PLANNING

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CONSULTANTS

ERM MITCHELL McCOTTER

KWINANA INTERNATIONAL MOTORPLEX

Societal Risk Report

Final Report

For:
WESTERN AUSTRALIAN SPORTS CENTRE TRUST

July 1999
299033

ERM Mitchell McCotter Pty Ltd. A.C.N. 002 773 248. A member of the Environmental Resources Management Group.

Report No. 299033

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Approved by:	*Keryn James*
Position:	Project Director
Signed:	Keryn James.
Date:	*5 July 1999*

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HAVE YOUR SAY

INVITATION TO MAKE A SUBMISSION

The Western Australian Planning Commission (WAPC) invites people to make a submission on this Societal Risk Report.

This document is available for public review from 5 July, 1999 to 9 August, 1999.

Comments from Government agencies and the public will assist the WAPC in considering the development application for the proposal.

WHY WRITE A SUBMISSION?

A submission is a way to provide information, express your opinion and put forward your suggested course of action which may include any alternative approaches. It is useful if you indicate any suggestions you have to improve the proposal. All submissions received by the WAPC will be acknowledged. Submissions will be treated as public documents, unless provided and received in confidence, subject to the requirements of the Freedom of Information Act.

WHY NOT JOIN A GROUP?

If you prefer not to write your own submission, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

DEVELOPING A SUBMISSION

You may agree, disagree or comment on the general issues discussed in this report. It helps if you give reasons for your conclusions, supported by relevant data.

When making your submission:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable; and
- suggest recommendations, safeguards or alternatives.

POINTS TO KEEP IN MIND

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- Attempt to list points so that the issues raised are clear. A summary of your submission is helpful.
- Refer each point to the appropriate chapter, section or recommendation in this document.
- If you discuss different sections of this document, keep them distinct and separate so there is no confusion as to which section you are considering.
- Attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether you want your submission to be treated as confidential.

The closing date for submissions is 9 August 1999.

Submissions should be addressed to:

Chairman, Western Australian Planning Commission
Albert Facey House
469 Wellington Street
Perth WA 6000
Attention : Mr David Nunn

Chapter 1

INTRODUCTION

An International Motorplex Facility Implementation Committee (IMFIC) was established by the State Government in 1994. This Committee was set up to identify and investigate sites for initially, Ravenswood International Raceway and then also Claremont Speedway. The Committee investigated eight sites and determined that the disused Alcoa residue storage area in Kwinana was the preferred site. A Project Control Group was established in 1998 to co-ordinate the preparation of the detailed design and documentation required for the planning and environmental approvals process.

The proposal to construct an International Motorplex at Kwinana will provide a new venue for activities which currently occur at the Ravenswood International Speedway and the Claremont Speedway and associated community-based activities. The new facility will include a speedway track and dragstrip and associated facilities such as pits, grandstands, catering areas, carparking and public amenities. The facility will be managed by the Western Australian (WA) Sports Centre Trust; Ravenswood International Raceway and Claremont Speedway will be given a license to operate on the site.

The proposed site for the Motorplex is located in Kwinana between Thomas Road to the south, Rockingham Road to the west, Anketell Road to the north and Abercrombie Road to the east. *Figure 1.1* shows the proposed facility.

The construction and operation of the Motorplex facility will have a number of environmental and social impacts. In order to adequately address these issues and to obtain approval for the construction of the facility, preparation of an environmental review document is required. The Environmental Protection Authority (EPA) has set the level of assessment for this project at Public Environmental Review (PER) and this document was released for public comment on 28 June 1999.

The EPA have also required that a societal risk report be prepared for the proposal and released for public comment. It should be noted however, that this is not a factor being considered in the formal environmental review. The matter of societal risk will be considered by the Western Australian Planning Commission (WAPC) with the development application for the facility.

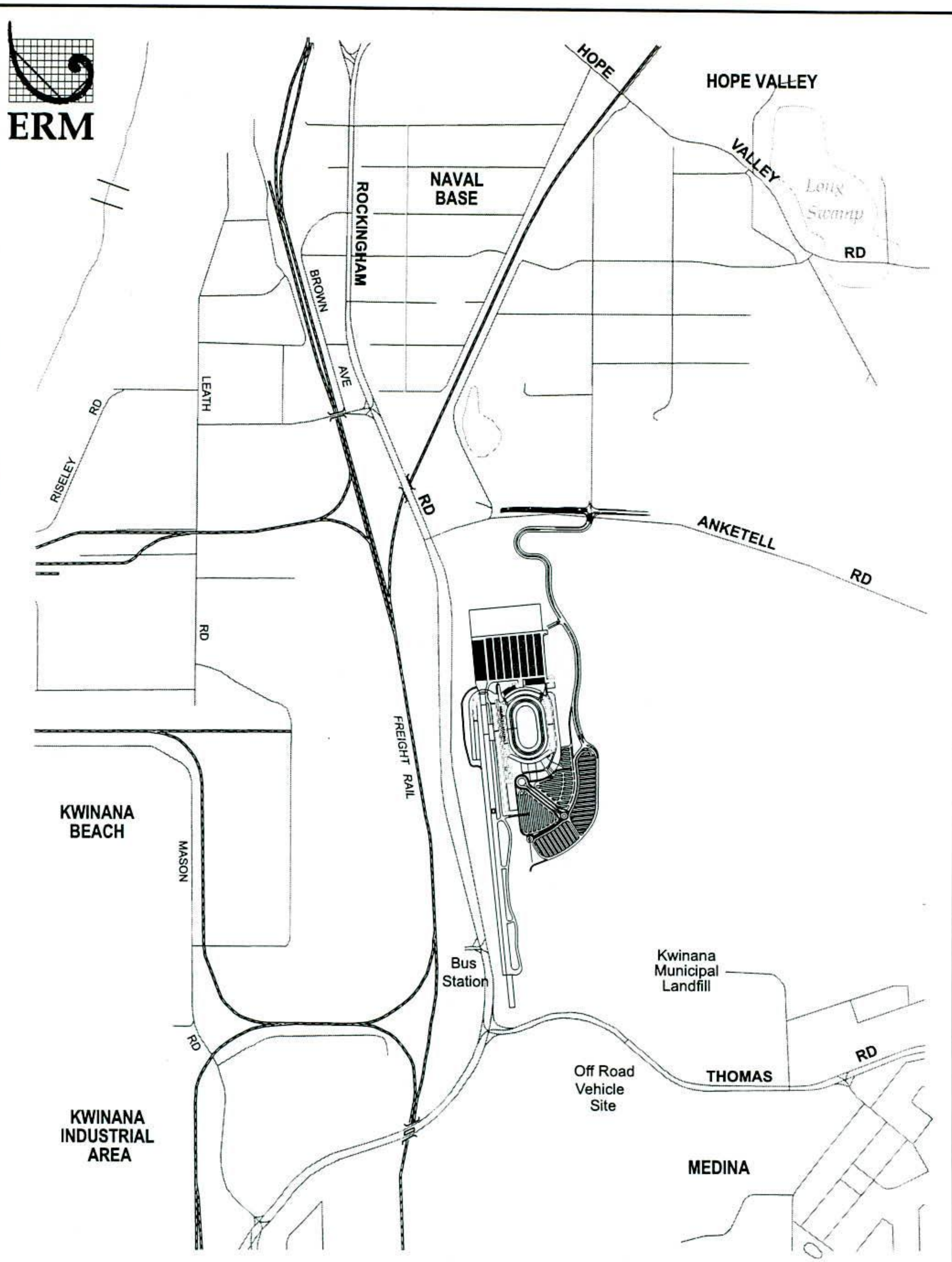

Figure 1.1 PROPOSED MOTORPLEX

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This document presents the Societal Risk Report for the Kwinana International Motorplex. It is intended as a companion document to the PER (ERM, 1999) for the Motorplex in which Individual Risk is discussed. This report uses technical data on societal risk levels presented in previous risk studies (AEA, 1994; ERS, 1999) and considers this data in the context of local and international societal risk criteria. This report is not intended as a review on the content or accuracy of the previous studies but rather provides a discussion of societal risk as it relates to the Kwinana International Motorplex.

The modelling outputs were produced by Environmental Risk Services (ERS) using the same input data used for the Kwinana Cumulative Risk Study (AEA, 1994). The basic raw data on risks associated with specific industries has not been provided to ERM and is subject to confidentiality agreements.

The report provides firstly, an explanation of the basic concepts and definitions of risk. This is followed by a discussion of the specific definitions of individual and societal risk, and perceptions of risk. A review of international societal risk criteria is then presented, with conclusions about the degree to which different criteria are applicable to the Kwinana Industrial Area (KIA). Finally the report considers societal risk levels in the KIA, with and without the proposed Motorplex facility.

Chapter 2

RISK ASSESSMENT FUNDAMENTALS

2.1 INTRODUCTION

This section introduces the basic concepts and definitions associated with risk and hazard evaluation. It is not intended as a comprehensive treatise on the philosophy of risk analysis but is merely a guide to the interpretation of the results and criteria presented in the remainder of the report.

2.2 HAZARD & RISK

Hazard refers to the potential of a situation to cause harm. This could include events which cause injury, ill health, property damage, environmental damage, system loss or increase liabilities.

Risk can be defined as "the likelihood of a specific undesired event occurring within a specified period or specified circumstance". Risk is usually considered to be a function of the frequency or probability of an event occurring and the consequences of its occurrence, particularly with respect to causing damage and injury.

2.3 MAJOR ACCIDENTS

A major hazard installation is generally taken as one having either process or storage units where in the event of an incident the resulting consequences could have a significant effect on the general public outside the site boundary. Such installations may now more generally be recognised as containing chemicals appearing on specific lists and having inventories above a certain level. An Australian National Standard has been published that includes a criteria for determining a major hazard site based on chemical inventories (Worksafe Australia, 1996). Other examples are the Control of Industrial Major Hazard Industries (CIMAH) Regulations in the UK and Occupational Safety and Health Administration (OSHA) Process Safety Management of Highly Hazardous Chemicals, Rule 29 CFR 1910.119 in the USA.

A *major accident* is defined as an accident in the processing, storage or transport of chemicals which has the potential to have an off-site impact in terms of injury to or evacuation of people and on-site has the potential to kill a number of people. It can cause damage both on and off the site to equipment, property or the environment.

The principal hazards which are usually considered in risk assessments stem from major energetic or toxic events, ie:

- explosion events: vapour cloud explosions, condensed phase explosions, BLEVEs;
- fire events: pool fires, jet fires, flash fires and fireballs; and
- toxic gas release events.

i. Explosions

A *confined explosion* is an explosion of a fuel-oxidant mixture inside a closed system such as a vessel or building.

A *pressure burst* is the rupture of a system under pressure which results in the formation of a blast wave and missiles which may have the potential to cause damage.

A *BLEVE* or *boiling liquid expanding vapour explosion* describes the sudden rupture due to fire impingement of a vessel/system containing liquefied flammable gas under pressure. The pressure burst and the flashing of the liquid to vapour creates a blast wave and potential missile damage, and immediate ignition of the expanding fuel-air mixture leads to intense combustion creating a *fireball*.

A *vapour cloud explosion* is a partially confined explosion in the open air of a cloud made up of a mixture of a flammable vapour or gas with air. This at one stage was described as an unconfined explosion but it is now appreciated that some degree of confinement is necessary for damaging overpressure to develop in the system.

ii. Fires

A *fire* is a process of combustion characterised by heat, smoke or flame or any combination of these. The main cause of harm or damage to people and objects is thermal radiation which is the propagation of energy in the infra-red region of the electromagnetic spectrum.

A *pool fire* is the combustion of flammable vapour evaporating from a layer of liquid at the base of the fire. A common source is a spill of flammable liquid into a bunded area.

A *jet flame* is the combustion of material emerging with significant momentum from an orifice, as when ignition occurs on material emerging from a flammable source under pressure.

A *flash fire* is the combustion of a flammable vapour and air mixture at less than sonic velocity, such that negligible damaging overpressure is generated.

A *fireball* is a fire burning sufficiently rapidly for the burning mass to rise into the air as a cloud or ball. It is particularly associated with a BLEVE.

iii. Toxic Events

Major toxic gas incidents have arisen as a result of atmospheric dispersion of dense, passive or buoyant gases, dispersion with the products of combustion and aquatic dispersion. Process material may be released on rupture or discharge through an abnormal opening.

Toxic exposure arises by contact with chemicals which enter the body either by inhalation, skin absorption or ingestion. Relatively inert gases can also kill, in high concentrations, by excluding oxygen and causing asphyxiation. Contact with corrosive substances affects exposed tissue.

Chapter 3

EXPRESSING RISK LEVELS

3.1 INTRODUCTION

Risk assessment involves determining the probability of fatalities occurring due to an activity. For industrial facilities or transport, risk levels are usually determined by performing a Quantitative Risk Assessment (QRA). The QRA will identify hazardous scenarios, predict their frequency based on historical events and determine the consequences of the event. This information is then summed to determine the overall risk.

Risk assessment results can be expressed as 'individual risk' and 'societal risk'. These are described further below.

3.2 INDIVIDUAL RISK

Individual risk is, as the name suggests, the risk to specific individuals (for example, various categories of workers, the general public, road users, etc.). Individual risk is in fact a frequency with which individuals within the specified category are expected to suffer harm (eg. to be fatally injured, or receive major injuries).

Definitions of individual risk commonly used in connection with the risk associated with major hazard sites are as follows:

- ***Individual Risk (IR)*** is the frequency of harm per year to a theoretical individual who is exposed to a hazard or hazards from a facility for 100% of the time. That is, no allowance is made for occupancy, escape or protection factors.

- ***Personal Individual Risk (PIR)*** is the frequency of harm per year to an actual individual who is exposed to a hazard or hazards from a facility, with account taken of temporal factors (eg., the probability of occupancy) which expose the individual to the hazard(s), and with account also taken of the probability of escape or protection from the hazards. The PIR may vary for different classes of individuals in the same region. For example, workers in a commercial establishment may experience a lower PIR than residents because they spend less time in the area near the hazardous industry.

For most risk assessments the specified level of harm to be assessed is fatality. This is because a level of harm defined as "serious injury" can be very subjective. Also, there is more literature available because most research is conducted to determine the dose required to cause fatality. However, fatality is not the only criteria that can be used. The UK calculations are based on the concept of a 'dangerous dose' and not fatality, ie. a dose that causes severe distress to most and may cause fatality to susceptible persons. The HSE have conducted their own research and provide a guides on what amounts to a "dangerous dose" is for common industrial chemicals.

For major hazard sites, individual risk (IR or PIR) is normally shown on a map around the hazardous installation (hazard source) as a series of frequency contours (say, 10^{-4}, 10^{-5} and 10^{-6} per annum, etc.) that represent the locations around the facility at which an individual would be subjected to that frequency of harm per year due to exposure to hazards induced by the facility.

It should be noted that the literature tends not to distinguish between IR and PIR. The type of individual risk (IR or PIR) to be calculated is normally specified by the regulatory body – NSW and Dutch criteria define the "classical" IR, whereas the UK and Hong Kong regulations define the PIR. The IR will always be higher than the PIR because the PIR has been factored down to account for the protection afforded by being indoors and the fraction of time a person spends in the area. The IR contours for the KIA are presented in the PER document (ERM, 1999).

3.3 SOCIETAL RISK

Societal risk is a measure of the overall risk associated with a situation or system. It accounts for the likely impact of all accidental events, not just on a particular type of individual, as in the case of individual risk, but on all individuals who may be exposed to the risk and it reflects the number of people exposed. Where the individual risk calculation is independent of the actual population (being based on a hypothetical person who remains at a given location 100% of the time) the societal risk attempts to reflect the actual number of people exposed to an event. For the sake of explanation consider a single explosion that would cause fatalities up to 100 metres from the event, and was estimated to have a frequency of 1×10^{-6} per year. If there were 20 people within 100 metres of the site:

- The 1×10^{-6} per year individual risk contour would be a 100 metres diameter circle around the location; and
- The societal risk would be expressed as 20 fatalities at a frequency of 1×10^{-6} per year.

If the population were increased to 200 people within 100 metres of the site then:

- The 1×10^{-6} per year individual risk contour would remain a 100 metre diameter circle around the location; and
- The societal risk would be expressed as 200 fatalities at a frequency of 1×10^{-6} per year.

This is a very simplified example of a single event, and in fact to calculate societal risk estimates have to be made for each identified accidental event and its possible outcomes. The frequency of the event per year, *f*, and the associated number of fatalities, *N* are estimated for each event. The resulting data takes the form of a set of *f-N* pairs, eg. 200 fatalities at a frequency of 1×10^{-6} per year is the f-N pair the event considered above. They can be plotted on a graph, in which case they will appear as series of unconnected points.

However, the usual measure of societal risk is a representation of the cumulative frequency, *F*, of all event outcomes that lead to *N* or more fatalities. These data are usually plotted on a graph as a continuous curve against logarithmic axes for both *F* and *N*. This allows for ready comparison against criteria (eg., for 'unacceptable' and 'broadly acceptable' levels of risk), which themselves can be represented as *F-N* curves. This representation of societal risk highlights the potential for accidents involving large numbers of fatalities.

Until recently criteria tended to distinguish three levels (areas) of risk: an upper level above which risk is 'unacceptable'; below this, a region in which risk is 'tolerable' providing it has been reduced to a level which is As Low As Reasonably Practicable (ALARP); and finally a lower level below which risk is 'broadly acceptable', so long as precautions are maintained, because it is very small. The concept is shown graphically in *Figure 3.1*.

The recent trend is to only define two areas of risk, an upper 'unacceptable' region and below this an ALARP region. That is, the F-N graph shows just one line that defines the limit of unacceptable risk.

If the risk level is in the top band, it must be reduced (regardless of cost), or the activity must cease. If the risk level falls in the ALARP region, cost may be taken into account when determining how far to go in the pursuit of safety.

The meaning of 'reasonably practicable' is well established in English case law:

> *'Reasonably practicable' is a narrower term than 'physically possible' and seems to me to imply that a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for*

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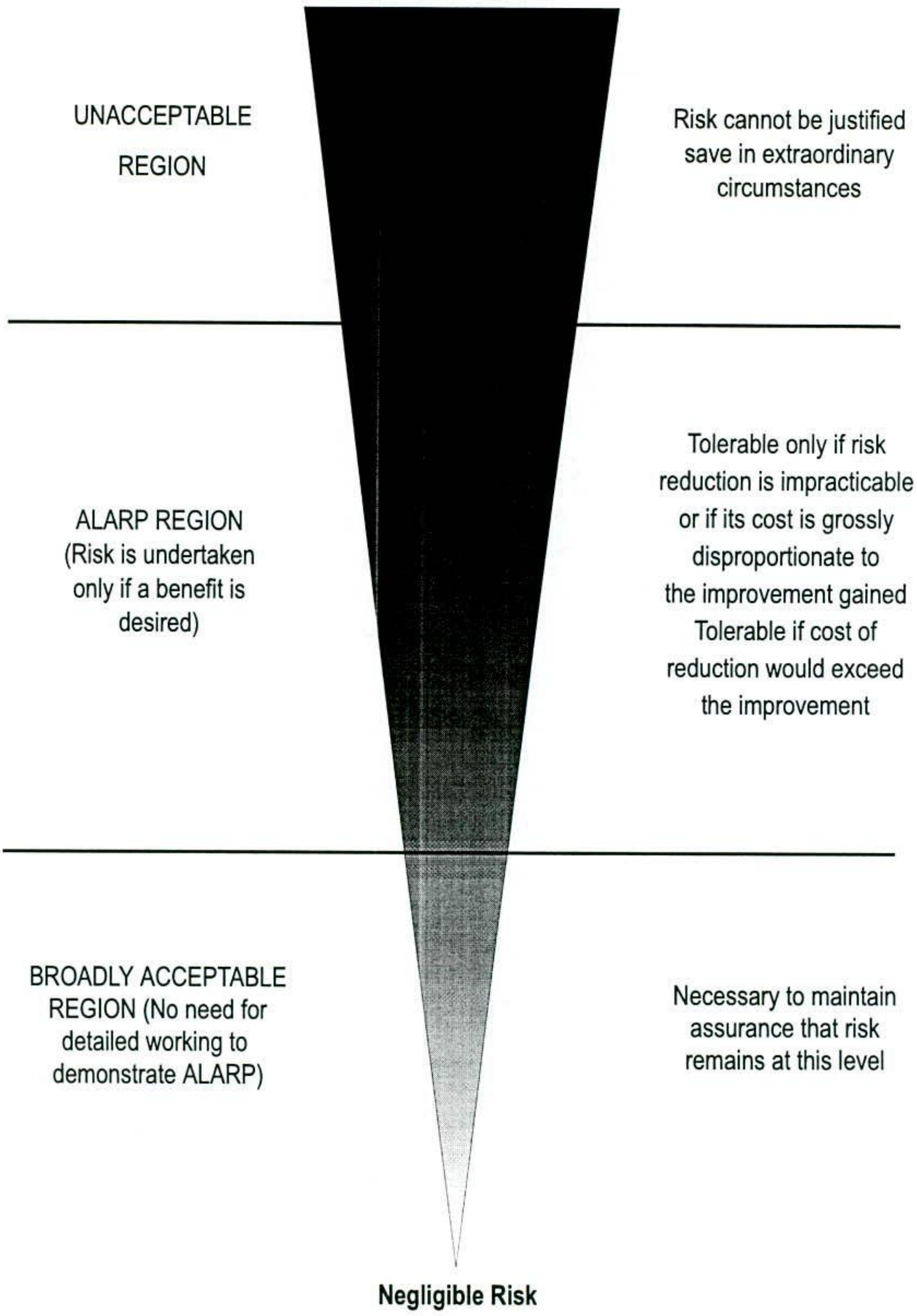

Figure 3.1 THE ALARP CONCEPT IN RISK CRITERIA FRAMEWORK

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averting the risk (whether in money, time or trouble) is placed in the other, and that, if it be shown that there is a gross disproportion between them - the risk being insignificant in relation to the sacrifice - the defendants discharge the onus on them. (Judge Asquith, Edwards v. National Coal Board, All England Law Reports Vol. 1, *p.*747 (1949)).

This ALARP principle was adopted in the UK Health and Safety at Work Act (1974), and is the basis of the approach adopted by the UK HSE in its regulation of the major hazard industries, including the nuclear, chemical and offshore oil and gas industries. In simple terms this reflects the fact that whilst almost any system can be made safer with additional expenditure on safety measures, beyond a certain point it becomes an extremely inefficient use of resources. Ultimately society is not prepared to pay large sums to reduce risks which it believes to be extremely small.

Chapter 4

RISK TOLERABILITY

Whenever anyone does something that involves taking a risk - even stepping off a pavement when there is traffic - it is usually done because it is believed that there is some benefit that outweighs it. There is thus a process of estimating the risk and then reducing or avoiding it if reasonably practicable. These simple principles apply to the assessment of any risk, however trivial or complex.

In addition to the risks each person undertakes willingly to secure the benefits they want (known as voluntary risks) there are a number of risks over which the individual has no control (known as involuntary risks). There is for example, a chance of about one in ten million per annum (NSW Department of Planning, 1992) that an individual will be killed by lightning. Due to the fact that lightning generally kills only one person at a time, and the frequency of occurrence is very low, the risk is regarded as negligible. Apart from taking certain simple precautions the possibility of dying in this manner does not influence our behaviour.

There are three important considerations relating to risk. First, that there is no such thing as 'zero risk' for individuals. However we occupy our time, even if we are at home, we are exposed to some kinds of risk; we would be exposed to other kinds of risk if we did something else. Second, we know that however remote a risk may be, it could just turn up. Remote risk is not the same as no risk at all. Third, each of us knows that our own chances may be more or less than the average, depending on where we live, whether we are fitter, or younger, or have better sight, and so on.

In the case of the risks we take voluntarily we are not usually deterred by statistics. For example, to learn that hundreds or thousands of people in various countries are killed each year by traffic does not prevent people from using the roads, though it warns them to be cautious. A woman who wants a child will not change her mind if she learns that the average chance of her dying as a result are of the order of about 1 in 10,000. We can judge such chances by experience. And apart from anything else, each of us is able to decide whether the benefit is worth the risk.

Certain risks, both voluntary and involuntary, are regulated by society as a whole, with the aim of securing general benefits. Thus, for example, roads are designed and laws applied to reduce traffic accidents.

When risks are regulated by society, the relevant judgements cease to be in the hands of the individuals who bear the risk. The risk will be shifted around, so that some people bear more and others less, and the benefits may also be unevenly distributed. For instance the building of a dam imposes risk on people nearby whereas the benefits are shared by people living further away. Societal risk may be redistributed in many other ways: for example through time, so that less risk is borne now, but more by some future generation. Or one kind of risk may be substituted for another.

People tend to view risk differently according to whether they can judge the hazard directly from experience, or whether the cause of the danger is not well understood or is particularly dreaded; or perhaps whether it could result in large adverse consequences from which individuals could not escape. Thus public expectations about the levels of protection required, or the level of risk which can be tolerated, may well differ according to the nature of the hazard in question and people's knowledge or feelings about the hazard. It has been suggested for example that people (in the UK) seem more ready to tolerate the idea of sudden death by electricity in the home (40 deaths a year) than they are by the thought of some more insidious hazard, such as poisoning.

There is nothing unusual about preferring one kind of hazard to another. In the nature of things, people have their own views and feelings in these matters. There may be disagreement about the importance or incidence of any benefits. Some people may have ethical objections to particular activities or forms of harm and may in any case doubt what experts say about them.

Table 4.1 outlines a broad range of voluntary risks for residents in NSW. *Table 4.2* gives examples of typical individual risks for causes of death averaged over the entire population.

Table 4.1 LEVELS OF FATAL RISK PER ANNUM IN NSW (NSW DEPARTMENT OF PLANNING, 1992)

Voluntary Risks	Risk of fatality per million person years (for participants)*
Smoking 20 cigarettes per day	5000
Drinking alcohol	380
Swimming	50
Playing rugby	30
Owning firearms	30

Notes : * *The average number of fatalities expected over a population of 1 million participants each year.*

Table 4.2 INDIVIDUAL RISKS IN NSW (NSW DEPARTMENT OF PLANNING, 1992)

Cause of Death	Risk of fatality per million person years (for whole population)*
Cancer	2800
Air pollution from burning coal to generate electricity	0.07-300
Accidents in the home	110
Accidental falls	60
Pedestrians being struck by motor vehicles	35
Homicide	20
Accidental poisoning	18
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
Meteor strikes	0.001

*Notes : * The average number of fatalities expected over a population of 1 million people each year.*

Societal risks for society can also be shown on an F-N curve. *Figure 4.1* shows the societal risk for some human caused events in the USA (NSW Dept of Planning, 1992).

To the extent that we give remote risks any thought at all, we do so knowing that everyone will ultimately die from some cause, or another. On average in Great Britain a man of 20 has roughly a 1 in 1,000 chance of dying within a year; for a man of 40 the chance is around 1 in 500. At 60 it is 1 in 50 for a man; for a woman, 1 in 100. Each particular risk or cause of death is just one contributor to the overall risk.

All the same, people tend to feel cautious about adding involuntary risks to the risks which they are already undertaking voluntarily. People do in fact demand that such 'additional risks' be reduced to very low levels compared to the ones they accept for themselves. In tolerating them, they may well want to know how the control of danger is achieved and how management of potentially hazardous industries works to reduce such risks. Such factors lead us onto the consideration of what levels of involuntary risk which are imposed on the public by a hazardous installation can be judged as "acceptable" or "tolerable" to the public.

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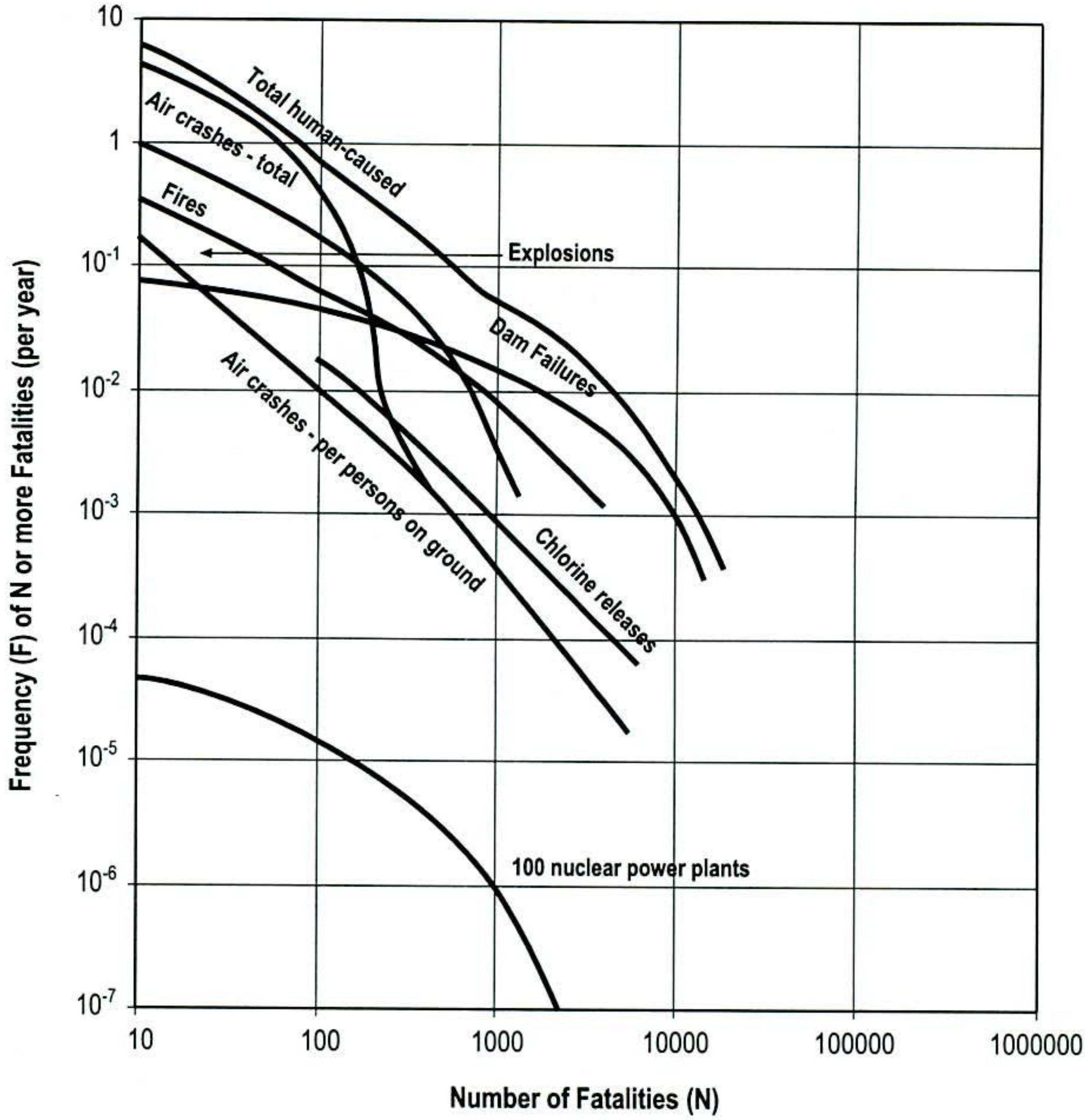

Figure 4.1 SOCIETAL RISK CURVES FOR SOME HUMAN-CAUSED EVENTS IN THE USA

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Chapter 5

SOCIETAL RISK CRITERIA

5.1 HISTORICAL BACKGROUND

The use of QRA techniques for the evaluation of risks from serious accidents associated with hazardous industries and the effect on the surrounding population was first brought to the fore in the UK in June 1978 with the publication of the first Canvey Report (HSE, 1981). In parallel with this, the Dutch authorities in Groningen formulated a criterion for societal risk in 1979.

A European Community Directive for the safety of the public located in areas in the vicinity of an installation involving hazardous substances was subsequently issued on 24 June 1982 with a requirement for member states to implement national standards by 8 January 1994. This was known as the Seveso Directive after an incident in Seveso, Italy, involving the release of dioxin. The national standards required all operators of hazardous activities within the particular country to demonstrate to the regulatory authority that they had identified the major accident hazards associated with their operations and had adopted appropriate safety measures (risk controls). The enactment of the Seveso Directive in the UK is known as the CIMAH (Control of Industrial Major Accident Hazards) Regulations.

A review of the risk acceptability criteria adopted by some countries is given below where the definitions of criteria and their interpretation is readily available from well known government publications.

5.2 AUSTRALIA

In Australia, the states of New South Wales (NSW Department of Planning, 1992), Western Australia (EPA, 1998) and Queensland have formulated and implemented individual risk criteria for use in hazardous industries and land use planning in their vicinity. At the present time there are no formalised societal risk guidelines available in WA. This is not an unusual situation, and is also the case in all other states and most countries, including the UK despite their extensive research on the topic. In NSW, the criteria which have been suggested are similar to the Hong Kong criteria but are not formalised and the Victorian government uses the Dutch criteria as required.

The Australian National Committee on Large Dams (ANCOLD) has prepared a document entitled *"Guidelines on Risk Assessment"* (ANCOLD, 1998) for use in assessment of the risk from existing or new dams. This is the only known published societal risk criteria in Australia. The guidelines propose individual and societal risk criteria. The societal risk criteria is shown in *Figure 5.1*. An interesting feature of this criteria is the horizontal line at 10^{-6} fatalities for the limit of tolerability. This reflects the ANCOLD position that failure rates below 10^{-6} for dams are too difficult to estimate realistically.

DnV Technica proposed a societal risk criteria specifically for the KIA in a 1991 report (DnV Technica, 1991). This criteria is reproduced in *Figure 5.2*. These guidelines are a suggestion produced in a KIA risk study and are not a criteria that has been officially adopted by the EPA for societal risk. They have, however, been used by AEA Technology in the Kwinana Cumulative Risk Study (1994) and in risk studies undertaken for the Fremantle Port (1993 and 1996).

The criteria includes an upper boundary above which societal risk is intolerable for the KIA as a whole. Below this is a region where the risk is tolerable if it is ALARP. The ALARP region is further subdivided into criteria for existing industrial plants and new industrial plants.

5.3 UK

The Health and Safety Executive (HSE) and other government departments in the UK are continuing in the process of developing their approach to the whole subject of QRA and the use of criteria. Various documents and reports on the subject have already been published.

The original 'criteria' was for use with nuclear power stations and this was published in 1987 (HSE, 1987). In 1989, further documents were published relating to the use of QRA techniques in decision-making (HSE, 1989a) and for the application of risk criteria to land use planning in the vicinity of major industrial hazards (HSE, 1989b). A further document on the tolerability of risk from nuclear power stations was published in 1988 and revised in 1992 which indicated that the criteria should apply not just to nuclear plants, but also to large industrial plants in any industry.

At present the HSE does not use formal standard societal risk criteria for fixed installations in a decision making process. However, it does consider societal risk in a simplified way for housing developments near existing installations. Some qualitative judgements are made for land use planning decisions using some surrogate judgements based on the individual risk criteria for different land uses.

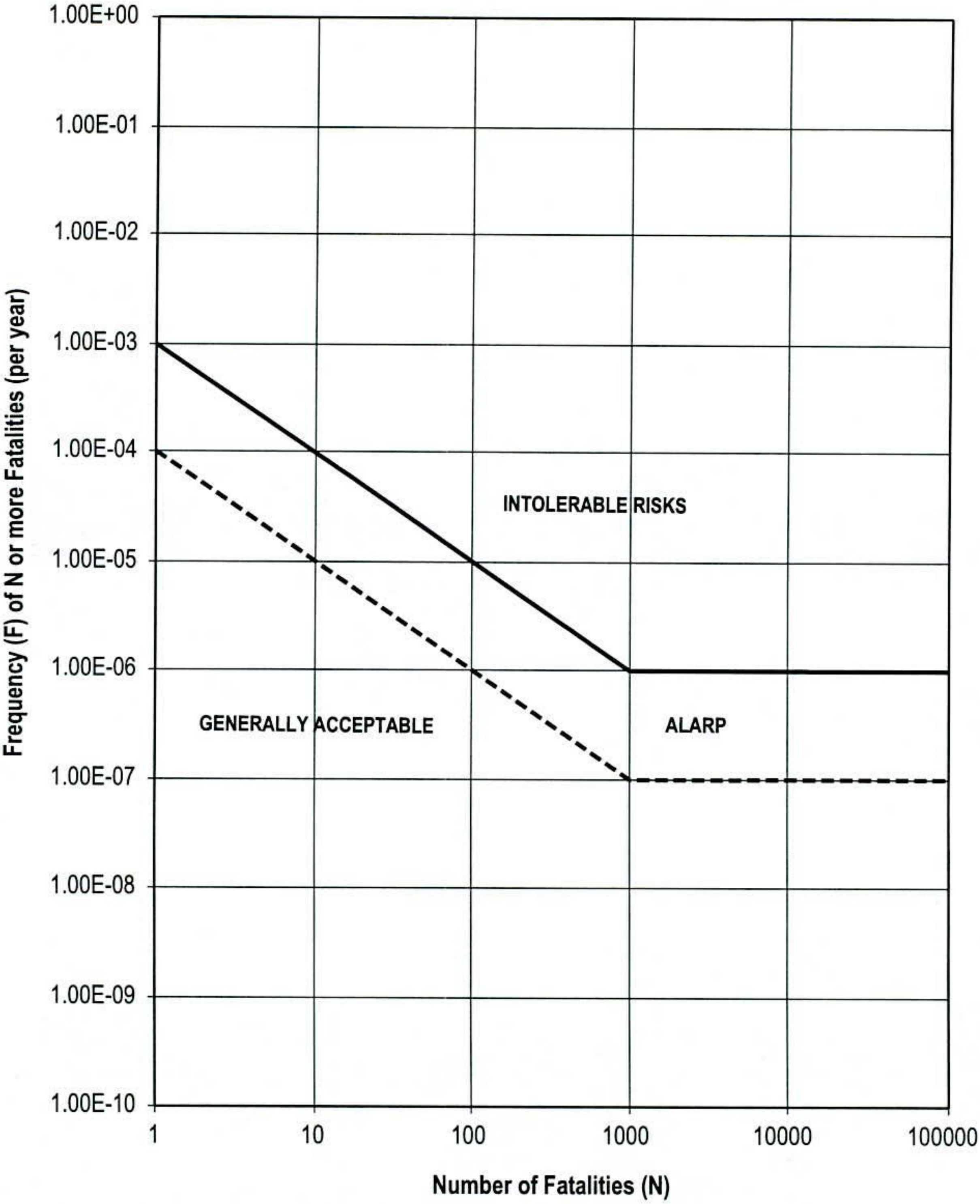

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Figure 5.1 ANCOLD SOCIETAL RISK CRITERIA FOR DAMS

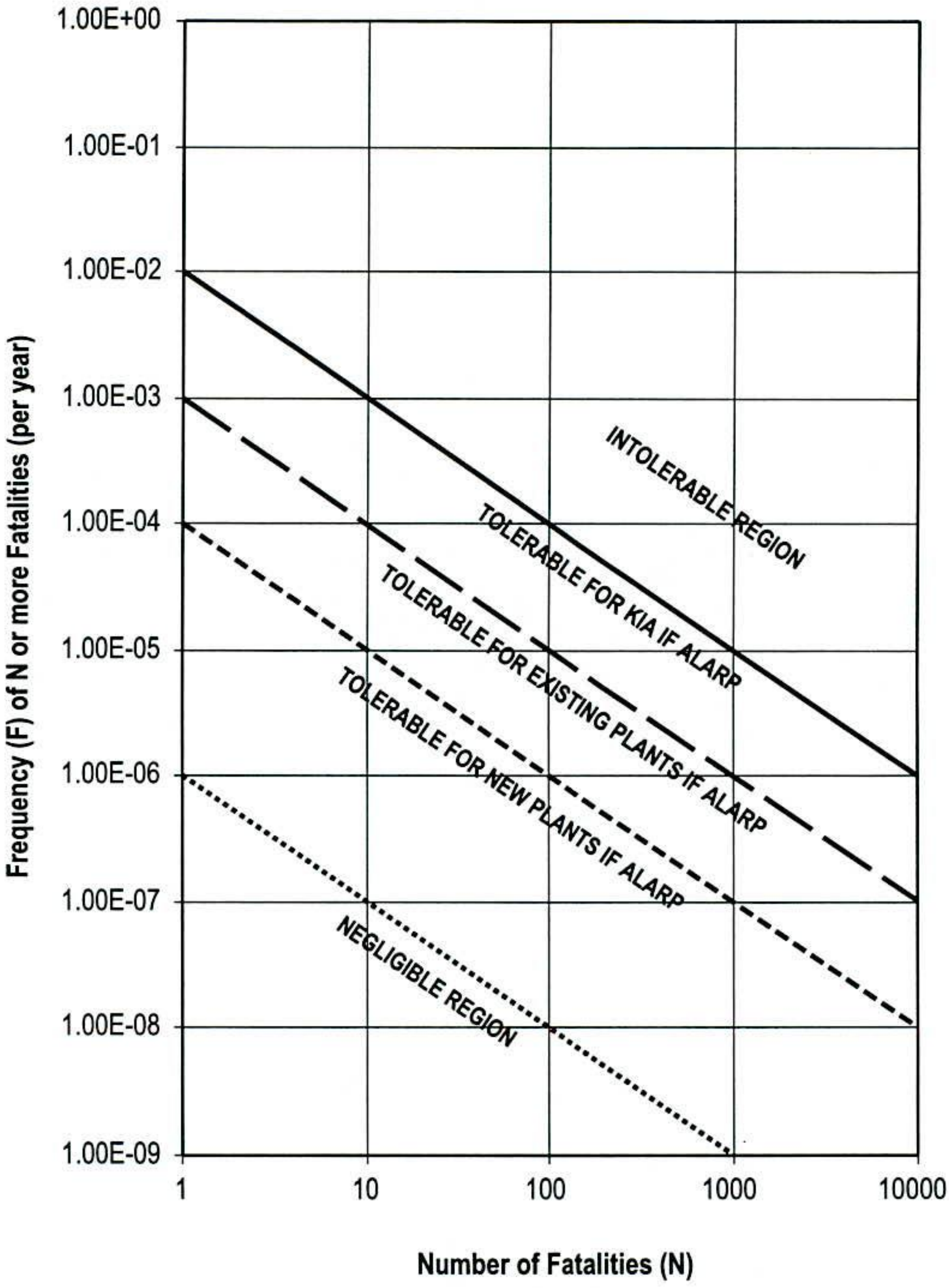

Figure 5.2 DnV TECHNICA PROPOSED SOCIETAL RISK CRITERIA FOR KIA

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However, a transportation study (ACDS, 1991) undertaken by a sub-committee of the Advisory Committee on Dangerous Substances (ACDS) on behalf of the HSC (Health & Safety Commission) in 1991 derived and applied societal risk criteria.

The F-N criteria are shown in *Figure 5.3*.

This may reflect the much larger study area that the ACDS criteria was intended to cover. As more industries and transport are added to a cumulative risk study the frequency of events calculated naturally increases. The frequency criteria must therefore be increased as the number of sites studied is increased.

For ports where the tonnage of hazardous substances might be substantially less than that at Canvey, the frequency would be adjusted downwards pro rata to tonnage per year to give a 'scrutiny' level, a level above which particular effort may be needed to reduce the risks. This scrutiny level is not as severe as a 'tolerability level' but would require extra effort and expenditure to demonstration that risk is ALARP.

In between the 'intolerable' and 'broadly acceptable' level, the ALARP principle applies. A cost of two million pounds sterling per fatality averted is used in the calculation of which risk reduction measures are considered to be "reasonably practicable".

Compared to the DnV Technica KIA criteria, this criteria is less stringent. The intolerable region is one order of magnitude higher and the "local scrutiny" line matches the "ALARP for new plants" line.

5.4 THE NETHERLANDS

In the external safety policy of the Netherlands (Lommers et al., 1995), hazardous industrial activities are evaluated with respect to their off-site risks, both in terms of individual risk and societal risk. For activities described as dangerous, these risks are compared with acceptability criteria. If risks are found to be unacceptable, either risk reducing measures or zoning (or both) are applied to bring the risk to an acceptable level.

The external (or off-site) risk assessment is QRA based and the societal risk criteria is shown in *Figure 5.4*. The societal risk criteria gradient is at a value of minus 2, which shows strong risk aversion (or more correctly, high consequence aversion) as shown in *Figure 5.4*. For example, in this approach, one incident involving 1,000 or so fatalities is considered less tolerable than 10 events involving 100 or so deaths in the same period, since a slope of -2 implies that a single event involving 1,000 fatalities is no more tolerable than one hundred incidents each of which involves 100 fatalities.

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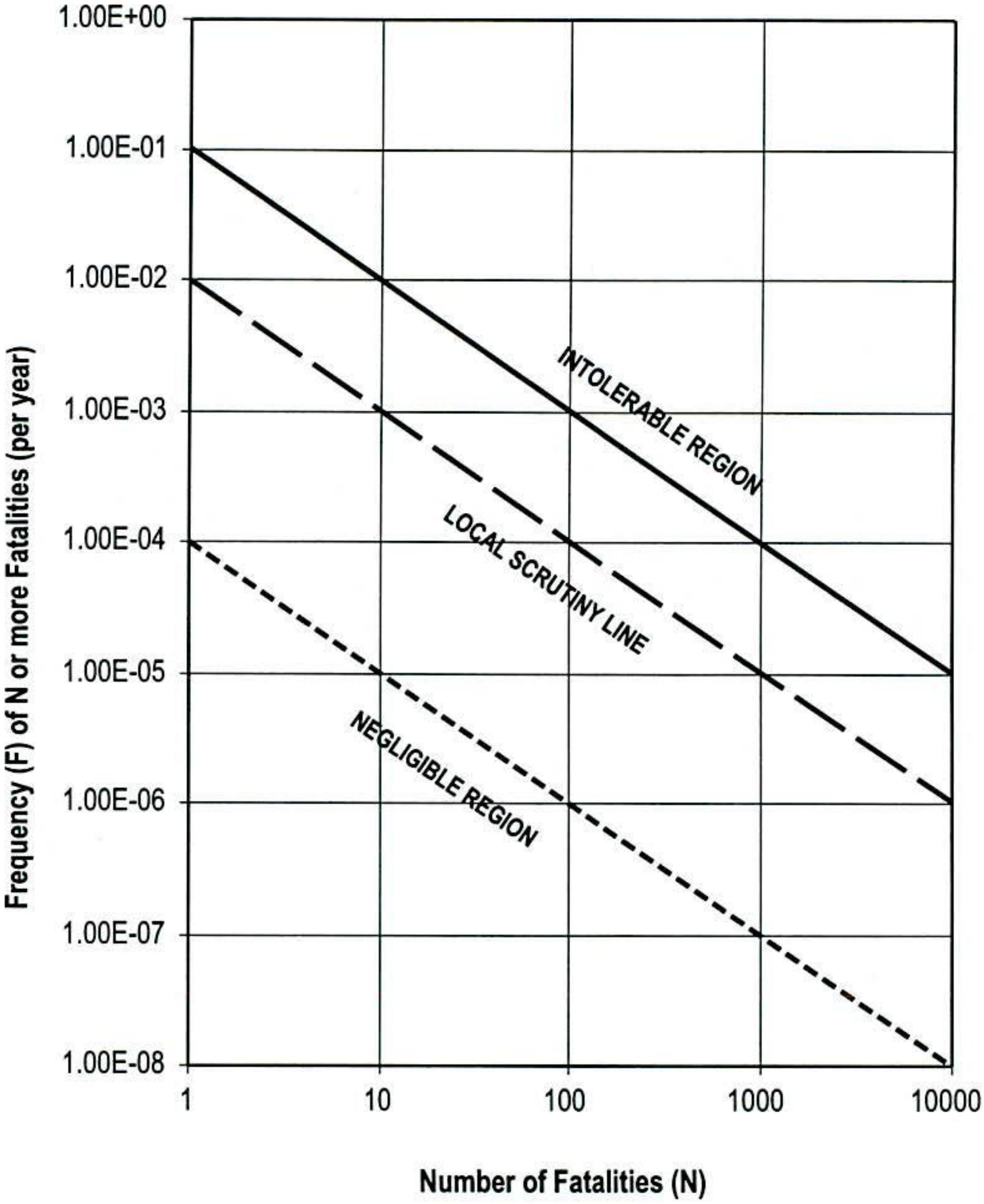

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Figure 5.3 UK ACDS SOCIETAL RISK CRITERIA FOR TRANSPORT

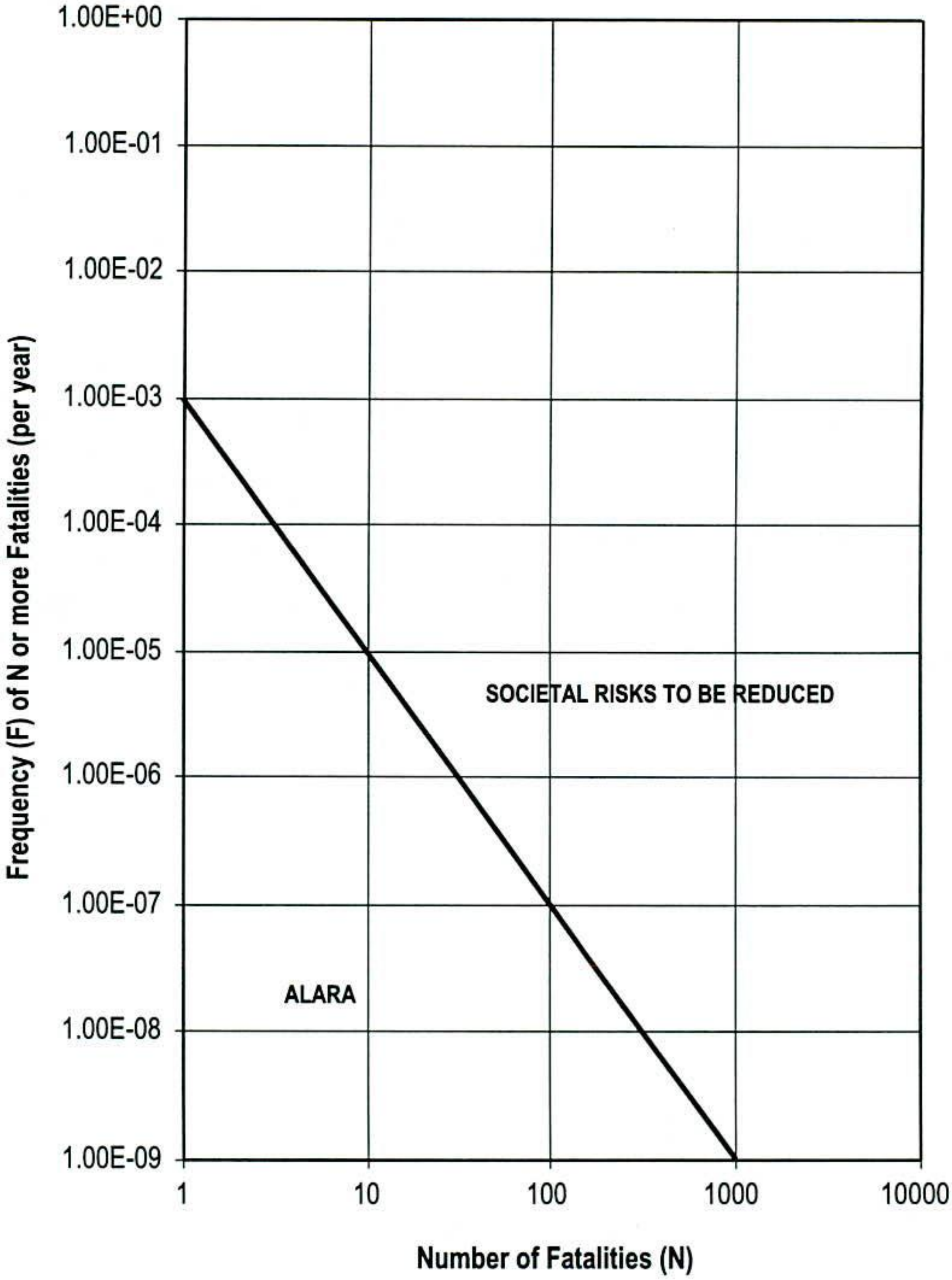

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Figure 5.4 DUTCH SOCIETAL RISK CRITERIA FOR NEW PLANTS

The supporting argument is that accidents causing large numbers of fatalities have, by comparison with less severe accidents, a disproportionately disruptive impact on society.

The Dutch Ministry for Housing recently confirmed the guidelines for Group Risk (November, 1998).

It should be noted that the societal risk criteria have been revised during recent years to eliminate the lower 'acceptable' line. That is to say, the risks are either 'unacceptable' or fall within the ALARA region (As Low As Reasonably Achievable), wherein, if ALARA is demonstrated then they are deemed to be 'tolerable'.

5.5 SWITZERLAND

The Federal and Kanton (state) criteria (Pikaar et al., 1995) address only the frequency and seriousness of accidents, ie. societal risk. There is no mention of risk contours or individual risk criteria in the published documents.

The Federal guidelines give a maximum and minimum societal risk criterion consisting of two lines with a gradient of -2 on an F-N graph, with vertical extension of the lines at both ends as indicated in *Figure 5.5*. The vertical extension of these lines (at both ends) has been interpreted as follows:

- Accidents below a certain size do not fall within the intent of the relevant law concerned with major accidents; and
- Accidents producing more than approximately 2,000 deaths at a frequency greater than 10^{-11}/yr will not be acceptable under any circumstances.

For proposed installations that impose risk levels which remain intolerable after all risk reduction possibilities have been exhausted, decisions have to be made at a political level. The authority can prevent industrial development that is too close to housing but the converse is not covered by law.

According to Pikaar & Seaman (1995), the Swiss situation (nationally) is still "fluid", with many parties still having to decide how they will proceed and what type of criteria to adopt, ie. whether to adopt guidelines or to impose firm limits to the risk levels.

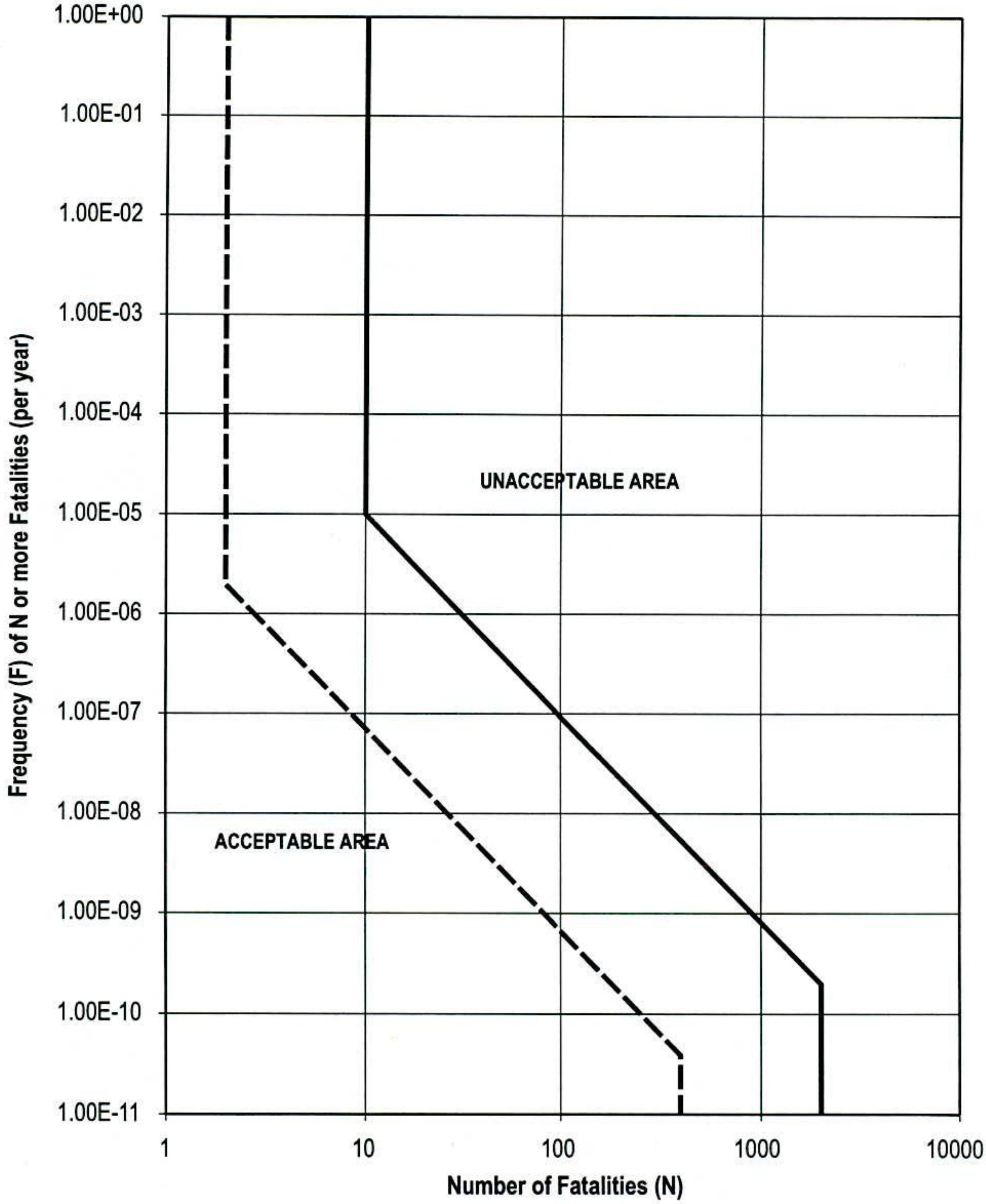

Figure 5.5 SWISS SOCIETAL RISK CRITERIA FOR NEW PLANTS

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5.6 HONG KONG

The use of QRA, and the application of risk criteria to assess the acceptability of risks to the public, is well developed in Hong Kong. The Hong Kong Government has established both individual and societal risk guidelines for planning applications around Potentially Hazardous Installations (ie. those installations that either store or process large quantities of toxic or flammable substances). The guidelines are published in the Hong Kong Planning Standards & Guidelines, Chapter 11. The societal risk criteria established by the Hong Kong Government are shown in *Figure 5.6*.

The guidelines were originally intended for application to new PHIs and expansion of existing PHIs. They have, however, been applied to all PHIs in Hong Kong, ie. those in existence preceding the introduction of the risk guidelines, and to all other new PHIs and expansions to PHIs. The guidelines are not intended to be applied as rigid criteria. They are intended for use as guidance in the complex decision-making process involving planning for and around PHI sites, although it is probably fair to say that in reality the criteria have been applied rather rigidly.

An 'unacceptable' high fatality level of 1000 is used for PHI sites in Hong Kong, ie., it is unacceptable to kill 1000 people or more in a single incident, unless the associated frequency is less than 10^{-9} per year (which is considered as non-credible). The use of the 1,000 fatality level, however, has proved to be a very stringent criterion for PHI sites in Hong Kong.

For the consideration of new developments, within the vicinity of PHIs, the risk guidelines are applied in a different manner. For example, if a new housing development is proposed near an existing PHI site (ie. within the 'Consultation Zone'), then the developer should carry out a Hazard Assessment (which includes a QRA) to demonstrate that the risks to the new development lay within the 'acceptable' region. By definition (of individual risk) this does not require consideration of the individual risk to the public to be redemonstrated, since the additional population will have no impact on the individual risk results. The developers are, however, required to demonstrate that the societal risk to the actual development (ie. the specific F-N curve for the development only) lies wholly within the 'acceptable' region. For a significant increase in population there may also be the potential for the overall F-N curve for the PHI to be raised higher up into the high ALARP or even the 'unacceptable' region - this would need to be taken into account during the land use planning process.

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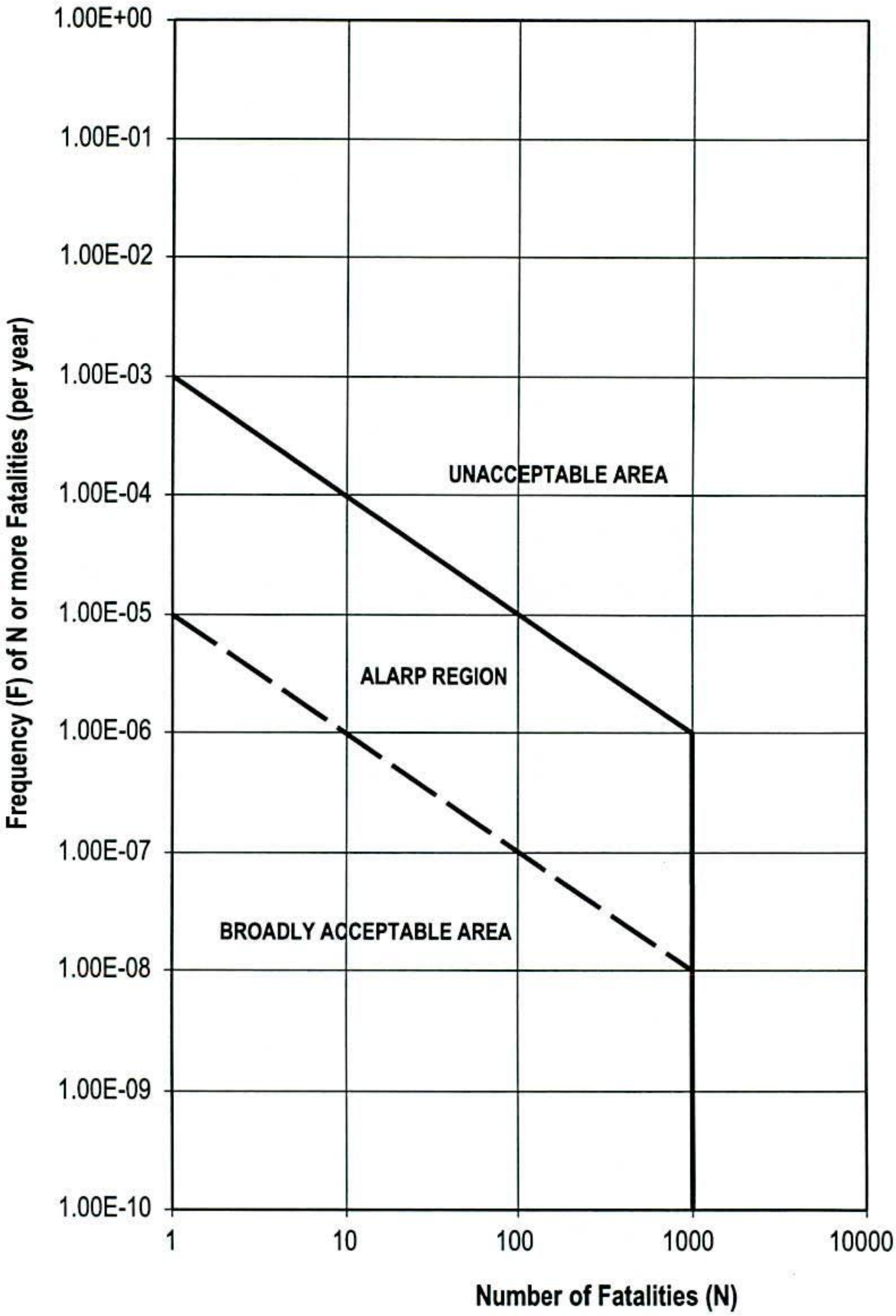

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Figure 5.6 HONG KONG SOCIETAL RISK CRITERIA FOR NEW PLANTS

5.7 CONCLUSION

It is difficult to compare the societal risk results reported for the KIA with any existing established societal risk criteria in the world. The results are not directly comparable with most established criteria for the following reasons:

- The AEA (1998) and ERS (1999) studies of the KIA combine transport and fixed installations – most criteria discussed above are generally intended for fixed installations only (except for the ACDS criteria which was intended for transport only);

- In accordance with methodology used in WA, the AEA (1998) and ERS (1999) studies do not take account of protective factors, ie. people indoors are protected to some extent from toxic gas ingress and heat radiation – most criteria assume that this factor is included when societal risk is calculated. Therefore the KIA study will predict higher numbers of fatalities; and

- The AEA (1998) and ERS (1999) studies only present fatalities to residential populations – most criteria intend that industrial populations from neighbouring sites are included (the population on the hazard site is excluded). In the KIA study all sites have been considered as sources which may explain why industrial populations have not been included.

The Hong Kong, Dutch, Swiss and ANCOLD criteria are not readily applicable to the KIA study because they were intended largely for use in assessing the risk posed by a single hazardous site to the surrounding neighbourhood. They were not intended to be used for assessing the risk posed by multiple sites or transport which is the format of the results presented in this study. However, the maximum of 1,000 fatalities (at frequencies above 10^{-9} per year) in the Hong Kong criteria and 2,000 fatalities in the Swiss criteria (at frequencies above 10^{-11} per year) could be considered to be applicable to a cumulative risk study, because they will apply regardless of the number of sites. However, the inclusion of transportation risk in the studies of the KIA means that even this comparison is not valid.

The DnV Technica criteria developed for the KIA is the most applicable because this criteria is the only criteria that considers societal risk assessed in the same manner as the AEA (1998) report, ie. no protection factors and residential populations only. However, it should be noted that this is a proposed criteria and is not formalised.

The UK ACDS criteria may also be used because this criteria is used for transport studies in the UK and therefore is somewhat applicable to the current study.

However, the criteria is less stringent than the criteria developed by DnV Technica, and hence the DnV Technica criteria will be the preferred criteria used in this report. Reference will also be made to where the risk falls in the ACDS criteria for comparison with an established criteria, although the results will not be shown plotted against the ACDS criteria (because of size of the study area).

Chapter 6

SOCIETAL RISK IN KIA

6.1 INTRODUCTION

The individual and societal risk level in the KIA was estimated in 1994 (AEA, 1995). The reported results included the risks associated with all industrial facilities, transportation of hazardous goods, ships at berths and pipelines. A number of factors must be remembered when comparing these results to societal risk criteria:

- No protection factors were included in the AEA (1998) and ERS (1999) studies;
- The AEA (1998) and ERS (1999) studies considered multiple sources and multiple receivers;
- Fixed installations, transportation, ships at berth and pipelines were all included in the AEA (1998) and ERS (1999) studies; and
- Residential populations only were included in the AEA (1998) and ERS (1999) studies.

No protection factors means that the curves assume that the population is unprotected, ie. present outside and exposed. In the case of the Motorplex, factors such as the embankment around the arena, that may provide some protection against heavier-than-air toxic gases, or shielding from heat radiation due to the grandstand, will not have been considered.

QRAs typically make many assumptions to calculate the overall risk, and generally when there is some uncertainty a conservative assumption is made, ie. the assumption used will lead to an over estimate of the number of fatalities. As with most other QRAs a "flat terrain" dispersion model was used in the AEA study ie. the effects of hills and buildings on dispersion of toxic gases were not considered.

The risk levels will be compared with societal risk criteria suggested for the KIA by DNV Technica and ACDS transport as these are the most applicable for a multiple source study (see *Section 5*) with transportation. The results have been superimposed on the DnV Technica criteria, as this is the more stringent criteria. The ACDS criteria can be easily considered when looking at the figures as the intolerable region is one order of magnitude higher and the "local scrutiny" line of the ACDS criteria matches the "ALARP for new plants" line of the DnV Technica KIA criteria.

However, it should be remembered that the ACDS study was for a much larger study area than the studies done for the KIA, and as recommended by ACDS, the criteria should in fact be reduced on a pro rata basis.

6.2 EXISTING SOCIETAL RISK LEVELS IN THE KIA

The existing level of societal risk (as at 1994) is shown in *Figure 6.1* (AEA, 1995). This is the societal risk for all industry and residential populations existing in 1994. This indicates a frequency of 6×10^{-6} per year for one or more fatalities with the curve falling with a slope of approximately –1 to cross 1000 or more fatalities at approximately 10^{-8} per year, then falling to a maximum number of fatalities of about 4,000 at a frequency of 10^{-10} per year.

This curve is in the ALARP region for the DNV Technica KIA criteria and falls completely within the negligible region of the ACDS societal risk criteria. Note also that the frequencies are low when compared to the overall societal risk in the USA presented in *Figure 4.1*, falling below the curve for 100 nuclear power plants.

6.3 PREDICTED SOCIETAL RISK LEVELS IN 2020

The predicted societal risk in 2020 for the KIA was estimated in 1994 (AEA, 1995) and updated in 1998 (AEA, 1998). The estimate was produced by copying the risk associated with certain existing facilities to other locations in the KIA to model an increase in the number of industrial facilities. This included heavy industrial plants located northwards from the existing Kwinana area to just north and east of the Naval Base. The predicted societal risk in the KIA in 2020 is shown in *Figure 6.2* (AEA, 1998).

The curve indicates a frequency of one or more fatalities of about 3×10^{-5} per year. The curve falls slowly to around 60 or more fatalities where there is a sharp fall in the frequency until 100 or more fatalities. The curve then falls steadily to a maximum number of fatalities of about 5,000 at a frequency of around 1×10^{-9} per year.

The curve is within the ALARP region of the DNV Technica KIA criteria and the Negligible and Local Scrutiny Region of ACDS criteria.

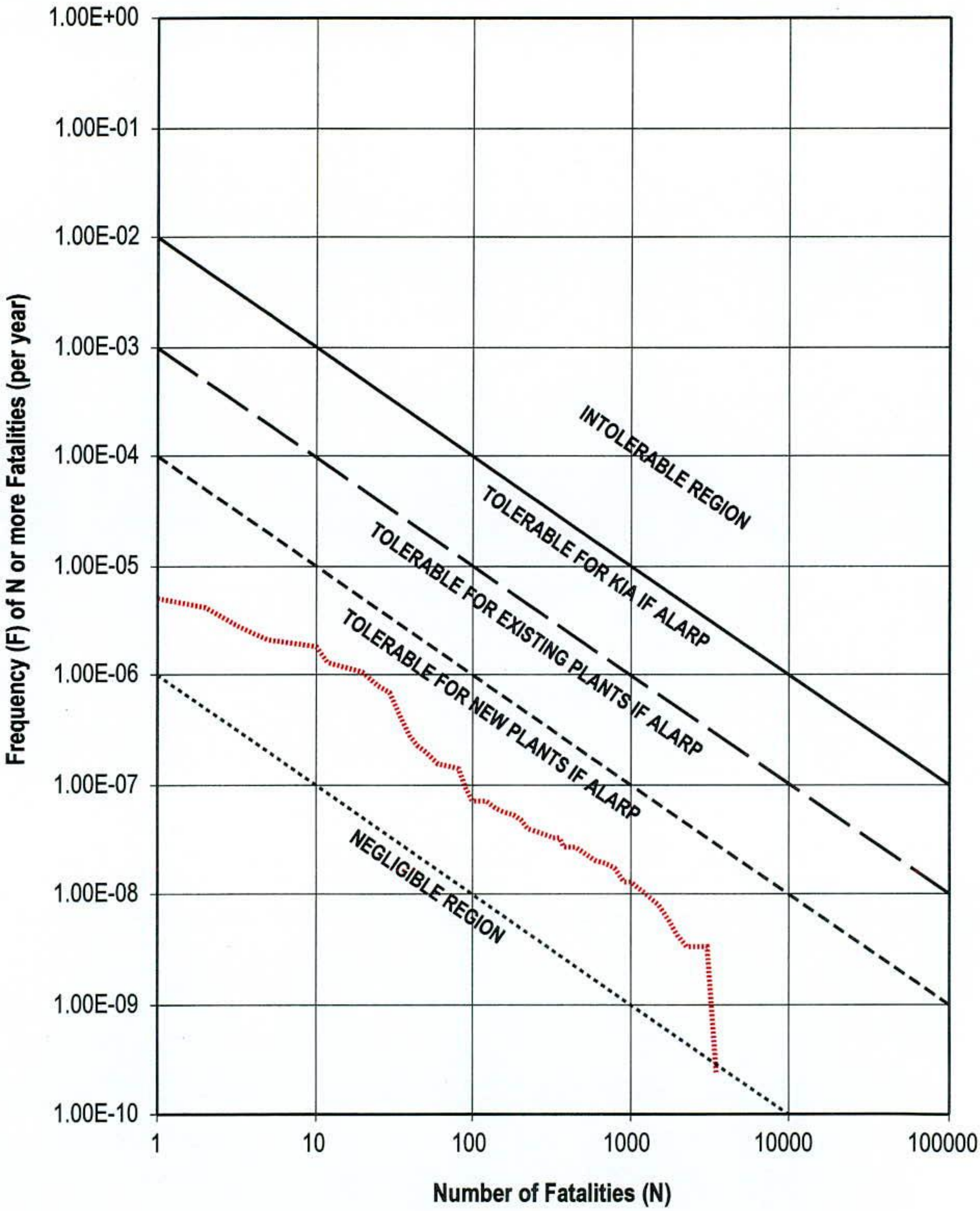

Figure 6.1 SOCIETAL RISK IN THE KIA IN 1994 WITH DnV TECHNICA KIA CRITERIA

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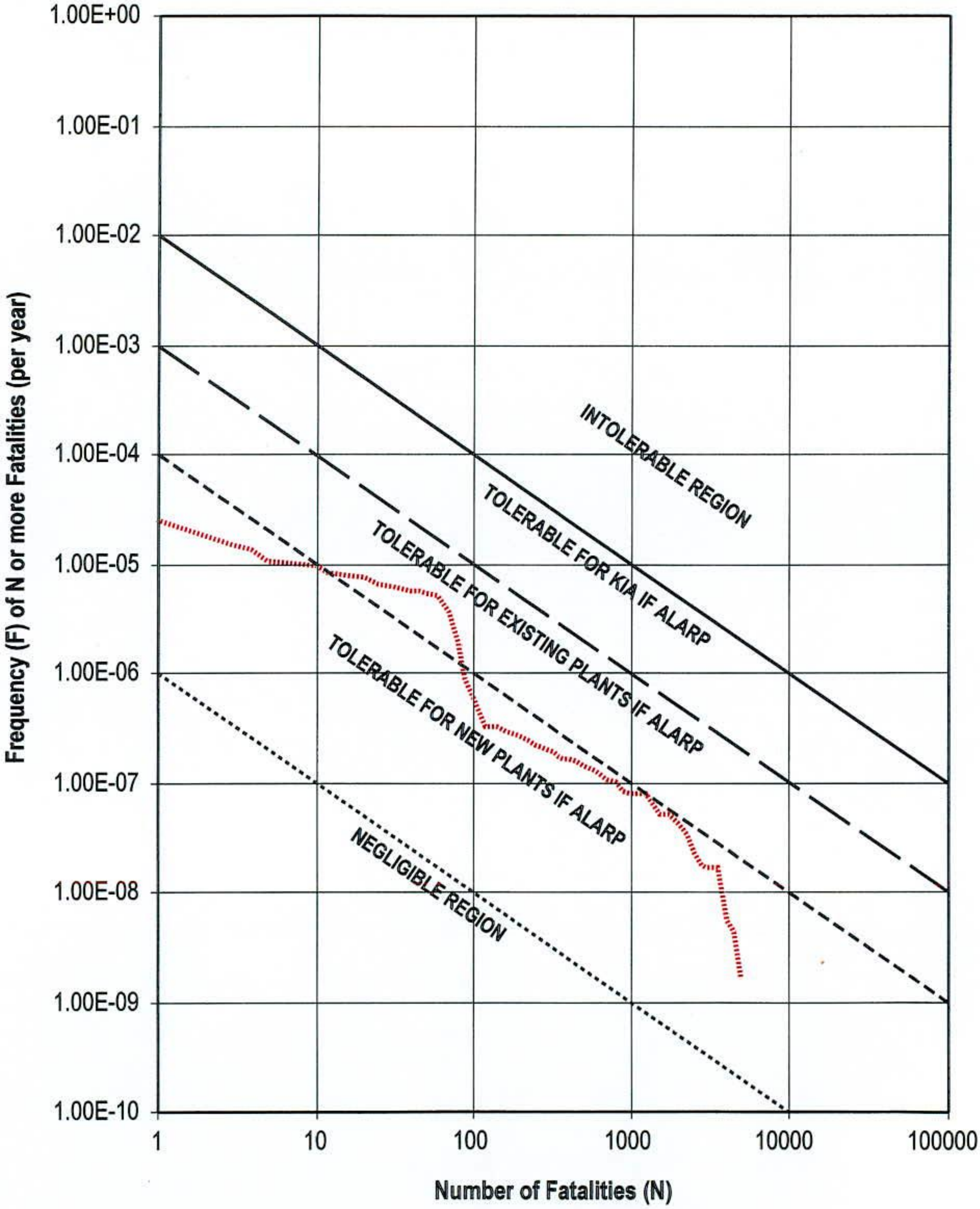

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Figure 6.2 PREDICTED SOCIETAL RISK IN THE KIA IN 2020 WITH DnV TECHNICA KIA CRITERIA

6.4 SOCIETAL RISK LEVELS WITH THE MOTORPLEX

The F-N curves for societal risk, with the Motorplex included in the population, is shown in *Figure 6.3* (AEA, 1995; ERS, 1999). The two curves represent the societal risk for the existing (1994) level of industry and transport in the KIA with and without the Motorplex population included. *Figure 6.4* shows the predicted (2020) future level of industry and transport in the KIA with and without the Motorplex population.

The 1994 results remains in the ALARP region for the DNV Technica KIA criteria and remains completely within the negligible region of the ACDS societal risk criteria with the Motorplex population included.

The curve for 2020 with the Motorplex is also within the ALARP region of the DNV Technica KIA criteria and the Negligible and Local Scrutiny Region of ACDS criteria.

6.5 DISCUSSION OF THE RESULTS

The 1994 curves indicate a small change in the total F-N curve up to the 1,000 fatalities at a frequency of 10^{-8} per year. At a frequency of 10^{-9} per year the Motorplex population begins to have a significant effect on the societal risk. Where the F-N curve for the existing situation drops away rapidly to a maximum number of fatalities of 4,000 at a frequency of approximately 10^{-10} per year, the case with the Motorplex continues to a maximum number of fatalities of 13,000 at around 5×10^{-11} per year. The frequencies are extremely low, reflecting the low probability of a large population being present in the Motorplex when a major accident occurs (15,000 people were assumed to be present for 1.25 days per year). Note that this frequency will increase if the Motorplex has large crowds on more occasions than predicted.

The 2020 curves show that the Motorplex population has little effect on the overall societal risk for fatalities less than 100 and frequencies above 1×10^{-6} per year. For incidents causing between 100 and 1,000 fatalities the Motorplex population begins to have a significant effect on the overall societal risk. It must be remembered that this is an estimated level of development in 2020 and the actual development in 2020 may of course be significantly different.

The low frequencies being calculated may be difficult to comprehend. As comparison, the risk of fatality by lightning strike is 10^{-7} per year (1 in 10,000,000 person years) and meteorite strike is 10^{-9} per year (1 in 1,000,000,000 person.years). The Hong Kong criteria consider any event calculated to occur at 10^{-9} per year or less as not credible.

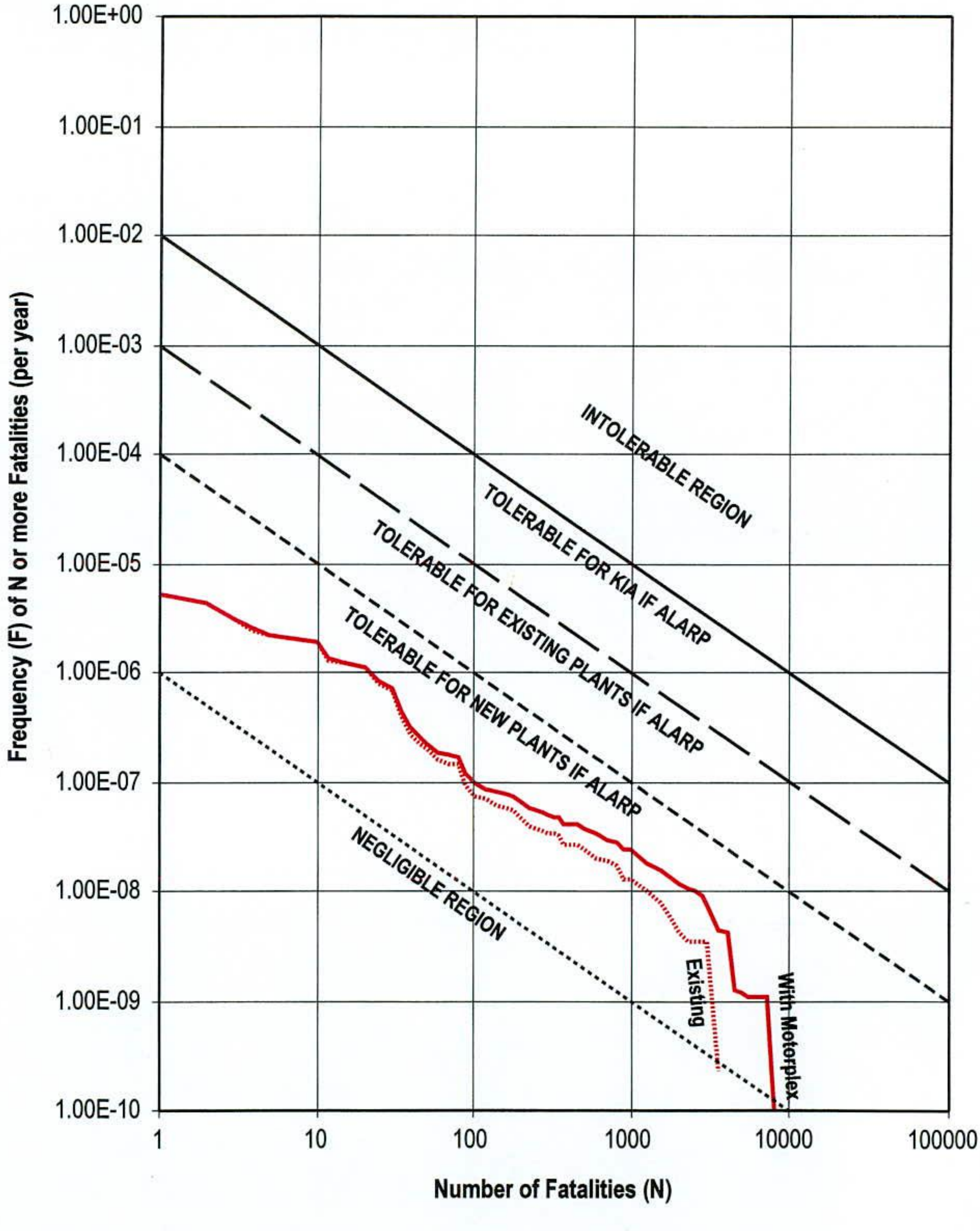

Figure 6.3 COMPARISON OF SOCIETAL RISK IN THE KIA IN 1994 WITH AND WITHOUT THE MOTORPLEX

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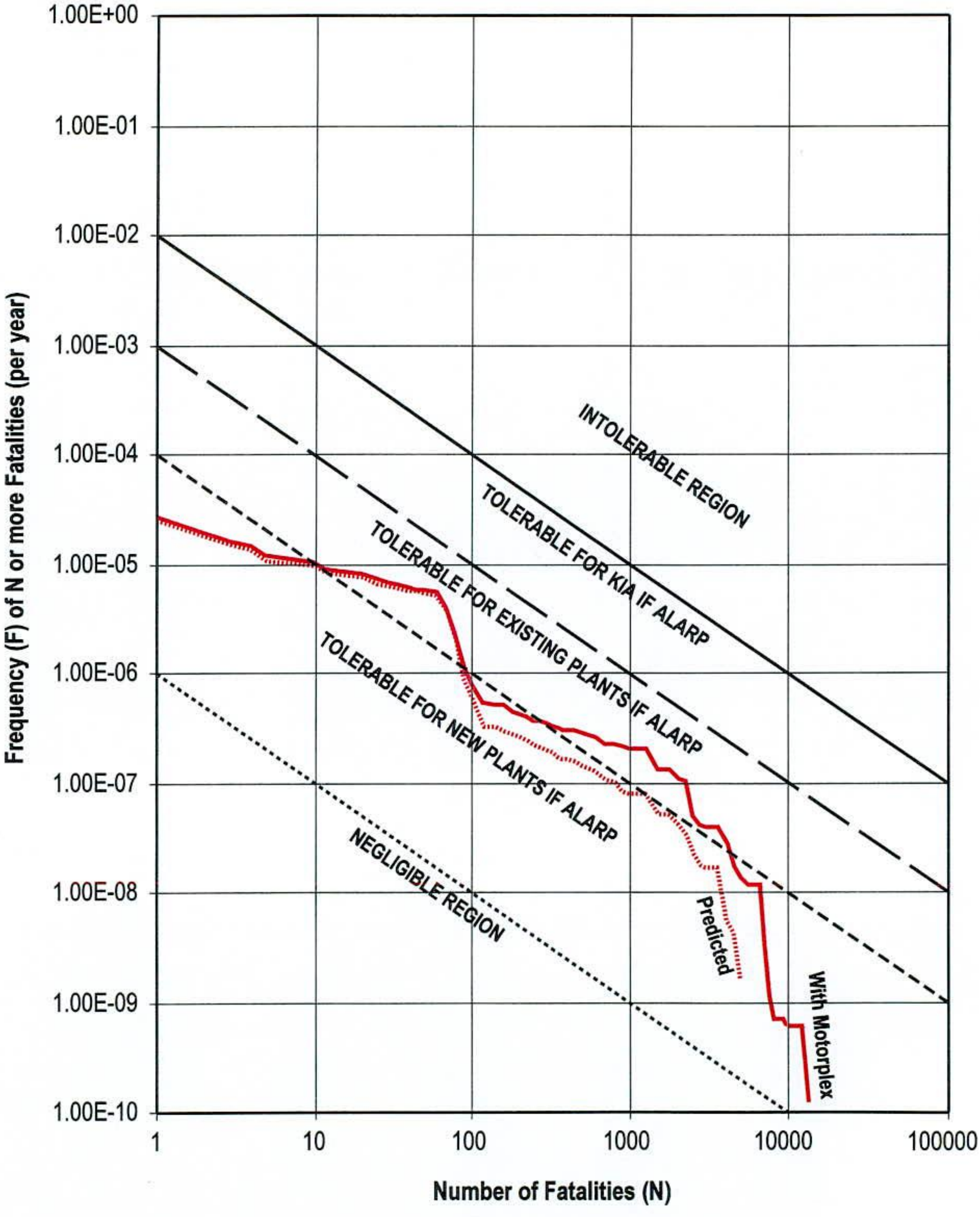

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Figure 6.4 PREDICTED SOCIETAL RISK IN THE KIA IN 2020 WITH AND WITHOUT THE MOTORPLEX

The increase in the maximum number of fatalities is made more dramatic by the exclusion of industrial populations in the AEA (1998) and ERS (1999) studies. The Motorplex is therefore the only population included in the KIA proper, all other populations being further afield. The Motorplex is therefore most likely the only population within the high fatality consequence zones from the industrial sites. If industrial population were included in the published results the effect of the Motorplex may not be as significant to the overall result.

Although the societal risk results presented for the KIA are not calculated in a manner that allows a fair comparison with the other societal risk criteria, for completeness a comparison of the results with other criteria has been conducted.

The ANCOLD societal risk criteria for dams are the only published Australian societal risk criteria. The 1994 societal risk for the KIA is in the generally acceptable region of the ANCOLD criteria both with and without the Motorplex. The 2020 societal risk levels are also within the ALARP region of the ANCOLD criteria, both with and without the Motorplex.

The societal risk for all cases (including the existing 1994 case) would fail the Hong Kong, Swiss and Dutch criteria (used by Victorian authorities) based on the high fatalities, even though they occur at very low frequencies. However these criteria are intended for assessing a single site, whereas the studies undertaken for the KIA include the sum of the risk from many sites and transportation. The Hong Kong and Swiss criteria have a maximum number of allowed fatalities of 1,000 (at frequencies above 10^{-9} per year) and 2,000 (at frequencies above 10^{-11} per year) respectively and these could be applied to multiple site studies, but they were not intended for studies including transport such as the AEA (1998) and ERS (1999) studies of the KIA.

It must always be remembered that a criteria from another region of the world, no matter how accepted where it is being used, may not be applicable to the local situation. This is particularly true in the case of a complex issue such as societal risk where there are many approaches and methodologies that can be used to calculate the risk. Many countries have not established a risk criteria at all, preferring engineering controls or minimum buffer distances. Determining the level of risk tolerable to society is not a simple matter. The tolerability of risk will be affected by local cultures and values or practicalities. Some areas of the world may tolerate a higher level of risk to achieve a goal of greater industrial production (wealth), or perhaps because there is no practical alternative.

6.6 RISK MANAGEMENT

Since the Motorplex risk levels fall within the ALARP region of the KIA, all measures should be taken to make the risks as low as reasonably practicable. Risk mitigation measures could be implemented may include:

- Monitoring of the risk levels and control of industrial developments near the Motorplex. This may restrict future development of hazardous facilities in the vicinity of the Motorplex;
- Installation of features at the Motorplex to improve protection of patrons, such as ensuring the stands prevent line-of-sight between patrons and the industrial area (to reduce potential heat radiation effects);
- Installation of evacuation features to allow smooth and rapid evacuation of the facility such as multi-lane exits;
- Installation of communication facilities to allow contact between Motorplex operators and patrons such as public address system and FM radio (to car radios to advise of evacuation routes);
- Comprehensive Emergency Response Plans (ERP). The operators of the Motorplex would be required to develop an emergency response plan which would include guidelines on when to evacuate;
- Any company with the potential to affect the Motorplex must update their ERP to include contacting the operators of the Motorplex if an incident has the potential to affect the Motorplex and advising of appropriate response; and
- Coordination between the operators of the Motorplex and industry to ensure that non-essential hazardous activities and transport do not coincide with the two days per year where crowds of 8,000 or more are expected to be present at the Motorplex.

Chapter 7

CONCLUSION

This report has been compiled using existing reports on societal risk in the KIA prepared on behalf of the Department of Resources Development by AEA Technology (1995, 1998) and additional modelling of the risks to the Motorplex by ERS (199) undertaken on behalf of the Ministry for Planning. The AEA reports calculated the societal risk to residents in the vicinity of the KIA from all industrial sites, hazardous material transport, ships at berth and pipelines. As with the rest of Australia and many other countries, there are no formalised societal risk criteria in WA. Therefore a review of international criteria was undertaken for comparison of societal risk levels in the KIA with those tolerated in other regions of the world.

The societal risk criteria identified were the ANCOLD (Australia) criteria for large dams, the DnV Technica criteria proposed for the KIA, the UK ACDS transport criteria, the Hong Kong, Swiss and Dutch criteria. Most criteria are not easily compared with the societal risk results reported for the KIA because:

- The criteria are generally for a single hazardous site (ie. single source) whereas the AEA studies (1994, 1998) included many sites and transportation risk;
- The criteria are established for societal risk calculated using "protection factors" (ie. an allowance is made for safety provided by being inside) whereas the AEA (1994) and ERS (1999) studies were based on unprotected people (ie. all people are always outside); and
- The societal risk for the KIA (AEA, 1994; ERS, 1999) only includes residential populations and excludes industrial populations, whereas most criteria intend that industrial populations are included in the calculation.

Given these difficulties the most appropriate criteria are the UK ACDS transport criteria and the KIA criteria developed by DnV Technica, because these criteria are intended for multiple sites. Although the DnV Technica KIA criteria is not used formally, and the upper limit has not been tested in a risk study, it has been applied as the preferred criteria for this report because it is more stringent. It also was prepared specifically for assessing the societal risk in the KIA and therefore accounts for the method of calculating the societal risk in the AEA 1994) and ERS (1999) studies.

According to both these criteria the present levels of societal risk are not unacceptable, the current situation being in the "ALARP" region of the DnV Technica KIA criteria and the "Tolerable" region of the ACDS criteria. The societal risk would increase if the Motorplex is added but still lies in the "ALARP" region of the DnV Technica KIA criteria and the "Tolerable" region of the ACDS criteria.

The societal risk was also estimated for a "fully developed KIA" in 2020, both with and without the Motorplex. The predicted societal risk is within the ALARP region of the DnV Technica KIA criteria and the Negligible and Local Scrutiny Region of ACDS criteria.

Locating the Motorplex in the KIA buffer region is acceptable according to these criteria for multiple site societal risk. However, the increased population in the region means that the area around the Motorplex would require careful planning to ensure the risk levels remain as low as reasonably practicable. This may affect the design of the Motorplex and future developments in the vicinity of the Motorplex, as well as requiring careful management and a comprehensive emergency response plan.

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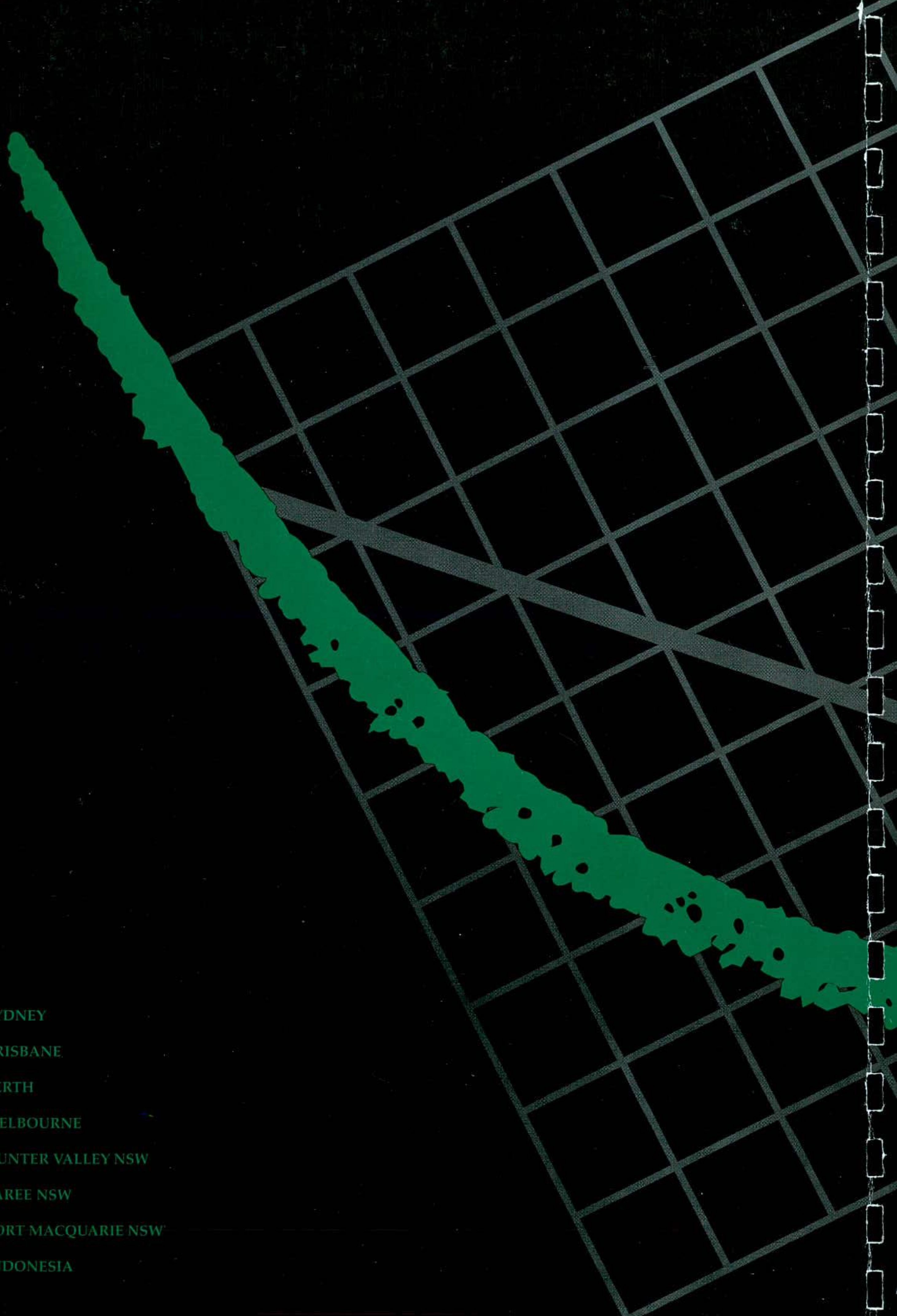

SYDNEY

BRISBANE

PERTH

MELBOURNE

HUNTER VALLEY NSW

TAREE NSW

PORT MACQUARIE NSW

INDONESIA