such fire fighting media as a joint industry effort should be initiated in the first instance.

The construction of Simblist Road at the Port would improve fire access to port facilities and is considered essential for further developments in the area.

10. OVERALL IMPLICATIONS OF ASSESSMENT RESULTS AND SUGGESTED CONTROL OPTIONS: CONCLUSION AND BASIS FOR RECOMMENDATIONS

Section 5 of this report, specifically section 5.5, indicates that some 985 dwellings (or 515 dwellings when excluding the impact from the Total oil refinery) are exposed to significant risks of fatality from the combined hazard impact of installations in the Botany/Randwick industrial complex and to a lesser extent Port Botany. "Significant" refers to being exposed to fatality risk levels in the range 5-10 chances or more in a million per person per year (that is, in the order of 5 to 10 times higher or more than "acceptable" criteria suggested for similar studies and tentatively adopted in this study pending further refinement).

These dwellings are also exposed to excessive probabilities of significant levels of heat radiation, explosion overpressure and toxicity with serious injury to people and damage to property. They have been classified in Figure (30) as primary risk areas where remedial measures and controls should be directed in the first instance. The number of people residing in these areas has been estimated at 2,000 (based on an overall occupancy rate for the Municipalities of Botany and Randwick of 2.0 taken as a guide from the 1981 census data).

Taking the exposed population of approximately 2,000 in the primary risk area as a whole, and based on an "average" fatality risk level of 8 in a million per person per year, the combined risk of fatality for this population on average is some 1.6 chances in 100 per year of being killed. The chances for the population in the affected primary risk area of being seriously injured and/or property damage occurring approaches 10 chances in 100 per year. (All figures are average, some people may experience higher risk levels.)

The contribution of the various companies in the industrial complex to the overall resultant risk levels has been discussed in section 5.6 and Appendix H of this report and is indicated in Figures (29(a) - 29(n)). The most significant installations exposing residences in primary risk areas are the I.C.I. Botany plant, the Total oil refinery at Matraville, A.C. Hatrick Chemicals, Amoco, H.C. Sleigh and the Bayer plant at Botany.

In the secondary risk areas indicated in Figure (30), overall risk levels vary, depending on the distance from the complex. Although these areas are exposed to relatively low risk of fatality, risk of injury to people and damage to buildings does exist. Secondary risk areas accommodate extensive residential and other land uses and adequate evacuation provisions should be formulated to account for all major types of hazards identified in this study, namely fire, explosions and release of toxic gas.

The main contribution to the overall hazard problem in this area relates basically to technical safety (operational and organisational) and land use planning considerations.

The following section discusses the implications of this analysis and suggests various control options as the basis for specific recommendations.

10.1 Technical implications and control

10.1.1 Technical and safety software control

(a) Hazard analysis by industry The Department's risk assessment study for installations in this area assumes various probability factors based on a high level of control. It is of utmost importance that those industries, identified as being significant contributors to overall risk in the area, immediately initiate their own hazard and operability and hazard analysis studies and present their findings to the Department. Specifically, the following industries should undertake these studies as a matter of urgency:-

(i) Total Oil Refinery, H.C. Sleigh, Amoco, A.C. Hatrick, Bayer, BP, Total Distribution, La Porte, Liquid Air, Collie, APM, Bulk Liquid Berth at Port Botany, overall shipping activities in Port Botany.

(ii) Hazard Analysis Studies have been already undertaken or required under conditions of development consent from P.D. Oils and Chemicals Storage, Terminals Pty Ltd, Boral Gas Ltd, Caltex, I.C.I.

This option is of prime significance to overall technical hazard control.

(b) Overall review of safety controls and protective measures. It was apparent from this assessment that a number of organisations have not been upgrading the protective systems of their existing facilities in line with the increasing overseas understanding of, and standards for, technical safety.

Where the public has been assessed as being at risk from such facilities, then one option which should be pursued vigorously is upgrading of the protective systems.

Typical systems are:

- flammable or toxic gas detectors and alarms, and remotely operated isolation valves
- other forms of leak detection
- remotely operated isolation valves
- provision of steam or water curtains to assist in gas dispersion
- passive fire-proof insulation on critical structures and vessels

- selective use of fixed sprinkler systems, with facilities for induction of a film-forming foam where hydrocarbon spills are the major risks

- automatic shutdown systems for processes, initiated by serious deviations from normal process conditions

- maintenance and auditing

Those installations identified in (i) above should immediately initiate an overall reassessment of their safety provisions in light of their hazard and operability investigations and hazard analysis results. In addition, comprehensive monitoring systems are seriously lacking in the area and should be given high priority.

(c) Fire protection and prevention. Specifically, an overall review of fire fighting facilities and appliances in the light of such hazard investigations by each company identified in section (i) above should be undertaken. An overall review of fire protection and prevention facilities and practices in the area, particularly Port Botany, is urgently needed. Section 8 and Appendix H of this report set the basic requirements for fire fighting measures to be implemented and the inadequacies of the existing provisions.

10.1.2 Statutory and organisational control

(a) State Environmental Policies and Guidelines: In order to mitigate and prevent future problems, appropriate State/regional environmental policies should be formulated and implemented regarding the location of hazardous industry, and to include the requirements for hazard analysis, etc. Locational requirements for residential land uses in the vicinity of hazardous industries should also be instituted in line with overseas planning practices.

Guidelines for risk analysis studies, in the land use planning context, together with relevant criteria and assessment procedures are urgently needed. Immediate guidelines for the location of L.P.G. installations, including those at the retail distribution level should be formulated by the Department and implemented by local councils.

(b) Amendments to designated developments and assessment procedures The list of designated developments listed in Schedule 3 under the Environmental Planning and Assessment Regulations is currently being expanded to account for hazardous installations storing, handling or processing quantities well below the currently designated quantities. Measures are being undertaken to ensure that hazard audit and risk assessment studies are incorporated as standard requirements for Environmental Impact Statements and assessment whenever applicable.

(c) Amendments to the Dangerous Goods Act and to current applicable safety standards.

- Mandatory requirements for the preparation of emergency plans should be part of annual licensing provisions for the handling, storing and processing of dangerous goods under amendments to the Dangerous Goods Act and Regulations.

- Provisions for the preparation of hazard and operability studies for hazardous industries should also be incorporated as requirements of the Dangerous Goods Act.

- Applicable Australian safety standards should accommodate the requirements for hazard analysis and emergency procedures. New updated standards should be formulated by an independent body if necessary. This is particularly relevant for the L.P.G. Code, as discussed in Section 8.3 of this report. The basis for amendments are detailed in Section 8 and Table (15).

- The Botany Bay Hazard/Emergency Sub-committee should oversee the preparation of the overall emergency plan for the area by the Police, Board of Fire Commissioners and State Emergency Services. All emergency procedures must be evaluated through that committee. The guidelines indicated in Appendix I should be uniformally implemented by industry.

10.2 Land-use planning controls

One of the most relevant and effective controls required to deal with the hazard problems identified in this study relate to land-use planning in the area.

Although technical and other control measures suggested in the previous section would significantly reduce the probability of mishaps and improve the overall risk environment, the extent of impact and conflicts on land use would still persist.

In addition, there are economic and technological limitations to industry of the magnitude present in the area to fully containing the cumulative risk levels within the boundaries of the industrial complex. Ultimately, planning controls would have to be implemented in order to effectively complement technical controls if the the present problems are to be resolved.

Basically two options are available in that regard:

(i) significantly limiting any further industrial expansions in this area and removing the most hazardous processes (i.e. relocating existing industry);

(ii) controlling any further residential densities and removing the residential areas most affected.

In relation to option (i) above, most installations in the area are well established with extensive infrastructure provisions. These installations form an integral part of an industrial complex of State and national significance and their closure or relocation is unrealistic. The State government (e.g. Sydney Regional Outline Plan, Draft Sydney Regional Environmental Plan - Botany Bay) is promoting the development of Port Botany and of the Botany/Randwick industrial complex for the purposes of chemicals/petrochemicals and related installations, subject to the most stringent safety and environmental controls, in recognition of the importance of this complex and associated infrastructure. An example in hand would be the recent I.C.I. plant expansions at Botany with a capital investment in excess of $500 million.

An exception is the Bayer plant at Botany. This plant was found to impose excessive risk levels to the surrounding residential areas. The plant is not directly related to the rest of the industrial complex and the company should be encouraged to relocate.

If land use conflicts (present and future) are to be resolved, the only available alternative option is to significantly restrict any further residential and other developments incompatible with the nature and function of the industrial complex in risk-affected areas. These areas have been quantitatively defined in Figure (30) as primary and secondary risk areas.

As a priority measure it is essential to repeal provisions which currently allow indiscriminate increase in dwelling densities in these areas. In addition, industrial developments in these areas should be restricted to non-hazardous processes or to hazardous processes where it could be conclusively demonstrated that no increase in cumulative risk impacts beyond those currently applicable would result. In all cases, all developments involving the erection of a building; the carrying out of a work; or the use of land or of a building or work; or the subdivision of land within the primary and secondary risk areas will need to require the consent of the Council (Botany or Randwick as applicable) and the concurrence of the Director of Environment and Planning (except where the land is affected by a direction given under section 101 of the Environmental Planning and Assessment Act, where development applications are referred to the Department for the Minister's determination).

Appendix J fully discusses the mechanisms available to implement such controls and it is suggested that a regional environmental plan specific to the area would be the most appropriate course of action.

The practice of restricting developments and particularly residential densities in proximity to hazardous industrial installations is a well established planning practice in several European countries, particularly the UK and The Netherlands. The

UK Health and Safety Executive, for example, has established formalised notification/consultation procedures for determining any residential intensification within 2000m from hazardous plants. This practice has resulted in a significant reduction in the number of people exposed to industrial risk, particularly within the first 1000m from the plant.

It is considered that the Department should formulate and publish guidelines for the location of residential areas in proximity to hazardous installations and for the general hazard locational requirements for such installations. Specific recommendations are made in that regard.

Primary risk areas: These areas, quantitatively defined in Figure (30) are the most affected by cumulative risk and limiting residential densities on its own would not resolve long-term land use conflicts since existing residences were found to be most at risk. The ultimate land use in these areas should be that of a special open space buffer zone where activities are strictly controlled to non-hazardous and non-sensitive to hazards. This would exclude residentially zoned land. As previously outlined, the primary risk area in question includes some 980 dwellings (or some 500 dwellings when excluding the impact from the Total oil refinery).

The contribution of each industry to residences affected in that area is as follows:

I.C.I.: 260 dwellings (169 flats, 44 semi-detached, 47 singles). Total estimated value: $10,000,000

Amoco: 41 dwellings (11 flats, 4 semi-detached, 26 singles) Total estimated value: $1,529,000

A.C.Hatrick: 55 single dwellings. Total estimated value: $3,000,000

H.C.Sleigh: 202 dwellings (151 flats, 51 singles) Total estimated value:: $12,000,000 to $19,000,000

Total Oil Refinery: 470 dwellings (16 flats, 31 semis and 423 singles) Total estimated value: $17,000,000 to $29,000,000.

Excluding the Total oil refinery's impact, the total acquisition cost would amount to some $30 Million. The feasibility and implication of such acquisitions should be immediately investigated. Appendix J provides a suggested mechanism of implementation. Ultimately, the acquisition of this area for buffer zone - open space purposes represents the most effective means of control. The exact delineation of these areas should be finalised once detailed hazard analysis and safety studies by industry have been completed.

10.3 Port Botany

The results of this analysis indicate that existing operating installations of the Port do not contribute to any risk of fatality at residential areas. There is, however, some risk of injury and/or property damage from overall port hazards, particularly for toxic gas release situations. Overall, no residential primary risk areas result from existing port installations.

This study, however, identified certain significant constraints on future land use allocation on vacant lands at the Port. The site of the proposed Boral L.P.G. installation is particularly sensitive from a hazard viewpoint and the use of a mounded storage would ensure a low risk interaction with adjacent existing facilities.

The lands previously allocated by the Simblist Inquiry (see figure 34) for the purposes of dry bulk/possible coal loader is, from a safety viewpoint, most suited for LP Gas and other flammable gases (liquified) and bulk liquid chemical storage.

The currently vacant lands nominated as Womeai Reserve is in a relatively high risk area for open space use. These lands do not in practice act as a buffer zone and could be usefully allocated for bulk liquid chemical storage, subject to stringent environmental and safety controls. The same comments would also apply to vacant lands west of Womeai Reserve with the exception that the type of bulk liquids be selected to least hazardous.

Figure (34) suggests a land use reallocation scheme for vacant lands at Port Botany in line with the results of this study. The scheme should be the basis of an overall vacant land use reallocation study for the Port.

As previously discussed, the construction of Simblist Road with a junction at Bumborah Point Road is essential to overall emergency response planning. In addition, Friendship Road should not be dedicated to Council and access controlled by the Maritime Services Board. Friendship Road is exposed to significant risk levels and access to the general public should be restricted.

10.4 Emergency planning

The results of this assessment regarding emergency planning and procedures in the area indicate significant shortfalls as to a specialised co-ordinated response action and improvements should be implemented as a matter of urgency. Table 22 provides specific recommendations in this regard.

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11. RECOMMENDATIONS

11.1 Recommendations that apply to specific industrial organisations as Identified in Tables 19 & 20

SAFETY REVIEW BY INDUSTRY

1. Industrial organisations listed in tables 19 and 20 should, in the first instance, undertake a thorough and detailed review of the safety of the design, physical conditions and operating methods of their plants, to include:

   (i) definition of all possible hazardous incidents related to each significant inventory of hazardous material in process and/or storage and a quantitative assessment of their risk impact to neighbouring facilities and to the general public using the consequence criteria in appendix G; and in accordance with Recommendation 3 below;

   (ii) identification of the causes of those incidents as specified in (i) above and definition of existing safety controls and protective measures to prevent, detect or limit the impact of those incidents;

   (iii) inspection of plants to determine the physical conditions of the critical controls and protective systems;

   (iv) Identification of deficiencies in the design and/or physical conditions and adequacy of safety controls and protective systems and comprehensive formulation of update controls, as necessary, and in line with modern technological practices.

UPDATE OF SAFETY CONTROLS BY INDUSTRY

2. In consultation with the Department of Environment and Planning and the Department of Industrial Relations and in the light of the safety review recommended in (1) above, industrial organisations listed in Tables 19 and 20 should prepare a timetable and provide firm commitments for the implementation of update safety controls and protective measures. The timetable for the implementation of safety controls update should reflect priorities to safety measures that would most rapidly reduce risk with due regard for cost effectiveness.

HAZARD ANALYSIS BY INDUSTRY AND RISK CRITERIA

3. Subsequent to the formulation of updated hazard controls and as an integral part of the implementation process, each of the industrial organisations listed in Tables 19 and 20 should, in liaison with the Department of Environment and Planning, undertake a hazard analysis study to quantify cumulative risk levels for each plant and conclusively determine whether the proposed hazard controls update are sufficient for the safety of the public and/or adjacent facilities.

Resultant risk levels should be quantified on a cumulative basis and be consistent with the following risk criteria (as applicable to the type of hazard and when considered in their totality):

(i) Fatality risk levels at the nearest residential areas from the plant shall not exceed one (1) chance in a million per person per year

(ii) Incident heat flux radiation and/or explosion overpressure (as applicable) at the nearest residential areas from the plant shall not exceed 12.6 kW/m^2 and/or 14kPa at frequencies more than ten (10) chances in a million per year

(iii) Incident heat flux radiation and/or explosion overpressure (as applicable) at the nearest residential areas from the plant shall not exceed 4.7 kW/m^2 and/or 7kPa at frequencies more than fifty (50) chances in a million per year;

(iv) Incident heat flux radiation and/or explosion overpressure (as applicable of 23kW/m^2 and/or 14kPa at maximum frequencies of fifty (50) chances in a million per year shall be contained within site boundaries.

(v) Whenever applicable, in-plant accident propagation potential estimated in terms of 25kW/m^2 and/or 35kPa (as applicable) shall not exceed levels of fifty (50) chances in a million per year.

<u>SAFETY MANAGEMENT & PROCEDURES</u>

4. In addition to the implementation of safety controls and protective measures update, industrial organisations listed in Tables 19 and 20 should formulate and implement management structures and procedures and operating methods consistent with the level of safety required. The adequacy of those procedures and methods should be evaluated as part of the hazard analysis requirements recommended in (3) above.

11.2 Recommendations that apply to potentially hazardous industry (present and proposed) within the study area

<u>CUMULATIVE RISK CONTROL FROM NEW INSTALLATIONS</u>

5. Expansions to existing processes and/or storage facilities in the area edged black on Figure 3 and/or the introduction of new installations of the type listed in Table 14 in that area should proceed only when it is demonstrated through preliminary hazard analysis studies at the development application stage that the relevant risk levels from the whole plant are consistent with the safety criteria indicated in Recommendation 3 above.

Any expansions or introduction of new installations in that area, which have been approved on that basis should, prior to commencement of operations, undertake detailed hazard analysis and hazard and operability studies as an integral part of detailed design considerations to ensure relevant risk levels are contained within site boundaries.

<u>HAZARD CONTROLS AT THE TOTAL NOW AMPOL OIL REFINERY</u>

6. Specifically, and in addition to significant upgrading of safety controls at the existing Total (now Ampol) oil refinery at Matraville in line with Recommendations 1 to 4 inclusive, no extensions to refining activities nor additions to storage facilities for petroleum and petroleum derivative products including liquefied petroleum gas (L.P.G.) should be permitted at that refinery unless:

(i) Recommendation 5 above is fully complied with; and

(ii) all L.P.G. and other liquified flammable gases storage facilities associated with the refinery are relocated to the Bunnerong Power Station site.

HAZARD CONTROLS FOR LP GAS STORAGE FACILITIES

7. Any pressurised L.P.G. storage within the area edged black on Figure 3 should not be permitted unless:

(i) Recommendation 5 above is fully complied with for storage vessels exceeding 30 tonnes in aggregate storage capacity;

(ii) all storages are fully protected against mechanical damage, flame impingement and prolonged exposure to heat radiation with preference given to underground or mounded facilities;

(iii) transfer of L.P.G. into or from each storage vessel does not exceed one tenth (1/10th) of the vessel storage capacity (per hour) unless it can be conclusively demonstrated that the risk criteria specified in Recommendation 3 are fully complied with and multiple automatic shut-off and other systems are used to prevent tank overfill and/or leakage from the transfer pipeline system.

HAZARD AUDIT

8. As a matter of policy, all industrial organisations currently operating or proposing to operate in the area edged black on Figure 3 should undertake comprehensive annual hazard audit for their whole installation with special emphasis on those parts of their operations with a potential for major hazards. In all cases annual hazard audits should be based on the principles specified in Recommendation 1. Modifications to plant and equipment should include a critical safety analysis by way of hazard and operability investigations or other methods of detailed safety review.

ACCIDENTS RECORDING AND INVESTIGATIONS

9. Industrial organisations currently operating or proposing to operate in the area edged black or Figure 3, should formulate and implement formal organisational procedures for recording and analysing hazardous incidents and atypical occurrences which could have resulted in a hazardous incident.

FIRE STUDY AND UPDATE OF FIRE FIGHTING MEASURES BY INDUSTRY

10. Industrial organisations listed in Tables 19 and 20 should undertake an overall fire study based on the safety review the principles of which are specified in Recommendation 1 and to include:-

(i) an overall review of fire fighting protection and prevention measures at each installation identified, with specific emphasis on fire fighting media appliances and practices;

(ii) flammable and/or toxic gas detectors and alarms and other forms of leak detection;

(iii) provision of steam or water curtains to assist in gas dispersion;

(iv) passive fireproof insulation on critical structures, vessels and sensitive plant items; and

(v) selective use of fixed sprinkler system with facilities for induction of a film-forming foam where hydrocarbon spills are the major risks.

Implementation of the results of fire studies and update of existing fire protection and prevention facilities in line with the considerations outlined above are urgently recommended as a matter of priority for all installations listed in Tables 19 and 20.

The subject investigations and implementation measures are to be undertaken in liaison with and to the satisfaction of the Department of Environment and Planning and of the Board of Fire Commissioners.

EMERGENCY PROCEDURES BY INDUSTRY

11. Industrial organisations listed in Table 21 should, as a matter of priority, formulate or update (as applicable) their internal emergency procedures with the view of formulating an overall emergency plan of action for the whole installation.

In all cases, emergency procedures for each installation are to be:

(i) in accordance with the Emergency Procedures Guidelines published by the Botany Bay Hazard/Emergency Committee;

(ii) co-ordinated with adjacent facilities to reflect the nature and extent of hazards present at those neighbouring installations;

(iii) formulated and implemented as to reflect the hazards of their operations as determined by the safety review specified in Recommendation 1 and by detailed hazard analysis as set out in Recommendation (3).

Copies of all such procedures should be lodged with the Department of Environment and Planning for access by the Botany Bay Hazard/Emergency Sub-Committee.

<u>INDUSTRIAL MUTUAL AID GROUP IN THE AREA</u>

12. The Department of Environment and Planning should initiate and promote discussions amongst all operating companies in the study area, particularly those listed in Table 21, with the aim of establishing, on an on-going basis, an industrial mutual aid group in the area. The main functions of this mutual aid group would include:

(i) improving understanding of the nature of hazardous incidents which could occur in the area and of the appropriate emergency responses;

(ii) improving awareness of the nature of specialist emergency and fire fighting facilities which could be available from other industries, and of possible benefits of standardisation in some fields;

(iii) exchange of information on mitigating measures for the avoidance and control of hazardous incidents and emergencies and formulation of standards;

(iv) co-ordination of industry's emergency procedures with those adopted by relevant state emergency organisations including the Police, the Board of Fire Commissioners and State Emergency Services;

(v) the dissemination of relevant safety information to local councils and to the general public in the area.

11.3 Recommendations that relate to land use controls and planning

LAND USE CONTROLS PRIMARY AND SECONDARY RISK AREAS

13. The Department of Environment and Planning should initiate immediate action to ensure that the following land use planning controls in the area identified on Figure 35 are implemented:

(i) no intensification of residential developments within the areas referred to as "Primary" and "Secondary" Risk areas to be allowed without the consent of Botany or Randwick Councils (as applicable) and the concurrence of the Director of Environment and Planning except where the land is affected by a direction under section 101 of the Environmental Planning and Assessment Act;

(ii) generally, all development involving the erection of a building, the carrying out of a work or the use of land or of a building or work, or the subdivision of lands within the areas referred to as "Primary and Secondary" risk areas should require the concurrence of the Director of Environment and Planning;

(iii) repeal provisions which increase residential dwelling density within the areas referred to as "Primary and Secondary" risk areas. The aim of any rezoning should be to expose fewer people to potential hazards than would result from a residential development;

(iv) all lands within the area edged black on Figure 3 should be covered by a direction under section 101 of the Environmental Planning and Assessment Act. The provisions of Recommendation 5 should apply to any intensification of industrial developments in that area.

It is recommended that the Department initiate a Regional Environmental Plan, the basis of which is outlined in Appendix J by way of implementing the planning control provisions outlined above.

LAND USE CONTROLS: PRIMARY RISK AREA

14. Where the program of safety upgrading and control measures and the results of detailed hazard analysis for those industrial organisations listed in Tables 19 and 20 and in accordance with Recommendations 1 to 4 inclusive indicate the relevant risk criteria are not contained within the boundaries of the industrial complex, then the Department of Environment and Planning should investigate and implement in liaison with the industrial organisations concerned an acquisition program for all properties within which the assessed risk levels exceed the Department of Environment and Planning's criteria. Table H1 to be used as a guide identifies the risk contribution from each industry to residences affected. Figure 36 indicates residential lands for acquisition.

BAYER PLANT AT BOTANY

15. The Bayer chemical plant at Botany should be encouraged to relocate. No extensions at the plant should be permitted.

LAND USE CONTROLS AT PORT BOTANY

16. The Department of Environment and Planning in liaison with the Maritime Services Board should initiate appropriate action for the implementation of the land use reallocation scheme for vacant lands at Port Botany.

LOCATIONAL GUIDELINES FOR HAZARDOUS INSTALLATIONS

17. The Department of Environment and Planning should formulate and publish locational guidelines for residential areas in proximity to hazardous installations and for the general hazard locational requirements for such installations based on hazard analysis considerations. Relevant State/Regional environmental planning policies should be formulated in that regard.

11.4 Recommendations that relate to emergency planning, fire fighting facilities and action plan by Government

FIRE AND EXPLOSION CONTROLS BY GOVERNMENT

18. An interdepartmental committee comprising representatives from the Department of Environment and Planning, the Board of Fire Commissioners and the Department of Industrial Relations should be established with the main objective of formulating and implementing fire, explosion and toxic gas releases prevention and protection measures for the overall industrial complex, edged black in Figure 3, to include:

(i) a comprehensive assessment of fire water adequacy and reliability, specifically for the Botany/Randwick industrial complex, with the aim of improving fire fighting provisions in the area;

(ii) an overall review of organisational fire fighting services including specialised appliances and effectiveness of response;

(iii) the feasibility of establishing a specialised fire brigade station in the area with specific responsibilities for the provision and co-ordination of specialised equipment, training, appliances and manpower to cope with all types of hazards identified in this study;

(iv) an overall review of all relevant fire prevention and protection standard requirements to ensure compliance with hazard analysis and hazard and operability studies principles and to reflect the locational safety constraints of the study area; and

(v) initiate discussions with and among operating industrial organisations in the area with the view of establishing a centralised storage area for specialised foam and dry powder fire fighting media of adequate capacity.

OVERALL EMERGENCY PLAN FOR THE STUDY AREA BY GOVERNMENT

19. The Botany Bay Hazard/Emergency Sub-Committee should appoint a working party to include representatives from the Department of Environment and Planning, the Police Department, the Board of Fire Commissioners and industry representatives to formulate and implement an overall emergency/counter diaster plan for all the hatched area indicated on Figure 30. The plan should form a master co-ordinated emergency and evacuation action plan for the area with specific emphasis on:

(i) significantly updating and co-ordinating the Police 'C' District plan and the Maritime Services Board's MARDAP plan to include all types and extent of possible fires, explosions and toxic gas releases as identified in the risk assessment study for the Botany/Randwick industrial complex and Port Botany;

(ii) the formulation of comprehensive specific emergency and evacuation procedures that closely relate to the findings of the study referred to in (i) above. The whole plan should be based on the findings of that study;

(iii) the formulation and publication of an outline emergency action plan booklet for local councils, industry and the general public in the area;

(iv) clearly specifying and agreeing on the specific role of each organisation involved in the implementation of emergency and evacuation procedures under various postulated conditions as nominated in the risk assessment study for the area;

(v) clearly and specifically nominating access evacuation routes, control points, manpower and appliances requirements as well as community health and other services availability and adequacy.

The plan must be fully co-ordinated and integrated with industry's emergency procedures through the mutual aid group recommended in Item 12.

<u>EMERGENCY ACCESS AND FIRE FIGHTING AT PORT BOTANY</u>

20. The construction of Simblist Road to improve emergency access at Port Botany and the upgrading of the fire water main supply at the port to a doubling of the existing capacity should be implemented prior to any additional facilities becoming operational in the port area.

<u>SAFETY CONTROLS, SECURITY AND SHIPPING HAZARDS AT PORT BOTANY</u>

21. The Maritime Services Board, in liaison with the Department of Environment and Planning and operating companies at the Port, should initiate detailed investigations with the view of:

(i) upgrading fire protection and prevention measures at the bulk liquids wharf with special emphasis on the provision of adequate quantities and means of application of foam and dry powder for spill fires;

(ii) provisions of adequate measures for detecting and isolating pipeline leaks from the pipeline corridor such that such leaks are isolated from the inventories other than the line contents within three (3) minutes of the start of the leak;

(iii) formulating and implementing an overall and comprehensive security management plan for Port Botany aiming at ensuring strict control access to general Port areas for any member of the general public, specifically the retention of Friendship Road as a private road with upgraded security arrangements;

(iv) formulating and implementing a comprehensive shipping hazards plan for Botany Bay, based on hazard analysis considerations with the main aim of specifying shipping routes and hours of operation and designating an exclusion controlled zone for general maritime vessels in line with overseas practice.

<u>DANGEROUS GOODS ROAD TANKERS ROUTE</u>

22. The Department of Environment and Planning should, in liaison with the New South Wales Traffic Authority and local councils, formulate and implement a route network for dangerous goods road tankers. The route network should be based on:

(i) traffic and road capacity/level of service considerations;

(ii) land use implications with particular emphasis on safety constraints and impacts based on comprehensive hazard analysis considerations;

(iii) transportation economics and operators' requirements.

<u>AMENDMENTS TO DESIGNATED DEVELOPMENTS</u>

23. The list of designated developments under the Environmental Planning and Assessment Act Regulations should include hazardous installations storing, handling and/or processing hazardous material in the maximum quantities specified in Table 14. Hazard

audit and risk assessment studies should be incorporated as standard requirements for environmental impact statements and assessment as applicable.

AMENDMENTS TO SAFETY STANDARDS

24. The Dangerous Goods Act and current Australian safety standards should be amended to include:

(i) mandatory requirements for the preparation of emergency procedures as part of annual licensing provisions for the handling, processing and/or storage of dangerous goods;

(ii) provisions for the preparation of hazard and operability investigations as a requirement of the Act;

(iii) hazard analysis as a requirement of Australian safety standards particularly the L.P.G. Code.

ENVIRONMENTAL RISK COUNCIL

25. Establishment of an Environmental Risk Council, under section 22 of the Environmental Planning and Assessment Act -

a) to consider and recommend to the Minister a new Act or regulation, or the drafting of appropriate amendments to the Dangerous Goods Act and/or Occupational Health and Safety Act to require review of all existing chemical/petrochemical processing plants and storage facilities to obtain -

(i) a hazard audit of the plant and its operations, including storage facilities, plus any necessary hazard and operability studies;

(ii) an overall safety update, on direction, of those facilities identified in Tables 19 and 20;

(iii) necessary powers of implementation, including the ability to require contribution towards acquiring properties significantly at risk from identified plants;

b) to oversee the implementation of the recommendations of this report with particular emphasis on any land-use control measures in the areas affected (including as a last resort, measures to acquire those properties where high risk remains in spite of updating of safety controls at the plants);

c) to initiate an overall co-ordinated mechanism for the integration and implementation of the latest developments in industrial safety controls into the overall planning process.

The recommended membership structure of the Council is:

- Department of Environment and Planning
- Department of Industrial Relations
- Board of Fire Commissioners
- Police Department
- Botany Municipal Council
- Randwick Municipal Council
- Australian Council of Trade Unions
- ICI Australia Ltd
- Australian Gas Light Company
- Shell Australia Ltd (or CSR Ltd)
- Australian Chemical Industry Council
- Independent person with special qualifications (to be nominated)

<u>SPECIALISED HAZARD ASSESSMENT UNIT WITHIN DEP</u>

26. A specialised unit should be established with the main functions to include:

(i) overseeing the implementation of all recommendations specified in this report with particular emphasis on co-ordinating and providing technical assistance to industry and relevant Government departments;

(ii) establishing a specialised hazard classification and notification system for hazardous installations throughout the State in line with overseas practices and requirements;

(iii) development and implementation of advanced hazard analysis and hazard and operability techniques as an integral part of the land use planning process;

(iv) development of an assessment mechanism including residential developments in proximity to hazardous installations and the formulation of relevant policies and guidelines;

(v) overall co-ordination of the relevant statutory requirements and the integration of such requirements into the planning process;

(vi) environmental impact assessment of developments as designated in Table 14.

APPENDIX A

FIGURES

APPENDIX (B)

TABLES

16. Overseas limitations on Population Densities in the Neighbourhood of Small LP Gas Storage and Distribution facilities.

17. Possible Order of Fire Brigade Response to an Emergency Situation at Port Botany.

18. Pipelines within the Botany/Randwick Industrial Complex and Port Botany.

19. Companies recommended as needing to undertake a comprehensive safety review and hazard audit.

20. Companies which are in need of a detailed fire safety study.

21. Companies which are in need of undertaking or updating emergency procedures in the study area.

22. Emergency Planning Action Requirements.

TABLE (1)

COMPANIES SURVEYED WITHIN THE STUDY AREA

- ICI Australia Ltd. - Botany (Chemical/Petrochemical)
- Esso Australia - Botany (storage terminal)
- Amoco Australia - Botany (storage terminal)
- H.C. Sleigh - Randwick (storage terminal)
- B.P. Australia - Botany (storage terminal)
- Total Distribution - Botany (storage terminal)
- A.C. Hatrick - Botany (Chemicals Manufacturers)
- APM - Randwick/Botany (paper mill & recycling)
- Catoleum - Botany (Chemicals Manufacturers)
- Kellogg - Botany (Food Processors)
- Carba - Botany (CO_2 processors)
- Johnson & Johnson - Botany (Medical & Hygenic)
- Mayne Nickless - Botany (Transport)
- Ampol - Botany (Truck Service)
- Wool Processors - Botany (processors)
- Fibre Containers - Randwick (packaging)
- Continental Distilleries - Botany (Distillers)
- Bayer - Botany (Chemical blenders & Manufacturers)
- Total Oil Refinery - Randwick
- Caltex - Botany (storage terminal)
- La Porte Chemicals - Botany (Chemicals Manufacturers)
- CIG - Botany (processing & storage)
- Liquid Air - Botany (processing & storage)
- Collie - Botany (Ink Manfuacturers)
- Sea Containers - Botany (Freight Depot)
- Davis Gelatine - Botany (processors)
- Ready Mix - Botany (concrete batches)
- Crest Chemicals - Randwick (Chemical storage/packing)
- Knebel - Botany (kitchen prefabricators)
- Shead's Transport - Botany (Transport)
- Metal Recyclers - Botany (recyclers)
- Cubico - Botany (Freight Depot)
- Email - Botany (appliance manufacturers)
- Alfa Romeo - Botany (car assembler)
- ACI - Botany (insulation materials)
- Pulford Compressors - Botany (compressor assemblers)
- Transport Services - Botany (Transport)
- ANL Port Botany - Botany (container terminal)
- CTAL Port Botany - Randwick (container terminal)
- ICI Port Botany - Randwick (hydrocarbon storage)
- PD Oil & Chemicals Port Botany - Randwick (storage terminal)
- Terminals Pty. Ltd. Port Botany - Randwick (storage terminal)
- Boral - Port Botany - Randwick (proposed LPG storage)
- Electricity Commission of N.S.W. Bunnerong power station - Randwick

TABLE (2)
ESTABLISHMENT DATES OF MAJOR INDUSTRIES IN THE STUDY AREA

Firm	Product	Establishment Date
Australian Paper Mills	Paper, cardboard packaging, recycling	1901
Davis Gelatine	Gelatine products used in food industries and photography	1917
Kellogg	Cereals	1928
Johnson & Johnson	Pharmaceutical, surgical and health aids	1936
Imperial Chemical Industries (I.C.I.)	Carbon bisulphide, polythene major extensions	1942 1957,1977, 1979-1982
Crest Chemicals	Industrial chemicals	1943
A.C.Hatrick	formerly Reichold Industrial Chemicals	1949
Caltex	Petroleum terminal	1956
Collie	Printers ink and printing plastic	1959
Total	Petroleum refinery new refinery plant	1948 1956
H.C.Sleigh (formerly Golden Fleece, now Caltex)	Petroleum storage major extensions	1958 1977
B.P.	Bulk fuel terminal	1960
Amoco	Bulk fuel terminal	1961
Catoleum	Silico-alumina catalysts	1963
La Porte Chemicals	Industrial chemicals (hydrogen peroxides)	1963
Esso	Bulk fuel terminal	1966

TABLE (3)

PROBABILITY DATA USED IN THE STUDY AREA

Item	Failure Probability (in one million per year per item)	Fire Probability (in one million per year per item)	Toxic Fume release (in one million per year per item)
* Storage Vessel (stock tanks)	600	1,000	140
* Bund	0.1	10	30
* Drum fill areas, etc.	N/A	1,000	N/A
* Pressure Vessel	2	1	1
* Pressure Vessel (mounded)	0.1	0.05	0.05
* Road tanker	10	2	1.5
* Nozzle	0.4	0.02	0.01
* Pipeline	6-12	0.20-0.50	0.01-0.1
* Pumps:			
Seal	5000	50	4
Shaft	200	4	1
Casing	20	1	0.2

TABLE (4)

CONSEQUENCES OF HEAT RADIATION

Heat Radiation (kW/m^2)	Effect
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second degree burns will occur).
12.6	. 30% chance of fatality for continuous exposure. High chance of injury. . Cause the temperature of wood to a point where it can be ignited by a naked flame after long exposure. . Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.
23	. 100% chance of fatality for continuous exposure to people and 10% chance of fatality for instantaneous exposure. . Spontaneous ignition of wood after long exposure. . Unprotected steel will reach thermal stress temperatures to cause failure. . Pressure vessel needs to be relieved or failure would occur.

Heat Radiation (kW/m^2)	Effect
35	. Cellulosic material will pilot ignite within one minute exposure. . 25% chance of fatality if people are exposed instantaneously.
60	. 100% chance of fatality for instantaneous exposure.

TABLE (5)

EFFECTS OF EXPLOSION OVERPRESSURE (AS ADOPTED IN THIS STUDY)

Explosion Overpressure	Effect
3.5 kPa (0.5 psi)	. 90% glass breakage . No fatality and very low probability of injury.
7 kPa (1 psi)	. Damage to internal partitions and joinery but can be repaired. . Probability of injury is 10%. No fatality.
14 kPa (2 psi)	. House uninhabitable and badly cracked.
21 kPa (3 psi)	. Reinforced structures distort . Storage tanks fail . 20% chance of fatality to a person in a building.
35 kPa (5 psi)	. House uninhabitable . Wagons and plant items overturned . Threshold of eardrum damage . 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open.
70 kPa (10 psi)	. Threshold of lung damage . 100% chance of fatality for a person in a building or in the open. . Complete demolition of houses.

TABLE (6)

EFFECTS OF DIFFERENT CONCENTRATIONS OF TOXIC GASES

EPICHLORHYDRIN	(PPM)
Threshold limit value	2
Max. concentration for exposure of 15 min.	5
Level immediately dangerous to life and health	100
PHOSGENE	
Minimum concentration detectable by odour	0.5-2 5.6
Maximum concentration for exposure of 15 min.	1
Minimum concentration affecting throat	3.1
Concentration dangerous for exposure of 1 hour	25
Concentration rapidly fatal for short exposure	50
Concentration capable of causing lung injury in 2 min.	167
CHLORINE	
Minimum concentration detectable by odour	1
Maximum concentration inhalable for 1 hr. without damage	4
Minimum concentration causing throat irritation	15
Minimum concentration causing coughing	30
Concentration probably fatal after a few deep breaths	400-1,000

EFFECTS OF DIFFERENT CONCENTRATIONS OF SOME TOXIC GASES

Gas	Concentration
SULPHUR DIOXIDE	
Least amount detectable by odour	3.5
Least amount causing immediate throat irritation	8-12
Least amount causing immediate eye irritation	20
Least amount causing immediate coughing	20
Maximum allowable for prolonged exposure	20
Maximum allowable for short (30 min.) exposure	50-100
Dangerous for even short exposure	40-500
AMMONIA	(PPM)
TLV	25
Concentration detectable by odour	20
Concentration causing severe irritation of throat, nasal passages and upper nasal tract	400
Concentration causing severe eye irritation	700
Concentration causing coughing, bronchial spasms, possibly fatal for exposure of less than 1-2h	1,700
Concentration causing oedema, strangulation, asphxia, fatal almost immediately	5,000
HYDROGEN SULPHIDE	
TLV	10
Concentration causing slight symptoms after exposure of several hours	70-150
Maximum concentration inhalable for 1h without serious effects	170-300
Concentration dangerous for exposure of 1/2-1h	400-700

TABLE (7)

AUDIT QUANTITIES OF HAZARDOUS MATERIALS

Group 1 Toxic Substances

	HSE	DEP
Phosgene	2 tonnes	2 tonnes
Chlorine	10 tonnes	2 tonnes
Acrylonitrile	20 tonnes	2 tonnes
Hydrogen cyanide	20 tonnes	2 tonnes
Carbon disulphide	20 tonnes	2 tonnes
Sulphur dioxide	20 tonnes	2 tonnes
Bromine	40 tonnes	2 tonnes
Ammonia	100 tonnes	2 tonnes

Group 2 Substances of Extreme Toxicity

Toxic liquids or gases likely to be lethal to man in quantities of less than one milligram	100 grammes	100 grammes
Toxic solids likely to be lethal to man in quantities of less than one milligram other than those which are and which will be maintained at ambient temperature and atmospheric pressure	100 grammes	100 grammes

Group 3 Highly Reactive Substances

Hydrogen	2 tonnes	2 tonnes
Ethylene oxide	5 tonnes	1 tonne
Propylene oxide	5 tonnes	1 tonne
Organic peroxides	5 tonnes	5 tonnes
Nitrocellulose compounds	50 tonnes	50 tonnes
Ammonium nitrate	500 tonnes	500 tonnes
Sodium chlorate	500 tonnes	500 tonnes
Liquid oxygen	1000 tonnes	100 tonnes

Group 4 Other Substances and Processes

Flammable gases not specified in any other group	15 tonnes	15 tonnes
Flammable liquids above their boiling point (at 1 bar pressure) and under pressure greater than 1.34 bar including flammable gases dissolved under pressure but not mentioned in any other category.	20 tonnes	20 tonnes

	HSE	DEP
Liquified petroleum gases such as commercial propane and commercial butane and any mixture thereof.	30 tonnes	20 tonnes
Liquified flammable gases under refrigeration which have a boiling point below 0°C at 1 bar pressure and are not included in Group 1-3.	50 tonnes	20 tonnes
Flammable liquids of flash point less than 21°C not included in Group 1-3.	10000 tonnes	10000 tonnes
Compound fertilisers	500 tonnes	*
Plastic foam	500 tonnes	*

* Not applicable to this Study.

TABLE (8)

INVENTORY OF HAZARDOUS MATERIALS IN THE BOTANY/ RANDWICK INDUSTRIAL COMPLEX AND PORT BOTANY

COMPANY	HAZARD GROUP	MAXIMUM QUANTITIES IN TONNES		
		IN STORAGE	IN PROCESS	TOTAL
ESSO	Flammable liquids	24,900	-	24,900
AMOCO	Flammable liquids	26,900	-	26,900
BP	Flammable liquids	10,300	-	10,300
TOTAL DISTRIBUTION	Flammable liquids	28,000	-	28,000
CALTEX	Flammable liquids	45,700	-	45,700
TERMINALS	Flammable liquids & Toxic	38,000	-	38,000
P.D. OIL	Flammable liquids & Toxic	32,400	-	32,400
BORAL (proposed)	LPG	4,500	-	4,500
I.C.I. - Port Botany	Liquified flammable gases	18,000	-	18,000
H.C. SLEIGH	Flammable liquids	12,000	-	12,000
LAPORTE	Flammable liquids LPG Highly Reactive	133 60	80 0.01 10	213 0.01 70
A.C. HATRICK	Highly Reactive Toxic Substances Flammable liquids	0.06 50 2816	0.05 24 -	0.11 74 2816
BAYER	Flammable liquids Toxic Substances	4500	-	4500

COMPANY	HAZARD GROUP	MAXIMUM QUANTITIES IN TONNES		
		IN STORAGE	IN PROCESS	TOTAL
AUSTRALIAN PAPER MANUFACTURERS	Toxic Substances	5	9	14
	LPG	9	-	9
	Flammable liquids	9	-	9
FIBRE CONTAINERS	LPG	1	0.35	1.35
	Flammable liquids	0.1	-	0.1
KELLOGG	Flammable liquids	5	-	5
	Liquified flammable gases	1	-	1
JOHNSON AND JOHNSON	Toxic substances	0.21	0.14	0.35
	Flammable liquids	14.35	-	14.35
CATOLEUM	Toxic	45	-	45
	Liquified flammable gases	2	-	2
	Flammable liquids	250	-	250
CARBA	Toxic	0	1	1
	Highly reactive	6	-	6
	LPG	6	-	6
	Flammable liquids	25	-	25
MAYNE NICKLESS	Flammable liquids	60	-	60
	Toxic	12		12
WOOL PROCESSORS	Highly reactive	18	-	18
	Flammable liquids	18	-	18
CONTINENTAL DISTILLERIES	Flammable liquids	9	-	9

COMPANY	HAZARD GROUP	MAXIMUM QUANTITIES IN TONNES		
		IN STORAGE	IN PROCESS	TOTAL
READY MIX CONCRETE	Flammable liquids Liquified flammable gases	60 4	- -	60 4
PULFORD & SONS	Flammable liquids	8.5	-	8.5
ALFA ROMEO	Flammable liquids	9	-	9
DAVIS GELATINE	Flammable liquids Liquified flammable gases Toxic gas	19 1 400	- - -	19 1 400
DAVIS FULLER ADHESIVES	Flammable liquids	10	-	10
CUBICO	Flammable liquids	10	-	10
ACMIL PLASTICS	Flammable liquids	20	-	20
EMAIL	Flammable liquids	5	-	5
ANL	Flammable liquids	135	-	135
CTAL	Flammable liquids	135	-	135
COLLIE	Flammable liquids Highly reactive	285 1	- -	285 1
VULCAN	Flammable liquids Flammable gases	10 27	- -	10 27

COMPANY	HAZARD GROUP	MAXIMUM QUANTITIES IN TONNE		
		IN STORAGE	IN PROCESS	TOTAL
SHEARD'S TRANSPORT	Flammable liquids	10	-	10
AMPOL	Flammable liquids	20	-	20
FLIWAY	Flammable liquids	9	-	9
LIQUID AIR	Reactive toxic/ cryogenic gases	950	10	1000
TOTAL OIL REFINERY MATRAVILLE	Liquified flammable gases	1770	23	1793
	Flammable liquids	154550	387	154937
SEACONTAINERS	Flammable liquids	10	-	10
TRANSPORT SERVICES	Flammable liquids	10	-	10
I.C.I. BOTANY CHEMICAL FACTORY	Toxic gas	500	20	520
	Toxic substances	20,000	100	20,100
	Flammable gases	0.1	0.01	0.11
	Liquified flammable gases	19	1	20
ETO FACTORY	Highly reactive	162	13	175
	Flammable gases	0	0.5	0.5
	Flammable liquids	787	23	810
OLEFINES FACTORY	Flammable gas	0	7	7
	Liquified flammable gases	2400	150	2550
	Flammable liquids	63,000	20	63,020

COMPANY	HAZARD GROUP	MAXIMUM QUANTITIES IN TONNES		
		IN STORAGE	IN PROCESS	TOTAL
PLASTICS FACTORY	Toxic gas	41	3	44
	Flammable gas	2	1	3
	Liquified flammable gas	1005	304	1309
	Flammable liquids	1414	37	1451
POLYTHENE	Highly reactive	12.6	0.6	13.2
	Flammable gas	-	2.5	2.5
	Liquified flammable gases	17	0.5	17.5
	Flammable liquids	78	2	80
OLEFINES	Liquified flammable gases	-	150	150

Estimated Total:-

* Flammable Liquids :

In storage	431,835t
In process	560
Total	432,395t

* Liquified Flammable Gases :

In storage	27,735t
In process	630
Total	28,365t

* Toxic Substances :

In storage	21,600t
In process	170t
Total	21,870t

* Highly Reactive Substances :

In storage	260t
In process	30t
Total	290t

Table 9

Table 9 (cont'd..)

TABLE (10)

GENERALISED HAZARD IDENTIFICATION FOR THE BOTANY/RANDWICK INDUSTRIAL COMPLEX AND PORT BOTANY

TYPES OF HAZARDS IDENTIFIED

A. Fires of tanks storing flammable liquids and associated loading/unloading facilities.

B. Fires from drums or vessels containing flammable liquids in enclosed buildings.

C. Fires at sundry small - medium industries engaged in processing or storage of flammable materials and general industrial fires.

D. Process Fires from flammable liquids and gases.

E. Fires, Fireballs, Flash Fires and Explosions from handling, processing or storage of liquified flammable gases (e.g. LPG).

F. Fires in warehouses and containers depots.

G. Explosions (confined, semi-confined and unconfined).

H. Toxic Gas or Asphyxiant Release.

I. Toxic Fumes generated from fires engulfing toxic materials.

J. Fires and Explosions from highly reactive materials.

K. Fires, Flash Fires and Explosions from pipelines carrying flammable liquids or liquified flammable gases.

L. Fires from Transport of flammable liquids.

M. Fires, Fireballs and Explosions from Transport of liquified flammable gases.

N. Dust Explosion.

O. Fires, Toxic Fumes and Explosions from ships and berthing facilities handling flammable liquids and liquified flammable gases.

Table 10 (cont'd)

Table 10 (cont'd)

Table 10 (cont'd)

Table 10 (cont'd)

TABLE 11(a)

CONSEQUENCE ANALYSIS: STOCK TANK FIRES

(Based on one tank fire in isolation).

Installation	Max Hazard Range to People (4.7kW/m²)	Requirements of Relevant Standard (see (Appendix D)	Are Any Residential Areas Affected?	Comments
* Port Botany (P.D. Oil and Terminals). (Tank diameters range 5m-20m)	20m to 80	-15m-50m to protected works. -2.5m-10m to adjacent tanks	No	-Water cooling of 4-6 adjacent tanks would be necessary. -Friendship Rd affected for more than one tank fire.
* Total Oil Refinery (Tank diameters 23m, 44m up to 60m)	160-250m	-50m to protected works. -1/2 diameter (largest tank) to adjacent tanks	Yes	-Area of impact would increase if more than one tank on fire
* H.C. Sleigh (10m-23m tank diameters)	35m to 90m	-20m-50m to protected works	Yes	-Area of impact would increase if more than one tank on fire.
* B.P. Storage (5m-25m tank diameter)	20m to 100m	50m to protected works	No	-Water response at adjacent terminals essential, otherwise escalation.

Installation	Max Hazard Range to People (4.7k W/m²)	Requirements of Relevant Standard (see (Appendix D)	Are Any Residential Areas Affected?	Comments
* Total Distribution (12m-24m tank diameters)	40m-100m	-50m to protected works -15m to boundaries or tank diameter	No	-Bund fires could affect open space. -Water for cooling essential at neighbouring facilities or escalation
* Esso (5m - 30m tank diameters)	20m to 120m	50m to protected areas	No	-Cooling at adjacent facilities
* Amoco (8m-25m tank diameters)	30m-100m	50m to protected works	Yes	-Impact significant in case of bund fires and more than one tank fire. -Cooling necessary at adjacent facilities to prevent escalation.
I.C.I Australia (5m to 35m tank diameters)	20m to 130m	50m to protected works	No	Adjacent plants items should should be water cooled to prevent escalation.
Caltex, Banksmeadow Terminal (5m to 26m tank diameters)	20-100m	50m to protected work	No	-Botany Road affected.

TABLE 11(b)

CONSEQUENCE ANALYSIS - LP GAS AND OTHER LIQUIFIED FLAMMABLE GASES

Installation	Hazard Range to People			Standard Requirements	Are Residential Areas Affected?	Comments
	From Fireballs	From Explosions	Dispersion Range to LFL			
Boral Gas Limited (Proposed 4,500t)						
(a) Complete vessel failure (130 tonne content).	600m	-600m to 7kPa -1,200m to 3.5kPa	1,300m	-45m to protected works. -22m to public places.	Yes. LFL range could extend to residential.	-Adjacent facilities affected by explosions when releases in excess of 3-5 tonnes.
(b) Release of 5 tonne.	N/A	-160m to 7kPa. -270m to 3.5kPa.	350m		No	
P.D. Oil Chemical Storage (1,500t proposed)						-Complete vessel failure not credible because of mounding.
(a) Road Tanker failure (10 tonne).	200m	-200m to 7kPa -350m to 3.5kPa	-450m	N/A, as required by statutory authorities	No.	-Adjacent facilities could be affected by releases higher than 5 tonnes.
(b) Release of 5 tonne.	N/A.	-160m to 7kPa -270m to 3.5kPa	-350m			

Installation	Hazard Range to People			Standard Requirements	Are Residential Areas Affected?	Comments
	From Fireballs	From Explosions	Dispersion Range to LFL			
<u>I.C.I Hydrocarbon Storage, Port Botany (1,400t LPG refrigerated and 5,000t ethylene refrigerated)</u>				Not specified subject to approval by statutory authorities.	-For residential not to be affected releases in excess of 150 tonnes should not occur.	-For large releases higher than 10 tonne.
(a) 50 tonnes release	N/A	-320m for 7kPa -600m for 3.5kPa.	-810m			
(b) 10 tonnes release		-200m for 7kPa -350m for 3.5kPa.	-430m			
<u>Total Oil Refinery</u>						
-Proposed 400t spheres (on Bunnerong Power Station site)	700m to 900m	700m to 1,200m	1,500m (for 200t release)	-Subject to approval (greater than 75m)	Yes.	-Other plant items significantly affected.
-Existing 60t (along Bunnerong Road).	350m to 420m	350m to 650m	950m	-25m for 100 tonne vessel	Yes	
-5t release from storage or process	N/A	160m to 270m	330m	-	No.	-Plants significantly affected.

Installation	Hazard Range to People			Standard Requirements	Are Residential Areas Affected?	Comments
	From Fireballs	From Explosions	Dispersion Range to LFL			
<u>I.C.I. Australia Botany</u>						
-300 tonnes storage (Butane)	550m	700m to 1,150m	1,600m	-50m to protected works	Yes	-Potential effect on adjacent plant items.
-5 tonne release	N/A	160m to 270m	330m		If not ignited within plant boundaries.	

TABLE 11(c)

CONSEQUENCE ANALYSIS: TOXIC GAS RELEASE

Installation	Toxic Chemical Released	Hazard Range to people for:-		Are residential Areas Affected?	Comments
		Injury	Irritation		
Port Botany (P.D. Oil and Terminals) Tank roof or total tank failure/bund filled.	(i) Chloroform. (1m^3/sec)	1,000m (1,000ppm IDHL)	N/A	No	Slightly lower concentration could occur but would not have an effect upon people over an hour's exposure.
	(ii) Epichlorhydrin (0.05m^3/sec)	700m (100ppm IDHL)	N/A	No	
	(iii) Phosgene (from Epichlorhydrin fire) (1.09m^3/sec maximum)	1100m (25ppm)	3.5km (3-5ppm)	Yes	Buoyant gas, concentrations for worse weather conditions. Needs to be contained to smaller tanks.
I.C.I. Matraville (6 pressure vessels liquid	(a) Chlorine release -				
	(i) 3.6m^3/sec	1,000m (to 50ppm)	2,000m (to 15ppm)	Yes	Heavy gas, release

Installation	Toxic Chemical Released	Hazard Range to people for:- Injury	Irritation	Are residential Areas Affected?	Comments
I.C.I. cont. chlorine) pipework fracturing		450m (to 150ppm)			rate is too great.
	(ii) 1.2m^3/sec	450m (to 50ppm)	1,100m (to 15ppm)	Yes	Maximum release rate should be less than 1m^3 /sec.
		200m (to 150ppm)			
	(b) Anhydrous Hydrogen Chloride (HCL) - 3.1m^3 /sec	900m (to 50ppm)	1,900m (to 15ppm)	Yes	
Transport Terminals/	Chlorine (Pool) fires - 0.04m^3 /sec	100m (to 50ppm)	400m (to 15ppm)	No	Buoyant release.
Bayer Pty. Ltd.	Sulphur dioxide from pesticides on fire - 0.1m^3 /sec	500m (to 20ppm)	750m (to 10ppm)	Yes	Buoyant release - rapidly disperses mainly of irritant interest requiring prolonged exposure for injury (1/2 - 1 hour).

TABLE 12 : POTENTIAL FOR INCIDENT PROPAGATION WITHIN FACILITIES

Company / facility	Potential for Incident propagation	Source(s)/Comments
(a) Port Botany		
ICI - hydrocarbon terminal	-	
Terminals P/L	+	Between tanks/heat only
P.D. Oil and Chemical Storage	+	Between tanks/heat only
Boral Pty	- ++	For mounded situation For unmounded situation
Shell Consortium	-	
(b) Industrial Complex		
ICI - Botany	I	Within factories but low between factories
TOTAL Oil Refinery	++	Very high interaction
Caltex	+	Between tanks - fire only
Esso	+	Between tanks - fire only
Amoco	+	Between tanks - fire only
Total Distribution	+	Between tanks - fire only
BP	+	Minor in nature
H.C. Sleigh	+	Between tanks - fire only
A.C. Hatrick	-	factory type fire only
APM	-	due to paper combustion but very low.
Catoleum	-	factory type fire only

TABLE 12 (cont.)

Company / facility	Potential for Incident propagation	Source(s)/Comments
Kellogg	-	
Carba	-	
Johnson & Johnson	-	factory fire only - cotton
Wool Processors	-	Wool smoldering
Fibre Containers	-	due to cardboard combustion but very low
Bayer	+	very low probability
La Porte	+	but low probability
Liquid Air	+	explosion/oxygen fed fire but low probability.

Key:
- \- negative potential (i.e. less than probability of 50 x 10^{-6} for heat and explosion criteria)
- \+ positive potential (at or greater than 50 x 10^{-6} for heat and explosion criteria - 25kW/m^2 + 35 kPa)
- ++ very high potential (greater than 38 kW/m^2 and 35 kPa)

TABLE 13: REVIEW OF RECENT HAZARDOUS INCIDENTS IN THE STUDY AREA

3rd February, 1980

A shipment of pool chlorine stored at Mayne Nickless Transport Terminal began decomposing 3 days after exposure to rain causing a number of minor explosions and a chlorine gas release. The emergency services attended and rendered the situation safe but the incident recurred the following day from the same material.

2nd October, 1980

Major spillage of petrol which leaked from a pipeline owned and operated by Esso. Approximately 120,000 litres of petrol escaped into Springvale drain but did not enter Botany Bay. The area was closed for approximately 38 hours.

21st February, 1980

A small commercial aircraft crashed incinerating 13 people (no survivors) when it attempted to land after taking off on the east-west runway but failed to negotiate its safe return (subject of an inquiry).

2nd January, 1981

Some 2,000 tonnes of crude oil overflow from a ship being unloaded at the single buoy mooring for Total. Some oil contaminated the Bay.

28th January, 1981

I.C.I. developed an ethylene leak within its ethylene factory. The leak was estimated at about 3 tonnes. Ethylene vapour was dispersed by the use of a steam curtain as it travelled towards the boiler house.

6th April, 1981

Kellogg had a 1,400 litre leak of sodium hypochlorite solution from a fractured pipe. Unless heated, it is not anticipated to have presented a problem.

1st October, 1981

A combustion started on the afternoon of October 1st, 1981, at the Bayer Factory in Wilson Street, Botany, of a pesticide (Azinphos-methyl) which released concentrations of what appears to be sulphur dioxide, carbon monoxide and mercaptans. Mercaptans at very small concentrations produce extremely pungent odours which can be nauseating and can result in headaches well below the toxic threshold level.

21st January, 1982

Polythene fire at I.C.I., Botany - as the result of ignition of an organic peroxide catalyst. Fire took some three hours before being able to be controlled.

5th February, 1982

Lubricating oil additive blended at PD Oil and Chemical Storage Company, became solidified due to overheating. Cleanup operation on this date released obnoxious odours causing complaints from residents.

9th March, 1982

Polypropylene fire at I.C.I., Botany. Due to organic peroxide igniting during a supervised maintenance operation. This fire quickly spread initiating a leak of liquid propylene (1.5 tonnes) which was of major concern. Injuries in the form of burns were sustained by an operator and a foreman.

11th October, 1982

Road tanker carrying ethylene dichloride to Terminals Pty. Ltd. leaked contents. Vehicle stopped at Arncliffe. Approximately 90 litres of material leaked from a 20 tonne load.

14th November, 1982

Fire at Johnson and Johnson in the Radiation Plant of the factory from an electrical fault. No injuries and safety system operated as designed with fire being quickly contained.

26th March, 1983

Pipeline leak between Caltex and Total distribution terminal with an estimated 6,000 plus litres leaking. Port Road block to traffic. Pipelines 14 inches in diameter and 3 km in length. The leak was discovered by a railway engine driver.

TABLE 14

Proposed Designated developments due to hazard potential.

Industrial Premises upon which are either stored, processed, handled or distributed the materials of the following description and quantities:-

(a) Toxic gases being of Class 2.2 under the Dangerous Goods Regulations in excess of 2,000 kg in aggragate;

(b) Flammable gases of a compressed nature being of Class 2 under the Dangerous Goods Regulations in excess of 5 tonnes in aggragate other than those materials referred to in sub-clause (c) below;

(c) Liquified flammable gases being a compound or a mixture of compounds having two, three or four carbon atoms in its structure in excess of an aggragate water capacity of 15kl;

(d) Flammable liquids being of Classes 3.1, 3.2 and 3.3 under the Dangerous Goods Regulations in excess of 1,000 tonnes in aggragate;

(e) Organic peroxides being of Class 5.2 (Category A, and C) in excess of 5 tonnes aggregate;

(f) Ethylene oxide or Propylene oxide in excess of 1 tonne individually;

(g) Explosives being of Class 1 under the Dangerous Goods Regulations having an aggregate of 1 tonne TNT equivalent in store;

(h) Highly reactive substances being of Class 4 in excess of 100 tonnes aggragate; and

(i) any highly toxic material likely to be lethal to a human if assimilated in quantities of less than one milligram (being more than 100 grammes in aggregate storage capacity).

TABLE (15)

LP GAS: COMPARISON OF CODE REQUIREMENTS AND HAZARD ANALYSIS CONSIDERATIONS

Vessel Capacity (tonnes)	AS 1596 Distance to protected works (includes schools, hospitals, residences)	Hazard Range to people from fire-balls (1/2 tank capacity).
0.5	3m	50m
1.0	6m	60m
3.8 (7.5kl)	10m	110m
5	11m	120m
10	15m	155m
20	17m	210m
25	17m	220m
50	20m	300m
100	25m	390m
250	45m	560m
380	60m	660m
500	75m	750m

TABLE 16

LIMITATIONS ON POPULATION DENSITIES IN THE NEIGHBOURHOOD OF SMALL LP GAS STORAGE AND DISTRIBUTION FACILITIES (SERVICE STATION) IN THE NETHERLANDS

Safety Distance (metres)	Maximum allowable Number of single detached houses
0-25m	0
25-50m	2
50-100m	8
100-150m	15
greater than 150m	no restriction

* No schools, hopsitals, churches allowed within 150m.

TABLE 17

POSSIBLE ORDER OF RESPONSE, BRIGADE VEHICLES AND MANNING TO AN EMERGENCY SITUATION AT PORT BOTANY

STATION	MANNING
Matraville	Station Officer and 2 men
Maroubra	Station Officer and 2 men
Botany	Station Officer and 5 men
Alexandria	Station Officer and 4 men (Telesqirt)
	2 men (Salvage)
Mascot	Station Officer and 3 men (Foam pump)
Randwick	Station Officer and 4 men
Headquarters	Station Officer and 5 men
Headquarters	2 men (Ladders)
Redfern	Station Officer and 4 men
Newtown	Station Officer and 4 men
Glebe	2 men (Snorkel)
Marrickville	Station Officer and 3 men (Snorkel)
Stanmore	Station Officer and 4 men (Telesqirt)
Glebe	Station Officer and 3 men
Woollahra	Station Officer and 3 men
Woollahra	2 men (Ladders)
Rockdale	Station Officer and 2 men
Darlinghurst	Station Officer and 4 men
Kogarah	Station Officer and 4 men (Telesqirt)
The Rocks	Station Officer and 3 men
Bondi	Station Officer and 3 men

Extra appliances available if circumstances are such that they are needed.

Waterloo	Breathing apparatus van
	Lighting vehicle
Drummoyne	Station Officer and 3 men (Foam)
Silverwater	Station Officer and 3 men (Foam)

TABLE 18: <u>PIPELINES WITHIN THE BOTANY/RANDWICK INDUSTRIAL COMPLEX AND PORT BOTANY</u>

PIPE LINE	PIPE DIA	SERVICE	PIPELINE OWNER	LENGTH METRES	TYPE OF INSTALATION. (Buried (B), Aboveground (A) or Submarine (S)
A	350	GASOLINE	AOR	1830	B & A
B	200	JET FUEL	AOR	1830	B & A
C	300	WHITE OILS	AOR	1830	B & A
D	200	BLACK OILS	AOR	1830	B & A
E	250	WHITE OILS	TOTAL	2440	B
F	250	WHITE OILS	AMOCO	585	B
G	250	WHITE OILS	CALTEX	370	B
H	150	GASOLINE	CALTEX	770	B
I	100	NAPTHA	CALTEX	500	B
J	300	WHITE & BLACK OILS	AMOCO	2440	B
K	300 200	BLACK OILS	TOTAL BORAL		S & B
L	450 300	WHITE OILS	TOTAL BORAL	1370	S & B
M	550	CRUDE	TOTAL BORAL		S & B
N	200	GASOLINE	TOTAL	1460	B & A
O	150	DISTILLATE	TOTAL BORAL	2195	B & A
P	150	GASOLINE	TOTAL BORAL	670	B
Q	200	GASOLINE	H.C. SLEIGH	120	B & A
R	150	DISTILLATE	H.C. SLEIGH	120	A

TABLE 18: PIPELINES WITHIN THE BOTANY/RANDWICK INDUSTRIAL COMPLEX AND PORT BOTANY

PIPE LINE	PIPE DIA	SERVICE	PIPELINE OWNER	LENGTH METRES	TYPE OF INSTALATION. (Buried (B), Aboveground (A) or Submarine (S)
S	150	WHITE OILS	CALTEX	180	A
T	150	WHITE & BLACK OILS	CALTEX	180	B
U	150	DISTILLATE	AMOCOL	5101	B
V	150	JET FUEL	TOTAL BORAL	3096	B
W	200	NAPTHA	AOR	1830	B
X	100	LPG	TOTAL BORAL		A
Y	100	NAPTHA	TOTAL BORAL		B
Z	80	WHITE OILS	TOTAL BORAL		B
AA	250	GASOLINES	AOR		S
BB	250	JET A1	AOR		S
CC	300	WHITE OILS	AOR		S
DD	200	BLACK OILS	AOR		S
EE	200	JET A1	CALTEX	8860	B & A
FF	250	WHITE OILS	ESSO		B
GG	100	LPG	TOTAL BORAL		S & B
HH	80	NAPTHA	AOR		S
II					
JJ	150	NAPTHA	CALTEX		
KK	150	WHITE OIL	CALTEX	365	B

TABLE 18: PIPELINES WITHIN THE BOTANY/RANDWICK INDUSTRIAL COMPLEX AND PORT BOTANY

LL					
MM	150	NAPTHA	ICI	700	A
NN	200	GENERAL	AOR HC SLEIGH	850	B
OO	300	HFO	CALTEX		B
PP	300	HFO	CALTEX		B
QQ	200	DFO	CALTEX		B
RR	200	JET A1	SHELL		B
SS	350	GENERAL	S.M.P.		B
TT	500	CRUDE	SHELL		B
UU	250- 300	CAUSTIC SODA	ICI	3.2km	A + B
VV	100	BUTANE LIQUID	ICI	850	A
WW	100	PROPANE LIQUID	ICI	750	A
XX	150	ETHYLENE VAPOUR	ICI	700m	A
YY	914 365 324 89	CRUDE OIL	AOR	APPROX. 2km	S

TABLE 19: COMPANIES REQUIRING A COMPREHENSIVE SAFETY REVIEW AND HAZARD AUDIT

ICI Operations (Australia Chlorine Plant)	- Botany
Amoco Australia	- Botany
A.H. Hatrick	- Botany
Total Oil Refineries Ltd	- Matraville
B.P. Australia Ltd	- Botany
Total Distribution Australia Ltd	- Botany
H.C. Sleigh	- Matraville
Bayer Australia	- Botany

TABLE 20: COMPANIES IN NEED OF A DETAILED FIRE SAFETY STUDY

- Total Oil Refineries Ltd - Matraville
- ICI Operations (Australia) Ltd - Botany plants
- Total Distribution Australia Ltd - Botany
- B.P. Australia Ltd - Botany
- Amoco Australia Ltd - Botany
- Esso Australia Ltd - Botany
- APM - Banksmeadow
- H.C. Sleigh - Matraville
- Bayer Australia - Botany
- A.C. Hatrick - Botany

TABLE 21

GENERALISED ASSESSMENT OF EMERGENCY PROCEDURES IN THE STUDY AREA

Installation	Emergency Plan Submitted			Results of Assessment (see Appendix H for details)
	Yes	No	Comment	
Esso		*		. Plan needs to be extensively revised and co-ordinated. . General principles are covered. . Plan lacks roles and responsibilities.
Amoco		*		. Urgent need to formalise a comprehensive emergency plan in view of risks associated with this terminal and associated impacts on residential areas.
H.C. Sleigh		*		. Procedures need to be extensively revised and expanded. Existing plans inadequate.
B.P.		*		. Formalised procedures must be prepared and implemented.
Total Distribution		*		. Co-ordinated procedures needed. Preferably a combined BP/Total plan.
Ampol		*		. No response to survey received.

Installation	Emergency Plan Submitted			Results of Assessment (see Appendix H for details)
	Yes	No	Comment	
Caltex	*			. Procedures are adequate Regular updating recommended.
ICI - Port	*		Plans for the LPG storage tanks currently under construction being formulated.	. Procedures for existing installation adequate. . Recommended to co-ordinate existing and proposed installation into one plan and regular updating.
P D. Oil & Chemical	*			. Procedures adequate. . Regular updating recommended.
Terminals Pty. Ltd.	*		Plans being further updated at present in view of proposed expansion.	. Procedures adequate. . Recommended to co-ordinate existing and proposed procedures into one overall plan.
Proposed Boral Gas Ltd.		*	Will be formulated if approval granted.	. Procedures need to be formalised prior to the commencement of any operations.
ICI Australia Ltd.	*			. Individual plans for various plants generally adequate. . Updating recommended in view of additional expansions. . Strong recommendation to formulate an overall co-ordinated plan for the whole site.

Installation	Emergency Plan Submitted			Results of Assessment (see Appendix H for details)
	Yes	No	Comment	
Total Oil Refinery	*			. Plans inadequate and need updating urgently in view of high risk impact.
A C Hatrick	*			. Overall review strongly recommended in line with the guidelines formulated. Plans lack co-ordination.
Catoleum	*			. Generally adequate recommended to review certain aspects in lines with the guidelines.
Bayer		*		. Major deficiency in lack of emergency planning. . Comprehensive plans should be formulated as soon as possible if operations are to continue on the site.
Collie		*		. Formalised procedures are urgently needed.
Johnson and Johnson	*			. A more comprehensive overall plan needs to be formulated in line with the guidelines.
La Porte	*			. Adequate. Certain aspects need to be included to make a more comprehensive plan.

Installation	Emergency Plan Submitted			Results of Assessment (see Appendix H for details)
	Yes	No	Comment	
Australian Paper Manufacturers	*			. Adequate. Needs to take into account potential hazards from neighbouring installations.

Table 22