NSW GOVERNMENT
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Land Use Safety Study

Kurnell Peninsula

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Kurnell Peninsula Land Use Safety Study

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Foreword

The Kurnell Peninsula is an area of national importance. In addition to its historic significance, the peninsula includes a residential village as well as an industrial zone that encompasses a number of critical industrial sites.

Comprehensive cumulative risk assessment studies of the Kurnell Peninsula were conducted by the former Department of Environment and Planning in the late 1980s. These studies were used to assist State and local planning authorities in their consideration of land use safety aspects of residential and industrial development.

The Sydney Regional Environmental Plan (SREP) No. 17 – Kurnell Peninsula, 1989 requires the risk assessment study reports to be taken into account in the assessment of development applications in the area covered by the Plan.

Since then, risk assessment techniques and tools have further developed, community perception and acceptance of risk has changed and industrial facilities have been modified.

The Department of Planning has now completed a new Land Use Safety Study of the Kurnell Peninsula to take account of these changes. It confirms the validity of the earlier work and provides a basis for informed decision-making for the benefit of industry and the residents in the Kurnell Peninsula.

I am pleased to release the final report of the study and am confident that it will provide a valuable resource for planning authorities, the Kurnell community as a whole and developers.

SHaddad

Sam Haddad
Director General

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Background

The Kurnell Peninsula, in the Shire of Sutherland, covers 2000 hectares bounded by the Tasman Sea and Botany Bay. It is an area of national importance as the landing place of Captain Cook, a prominent suburb of Sydney containing a fine wetlands system, as well as the Kurnell Village, housing over 2000 people and an industrial zone that encompasses a number of important industrial facilities.

In this diversity there is potential for land use conflict and development requires careful management to ensure the protection of heritage areas, environmentally sensitive areas and residential areas in proximity to potentially hazardous industries.

In 1986, the former NSW Department of Environment and Planning conducted a risk assessment study of the Kurnell Peninsula, which was updated in 1989. While the studies covered a number of industrial facilities, the focus was on the Caltex Refinery, portions of which are located in proximity to the Kurnell Village.

While it was concluded that the Refinery did not pose a significant risk to residential areas, the studies recommended that there be no further intensification of residential development in the Village.

Development in the Peninsula is controlled by Sydney Regional Environmental Plan (SREP) No. 17 – Kurnell Peninsula. A key provision of SREP 17 is that the council is required to consider the contents of the relevant risk assessment reports prepared by the Department before consenting to any development application to which the Plan applies.

Since 1989 there have been a number of changes in the industrial area as well as improvements in risk assessment techniques, safety management and emergency planning. Hence, an updated risk assessment has been carried out, focussing on fuel storage tanks located in proximity to residential areas.

Figure 1 shows the location of key features, while Figure 2 is an aerial photograph showing the Refinery and the nearby land uses.

Study Outline

The primary purpose of the current study is to assess the current risks from Caltex Refinery operations to existing and future residential land uses in the vicinity and provide recommendations for risk reduction and development control.

The study has four main components:

1. a risk screening, of the Refinery site as a whole, using risk approximation techniques to confirm the focus of the study on the large storage tanks and associated transfer pipelines at the northern end of the site;
2. a detailed analysis of hazards associated with the northern end of the site, possible accidents, their consequences and likelihood, together with a comparison against the Department’s risk criteria;
3. a review of safety management systems at the Refinery and emergency management arrangements for the Kurnell Peninsula; and
4. analysis of findings and formulation of recommendations.

During the course of the study there has been consultation with community representatives, Sutherland Shire Council, Caltex and relevant Government agencies.

All technical work was carried out by members of the Department's Major Hazards Unit.

Results and Recommendations

There are three main sources of risk from the Refinery:

1. fires from large crude oil and refined petroleum product storage tanks and associated transfer pipelines;
2. fires, explosions or toxic gas releases from processing areas; and
3. fires and explosions from large liquefied petroleum gas (LPG) storages.

Processing areas are located well away from residences and the large LPG storages are fitted with automatic water deluge systems to cool them in the event of external fire, as well as being separated from the residential areas. Risk screening shows that these two sources have a very low risk impact on the Kurnell Village.

Both the risk screening and the more detailed assessment of the fuel storage tanks close to the Kurnell Village show a very low overall level of risk to the public from the Refinery. The risk meets published Department of Planning criteria for both fatality risk and injury risk. Societal risk is negligible.

The risk screening results are shown in Figure 10 and Figure 11, while the results of the more detailed gasoline storage area risk assessment are covered in Figure 12, Figure 13 and Figure 14. The risk screening results are conservative.

Although some extreme events at the refinery have a potential to impact beyond the Refinery boundary, the likelihood of impingement on residential areas is very low. Nevertheless, the possibility of these and naturally occurring extreme events, together with constrained road access to the Kurnell Village for emergency response and evacuation, reinforces the long standing Departmental position that residential development in the Kurnell Village should not be intensified.

There have been a number of technical and safety management improvements at the Refinery since the 1986 and 1989 studies were conducted and the Department's review of the Refinery's safety management system shows it to be robust and effective.

Findings and recommendations are detailed in section 4 of the report and summarised below.

Key Findings

Public Risk

- Both individual fatality and injury risks meet current Department of Planning criteria:
  - no residential areas are exposed to a fatality risk higher than five in a million chances per year (well within the 10 in a million risk criterion for existing industry); and
  - no residential areas are exposed to an injury risk higher than 50 in a million chances per year (risk criterion for new industry).
- Societal risk is negligible.
- Notwithstanding the low level of risk, there are still opportunities for technical improvements, particularly in the areas of detection and containment of leaks of flammable material and fire fighting system integrity. These may further reduce the consequences and/or frequency of a major accident.

Safety Management

- The Refinery has a robust and effective safety management system, which has been recently enhanced by implementing a Process Safety Management Program to prepare for future NSW Major Hazard Facilities regulatory requirements.

Emergency Response

- Emergency access to the Kurnell Peninsula is constrained by the single, two-lane access road. This could present difficulties if large-scale evacuation becomes necessary, as a result of a major accident or extreme natural event, such as bushfire or inundation. Night time residential evacuation would be a significant challenge.

Land Use Planning

- Any increase in the residential capacity of the Kurnell Peninsula has the potential to hamper evacuation and emergency services access in the event of a major accident at the Refinery or extreme natural event.
- While public risk remains very low, there is a need for land use plans and policies to take account of these constraints.

Key Recommendations

Based on these findings, key recommendations are:

Risk Reduction

- The common bund sewer (Caltex Tanks 101 to 104) should be moved outside of the bund area and individual bund isolation provided.
- Fire protection systems should be installed on critical pipe systems (Tanks 101 to 104), such as motor operated valves, that are located inside the tank bund.
- A fixed foam monitor/system should be considered along the main pipe way between Gate 5 and near the transfer pumps.
- Installation of leak, heat or smoke detectors in tank bunds and along pipe ways, where fires could have an offsite impact, should be considered.
- The effectiveness and integrity of leak detection and water deluge systems on the LPG storage vessels should be re-examined.

Safety Management

- The Department of Planning should continue to monitor the status of the Refinery's safety management system to ensure it remains fit for purpose.

Emergency Response

- There should be ongoing consultation between the local emergency services agencies and the planning authorities, whenever significant changes to land use or emergency response arrangements are proposed, to ensure emergency arrangements remain appropriate.
- Evacuation options from the Kurnell Village should be further considered, in particular, the viability of evacuation by sea.

Land Use Planning

- There should be no increase in residential capacity (i.e. no new land releases or subdivision) within the Kurnell Village.
- Sutherland Shire Council should specifically consult with the Department of Planning before approving any significant new development within 500 m of the Refinery boundary.
- The assessment of major new developments or land releases anywhere on the Kurnell Peninsula should take into account the need to ensure adequate road access in times of emergency, particularly access to the Kurnell Village.

1 Introduction

1.1 Background

From the 1970s, environmental and safety awareness has been progressively raised by a number of reported major industrial accidents. This has been accompanied by recognition of the limitations of engineering safety controls when applied in isolation. In response, tools, such as hazard analysis and quantified risk assessment have been developed as decision making tools for land use planning. Their use involves a formal identification of the relevant hazards and an estimation of the risk level through consideration of the likelihood and possible consequences of hazardous incidents.

The approach acknowledges that risks can never be eliminated completely. However, an understanding of the nature and extent of risks can provide a basis for the development of land use strategies and controls that will ensure that risks are appropriately managed. The availability of systematic assessment techniques enables an educated debate leading to judgements as to the tolerability of the residual risk to the broader community.

Since the early 1980s, The Department of Planning (the Department) and its forbears have developed, implemented and maintained leadership, both nationally and internationally, in risk assessment and management. This has been applied through the planning and assessment process and in regional risk studies for major industrial areas such as the Botany/Randwick industrial complex, Port Botany and Kooragang Island.

While the main emphasis has been on the control of new potentially hazardous development, there is a growing understanding of the need for land use planners to also control development in the vicinity of such facilities, through strategic planning and assessment of individual proposals.

As part of this process, a comprehensive cumulative risk assessment study of the Kurnell Peninsula was conducted by the then Department of Environment and Planning in 1986 and updated in 1989. The significance of this study is discussed in section 1.5.

1.2 The Kurnell Peninsula

The Kurnell Peninsula, in the Shire of Sutherland, covers 2000 hectares bounded by the Tasman Sea and Botany Bay. It is an area of national importance, as the landing place of Captain Cook, and contains a fine wetlands system, residential village housing over 2000 people and an industrial zone occupied by a number of important industrial facilities.

In this diversity there is potential for land use conflict and development requires careful management to ensure the protection of heritage areas, environmentally sensitive areas and residential areas in proximity to potentially hazardous industries.

Figure 1 shows the location of key features, while Figure 2 is an aerial photograph focussing on the Refinery and the nearby land uses.

Figure 1: Kurnell Map Showing the Refinery

Figure 2: Kurnell Aerial Photograph

1.3 The Caltex Refinery

Of the existing industrial sites on the Kurnell Peninsula, the Caltex Refinery is the largest.

The Refinery, which was commissioned in 1956, is the largest Refinery in NSW and the second largest in Australia. It has a throughput capacity of approximately 20 million litres of crude oil per day to produce a range of products that include petrol (gasoline) (50%), diesel (22%), jet fuel (15%), fuel oil (5%), liquefied petroleum gas (LPG) (4%) and bitumen (1%). The facility also produces lubricating oil, waxes, process oils and sulphur. The Refinery operates 24 hours a day, 365 days per year.

The crude oil feed stock is offloaded from marine tankers at a berth in Botany Bay and is transferred by mainly underground pipelines to storage tanks at the Refinery. The products from the Refinery are also piped below Botany Bay to distribution depots in Banksmeadow as well as piped to ships at the Kurnell Wharf. Caltex owns and operates a 200 km pipeline between the Kurnell Refinery and the Wickham terminal in Newcastle. This pipeline is used to transfer fuel products such as petrol, diesel and jet fuel. A relatively small number of road tankers transport selected products directly to users from the Refinery.

1.4 Planning Context

Residential and industrial developments were established in the Kurnell peninsula in an incremental manner through the mid 1900s, facilitated by the opening of Captain Cook Drive, which was constructed in parallel with the Refinery.

The relative closeness of some parts of the Kurnell Village to the Refinery reflects common practice at that time to locate housing so as to provide ready access to places of employment.

In the 1950s, land use safety concepts were not well understood and development planning and approvals did not always take land use safety conflicts into consideration. This situation was not unique to the Kurnell Peninsula, but applied in a number of residential/industrial suburbs throughout Sydney and other industrial cities in NSW. The Botany/Randwick area in Sydney and Newcastle/Kooragang Island are typical examples.

Most residential development is on the eastern side of the Peninsula between Quibray Bay and Botany Bay and extends to the boundary of the industrial zone, including a number of residential lots along Cook Street and Reserve Road that are in close proximity to the oil Refinery.

Industrial activities in the Peninsula include the Caltex Refinery, a brick plant, a carbon black plant and a large hydrocarbon storage and processing plant. A jetty and moorings, used for the transfer of crude oil and refined products to and from ships, are associated with the oil Refinery. There are also a number of light industrial operations such as a boat builder, small factories and a sewerage treatment plant.

In addition to these industrial operations, there is a sand mining operation south of Quibray Bay and small oyster farm leases in Woolooware Bay and Quibray Bay.

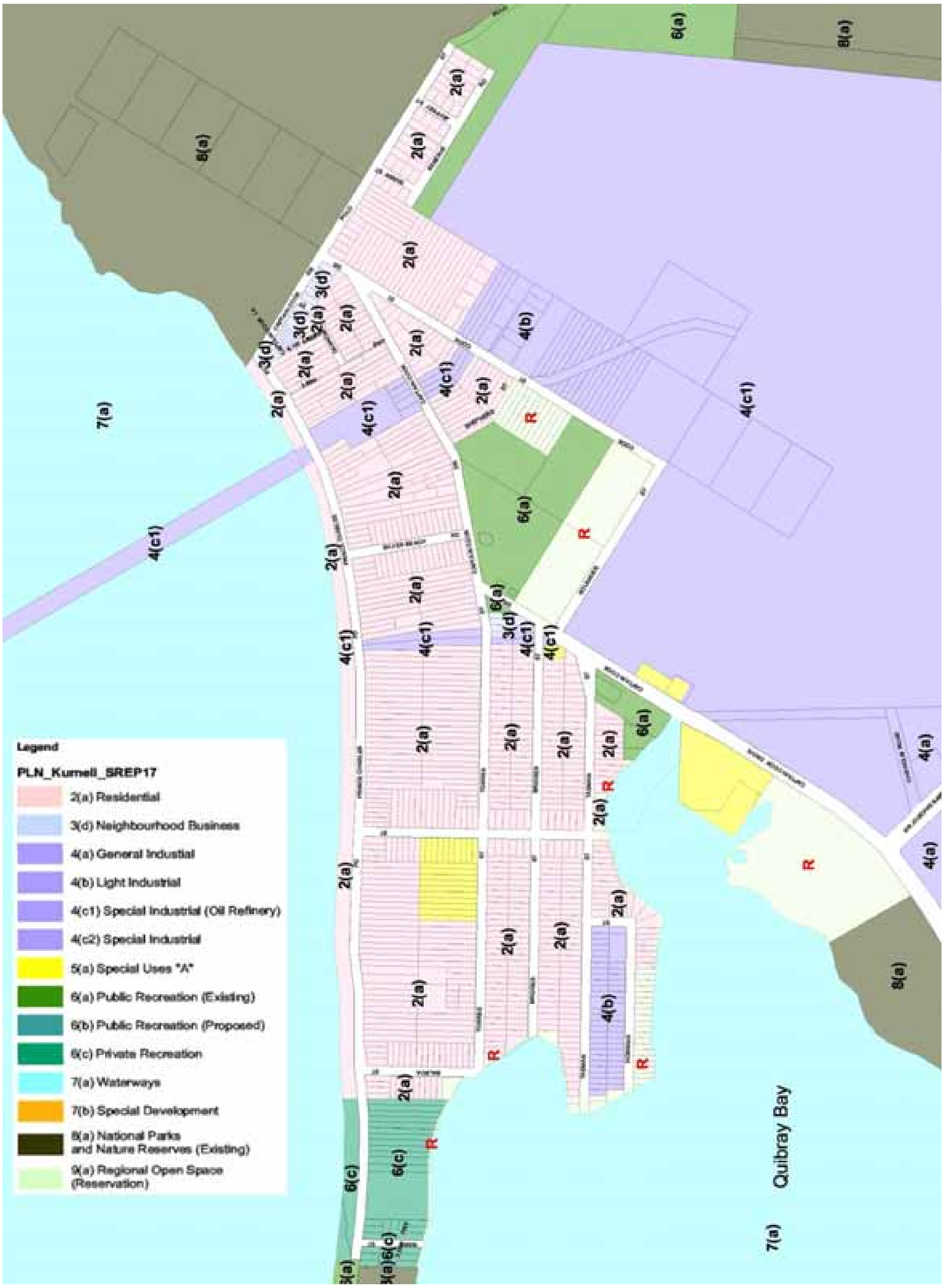
A number of other industrial operations that existed on the Peninsula in the 1970s and 1980s have been closed and several blocks of land zoned industrial remain vacant.

The only land access to the Peninsula is via Captain Cook Drive, a road with only one lane in each direction.

Development in the Peninsula is controlled by Sydney Regional Environmental Plan (SREP) No. 17 – Kurnell Peninsula, which has as a key aim ‘to conserve the natural environment of the Kurnell Peninsula and ensure that development is managed having regard to the environmental, cultural and economic significance of the area to the nation, State, region and locality.’

Figure 3 sets out the various zones in the vicinity of the Kurnell Village, as set out in SREP 17[1].

Figure 3: Kurnell Village Land Use Zones (SREP 17)



[1] Drawing is reproduced by courtesy of Sutherland Shire Council.

1.5 The Risk Context

1.5.1 The 1986 Risk Assessment Study

The findings and recommendations of the 1986 report and its 1989 update have formed the basis for land use safety planning in the area since that time.

The main finding of the 1986 study was:

> *The results of the overall risk analysis for the existing major industries on the Kurnell Peninsula are that, on a combined probability and consequence basis, risk levels from fire and explosion are within acceptable limits. Some areas of residential development immediately adjacent to the Refinery would be affected by fire or explosion only on a worst possible case basis.* (Page 47 – 1986 report.)

Other findings were:

- Heat radiation effects to residential areas from tank, pool or jet fires at the works [Refinery] are confined to an area near the gasoline storage tanks at the north-eastern boundary of the Refinery. In this area the 12.4 Kw/m^2 heat flux level could extend marginally beyond site boundaries and the 4.7 Kw/m^2 level up to approximately 80-100 m beyond site boundaries. However, even in these areas the potential for significant impact is low, and on a risk basis, individual fatality risk levels are below the $1X10^{-6}$ person/year criteria. (Page 13 – 1986 report.)
- However, while fire heat radiation is at most only a limited concern, smoke from such fires or from major fires elsewhere in the Refinery could require evacuation from these areas or other parts of the village if prevailing winds were towards the village, and certain other (adverse) meteorological conditions applied. (Page 13 – 1986 report.)

The report assessed the potential hazards and the risks from other parts of the Refinery and other industries in the Peninsula at the time and reached the conclusion that:

> *on a combined probability and consequence basis, risk levels from fire and explosion are within acceptable limits.*

The report also assessed the overall emergency management arrangements for the Peninsula as well as the safety management systems of the main industrial sites with a view to identifying opportunities for improvements and for the reduction of risk levels.

The study was updated in 1989. The 1989 report, which broadly supported the earlier findings, stated:

> *Cumulative risk levels of existing industrial operations (in terms of both consequences and probabilities of incidents) of up to the one in a million per person per year fatality risk are generally localised in the immediate surrounds of the Refinery. Risk levels from that Refinery are comparatively lower than those associated with other refineries of comparable size.* (Page 12 – 1989 report.)
>
> *The one in a million cumulative risk level (relevant to residential development) extends northward into some areas of the Kurnell village and westward some 150 meters into the 4(a) Abbott land.* (Page 12 – 1989 report.)

In addition to specific recommendations aimed at improving safety in existing industrial facilities, improving transport and access to, and from, the Peninsula and improving emergency planning and management, the 1986 report recommended that no intensification of residential development in the Kurnell village should take place. In providing a rationale for this recommendation, the 1986 report stated:

> *While the risk levels are acceptable on a cumulative basis for the village, emergency planning considerations and the consequences of certain incidents suggests that*

> *there should be no further intensification of residential development in the village area.* (Page 48– 1986 report.)

This view was further reinforced in the 1989 report which stated:

> *Furthermore, the review found that certain accidents at the Refinery, although unlikely and of low probability would, if they occur, affect a larger area of the Kurnell village as well as an area of 500 m in width of the Abbott's land opposite Sir Joseph Banks Drive. Efficient emergency and evacuation procedures will be essential in the case of such accidents….Increasing population density in the village or within the 500 m zone of the Abbott land will be incompatible with emergency planning requirements and will place excessive pressure on emergency infrastructure.* (Page 4 – 1989 report.)

In response to these findings and the recommendations in both the 1986 and 1989 reports, SREP 17 1989 included a clause requiring the council to consider the contents of the relevant risk assessment reports prepared by the Department before consenting to any development application in the Peninsula.

1.5.2 The Current Review

Since the publication of the 1986 and the 1989 study reports, risk assessment techniques and tools have further developed, community perception and attitudes to the acceptance of risk have changed and approaches to land use planning have been refined.

In view of the significant time that has elapsed since the earlier studies were conducted, the Department has updated the risk study for the Peninsula, focussing on the level of risk posed by the Refinery to the Kurnell Village, scope for further safety improvements and the need for ongoing development controls.

2 Study Description

2.1 Objectives

The primary purpose of the current study is to assess the current risks from Caltex Refinery operations to existing and future residential land uses in the vicinity and provide recommendations for risk reduction and development control.

The study:

- identifies existing and potential future residential land around Caltex Refinery that may be impacted by the operation of the Refinery, especially the gasoline storage tanks situated near the north-west boundary of the Refinery;
- assesses the risks to the identified residential areas affected; and
- provides policy advice to the Department of Planning and to the Sutherland Shire Council on future development and on land use safety issues in the area.

2.1.1 Study Deliverables

The main project deliverable is this report, which includes:

- results of a risk screening study carried out to confirm the scope of the study;
- a summary of identified scenarios and consequences from the portion of the Refinery within the study area;
- individual fatality and injury risk contours;
- recommendations for safety improvements at the Refinery to minimize the risks;
- identified risk-related constraints to future developments in the area;
- recommendations/advice regarding development control; and
- recommendations for further work.

2.2 Scope

The findings of the 1986 study and the 1989 update indicated that the overall risk level from the [at the time] existing major industries on the Kurnell Peninsula was within acceptable limits. However, the study identified some residential developments immediately adjacent to the north-west boundary of the Refinery to be potentially affected on a worst case basis. As a result, in order to focus efforts on key areas, this study concentrates on that portion of the Kurnell Refinery and its surrounds in which risk from the Refinery has a potential to impact on current and potential future residential and sensitive land uses.

While the study mainly covers the north-western storage portion of the Refinery site, which is in proximity to existing and potential future residential areas, a risk screening assessment has also been carried out for the site as a whole.

The main study area is shown in the aerial photograph in Figure 4, which indicates the location of the gasoline storage tanks at the northern end of the Refinery and the nearby residential area.

Figure 4: Aerial photograph showing residential area closest to the Refinery

2.3 Project Organisation and Management

Sam Haddad (Director General, Department of Planning) had overall responsibility and accountability for the study. Dr Derek Mullins (Director, Major Hazards Unit) led the project team, supported by members of the Unit.

Sutherland Shire Council and Caltex were consulted in relation to technical and planning aspects of the study, respectively. Discussions were also held with other relevant government agencies. These included the Department of Environment and Conservation (DEC), WorkCover NSW, the NSW Fire Brigades, the Department of Energy, Utilities and Sustainability (DEUS) as well as the Department of Planning regional office.

Local community groups were consulted during the study and issues raised were considered in finalising the report.

The study results and draft recommendations were documented in a consultation draft report. Stakeholders were invited to comment on the draft report before finalisation and a public meeting was held to give further opportunity for community feedback.

This final report takes account of comments received during the consultation period.

Officers of the Major Hazards Unit have independently undertaken all main project tasks, including the collection and analysis of relevant data, the modelling of risks and the drafting of the findings and recommendations.

Policy recommendations, particularly as regards strategic land use safety planning have been developed in consultation with the departmental Sydney Region East planning team and planning officers of the Sutherland Shire Council.

Issues of security and confidentiality of information have been respected in the consultation and documentation phases of the project and drafting of the report.

2.4 Timing

2.4.1 Main Tasks

The main project tasks, identified in consultation with the Department, Sutherland Shire Council and Caltex were:

1. obtain initial information on Refinery activities to allow risk screening to be conducted;
2. conduct a screening risk assessment for the whole Refinery to confirm the identification of Refinery hazards and residential areas where the potential for offsite effects exists;
3. refine the scope of the study, including the geographical scope, in consultation with Caltex and the Sutherland Shire Council;
4. identify key stakeholders in consultation with the Sutherland Council and Caltex and carry out initial community consultation;
5. obtain detailed technical information from Caltex;
6. visit the Caltex Refinery to confirm and clarify information provided;
7. conduct a comprehensive review of other relevant risk studies;
8. collate & analyse Refinery data, including relevant meteorological data;
9. carry out a detailed risk assessments for the hazards and areas identified in the previous step;
10. prepare an initial technical report, including fatality and injury risk contours and a review of societal risk implications, especially in relation to the north-eastern boundary of the Refinery;
11. where offsite risk is significant, discuss with Caltex the possible opportunities for further safety improvements and risk reduction;
12. undertake preliminary discussions with the Sutherland Shire Council to explore appropriate future development policies for the area;
13. prepare and present the draft findings to stakeholders;
14. obtain feedback from stakeholders regarding the draft report and refine the report based on feedback; and
15. produce and issue a final report, including recommendations for risk reduction and development control.

2.4.2 Study Timing

Based on an analysis of these tasks, it was originally anticipated that results would be available before the end of the 2005 Calendar Year. However, the need to further clarify some information delayed completion by about two months. The broad sequence of key milestones is summarised in Table 1.

Table 1: Project Milestones

Milestone	Completion Date
Planning for the project and preparation of a detailed brief	30/6/2005
Review of previous studies, including studies commissioned by the council and Caltex as well as the 1986 Departmental study and 1989 update	10/7/2005
Initial consultation with stakeholders	5/8/2005
Obtain detailed data about Caltex Operation and visit the Caltex Refinery to verify/obtain further details.	18/8/2005
Conduct detailed analysis of data and quantitative risk assessment	25/11/2005
Consider practical and policy implications of risk results	25/11/2005
Review safety management and emergency response aspects	25/11/2005
Collate initial study results for consultation with Stakeholders	2/12/2005
Update calculations, consider recommendations and prepare draft report prior to public consultation	15/2/2006
Stakeholder consultation on draft report	March to August 2006
Finalise report following stakeholder feedback	October 2006

2.5 Methodology

2.5.1 Introduction

Once initial gathering of basic data had been completed, the study had four main components:

- risk screening to direct the focus of the assessment towards those activities with a significant potential to impact the surrounding community;
- detailed risk assessment of activities identified as potentially significant in the risk screening;
- assessment of organisational safety (safety management systems and emergency response); and
- summarisation of findings and recommendations in the areas of risk reduction, emergency management and land use controls.

These are discussed in the sections which follow.

2.5.2 Risk Screening

Risk screening uses approximation techniques to form a broad picture of the overall risk from an area and the main risk contributors. The technique is described in the Department's publication *Multi-level Risk Assessment*.

The technique, as published, is based on work carried out by the International Atomic Energy Agency (IAEA) and uses tables of material types and quantities, classes of activities and factors related to safety management and materials handling to estimate the risk.

The Department is further developing this approach in the form of a computer program, which is able to more closely model heat radiation from fires and explosions and present the results in the form of risk contours. Experience has shown good agreement with the results of more detailed analysis, using conventional techniques, as described in section 2.5.3. Screening results tend to be conservative (i.e. erring on the 'safe' side).

The risk screening considered all major storage tanks on the refinery site containing flammable and combustible fuel liquids, as well as liquefied petroleum gas (LPG) storages and the major processing areas.

In the case of the large floating roof storage tanks, the screening considered full surface roof top fires and full surface bund fires, which represent worst case scenarios. Major fuel transfer pipelines running from these tanks to the site boundary (at which point they pass underground) were also considered.

The screening results are shown in section 3.1.

2.5.3 Risk Assessment

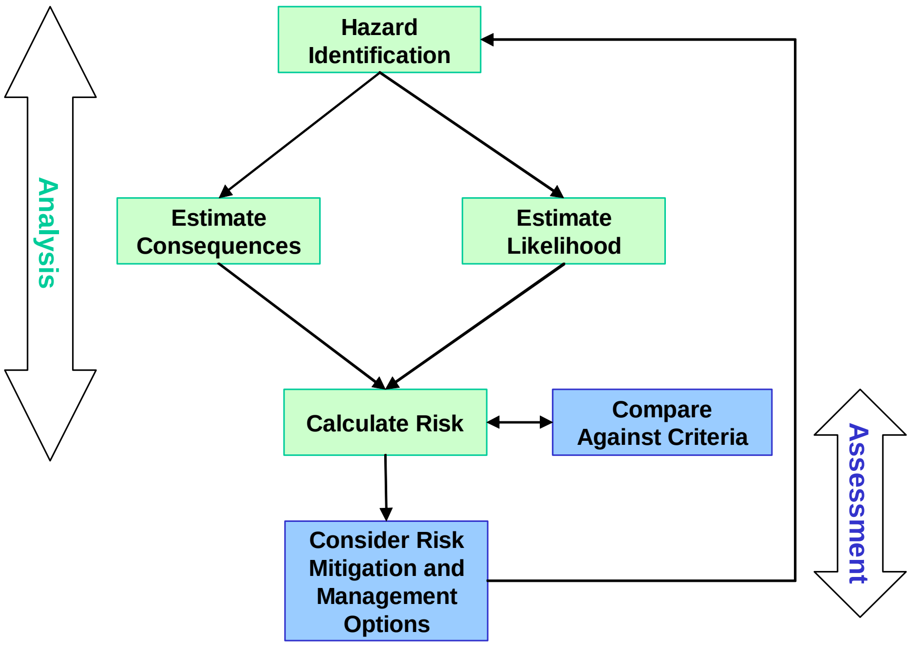
The purpose of a risk assessment is to:

- identify the potential hazards associated with the industrial operations;
- analyse the hazards in terms of their consequences (effects) and their likelihood of occurrence;
- quantify the analysis and estimate the resultant risks to surrounding land uses;
- assess the risks in terms of the location, land use planning implications and compliance with risk criteria and ensure that the safeguards are adequate; and
- demonstrate whether the operations impose an unacceptable level of risk.

The process of risk analysis and risk assessment is shown in Figure 5. Risk criteria for land use safety planning are discussed in section 2.5.4.

The techniques used in carrying out a hazard analysis are described in greater detail in the Department's Hazardous Industry Planning Advisory Paper (HIPAP) No. 6.

Figure 5: The Risk Analysis and Assessment Process



These components are described in the following paragraphs.

2.5.3.1 Hazard Identification

Hazard identification involves the systematic identification of hazardous events, their potential causes and the consequences (in qualitative terms) of such events. Consideration is also given to the proposed operational and organisational safeguards that would prevent such hazardous events from occurring or, should they occur, that would protect the plant, its equipment, people and the environment. This process enables the establishment, at least in principle, of the adequacy and relevancy of proposed safeguards.

The Department's publication *Applying SEPP 33* provides screening guidelines to assist in determining whether hazardous development poses significant risks to surrounding land uses. Risks identified as having significant offsite impacts may require more detailed, quantitative analysis, according to multi-level risk assessment.

In the case of the Caltex gasoline tanks, the main hazards arise from ignition of accidental product releases, which may occur during blending or transfer operations or during static storage.

Releases may range from minor vapour emissions from floating roof seals to major losses due to rupture of a tank or pipeline. Table 3 of section 3.2.1 summarises the main hazards identified in the study.

2.5.3.2 Consequence Estimation

Consequence estimation relates to the assessment of the effects of potentially hazardous incidents associated with the operations of a proposed development. Mathematical models and computerised tools are available to enable the estimation of the effect of such incidents as fires, explosions or the release of toxic substances on the people, buildings and the environment.

In the case of the Kurnell Refinery, the main consequence is that of heat radiation arising out of fires in the storage tank areas. The Department has used detailed computer modelling software, which has been validated against actual heat radiation measurements, to estimate these effects.

In the case of gasoline and other petroleum products, the effect distances are significantly less than might be expected, due to the smoky flames produced by such fires.

This is illustrated in the following photographs. Figure 6 shows a large alcohol (ethanol) storage tank fire, burning intensely and with little smoke, while Figure 7 shows a large gasoline storage tank fire, which is much less intense and accompanied by heavy smoke. Fire-fighters are able to stand relatively close to the tank in the second example.

Figure 6: Large Ethanol Tank Fire[2]

Figure 7: Large Gasoline Tank Fire[3]

It is essential to recognise that some hazardous incidents, while possible, may in fact never occur during the operating life of the development. This is because of the availability of design and construction standards and other operational safety controls aimed at preventing their occurrence. Estimating consequences is therefore not in itself sufficient for determining the level of risk from a facility.

The assessment process must, however, fully account for the likelihood or probability of hazardous incidents occurring, as well as for the likelihood of the effects of such incidents being realised. Likelihood estimation is therefore also necessary.

[2] Courtesy NSW Fire Brigades.

[3] Courtesy UK Institute of Chemical Engineers (IChemE).

2.5.3.3 Likelihood Estimation

Likelihood estimation involves the derivation of both the probability of incidents occurring and the probability of particular outcomes (or effects) should those events occur. For example, in the case of toxic gas storage, probability of failure of items such as storage vessels, transfer pipes and pumps with the resultant releases should be established. The frequency of such elements as wind and stability conditions is also necessary to determine the probability of concentrations in the air or water, and hence of fatality, injury or other effects of exposure of people or the environment.

Due to the low frequency of major accidents, it is often necessary to indirectly estimate accident frequencies using equipment failure frequency statistics and techniques such as fault and event tree analysis.

While these techniques have been used in this study, a substantial amount of historical information on large floating roof storage tank fires is available through the LASTFIRE project.

The LASTFIRE Project

Recognising the need to have validated data on the risks associated with fires in large, open top floating roof storage tanks, 16 major international oil companies joined together to form a project group to thoroughly investigate these facilities. The project was known as LASTFIRE**.**

The Project was initiated due to the oil and petrochemical industries' recognition that the fire hazards associated with such tanks, although known to be relatively low, were insufficiently understood to be able to develop fully justified site specific fire response and risk reduction policies. Open top floating roof tanks, introduced to reduce evaporative losses of product to atmosphere, had always been recognised within the industry as having a relatively good fire incident record when compared to other types of facility. However, the associated risk had not been sufficiently quantified.

From studies of incident histories and industry experience, the credible types of incident scenario were identified along with potential escalation consequences to life safety, the environment, business interruption, asset value or other issues such as public image or insurance costs.

The study enabled the determination of:

- dominant ignition mechanisms;
- frequencies of initial fire events;
- effectiveness of detection and protection systems and fire fighting techniques; and
- estimates of asset loss and incident response.

The statistics in the study were used as a basis for estimating the frequency of large diameter storage tanks fires at the Caltex Kurnell Refinery, as set out in section 3.2.3.

2.5.3.4 Overall Risk Estimation

The consequence and likelihood estimations are cumulatively combined for the various hazardous incident scenarios and events to give a *quantified risk* level. Detailed quantified risk assessment need only be performed if the results of the risk screening indicate this is warranted.

In calculating risks to people at a particular location, the modelling took into account wind and weather patterns as well as the probability of death or injury at various levels of heat radiation. The weather data for Kurnell are summarised in Appendix 2.

Risk results are most commonly expressed in terms of human fatality. The analysis and results can, however, also be expressed in other terms such as levels of injury, property damage or environmental damage.

Human fatality risk results are expressed in two forms, individual risk and societal risk. Individual risk is the risk of death to a person at a particular point. Societal risk takes account of the risk of a multiple fatalities occurring from single incidents.

The societal risk concept is based on the premise that society is more concerned with incidents which kill a larger number of people than incidents which kill fewer numbers.

Risk criteria are summarised in section 2.5.4.

2.5.4 Risk Criteria for Potentially Hazardous Development

Risk criteria for land use safety planning are set out in the Department's Hazardous Industry Planning Advisory Paper (HIPAP) No. 4.

2.5.4.1 General

In assessing the tolerability of risk from potentially hazardous development, both qualitative and quantitative aspects need to be considered. Relevant general principles are:

- the avoidance of all *avoidable* risks;
- the risk from a major hazard should be reduced wherever practicable, even where the likelihood of exposure is low;
- the effects of significant events should, wherever possible, be contained within the site boundary; and
- where the risk from an existing installation is already high, further development should not pose any incremental risk.

Criteria are set conservatively, recognising that there is always a degree of uncertainty in the results of the risk analysis.

The main quantitative criteria considered are fatality, injury, property and environmental damage. The criteria most relevant to the study area are discussed below.

2.5.4.2 Individual Risk

Fatality (New Industrial Development)

Individual fatality risk is the risk of death to a person at a particular point.

For new industrial development, the Department has adopted a fatality risk criterion of one in a million per year (1×10^{-6} per year) for residential area exposure.

The residential risk criterion is demonstrably very low in relation to the background risk shown in Table 7. The criterion assumes that residents will be at their place of residence and exposed to the risk 24 hours a day and continuously day after day for the whole year. In practice this is not the case and these criteria are therefore conservative.

People in hospitals, children at school or old-aged people are more vulnerable to hazards and less able to take evasive action, if need be, relative to the average residential population. A lower risk than the one in a million criteria (applicable for residential areas) may be more appropriate for such cases.

On the other hand, land uses such as commercial and open space do not involve continuous occupancy by the same people. An individual's occupancy of these areas is on an intermittent basis and the people present are generally mobile. As such, a higher level of risk (relative to the permanent housing occupancy exposure) may be tolerated.

Table 2 summarises the preceding criteria for the various categories of land use.

Table 2: Individual Fatality Risk Criteria (new development)

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

Fatality (Existing Industrial Development)

While the above criteria were the target risk levels used at the time of the 1986 study, formal departmental guidelines issued in 1990, *Hazardous Industry Planning Advisory Paper No. 4: Risk Criteria for Land Use Safety Planning* (HIPAP 4), recognized that these were not necessarily appropriate for existing situations.

The guidance notes in HIPAP 4 on the implementation of the criteria state (in part):

> *The implementation of the risk criteria should differentiate between existing land use situations and new situations in terms of applicability to reflect a tighter locational and technological standard applying now than at earlier times…*
>
> *The criteria suggested in these guidelines apply to new industry and surrounding land use proposals. In theory they should apply to existing situations, but this may not be possible in practice.*
>
> *For existing situations, an overall planning approach is necessary. In terms of criteria, the following principles should apply:*
>
> *The 1×10^{-6} individual fatality risk level is an appropriate criteria within which no intensification of residential development should take place. Safety updates/reviews and risk reductions at facilities where resultant levels are in excess of the 10×10^{-6} individual fatality risk level should be implemented to ensure that operational and organisational safety measures are in place to reduce the likelihood of major hazardous events to low levels.*

The guidelines recognise that, while risks should always be reduced as far as possible (the principle of *avoiding avoidable risk*), formal risk reduction measures are not warranted unless the risk of fatality in residential areas exceeds 10 in a million per year.

Injury Risk

Relying entirely upon fatality risk criteria may not account for the following factors:

- Society is concerned about risk of injury as well as risk of death.
- Fatality risk levels may not entirely reflect variations in people's vulnerability to risk. Some people may be affected at a lower level of hazard exposure than others.

It is therefore appropriate that risk criteria also be set in terms of injury, i.e. in terms of levels of effects that may cause injury to people but will not necessarily cause fatality.

Heat Radiation

Table 9 in Appendix 1 indicates the effects of various heat fluxes (radiation) as the result of a fire incident. The ultimate effect would depend on the duration of people's exposure to the resultant heat flux.

For the purpose of injury, a lower heat radiation level (relative to that level which may cause fatality) is appropriate. The 4.7 kW/m heat radiation level (see Table 9) is considered high enough to trigger the possibility of injury for people who are unable to be evacuated or seek shelter. That level of heat radiation would cause injury after 30 seconds' exposure. Accordingly, a risk injury criterion of 50 in a million per year at the

4.7 kW/m heat flux is suggested. The Department's experience with the implementation of that criterion indicates that it is achievable and appropriate.

The suggested injury risk criterion for heat radiation is that incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m at a frequency of more than 50 chances in a million per year.

Risk of Property Damage and Accident Propagation

The siting of a hazardous installation must account for the potential of an accident at the installation causing damage to buildings and propagating to a neighbouring industrial operations and hence initiating further hazardous incidents - the so-called 'domino effect'. The siting process must also account for existing risk conditions at the proposed site.

The principle of setting risk criteria to reflect the potential for accident propagation is that the risk of an accident at one plant triggering another accident at another neighbouring plant should be low and that adequate safety separation distances should be provided as part of siting and layout of plant and equipment.

Heat radiation levels of 23 kW/m^2 as the result of fire incidents at a hazardous plant may affect a neighbouring installation to the extent that unprotected steel can suffer thermal stress that may cause structural failure. This may trigger a hazardous event unless protection measures are adopted.

The criteria for risk of damage to property and of accident propagation are as follows:

- Incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations should not exceed a risk of 50 in a million per year for the 23 kW/m^2 heat flux level.
- Incident explosion overpressure at neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings should not exceed a risk of 50 in a million per year for the 14 kPa explosion overpressure level.

These criteria do not remove the need to consider higher consequence levels at lower frequencies. The hazard analysis should consider the whole picture, not just the nominated quantitative criteria.

2.5.4.3 Societal Risk

Developing criteria on tolerability of risks for hazards giving rise to societal concerns is difficult. Hazards giving rise to such concerns often involve a wide range of events with a range of possible outcomes. The summing or integration of such risks, or their mutual comparison, may call for the attribution of weighting factors for which, at present, no generally agreed values exist as, for example, the death of a child as opposed to an elderly person.

The Department has provisionally adopted indicative criteria as shown in Figure 9 for addressing societal concerns arising when there is a risk of multiple fatalities occurring in one event. These were developed through the use of so-called FN-curves (obtained by plotting the frequency (F) at which such events might kill N or more people, against the value of N).

The suggested criteria take into account the fact that society is particularly intolerant of accidents, which though infrequent, have a potential to create multiple fatalities. The criteria are broadly consistent with those adopted in a number of other jurisdictions and have been refined by consideration of the results from land use safety studies conducted by the Department in and around the industrial installations in the Port Botany and Botany/Randwick industrial areas.

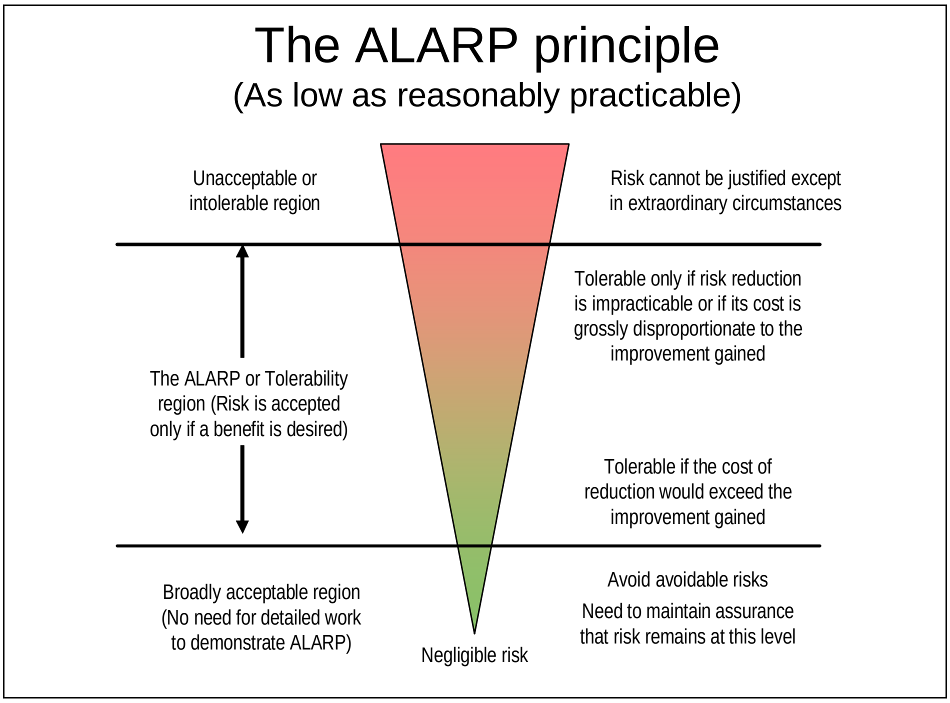
The indicative societal risk criteria incorporate an ALARP (As Low As Reasonably Possible) approach.

The ALARP Principle

ALARP is a principle that may be applied in relation to the degree of risk reduction that may be sought from a particular activity.

The concept is illustrated in Figure 8.

Figure 8: Applying ALARP

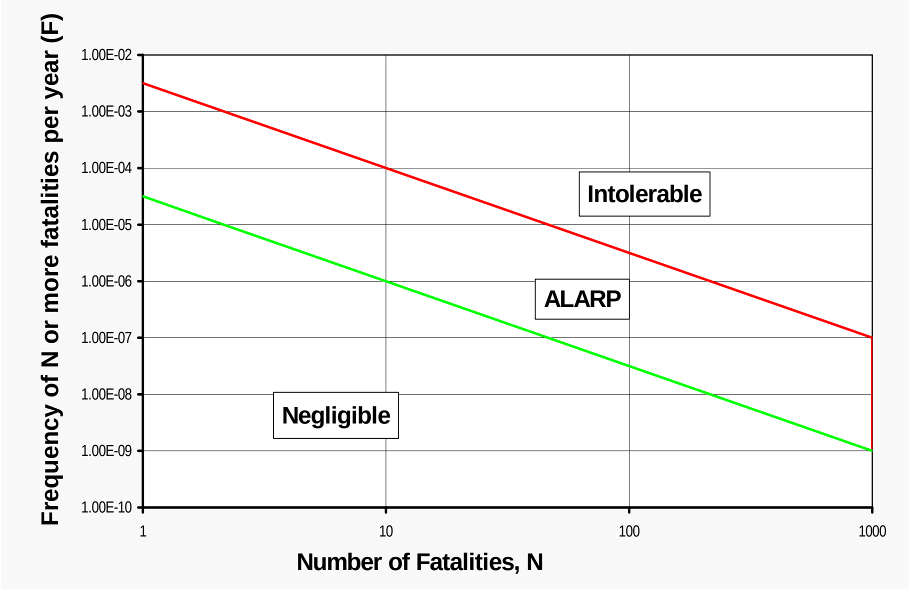


It should be noted that, irrespective of numerical risk criteria, the broad aim should be to *avoid avoidable risk*.

The indicative societal risk criteria reflect these regions as three societal risk bands: negligible, ALARP and intolerable, as shown in Figure 9.

It should be emphasised that the criteria in Figure 9 are indicative and provisional only and do not represent a firm requirement in NSW.

Figure 9: Indicative Societal Risk Criteria



Below the negligible line, provided other individual criteria are met, societal risk is not considered significant. Above the intolerable level, an activity is considered undesirable, even if individual risk criteria are met. Within the ALARP region, the emphasis is on reducing risks as far as possible towards the negligible line. Provided other quantitative and qualitative criteria of HIPAP 4 are met, the risks from the activity would be considered tolerable in the ALARP region.

2.5.4.4 Development in the Vicinity of Potentially Hazardous Industry

Ideally, the risk from potentially hazardous facilities, especially those with a potential for a major accident, should be controlled to such a degree that there need be no restriction on surrounding development on safety grounds. In practice, however, elimination of risk is seldom possible and development controls need to be established to ensure that new development in the vicinity does not increase overall risk by increasing the degree of exposure to the consequences of major accidents.

While the suggested risk assessment criteria set out in section 2.5.4.2 directly apply when assessing the land use safety implications of industrial development, they are also relevant to the considerations of land use safety and development in the vicinity of potentially hazardous facilities.

The following criteria should be read in conjunction with the discussion in section 2.5.4.2.

Individual Fatality Risk

The individual risk criteria relating to risks to residential and sensitive land uses from new industry proposals are significantly more stringent than those which apply to less sensitive uses, such as industrial and commercial activities.

Consequently, while existing industry should ideally meet the same residential and sensitive land use criteria as new proposals, it is recognised that this may not be possible in practice. The following principles apply to residential and sensitive use development in the vicinity of existing industry:

- the half in a million per year individual fatality risk level is an appropriate criterion above which no intensification of sensitive use development should take place; and
- the one in a million per year individual fatality risk level is an appropriate criterion above which no intensification of residential development should take place.

Individual Injury Risk

In the case of proposed development for residential and sensitive uses, possible injury and irritation impacts should also be considered. The suggested criteria are as for new industrial development.

2.5.5 Safety Management

A review of the Refinery safety management system (SMS) was also carried out. In addition to considering safety management measures applicable to the gasoline storage and handling areas, it also considered the overall site SMS, covering such areas as:

- safety management policy and review;
- hazard identification and risk assessment;
- fire safety assessment;
- risk minimisation;
- process safety information;
- operating procedures;
- safe work practices;
- equipment integrity;
- management of contractors;
- management of change;
- training, learning and development;
- emergency planning;
- accident/incident investigation and reporting;
- consultation with employees;
- consultation with the community;
- consultation with local emergency services;
- consultation with government agencies
- facility security; and
- assurance (monitoring and review).

An overview of the outcomes of the review is given in Section 3.3.

2.5.6 Emergency Management and Response

The 1986 and 1989 report identified the potential for a major accident to impact on emergency response, especially an emergency requiring the mass evacuation of residents in the Kurnell Village. The potential arises from two factors:

- Road access to the Kurnell Village and the industrial facilities in the Peninsula is through one two-lane road, Captain Cook Drive. The 1986 report stated: *Emergency access to the peninsula and evacuation is constrained by the one access route. Safe evacuation areas should be identified as a priority in the absence of alternative route access.* (Page 48 – 1986 report.)
- In case of an incident at the Refinery, the smoke from the resultant fire could make it desirable to evacuate areas surrounding the Refinery as well as other parts of the Village. The 1986 report stated: *While fire heat radiation is at most only a limited concern, smoke from such fires or from major fires elsewhere in the Refinery could require evacuation from these areas or other parts of the village, if prevailing winds were towards the village.* (Page 13 – 1986 report.)

In identifying the two issues of difficulty of access and egress to the Village and the potential for the need to evacuate during a fire anywhere in the Refinery, the 1986/1989 reports concluded: *Efficient emergency and evacuation procedures will be essential in the case of such accidents…Increasing population density in the village or within the 500 m zone of the Abbott land will be incompatible with emergency planning requirements and will place excessive pressure on emergency infrastructure.* (Page 4 – 1989 report.)

The 1986 report made a number of recommendations in relation to emergency management at the Peninsula. The current study has reviewed the issues raised in the 1986 and 1989 reports.

The review involved consultation with the relevant agencies concerned with emergency planning for the Sutherland Shire, including the Kurnell Peninsula. The consultation focused on agencies that would be involved in responding to an emergency at the Refinery. An initial meeting was held with the District Emergency Management Officer, the Local Emergency Management Officer, the local commander of the NSW Fire Brigades and the local commander of the NSW Rural Fire Services. A follow-up meeting was held with these people as well as representatives of the NSW Ambulance Service and the NSW Police, who would be tasked with implementing an evacuation, should such a response be required.

The outcomes from these discussions are summarised in section 3.4.1.

3 Study Outcomes and Implications

3.1 Risk Screening

The results of the risk screening are shown in Figure 10 and Figure 11. As previously noted, the risk screening techniques tend to give conservative results and it would be expected that detailed analysis would show a lower risk (as confirmed later in the report). The sole purpose of the screening is to ensure that significant sources of risk are not overlooked.

The screening shows three main sources of risk from the Refinery:

1. fires from large crude oil and refined petroleum product storage tanks and associated transfer pipelines;
2. fires, explosions or toxic gas releases from processing areas; and
3. fires and explosions from large liquefied petroleum gas (LPG) storages.

Figure 10: Risk Screening Results - Individual Fatality

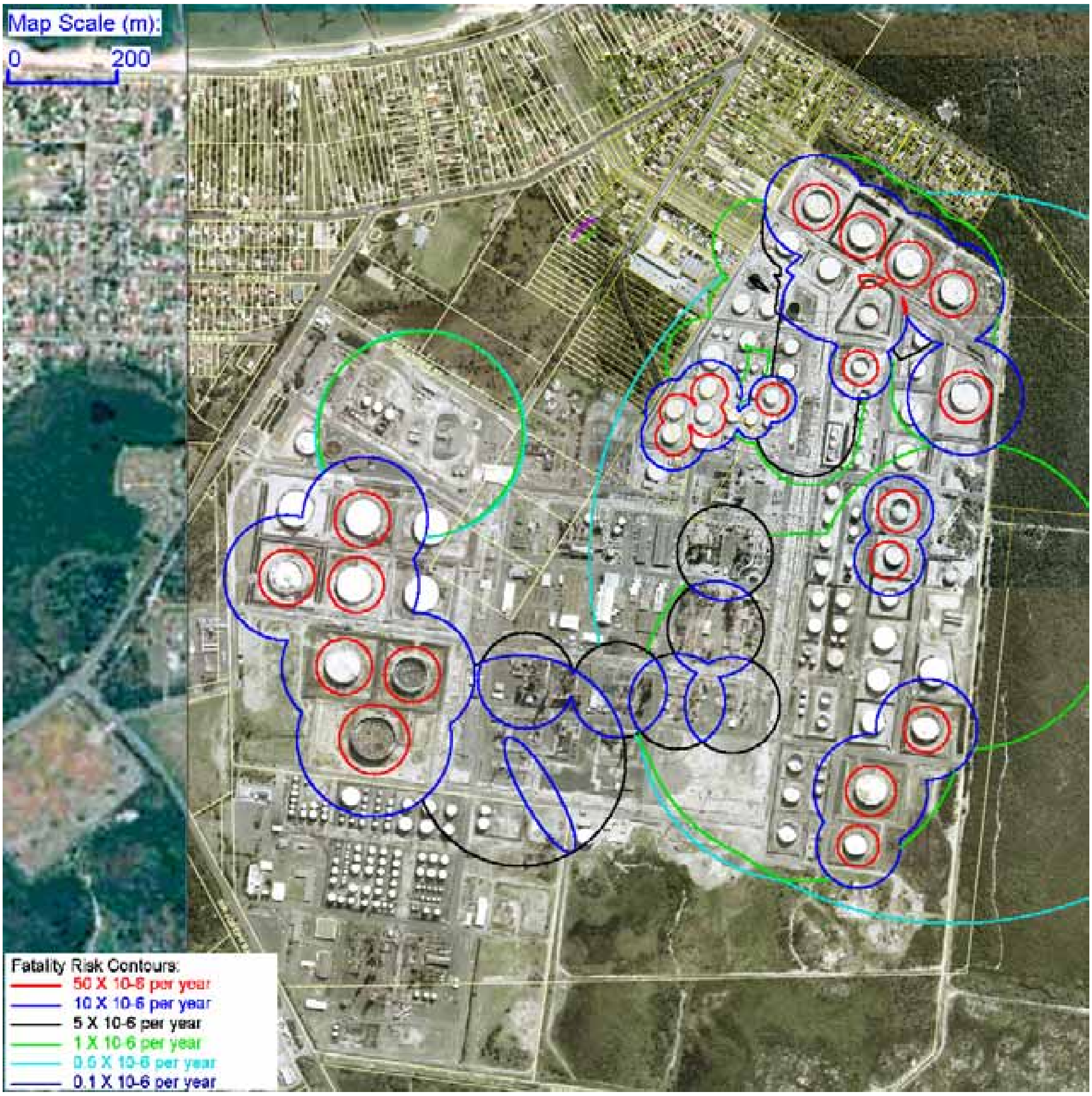
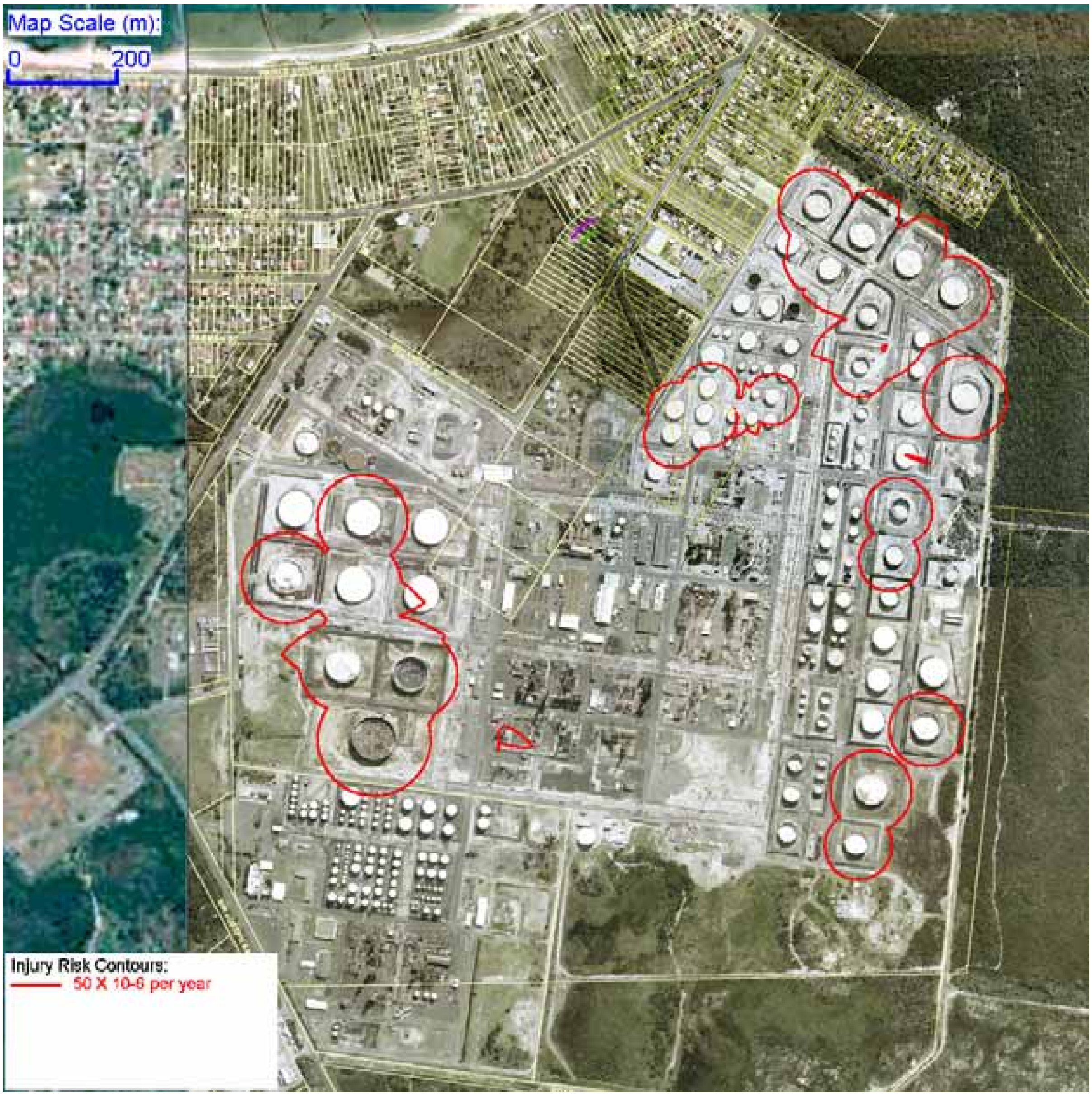


Figure 11: Risk Screening Results – Individual Injury



The above results, while approximate, show that significant impacts, other than very low frequency extreme events, are largely contained within the Refinery boundary and that only those fuel storage tanks and transfer pipelines at the northern end of the site have a potential impact in residential areas.

Hence, the detailed risk assessment focussed on this area.

The screening did show that BLEVE (Boiling Liquid Expanding Vapour Explosion) events associated with large LPG spheres could have impacts several hundred metres into the reserve to the east of the site, as well as into a small portion of residential land near the north-west corner of the site. However, these tanks are protected by automatically actuated water deluge sprays and actual fatality risks would be expected to be significantly below the already low level (0.5 in a million per year) shown in the screening.

Processing areas are located away from residences and potential impacts do not extend beyond the site boundary.

3.2 Risk Assessment

3.2.1 Hazard Identification

Hazard Identification was carried out by examining the various storage tank operations in the light of industry experience, drawing particularly on the review of accidents in the LASTFIRE Report.

The most relevant hazards are summarised in Table 3. A more detailed analysis, including prevention and protection measures is in Table 10 (Appendix 2).

Table 3: Summary of Identified Hazards

Area/Incident	Possible Initiation	Possible Consequences
Floating Roof		
Rim seal leak	• Lightning and electrostatic discharge	• Minor fire
Spill on roof	• Overfill • Corrosion or mechanical failure of tank roof • Roof drain failure	• Fire (effects within site boundary)
Full surface fire	• Escalation of rim seal fire or roof spill fire • Failure of roof leg pads • Damaged pontoon • Sinking of roof and ignition	• Fire • Fatality and injury
Explosion in a pontoon or other confined spaces	• Build up and ignition of flammable vapour following roof seal failure	• Fire • Fatality and injury
Bund (spill outside tank)		• Fire • Fatality and injury
Leak/Fire	• Product overflow • Corrosion of tank • Drain failure • Mixer Leak • Leak from pipe work, flange or valve • Hole in the tank – mechanical damage	• Fire • Fatality and injury
Pipelines		
Leak/Fire	• Pump seal failure • Flange failure • Corrosion	• Fire • Fatality and Injury

3.2.2 Consequence Evaluation

Three types of event have been identified as having potential significant offsite impacts extending into residential areas. These are:

- full surface fires on floating roof tanks;
- large bund fires; and
- leaks from large diameter above-ground fuel transfer pipelines.

In each case, the impacts are those of heat radiation from fires.

There is also a potential for heat radiation impacts from BLEVEs (Boiling Liquid Expanding Vapour Explosions) from fires on above ground LPG (propane, propylene or butane) storages.

However, these events are extremely rare and these storages are fitted with automatically actuated water deluge systems. The risk screening shows that BLEVEs do not contribute significantly to offsite risks.

Processing areas are well separated from residential boundaries and accidents in these areas do not have a significant offsite impact.

Table 4 shows typical heat radiation impacts from large storage tank fires. Distances are measured from the edge of the tank, pipeline or bund, as appropriate.

Table 4: Heat Radiation Impacts

Event	Distance to fatality (m) (approx 12.5 kw/m^2)	Distance to injury (m) (approx 4.7 kw/m^2)
Full surface fire (large storage tank)	5	35
Full bund fire (large storage tank)	8	70
Multiple bund fire (large storage tanks)	10	100
Fire from large transfer pipeline leak	60[4]	105

Because of their localised impact, consequence distances for rim seal fires, spill on roof fires and small to medium bund fires are not shown.

3.2.3 Accident Frequency

As noted earlier, the LASTFIRE study was used as a basis for estimating the large storage tank fire frequency at Kurnell.

Table 5 shows the generic event frequencies for fires other than rim seal fires.

Table 5: Generic Frequencies - LASTFIRE Report

Type of Fire	Base Frequency Per million tank years
Spill on roof fire	30
Small bund fire (mixers, pipes, valves or flanges)	90
Large bund fire (major spillage)	60
Full surface fire following sunken roof	30

It should be noted that one accident in the LASTFIRE survey designated a ‘large bund fire’ occupied a comparatively small fraction of the total bund surface area and, for the purpose of risk assessment, should be designated as a ‘medium bund fire’. The remaining ‘large bund fire’ covered about 80 percent of the bund surface area. However, it involved a comparatively small volume of fuel, which was spread by a large

[4] This is greater than for a bund fire, due to pool formation. Distances are measured from the pipeline, rather than the edge of the pool.

volume of applied fire-fighting water. This would be expected to occur in a minority of cases at Caltex, since foam is the usual medium for fighting bund fires, rather than water, which is used to cool adjacent tanks. Additionally, some accident causes relate to factors that do not apply to the Caltex tanks. A conservative estimate of large bund fire frequency is 15×10^{-6} per year.

Based on an analysis of the statistics in the LASTFIRE report, adjusted to be applicable to the Caltex Refinery large diameter tanks, representative accident frequency rates used in the risk calculations are set out in Table 6.

These frequencies take into account accidents involving product release, the likelihood of subsequent ignition and escalation of small initial fires into larger events.

Because of the time delays typically associated with ignition and escalation, these rates are conservative when used to calculate overall risks, since they do not make any allowance for escape during the period of fire build up.

Table 6: Tank Fire Frequency Rates Used in the Study

Event	Frequency in a million per year	Comments
Rim seal fires	5000	Small fires, which rarely escalate. These have no impact beyond the tank.
Full surface tank top fires	90	Roof sinking plus escalation from rim seal and spill on roof fires.
Small to medium bund fires	120	Caused by small to medium leaks from tanks, equipment or fittings. Considered small to medium if area less than 10 percent of bund area. Effects are largely contained within the bund.
Large bund fires	15	Based on the adjusted LASTFIRE report frequency. Caused by major tank or fitting failures or leaks.
Catastrophic bund fires	2	A four bund fire (tanks 101-104) caused by major rupture (based on industry failure frequencies).

The frequencies used are consistent with those derived from fault and event tree analysis.

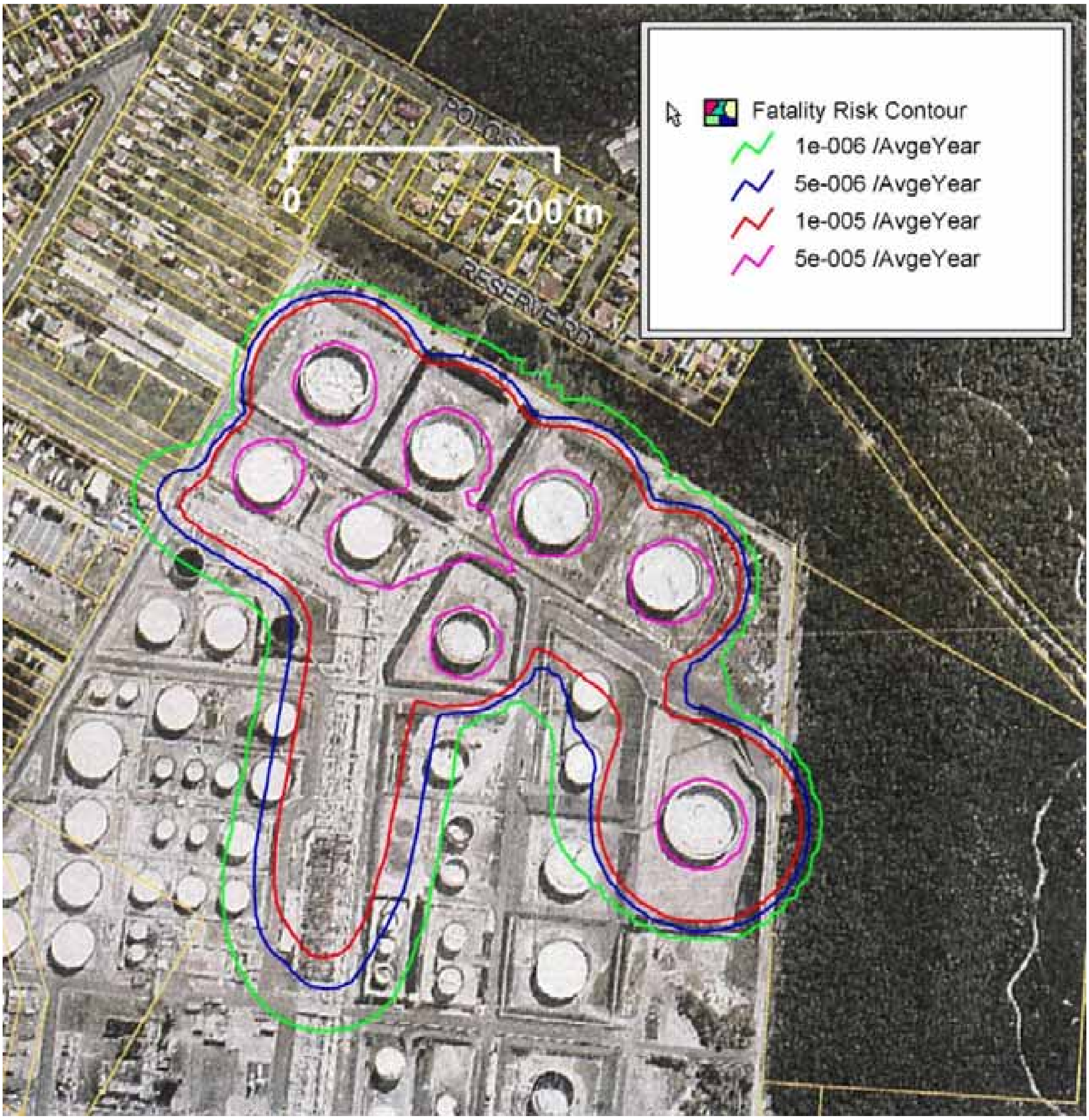
3.2.4 Overall Risk

Results and their implications are presented in sections 3.2.4.1 to 3.2.4.4.

3.2.4.1 Individual Fatality

The individual fatality risk results are presented in Figure 12 in the form of risk contours. The 50, 10 and five in a million per year fatality risk contours do not extend into any residential areas. The one in a million fatality risk contour extends slightly (approximately five metres) into the rear of some Cook Street residential properties. The highest risk level at a residential boundary is approximately three in a million per year.

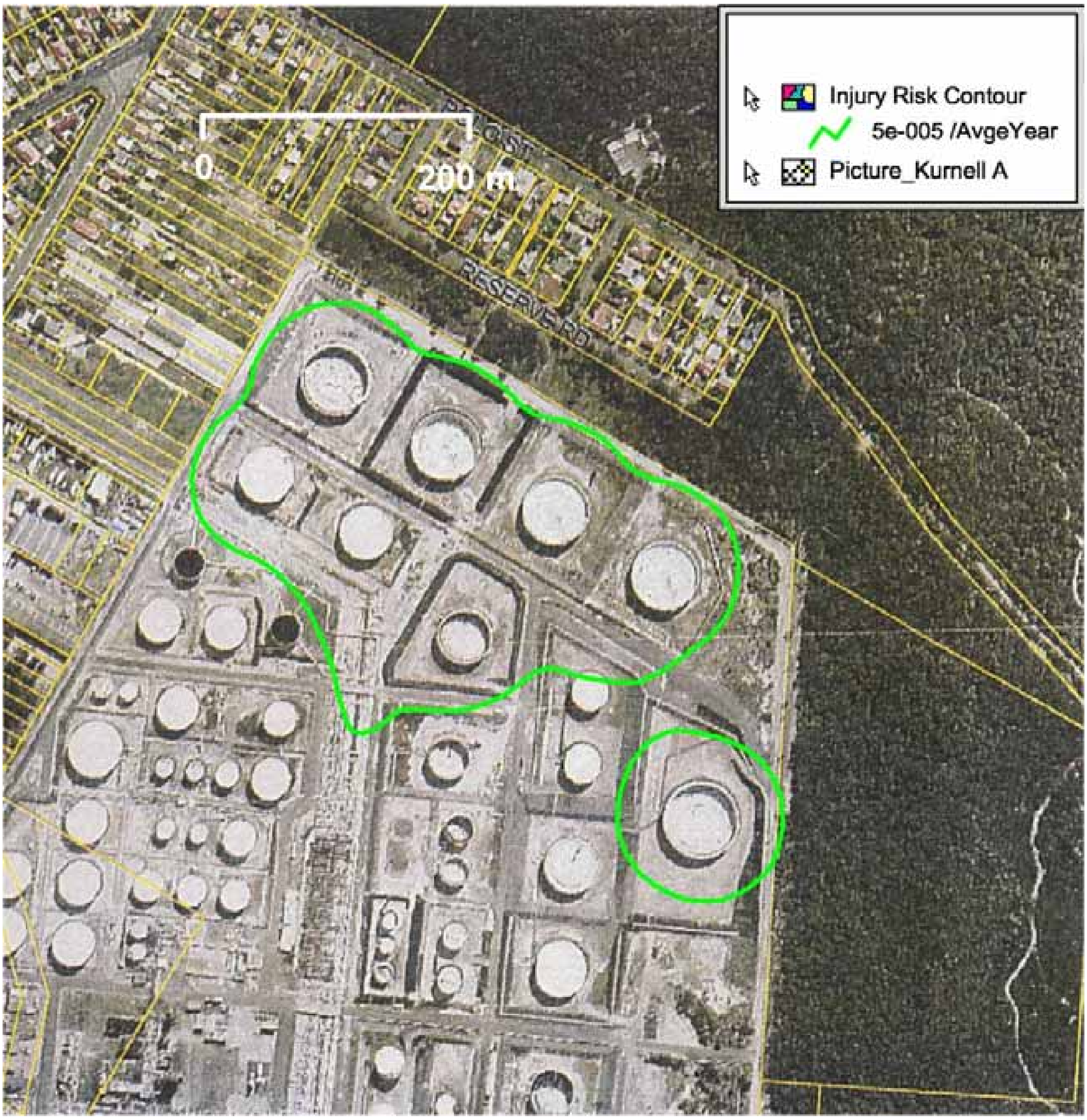
Figure 12: Individual Fatality Risk Contours



3.2.4.2 Individual Injury

The 50 in a million individual injury risk contour is presented in Figure 13. It does not extend into any residential area.

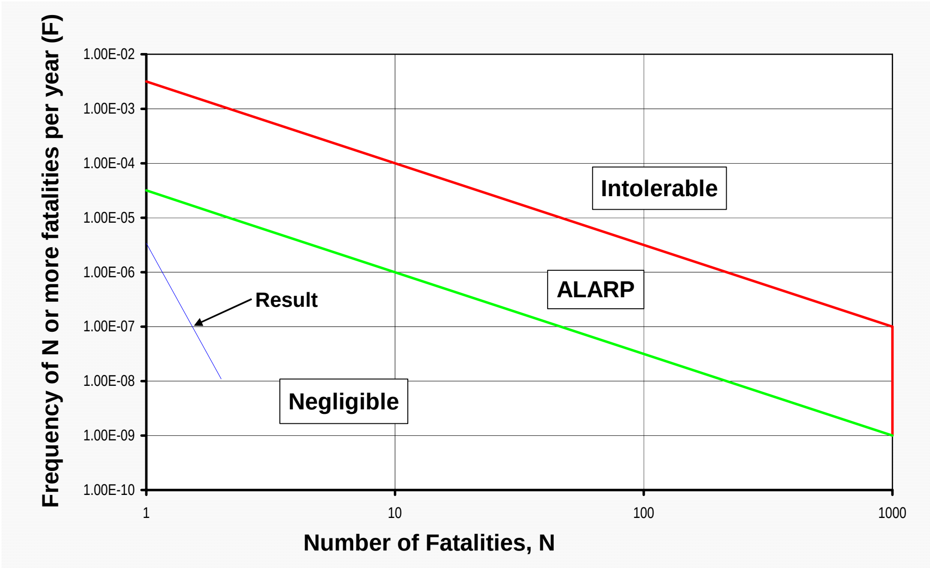
Figure 13: Individual Injury Risk Contours



3.2.4.3 Societal Risk

The societal risk results are shown in Figure 14. Results are compared with the Department's indicative societal risk criteria (see section 2.5.4.3). The results are in the negligible range.

Figure 14: Societal Risk



3.2.4.4 Overall Risks to the Public from the Kurnell Refinery

The results of the current study confirm the conclusion of the 1986 and 1989 studies that offsite risks from the Refinery do not extend significantly into residential areas. The Department's fatality risk criteria for risk exposure from existing industry are fully met.

The five and10 in a million per year individual fatality risk contours do not extend into any residential area.

For the most part, the one in a million per year residential fatality risk criterion applicable to new development is also met, the exception being at the rear of some properties in Cook Street. The one in a million per year individual fatality risk contour extends about 5 metres into properties close to Tank 101, as shown in Figure 12. No residences are affected.

The 50 in a million per year individual injury risk contour does not reach any residential area.

Risk Reduction

Notwithstanding the low level of risk, the principle of 'avoiding avoidable risk' needs to be applied through consideration of technical and management measures to reduce the frequency and impact of major accidents.

An examination of the risk results indicates that very large bund fires and fires from large transfer pipeline leaks have the greatest risk potential in the residential area. A number of possible ways of reducing these and other risks have been explored with Caltex. These include:

- Separation of bund drainage systems for Tanks 101 to 104 should eliminate the potential for a major spill in the bund to spread across all four bunds. This measure will reduce the magnitude of the worst case consequence. The worst case scenario will be reduced from a fire covering four bunds, to a fire covering a single bund, with the worst case impact zones reduced accordingly.

- Leak, heat and smoke detectors in areas close to the residential boundary, where fires could have offsite impacts, may improve the response time following a leak or the initiation of a fire;
- Installation of fire protection systems to critical pipeline components, such as motor operated valves, that are located inside the tank bund should increase the reliability of the valves under fires conditions and their ability to operate as required to minimise a release.
- Installation of a fixed foam delivery system on the Tanks 101 to 104, to the same design as that applied to the crude tanks, will improve the response time for application of foam for a rim seal fire. This will reduce the likelihood of escalation from a rim seal fire to a full surface bund fire. Consideration should also be given to remote line up and activation from a manned location (eg. OMC). However, a full surface tank fire only contributes to the risk relatively close to the tank, so this may not make a significant change to the risk in the residential areas.
- Installation of a fixed foam system with monitors along the main pipe way between Gate 5 and near the transfer pumps, and the provision of a foam/monitor system for the pipe way would enable a fire to be combated more readily. However, this may not significantly alter the risk results, as the fire and its impacts would already have occurred. For maximum effectiveness, a foam system would need to be combined with segregation of the pipe way to limit the spread of any release, hence making any fire easier to extinguish.

The consequences of major accidents associated with the LPG storages can extend well offsite, even though they do not contribute significantly to the overall risk because of their low likelihood. There may be opportunity to further reduce the risk from these events by further upgrading the existing leak detection and water deluge systems on these tanks.

3.3 Safety Management

Overall, the review indicated that the facility has implemented a robust safety management system which is being enhanced with a specific Process Safety Management Program to meet the requirements of the proposed Major Hazard Facility legislation in NSW.

The gasoline tanks have been designed and constructed in accordance with the American Petroleum Institute Standard API 650, while the inspection and maintenance program are in accordance with API 653.

The 100 series gasoline tanks (i.e. Tanks 101 to 105, which were the focus of the study) have had a cathodic protection corrosion system installed in the 1970s and 1980s. In addition to regular inspection of these tanks, a complete inspection and maintenance program in accordance with API 653 is implemented at scheduled turnaround inspection of the tanks. Magnetic particle inspection and ultrasound techniques are used during these inspections, as well as hydro-testing of the tanks and all lines.

All the 100 series gasoline tanks are grounded with 3–4 earthing rods as a protection measure against lightning. Further earthing is achieved by using shunts and straps to connect the floating roof to the shell of the tank.

All major transfer pipelines are subjected to regular inspection, including the use of ‘intelligent pigging’.

The maintenance of a robust safety management system at the Refinery is the key to the minimisation of risk to the public.

While the Refinery’s safety management system is considered to be effective, continuous monitoring and improvements are essential in ensuring a high safety standard.

The facility is subject to a number of statutory safety requirements, including the *Occupational Health and Safety Act 2000* and the Occupational Health and Safety Regulation 2001.

Furthermore, the NSW Government is in the process of introducing a regulatory framework for the control of Major Hazards Facilities, consistent with the National Standard for the Control of Major Hazard Facilities. Under this Standard, operators of such facilities are required to prepare and submit to Government a Safety Report. The Safety Report identifies hazards, assesses the risks associated with those hazards and describes the management system for managing those risks, particularly the risk of a major accident.

3.4 Emergency Management and Response

3.4.1 Current Situation

There have been a number of significant changes in emergency management and response arrangements in NSW since the 1986 and 1989 studies. In general, the current situation may be summarised as follows:

- Current arrangements provide for an ‘all agency’ response, requiring a coordinated response from a number of emergency services providers, including local councils, with defined roles and responsibilities.
- There is regular liaison between the agencies and between the agencies and the major industries in the district. A District Plan has been developed and is regularly updated.
- The Plan takes into account a range of emergencies relevant to the Kurnell Peninsula, including those arising from bushfire, flood and inundation.
- Additionally, a specific State plan for responding to an emergency involving Hazardous Materials, HAZMATPLAN, has been in place for a number of years and would be the main plan implemented should an incident occur at the Refinery.
- The agencies engage in regular exercises to test and improve their plans capabilities. While this study was being undertaken, a table top exercise and a field exercise were conducted to test the agencies’ response to a fire in a Refinery storage tank.
- Planning and training activities are well resourced in view of the range of hazards presented in the area. Bush fire and flood/inundation hazards need to be addressed as well as hazards associated with the Refinery and other industrial installations on the Peninsula.
- The Kurnell Peninsula is not part of the Sydney Fire District and fire fighting in the Peninsula is primarily the responsibility of the NSW Rural Fire Services.
- However, should a HAZMAT (i.e. hazardous materials) incident occur at the Refinery, it would be responded to by the NSW Fire Brigades operating from the Cronulla station.
- Access problems associated with the Peninsula identified in the 1986 report remain. The only road to the Peninsula is Captain Cook Drive. The road remains a two-lane road and there are no plans to widen it as it is currently considered to be impractical to do so.
- The Kurnell Peninsula presents particular challenges in the event a major evacuation should one become necessary:
  - A fire anywhere in the Refinery has the potential to produce large volumes of smoke, as shown in Figure 7 and noted in the 1986 study report. While this would be an unlikely event, depending on weather conditions and wind directions, a significant portion of the Kurnell Village may need to be evacuated.

- – The evacuation of nearby residents may be hampered by road congestion, if the Fire Brigades need to have access to a large scale fire at the north-west boundary of the Refinery.
- – With the possibility of extreme natural events and with the Refinery operating 24 hours a day, there is a potential for a difficult residential evacuation during the night or in partial darkness.
- – Should large numbers of people be required to be evacuated and should Captain Cook Drive prove to be inadequate for the process, there are back-up plans for evacuating the Village residents by boat from the boat ramp and beach.

3.4.2 Implications

While there are robust emergency management arrangements in place, the constraints associated with evacuation, discussed in section 3.4.1 remain a cause for concern to emergency response agencies. Night time residential evacuation is a particular concern. All agency representatives consulted confirmed the continuing validity of the 1986 study finding that the intensification of residential developments will exert unnecessary pressure on the emergency infrastructure.

Taking into consideration the single access road to the Peninsula and especially, the possible need to evacuate as a result of an emergency at the Refinery or an extreme natural event, future development will need to take account of current emergency management requirements for the Kurnell Peninsula as a whole.

3.5 Land Use Planning

The public risks from the Caltex storage tanks are low and meet NSW Government criteria. Nevertheless, risks can never be totally eliminated and, in the worst case, a major accident at the Refinery site may have significant impacts into the residential area.

Accordingly, it is appropriate that there should continue to be controls on the intensification of residential development. Given the restricted access to the Peninsula, emergency response and evacuation arrangements should not be hindered by increasing significantly the number of residents in the Kurnell Village.

Furthermore, no new development on the Kurnell Peninsula should compromise emergency access, including access to Kurnell Village

Again, it needs to be emphasised that this conclusion does not arise from a high level of risk but rather the need to make a responsible response to the possibility of extreme events, whether naturally occurring or arising out of a Refinery accident.

Additionally, it would be prudent for council to consult with the Department before approving any significant development within the area that could be affected by extreme Refinery events. While it is not possible to precisely define such an area, it is suggested that it would be appropriate to require consultation for development within 500 m of the Refinery boundary, based on the typical impact distances that have been associated with major overseas petrochemical incidents.

3.6 Community Consultation

A number of issues were raised by the community during an initial public meeting and through subsequent correspondence and discussion. These included:

- independence of the study;
- consistency between the 1986 and 1989 reports;
- relocation of major storage tanks away from residential areas or provision of a buffer zone;
- public access to the 1986/1989 reports;

- voluntary and involuntary risks;
- change of use of the ‘100 series tanks’, which did not originally contain gasoline;
- elimination of risks to the public from the Refinery;
- whether the State Government can force Caltex to take action, including compensating the residents;
- relevance of the Dangerous Goods National Standard to separation of the Caltex storage tanks from ‘protected works’;
- new development at the Refinery since the 1986 and 1989 studies were conducted;
- inclusion of risks from external sources in the risk calculations (eg lightning, plane accidents, terrorism);
- impact of other proposed industrial facilities (e.g. cogeneration plant, desalination plant); and
- responsibility for decision-making on development.

A number of these have been dealt with in the body of the report. Additional discussion of areas of concern is contained in Appendix 2.

4 Findings and Recommendations

Findings of the study have been categorised into four components:

1. Level of Risk
2. Refinery Safety Management
3. Emergency Response
4. Land Use Planning

4.1 Findings

4.1.1 Level of Risk

4.1.1.1 No residential areas are exposed to a fatality risk higher than five in a million chances per year (well within the 10 in a million risk criterion for existing industry).

4.1.1.2 No residences are exposed to a fatality risk higher than a one in a million chances per year (risk criterion for new industry), although the one in a million fatality risk contour extends about 5 metres into the rear of some properties in Cook Street.

4.1.1.3 No residential areas are exposed to an injury risk higher than 50 in a million chances per year (risk criterion for new and existing industry).

4.1.1.4 Societal risk falls into the negligible range of the Department's indicative societal risk criteria.

4.1.1.5 Despite the low level of risk, there are opportunities for technical and safety management improvements, which may further reduce the consequences and/or frequency of a major accident.

4.1.1.6 While major accidents involving the large LPG storages are highly unlikely, worst-case consequences extend significantly offsite. Hence, ongoing tank inspection and maintenance of effective leak detection and water deluge systems are particularly important.

4.1.2 Refinery Safety Management

4.1.2.1 The Refinery safety management system is robust and effective.

4.1.2.2 The safety management system has been recently enhanced by implementing a Process Safety Management Program that will prepare the facility to meet the requirements of the proposed Major Hazard Facilities legislation in NSW.

4.1.2.3 A detailed evaluation of the safety management program for the operation and maintenance of the 101–104 gasoline storage tanks has shown the program to be robust and effective. Improvements are recommended to further enhance the safe operation of these tanks.

4.1.2.4 With the proposed introduction of regulations to control major hazard facilities in NSW, the Refinery will be required to submit to Government a Safety Report that will include a formal risk assessment, details of its safety management system, including all the relevant process safety elements, its security systems and its fire safety system.

4.1.3 Emergency Response

4.1.3.1 The Emergency management constraints highlighted in the 1986 report remain and the Kurnell Peninsula continues to present challenges to the Emergency Services, especially in situations where public evacuation becomes necessary as a result of a major accident or extreme natural event.

4.1.3.2 The local emergency response agencies are aware of the difficulties and are well resourced and trained. Response plans are in place, including plans for public evacuation by road and by sea.

4.1.3.3 Concerns have been expressed that there should not be a significant increase in the population of the Kurnell Village, thus further exacerbating existing emergency management constraints.

4.1.3.4 As in 1986, response to a fire in Kurnell is usually the responsibility of the NSW Rural Fire Services. However, a fire at the Refinery would be a HAZMAT Incident and the NSW Fire Brigades, operating from Cronulla, would be the combat agency.

4.1.4 Land Use Planning

4.1.4.1 Any increase in the residential capacity of the Kurnell Peninsula has the potential to hamper evacuation and emergency services access in the event of an extreme natural event or a major accident at the Refinery.

4.1.4.2 While public risk remains very low, there is a need for land use controls to recognise the emergency management constraints arising out of the constrained road access to the Peninsula.

4.2 Recommendations

4.2.1 Level of Risk

The following recommendations are made in the interests of avoiding avoidable risk. It is recommended that Caltex should consider:

4.2.1.1 moving the common bund sewer outside of the bund area (Tanks 101 to 104) and providing individual bund isolation. In sewer redesign consideration should be given to other improvements such as fire traps and siphon systems that would improve fire combat capacity;

4.2.1.2 installing fire protection systems to critical pipe systems (Tanks 101 to 104), such as motor operated valves, that are located inside the tank bund;

4.2.1.3 installing a fixed foam delivery system to combat a rim seal fire on the tanks 101 to 104 to the same design as that applied to the crude tanks, with remote line up and activation from a manned location;

4.2.1.4 installing a fixed foam monitor/system along the Main Pipe way between Gate 5 and near the Transfer pumps;

4.2.1.5 installing leak, heat or smoke detectors in tank bunds and along pipe ways, where fires could have an offsite impact; and

4.2.1.6 examining and further improving the effectiveness and integrity of condition monitoring, inspection, leak detection and water deluge systems on the LPG (both propane and butane) storage vessels.

4.2.2 Refinery Safety Management

4.2.2.1 The Department of Planning should continue to monitor the status of the Refinery's safety management system to ensure that it remains fit for purpose.

4.2.2.2 Should the introduction of the proposed Major Hazard Facilities regulatory framework in NSW be delayed more than one year from the time of the publication of this report, CALTEX should be required to undertake a comprehensive audit of the Refinery's Safety Management System. The audit should be carried out by an independent auditor approved by the Department of Planning.

4.2.3 Emergency Response

4.2.3.1 There should be ongoing consultation between the local emergency services agencies and the relevant planning authorities, whenever significant changes to land use or emergency response arrangements are proposed, to ensure emergency arrangements remain appropriate (see also recommendation 4.2.4.3.

4.2.3.2 Evacuation options from the Kurnell Village should be further considered, in particular, the viability of evacuation by sea. The review should consider the adequacy of existing facilities, such as the boat ramp and jetty, as well as egress routes and the availability of suitable vessels.

4.2.4 Land Use Planning

4.2.4.1 There should be no increase in residential capacity (i.e. no new land releases or subdivision) within the Kurnell Village.

4.2.4.2 Sutherland Shire Council should specifically consult with the Department of Planning before approving any significant new development within 500 m of the Refinery boundary.

4.2.4.3 The assessment of all major new developments or land releases on the Kurnell Peninsula should take into account the need to ensure adequate road access in times of emergency, including access to the Kurnell Village (see also recommendation 4.2.3.1).

4.2.4.4 Planning instruments relevant to the Kurnell Peninsula should be updated to take account of the findings and recommendations of this study, in particular recommendations 4.2.4.1 and 4.2.4.3

4.2.4.5 Section 149(2) planning certificates on any properties affected by adoption by council of these recommendations should be updated to show any resultant land use restrictions.

Appendix 1

Risk Criteria in Context

The following tables, some of which were originally published in HIPAP 4 provide useful background information on the risks of various types of activity and the consequences of individual exposure to heat radiation and explosion overpressure.

The tables provide a context against which some of the suggested numerical risk criteria can be compared and demonstrate the significant degree of conservatism in the criteria when compared against risks from normal daily activities.

Table 7 shows the Annual risk of death for various United Kingdom age groups based on deaths in 1999 (Annual Abstract of Statistics 2001, Health Statistics Quarterly – Summer 2001). Australian statistics would be expected to be similar.

Table 7: Annual Risk of Death from All Causes in the UK

Population group	Risk as annual experience	Risk as annual experience per million
Entire population	1 in 97	10,309
Men aged 65–74	1 in 36	27,777
Women aged 65–74	1 in 51	19,607
Men aged 35–44	1 in 637	1569
Women aged 35–44	1 in 988	1012
Boys aged 5–14	1 in 6,907	145
Girls aged 5–14	1 in 8,696	115

Regulators have concluded that if a risk from a potentially hazardous installation is below most risks being experienced by the community, then that risk may be tolerated. This is consistent with the basis of criteria setting used in Department of Planning guidelines, as well as those adopted by most authorities nationally and internationally.

Table 8: Risks to Individuals in NSW[5]

	Chances of fatality per million person years
Voluntary Risks (average to those who take the risk)	
Smoking (20 cigarettes/day)	
• all effects	5000
• all cancers	2000
• lung cancers	1000
Drinking alcohol (average for all drinkers)	
• all effects	380
• alcoholism and alcoholic cirrhosis	115
Swimming	50
Playing rugby football	30
Owning firearms	30
Transportation Risks (average to travellers)	
Travelling by motor vehicle	145
Travelling by train	30
Travelling by aeroplane	10
Risks Averaged over the Whole Population	
Cancers from all causes	
• total	1800
• lung	380
Air pollution from burning coal to generate electricity	0.07–300
Being at home	
• accidents in the home	110
Accidental falls	60
Pedestrians being struck by motor vehicles	35
Homicide	20
Accidental poisoning	
• total	18
• venomous animals and plants	0.1
Fires and accidental burns	10
Electrocution (non-industrial)	3
Falling objects	3
Therapeutic use of drugs	2
Cataclysmic storms and storm floods	0.2
Lightning strikes	0. 1
Meteorite Strikes	0.001

[5] Edited from D. J. Higson, Risks to individuals in NSW and in Australia as a Whole, Australian Nuclear Science and Technology Organisation, July 1989.

Table 9: 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	• Significant chance of fatality for extended exposure. High chance of injury • Causes the temperature of wood to rise 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	• Likely fatality for extended exposure and chance of fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved or failure would occur
35	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of fatality for people exposed instantaneously

Appendix 2

Hazard Identification Table

The most relevant identified hazards were summarised in Table 3 in section 3.2.1. Table 10 provides a more detailed analysis.

Table 10: Hazard Identification Table

Area/Incident	Possible Initiation	Possible Consequences	Prevention/Protection Measures
Floating Roof			
Rim seal leak	• Lightning and electrostatic discharge • Maintenance and installation work on live tanks	• Minor fire	• Tank earthing • Regular seal inspection • Tank and rim seal design in accordance with recognised standards (API 650) • Secondary rim seals for high pressure products • Fire retardant rim seal material • Visual surveillance (common to all leak/fire scenarios) • Heat and smoke detection system • Effective site fire fighting system (common to all tank and bund fire scenarios)
Spill on roof	• Overfill • Cracks due to corrosion or mechanical failure of tank roof • Roof drain failure • Product on roof • Gas in line • High vapour pressure product	• Fire (effects within site boundary)	• Rigorous filling procedures • Effective maintenance program • Corrosion protection • Remote tank level monitoring • Tank and roof design in accordance with recognised standards (API 650) • Incorporation of a roof

Area/Incident	**Possible Initiation**	**Possible Consequences**	**Prevention/Protection Measures**
			drain to drain accumulated rain water • Control of ignition sources • Heat and smoke detection system • Effective site fire fighting system
Full surface fire	• Escalation of rim seal fire or roof spill fire • Failure of roof leg pads • Damaged pontoon • Sinking of roof and ignition	• Fire • Fatality and injury	• Inspection and maintenance procedures • Tank and roof design in accordance with recognised standards (API 650) • Control of ignition sources • Heat and smoke detection system • Effective site fire fighting system
Bund (spill outside tank)			
	• Product overflow • Corrosion of tank bottom • Bottom annular plate corrosion • Drain failure • Mixer Leak • Leak from pipe work, flange or valve • Hole in the tank – mechanical damage	• Fire • Fatality and injury	• Rigorous filling procedures • Visual surveillance • Effective maintenance program • Bund design in accordance with appropriate standards • Control of ignition sources • Heat and smoke detection system • Effective site fire fighting system • Corrosion protection • Protection of tank from mechanical impact
Explosion in a pontoon or other confined spaces	• Build up and ignition of flammable vapour • Roof is landed on its legs and	• Fire • Fatality and injury	• Monitoring of build up of flammable gases • Control of ignition sources • Procedures for hot

Area/Incident	Possible Initiation	Possible Consequences	Prevention/Protection Measures
	air is pulled into the vapour space		work in the vicinity of, and on, live tanks
Pipelines			
Leak/Fire	• Pump seal failure • Flange failure • Corrosion	• Fire • Fatality and Injury	• Regular inspection and maintenance

Appendix 3

Issues Raised During Community Consultation

A number of issues raised by the community are addressed in the body of the report. This appendix further explores areas of concern.

1 Independence of the study

Essential data concerning the materials stored in storage tanks and information relating to the operation of the Refinery, the facility's safety management system and the maintenance program of the storage tanks was obtained from Caltex. Information relating to specific planning issues in the Kurnell Peninsula was also obtained from Sutherland Shire Council.

The Department's risk assessment, while drawing on these resources, was carried out totally independently using internationally recognised techniques.

While study outcomes were discussed with both Caltex and council, the final findings and recommendations are the Department's.

2 Consistency between the 1986 and 1989 reports

The two reports are generally consistent in their assessment of the level of risks and in their recommendations. The draft 1989 report suggests that some risks may extend up to a distance of 150 meters from the site but the level of risk is not explicitly documented.

As in the 1986 report, the draft 1989 report indicates a low level of public risk and the overall findings of both reports are consistent.

The present study confirms that offsite risk levels meet Departmental criteria.

3 Relocation of major storage tanks away from residential areas or provision of a buffer zone.

It has been suggested that Caltex should be required to move major gasoline storages away from residential areas or a 'buffer zone' established.

The findings of the study indicate that the risk level to the community is very low and is within Departmental and internationally recognised risk criteria.

There is no basis for recommending relocation.

4 Public access to the 1986/1989 reports

A number of members of the community indicated they were not aware of these studies or their implications.

At the time the 1986 study was completed, the report was provided to Sutherland Shire Council as a public document and was also available in the Department's offices and Library.

The Sydney Regional Environmental Plan (SREP) No. 17 (clause 28) explicitly requires the relevant Departmental reports to be taken into consideration by the council.

5 Voluntary and involuntary risks

It is recognised that individuals are more willing to accept voluntary risks than non-voluntary risks. For example, an individual may be prepared to accept the risks of smoking or driving a vehicle, but not to accept the risk of an accident from the operation of a facility where the individual has no control over that operation.

The criteria established for acceptable risk take into consideration the fact that the risks to be assessed are involuntary risks and hence, are set at a very low level in relation to other background risks. Relevant information is included in Appendix 1.

6 Change of use of the '100 series tanks', which did not originally contain gasoline

The 1986 and 1989 reports indicate that at the time of the studies in the mid to late 1980s, the 100 series tanks contained petrol or gasoline. Risk calculations were based on these materials. Dangerous Goods classes of materials stored in these tanks have not changed since then.

7 Elimination of risks to the public from the Refinery.

Total elimination of risk is seldom possible. As noted in the response to question 5, internationally, risk criteria have been set on the basis that the risks to the public from industrial activities should be low in relation to background involuntary risks.

8 Whether the State Government can force Caltex to take action, including compensating the residents.

See response to question 3. As the level of risk is very low and meets Departmental criteria, the issue of compensation has not been explored.

9 Relevance of the Dangerous Goods National Standard to separation of the Caltex storage tanks from 'protected works'.

The legislation for the storage and handling of Dangerous Goods in NSW is administered by WorkCover.

WorkCover has indicated that for offsite risks, it may be guided by the risk criteria established by the Department of Planning. Further inquiries regarding the requirements of the Dangerous Goods Legislation should be addressed to WorkCover.

10 New development at the Refinery since the 1986 and 1989 studies were conducted

The following significant projects have been completed or are in progress:

- new water treatment plant;
- demolition of the stack;
- clean fuels project;
- refinery fire system upgrade (new fresh water tanks, new pumping stations, new and larger headers);
- security upgrades to Refinery and wharf (CCTV monitoring, more guards, more patrols, repairs to fencing);
- effluent upgrades;
- stormwater diversion and retention;
- new flare stack (greater capacity/higher);
- wharf improvements (upgrade of fire system, new monitors, new loading arms, remote emergency isolation valves);
- fireproofing upgrades; and
- installation of flammable vapour and hydrogen sulphide detectors and alarms.

None of these projects has resulted in an increase in offsite risk and a number have been specifically aimed at safety improvements.

11 Inclusion of risks from external sources in the risk calculations (e.g. lightning, plane accidents, terrorism)

Hazards from both internal and external sources have been considered in the risk calculations.

Terrorism or other intentional acts of vandalism have not been included in the risk calculations, given their very low historical occurrence.

The State and Federal Governments have in place a comprehensive program for the protection of critical infrastructure against terrorist acts and mitigation of the effects of such acts.

12 Impact of other proposed industrial facilities (e.g. cogeneration plant, desalination plant)

The study concentrates on the potential impact of the Refinery on nearby residential areas, focusing on the impact of the gasoline storage tanks at the northern end of the site.

Any new potentially hazardous industrial developments will be the subject of separate and comprehensive impact assessment to ensure overall risks meet Departmental criteria.

13 Responsibility for decision-making on development

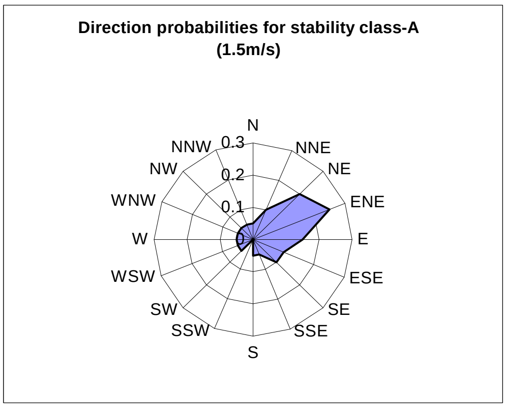
Sydney Regional Environmental Plan number 17 (1989) (SREP 17) commenced on 30 June 1989. Clause 7 provides that the Sutherland Shire Council is the consent authority for development applications in respect of land the subject of SREP 17, which includes the study area.

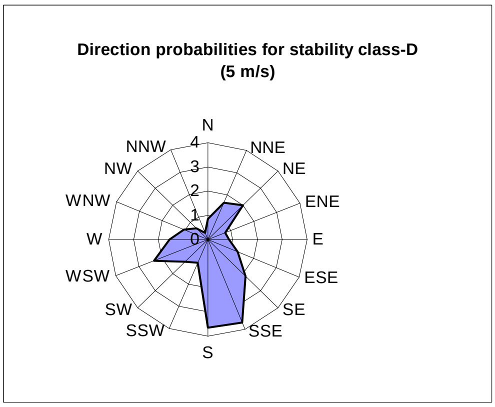
Clause 28 of SREP 17 states:

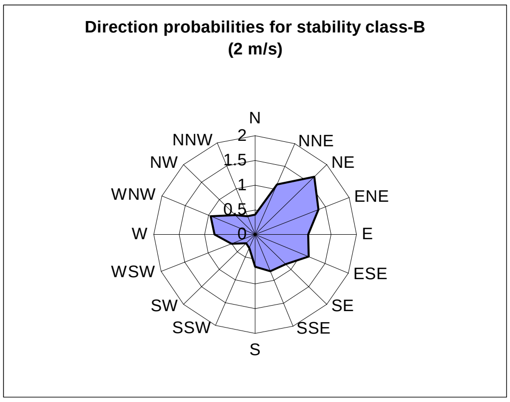
> *The council shall not consent to the carrying out of development on land to which this plan applies unless it has first considered the contents of any reports prepared by the Department relating to:*
>
> *(a) risk assessment for the Kurnell Peninsula,*
> *(b) transportation on the Kurnell Peninsula,*
> *(c) dangerous goods routes, and*
> *(d) guidelines on risk assessment criteria and methodology.*

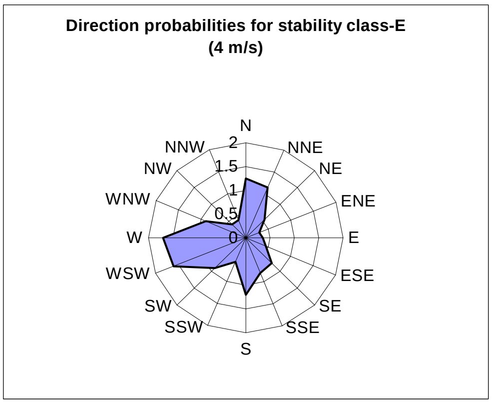
Appendix 4

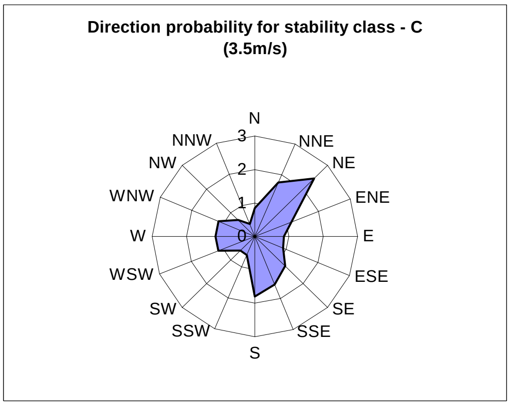
Kurnell Weather Data (January 2001 – December 2002)

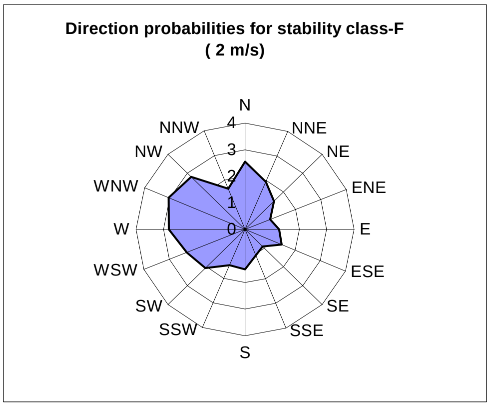












Additional Information

Relevant Department of Planning Publications

Hazardous Industry Planning Advisory Papers (HIPAPs):

No. 1 Industry Emergency Planning Guidelines
No. 2 Fire Safety Study Guidelines
No. 3 Environmental Risk Assessment Guidelines
No. 4 Risk Criteria for Land Use Planning
No. 5 Hazard Audit Guidelines
No. 6 Guidelines for Hazard Analysis
No. 7 Construction Safety Studies
No. 8 HAZOP Guidelines
No. 9 Safety Management System Guidelines

Land Use Safety Studies:

Port Botany (1996)
Botany/Randwick (2001)

Other Departmental Publications:

Multi-level Risk Assessment (1999)

Electronic copies of some of these publications are available at:
www.planning.nsw.gov.au