Auckland Regional Council

Assessing Risk from Potential Air Discharges Following Industrial Incidents

A Discussion

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SINCLAIR KNIGHT MERZ

Sinclair Knight Merz
Level 12, Mayfair House
54 The Terrace
PO Box 10-283
Wellington
New Zealand
Telephone: +64 4 473 4265
Fax: +64 4 473 3369

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1. Executive Summary

1.1 Report Aim

The Auckland Regional Council has commissioned this report to progress the production of guidance for those submitting applications for discharges to air. It is a discussion document written as part of the process of developing the Regional Plan. This report focuses on the potential effects of air discharges from industrial incidents, since such discharges present a risk that currently may not be fully considered during applications for Resource Consents.

The meaning of 'effect' in section 3(f) of the Resource Management Act (RMA) includes potential effects of low probability, which have a high potential impact. The interpretation of this clause has caused some uncertainty and the assessment of potential effects of this kind is possibly one of the least understood areas in the resource consent process. This report aims to discuss how and when this category of effect should be assessed and provide information that may assist applicants with respect to specific tools and evaluation criteria.

1.2 Recommendations

The following recommendations and observations arise out of this report:

1) In developing rules for the Regional Plan, the Council may need to consider those activities with a potential to discharge contaminants to air as a result of an industrial incident. More work may be necessary to clearly establish the Council's jurisdiction, but it is possible that controls should be placed on some hazardous activities, even though they would normally be expected to have a minor discharge to air.

2) A guideline on assessing air discharges from industrial incidents should be as consistent as possible with the Hazardous Facility Screening Procedures (HFSP) adopted by the territorial local authorities in their District Plans.

3) This report has attempted to broadly identify those activities that should include a risk study as part of an application for air discharge consent. Some of these could be identified by the HFSP. However, these proceedures should be complemented by other criteria that identify activities employing hazardous processes. For example, guidelines described by the Occupational Safety and Health Service in their Approved Code of Practice highlight some hazardous processes that could be considered.

4) More work may be necessary to provide specific guidance as to which activities should include a risk study as part of an Assessment of Environmental Effects. Particularly as the drafting of Plan rules progress to the final stages.

5) Applications for air discharge permits that involve a risk study should include at least three elements: an analysis if what can happen and the associated

probability, an account of the consequences and a description of what controls are in place to mitigate the risk. It is also necessary to identify the most significant risks. The specific tools and level of detail required for such a study depends on the activity and type of hazard.

6) Given that the Auckland Regional Council will need to decide whether risks associated with an activity are acceptable or not, the identification of an acceptable level of risk becomes critical. It will therefore be necessary to develop Risk Tolerability criteria. This will need to state absolute levels of tolerability as well as any risk to benefit trade-offs that may be considered.

2. Introduction

This report is concerned with the risk of air discharges from engineering or process plant accidents. It concentrates on those activities that discharge contaminants to air or have the potential to discharge contaminants to air. While risk management should not be limited in scope to one environmental medium, the report was commissioned to discuss guidance for those who must apply for air discharge permits

Those activities classified as discretionary by the Regional Plan will be required to obtain consent and prepare an Assessment of Environmental Effects as part of their application. The Plan has not been completed at the time of writing this report but it is possible to assume at least the general types of activities that may be considered discretionary. Within this category there will be a sub category of activities with characteristics that pose a potential air pollution risk. These processes need to be identified and some guidelines provided as to appropriate incident assessment methods.

The term *risk assessment* can be confusing particularly in the context of air pollution assessments. What this document describes is a risk-based approach to assessing industrial incidents. A risk-based approach is a methodology that takes account of the probabilistic nature of unintended events. Tools that aid the identification of untoward events and an understanding of the potential consequences are also discussed.

The probabilistic approach contrasts with the more recognised assessment methods used for air quality impacts. These are usually deterministic in nature and do not facilitate the identification of hazards or the resulting failure sequences. In most circumstances, normal or expected air discharges are compared to a specific guideline or criterion, such as an ambient air threshold. However, many criteria used in the deterministic assessments have been developed by way of a risk-based approach that includes a probabilistic element. For example, ambient air concentration limits for many contaminants have been determined by health risk assessments, which deal with evaluating long-term exposure in relation to an acceptable likelihood of illness or death. Health risk assessments are not the subject of this report, nor is a broad treatment of risk management.

Councils, Applicants and Consultants alike are comparatively comfortable with deterministic tools, such as dispersion models and environmental threshold values. These tools are appropriate for dealing with normal, designed or intended discharges to air. However, a similar level of experience and familiarity with the potential effects of abnormal discharges, particularly those considered a low probability, does not currently exist in New Zealand.

There is some overlapping responsibility for controlling the risks of industrial incidents and probably the greatest potential overlap is with Territorial Local Authorities (TLAs). Risk management tools are already required through District Plans and the 'Hazardous Facility Screening Procedures'. However these requirements may not deal with all discharges to air, due to differences in scope and emphasis. The Occupational Safety and Health Service of the Department of Labour also administers a number of regulations and legislation that deal with workplace hazards associated with a range of activities and substances. The recently enacted Hazardous Substances and New Organisms Act also deals with risk issues associated with the production, import and use of hazardous substances. Some discussion is necessary to help clarify where responsibilities lie in respect to discharges to air.

The aim of this report is to provide a discussion that can help resolve some of these issues and lead towards clear guidance for the assessment of potential industrial incidents. A pragmatic approach is advocated so that industrial incidents to be assessed in an appropriate manner consistent with the scale and type of risk.

The document is divided into five sections, as follows:

- Section 3 provides a general overview of risk analysis and assessment terminology.
- Section 4 describes the regulatory context. It provides a background with respect to the RMA and other legislation in New Zealand and overseas, and discusses Regional Council and Applicant responsibilities.
- Section 5 aims to determine which particular types of activities should require a risk analysis or assessment of industrial incident risks.
- Section 6 discusses what should be included in an Assessment of Environmental Effects for those activities where it is appropriate to assess potential incidents.
- Section 7 describes some tools that may be applicable to risk-based air discharge assessments.
- The final section aims to discuss how tolerable risk may be evaluated.

3. Terms and Concepts

The discussion in this section provides a general introduction to some terms and concepts used in the context of management and evaluating risks from industrial incidents. In this respect there is a range of standards and other documents which provide guidance on risk management in general and the specific tools that are used. For example, the reader is encouraged to consult the Australian and New Zealand standards AS/NZS4360:1999 and AS/NZS3931:1998 for some useful summaries of the types of tools relating to risk management.

3.1 What is Risk?

Firstly, the fundamental concept of risk always involves two elements: the frequency or probability with which a hazardous event occurs and the consequence of that event. A risk *analysis* deals with both elements, while risk *assessment* is the process used to determine management priorities by comparing the level of risk against predetermined standards or other criteria. In the case of applications for Discharge Consents such criteria will need to be based on community values and possibly stipulated in some form in the Regional Plan. Risk tolerability criteria will be discussed further in section 8.

3.2 Individual/Societal Risk

It is necessary to define the most appropriate way of measuring risk. In some cases it will be necessary to investigate and measure the risk posed to an individual or a defined receiving environment. In other cases the important element may be seen as risk to society or the environment as a whole. When referring to human safety risk it is normal to define risk in terms if the individual or society; "societal risk" or "individual risk.

Put simply, societal risk is the likelihood of a disaster. It can be defined as "*the relationship between frequency and the number of people suffering from a specified level of harm in a given population from the realisation of specified hazards*". Societal risk is difficult to express as a single probability figure as it is necessary to consider the size of the disaster as well as its probability. In reality there would be a range of possible sizes, each with a different probability.

3.3 Hazard and Hazard Identification

A hazard is a source of risk or potential harm and a hazard identification process "*involves a systematic review of the system under study to identify the type of inherent hazards that are present together with the ways in which they could be realised*". In other words, a review of what can cause an incident.

This can involve a range of methods and some of these are described in later sections. The hazard identification process is without doubt the most important step of any risk-based study. Risks cannot be assessed or managed if they remain unknown.

3.4 Risk Estimation and Analysis

As discussed above, risk analysis is the process of determining how often incidents may occur and the severity of the associated consequences so as to establish the actual, as opposed to the perceived level of risk. This process can be carried out using detailed mathematically-based tools or by a more general process involving the extensive use of judgement based data. The first methodology is known as 'qualitative', the latter, 'qualitative'.

A quantitative risk analysis provides a measure of risk by using estimates of frequency or probability of the undesired events that are based upon historical data or calculations based upon an analysis of failure sequences. This work is then supported by the calculation of the impact of the consequences.

Quantitative risk analysis can be very demanding and in practice, there is a potential for a very large range of accident scenarios. It therefore may not be feasible to undertake a detailed frequency and consequence analysis for each one. In these circumstances it may be better to rank the scenarios qualitatively and then concentrate on those events that are assessed as having the highest risk. Thus, risk estimation techniques provide a useful approach for ensuring the quantitative effort is focused on events of greatest concern.

3.5 Frequency Analysis

A frequency analysis forms part of a risk analysis described above. It involves the quantitative determination of the likelihood or frequency of events identified at the hazard identification stage. Again, a number of methods are available and some will be described in latter sections.

3.6 Consequence Analysis

Consequence analysis involves methods for calculating or estimating the impact of the incident. This could include a study of the effects of any harm caused such as on people, property or the environment and must relate the sensitivity of the local environment to the event.

In general terms, consequence analysis determines the effects from fires, projectiles, falling structures etc. However, in the context of an air discharge consent application the focus is on the consequence of the release of contaminants to air. A range of tools are available for assessing the consequence and these are also discussed further in section 7. Some of these can be very sophisticated and demanding to use. It is important that the tools are used appropriately, consistent with the scale and nature of the consequence of concern.

3.7 Cumulative Risk

The total risk faced by an individual or society is the sum of all individual risks. Therefore, when considering the calculated risk from a facility, it is necessary to also consider any existing risks posed by other nearby facilities. Even when the new facility may present a small risk relative to an existing one, the total or cumulative risk will still be increased, possibly to a level that may be deemed intolerable.

3.8 Uncertainty

As risk is a function of both probability and the future, there will invariably be a level of uncertainty associated with any analysis of risk. This uncertainty relates to the inability to know exactly how and when events may occur.

The uncertainties may arise in various parts of an assessment, including failure rate estimates, consequences, or assumptions about human error. In many cases therefore a quantitative evaluation criteria may have limited value and a more qualitative criteria may be more appropriate. In some cases the appropriate approach will be to consider the worst case, thereby adding an element of precaution.

Furthermore, it may be very difficult to derive quantitative criteria for ecological risk for example, since often the values being protected are not well understood.

As a result any data derived from risk analysis must be interpreted with a full understanding of the associated uncertainties. Those tasked with risk-based decision making need to be aware of the inherent uncertainties associated with the information so that any judgement or decisions, which result are taken in their knowledge. Thus any a risk analysis presented as part of an application for a discharge to air, will need to, at the very least, make comment on the level of uncertainty associated with the critical data.

3.9 Risk Communication

An important aspect in the context of determining the information requirements for an air discharge consent application is that of risk reporting or '*risk communication*'. The range of risk management and analysis tools available can be expected to lead to a range of solutions and reporting structures. While the use of AS/NZS4360 establishes a standard high-level framework for risk studies, it is not sufficiently detailed to prevent the presentation of a broad range of methodologies each with differing reporting solutions.

It is therefore considered important that a standard study and reporting structure be established for air discharge applications and AEEs in particular. This will help both Council and applicants because it would clarify the requirements and facilitate clear communication of risk. Some recommendations will be discussed further in section 7.

4. Regulatory Context

4.1 Resource Management Act

The Resource Management Act 1991 (RMA) empowers Regional Councils through statutory instruments such as Regional Plans to manage environmental effects in their region in relation to discharges to air, water and land. Section 2 of the RMA provides definitions for "*discharge*" and "*contaminant*", and Section 3 defines the meaning of "*effect*"as follows:.

"Meaning of "effect"…… includes:

- *(a) Any positive or adverse effect; and*
- *(b) Any temporary or permanent effect; and*
- *(c) Any past, present, or future effect; and*
- *(d) Any cumulative effect which arises over time or in combination with other effect – regardless of scale, intensity, duration or frequency of the effect and also includes –*
- *(e) Any potential effect of high probability and*
- *(f) Any potential effect of low probability which has a high potential impact."*

Section 3(f) describes those unintended events that are the subject of this report. An industrial incident, process equipment failure or control equipment failure, which discharges contaminants to air and has a low probability of occurrence but has a high potential impact on the surrounding environment is classified as an "effect".

Not every industrial incident will result in the discharge of contaminants to air. Fires, explosions, and pressure waves are generally regarded as major industrial incidents. However, the Regional Council may find it difficult to manage adverse environmental effects from these events within the framework of air discharge rules in a Regional Plan. Fires do result in the discharge of contaminants to air, including toxic contaminants. However, fires that release such contaminants are not limited to industrial or chemical processes. For example, a fire in a furniture warehouse can release toxic gases such as cyanide due to the combustion of polyurethane-based foams. The practicality of regulating the discharge of contaminants to air from facilities for fires is fraught with difficulty and as such should not be considered in the context of this discussion.

A pressure wave will result in adverse effects on the environment and, in terms of the Resource Management Act's definition of a "contaminant", could be classified as such because the definition includes energy. This is similar to the argument for radio waves and other forms of energy. However any discussion on this subject is beyond the scope of this report. In any case, it is most likely that these issues are best dealt with through the land use management rather than discharge consents.

There are also a number of industrial undertakings where hazardous substances are stored or used, that do not result in any discharge to air, except in an incident situation. These would include, drum stores, chemical warehouses, chlorination plants, refrigeration plants, etc. In an incident situation they could result in a major release.

The RMA definition of a "discharge" is "emit, deposit, and allow to escape." (emphasis added) The Court of Appeal found in considering the definition of discharge and the meaning of section 15 of the RMA that "*a person allows a contaminant to escape who fails to take precautions that a reasonably prudent person would take to prevent escape.*[1] This suggests that the escape of contaminants to air from industrial accidents may be regarded as a discharge under the Act where the accident could have been foreseen by the operator and they have not taken appropriate precautions to mitigate the escape or its impact.

The Court of Appeal goes on to state "*It is sufficient if there is awareness of fact from which a reasonable person would recognise the escape would occur. In that case, failure to investigate and take appropriate preventative steps would amount to allowing an escape should it subsequently occur.*"[2]Management tools as described in this report can form part of those preventative steps.

An interpretation of the above statements from the Court of Appeal could imply any accidental escape has potential to be designated as an illegal discharge to air. It is desirable therefore that the Regional Council evaluate how the Plan may accommodate discharges from incidents, especially for those activities that have insignificant normal or designed discharges but have potential for very significant discharges in an incident.

It is clear however, that no matter how the Plan is structured, applicants for consents must assess all potential effects. Section 88(6) specifies the information requirements for an application, which include an Assessment of Effects on the Environment (AEE) with details pertaining to the identification of discharges, their effects and mitigation measures. As far as industrial incidents are concerned, this could include an assessment of potential sources of escape, an analysis of the consequences (impact) of the escape and measures taken to mitigate the escape or the impact of the escape (such as an emergency management plan for off site effects). These will be discussed in detail later in the report.

Many of the issues described above are related to interpretations of the RMA and may need to be explored further. Legal advice may be required. At this stage however, it is recommended that a pragmatic approach be used to establish which activities should be assessed as to the potential effects resulting from discharges from industrial incidents. This report therefore is only concerned with those activities that require air discharge permits under the normal criteria. Thus it is most likely confined to those activities that generate a significant discharge as part of their normal activities.

4.2 Land Use Controls

Territorial Local Authorities are charged with the responsibility of controlling Land use under the Resource Management Act. These controls are expressed principally

[1] McKnight v NZ Biogas Industries Ltd. CA526/93 Court of Appeal, Gault J, 17 May 1994, 3NZPTD 403.

[2] Canterbury Regional Council v Doug Hood Ltd., CRN 7076006424, Christchurch District Court, Judge Skelton, 30 June 1998.

through District Plans. In the Auckland region, a number of Territorial Local Authorities have adopted a common approach in their District Plans for controlling the potential effects from facilities that store or handle hazardous substances.

They have adopted a Hazardous Facility Screening Procedure (HFSP) to determine the consent status of the facilities relative to their location within particular planning zones. This procedure focuses on screening the potential effects of all hazards including those that effect the environment. However, it is limited to new facilities only or to existing facilities that expand or alter their operations. It is also only based on the nature of hazardous substances, their physical form, and the manner in which they are stored or used. Limited consideration is given to hazardous *processes* or activities, and this is not adequate for those activities that would normally be subject to air discharge consents.

The screening procedure focuses on the potential effects in three groups, namely effects caused by fire or explosion, effects on human health and effects on the environment. The procedures are used to calculate an 'Effects Ratio' based principally on the quantity of material stored on site. This ratio is compared to 'Trigger Level' values for each planning zone. Facilities with an Effects Ratio above the trigger level are not permitted and are subject to a higher degree of scrutiny in the form of a land use consent application, which must be accompanied by an Assessment of Effects on the Environment (AEE). The AEE should contain a risk study, which will take into account both the probability and consequences of potential accidents, and specify the proposed measures to mitigate, manage and reduce risks.

Any guidelines developed by the Auckland Regional Council in regards to managing unintended (accidental) discharges to air will need to be closely aligned with the HFSP for managing hazardous substances. While the scope and emphasis of these procedures may be limited with respect to activities that discharge contaminants to air, it is sensible to follow the HFSP at least for those activities that apply to the procedures. Appendix A provides a copy of a flow chart showing the steps involved, from the Auckland District Plan.

4.3 Other New Zealand Legislation

As well as the Resource Management Act there are other pieces of legislation that place a duty on industrial or trade processes to identify hazards and evaluate risk in respect to effects on human health and the environment.

This duty is contained in the following legislation.
- Hazardous Substances and New Organisms Act 1996
- Health and Safety in Employment Act 1992
- Health Act 1956
- Toxic Substances Act 1979
- Dangerous Goods Act 1984

4.3.1 Hazardous Substances and New Organisms Act

The Dangerous Goods and Toxic Substances Acts and their regulations will soon be superseded by the Hazardous Substances and New Organisms Act 1996 (HSNO), and it's regulations. The regulations controlling hazardous substances have not been finalised and at this stage, so it is difficult to provide a clear picture of how they will operate in respect to managing hazardous substances. However, the regulations will cover the manufacture, use, storage, transportation and disposal of hazardous substances in New Zealand.

An emergency is defined under Part IX of the HSNO Act as:

> *"(a) actual or imminent danger to human health or safety; or*
> *(b) danger to the environment or chattels so significant that immediate action is required*
> *to remove the danger."*

The proposed regulations under the HSNO Act focus on steps to prepare for emergencies so that when they occur the effects can be minimised in both severity and impact. Currently proposed is a three-tier framework for classifying types of emergencies. The tiers link the degree of emergency preparedness to the level of potential harmful impact. "*Level 1*" is the lowest tier, while "*Level 3*" is for a potential large-scale impact.

The regulations will specify the requirements for "*preparedness*" for each level and theses are also designed to account for cumulative risk. Thus Level 3 requirements may be include requirements for Level 2 and Level 1.

Trigger quantities of hazardous substances on site have been proposed for defining those activities falling into Level 3. These quantities have been derived from "base threshold quantities" for a "heavy industrial area" described in the Hazardous Facility Screening Procedure. Where the quantity of substances on site exceeds the thresholds for Level 3, a comprehensive emergency management plan will be required. The key element of the plan is that it identifies "*reasonably credible incidents*", and provides systems/procedures for managing these incident scenarios. It is proposed that a test certificate issued by a third party is required for the plan.

The Hazardous Substances Regulation will play a significant role in the management of hazardous substances. It is therefore recommended that the Auckland Regional Council review the regulations when they are finalised, so their potential impact on the management of discharges to air is understood.

4.3.2 Health and Safety in Employment Act

The Health and Safety in Employment (HSE) Act 1992 requires employers to take all practicable steps to ensure the safety of employees while at work, and for employees not to harm other persons while at work, including members of the public. This Act provides for Approved Codes of Practices, which are statements of preferred work practice and may include procedures that could be taken into account when deciding on practicable steps to manage risk. While compliance with codes of practice is not mandatory, they may be used as evidence of good practice in court.

The HSE Approved Code of Practice for Managing Hazards to Prevent Major Industrial Accidents (ACOP) describes a management system for hazardous activities. This code provides a means to:

- Prevent major industrial accidents from occurring.

- Minimise the consequences of a major industrial accident, and
- Ensure appropriate emergency planning procedures are in place.

The ACOP recommends that a "*safety case*" or "*safety report*" is prepared. This report collects all the safety information into one document so that all persons on the installation are aware of the hazards and safety of the installation. The safety report describes:

- The installation, processes and hazardous substances used;
- The hazards and their control;
- The consequences to people and the environment of potential major industrial accidents by means of systematic hazard analysis;
- The organisation of the installation and the management of its safety;
- Emergency systems provided to mitigate the consequences of major industrial accidents.

The code provides a guide to identifying those 'installations' or activities that may have a significant potential hazard. While relatively general, this guide is more comprehensive than the screening procedures (HFSP) used in District Plans because it includes hazardous activities, such as industrial operations involving distillation, oxidation and chemical reactions, and is not just focused on hazardous materials. Therefore, while it is occupational health and safety-focused, the ACOP provides a useful guide to the types of activities that should be considered in regards to effects of unintended incidents in the course of applying for a consent to discharge contaminants to air. This is discussed further in section 5.

4.4 Overseas Regulations

The approach adopted by many overseas regulatory agencies in managing hazardous industrial activities is similar, in that risk management methods are advocated for those activities identified as hazardous, and the hazard classification is often based on the quantity of hazardous material stored or used. However, the agency responsible for enforcing the legislation differs with two distinct routes evident: environmental or occupational safety and health. In the US the Environmental Protection Agency is the agency given the responsibility for administering chemical accident prevention while in Australia and Europe this function is that of the occupational safety and health enforcement agencies. In the following sections an overview of a selected number of relevant overseas legislation is provided.

4.4.1 United States

In the United States, those who handle, manufacture, use or store toxic and flammable substances are required to develop a *Risk Management Program* under the accidental release provisions of the Clean Air Act. Potential sources are regulated if they involve quantities of such substances above the thresholds listed in the Code of Federal Regulations. The goal of Risk Management Program is to prevent accidental releases of substances that can cause serious harm to the public and the environment from short-term exposures and to mitigate the severity of releases that do occur. A Risk Management Program is required to include:

- Hazard identification and assessment
- Analysis of potential off-site consequences of accidental releases.
- A release prevention program.

- An emergency – response program.
- An overall management system.

The program must analyse the worst-case release scenario for the process and document that the nearest public receptor is beyond the distance to a toxic or flammable endpoint (described in Section 7.2.5 of this report). A five-year accident history must be submitted in the program, which demonstrates there has been no off-site impacts from an accidental release, and any response actions must be co-ordinated with local emergency planning and response agencies.

4.4.2 United Kingdom

The relevant legislation in the United Kingdom is the Planning Control of Major Accidents Hazards Regulations 1999 (COMAH). The environmental component of these regulations is administered by the Department for the Environment, Transport and Regions. They require industrial activities to prepare a "S*afety Case*" and analyse the consequences to the environment of a major industrial accident.

The definition of major accident is "*an occurrence (including in particular, a major emission, fire or explosion) resulting from uncontrolled development in the course of the operation of any establishment and leading to serious danger to human health or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substance*."

The COMAH Regulations apply to all "*establishments*" where quantities of "*dangerous substances*" used or stored equal or exceed specified thresholds. There is no differentiation between storage and processing and the list of "dangerous substances" relies more on generic classes of dangerous substances than the USEPA criteria.

Existing establishments defined as "top tier" in these regulations must:

- Identify all major hazards by conducting a hazard analysis that covers the potential consequences of accidents caused by internal or external influences and pays particular attention to the possible extent and severity of an accident;
- Provide maps showing land use and the location of sensitive parts of the environment;
- Describe the environment surrounding the establishment in a level of detail proportionate to the hazard;
- Take into account the ecotoxicology of substances that might be released;
- Describe the measures of protection and intervention designed to limit the consequences of the accident; and
- Set out measures to mitigate post-accident impacts and to aid the recovery of the environment from the impacts of the accident.

4.4.3 Australia

The National Commission for Occupational Health and Safety (NOHSC) released the National Standard for Control of Major Hazard Facilities in 1996. State health and safety agencies are currently developing regulations in order to implement the National Standard. It is envisaged that the regulations will be similar to the regulatory requirements in force in Europe and on Australia's offshore oil and gas operations.

Under the proposed regulations in Victoria, a 'Major Hazard Facility' is defined as a site that stores, handles or processes large quantities of dangerous chemicals or products. Typically, they include refineries, chemical and gas processing plants, LPG storage and distribution sites, and even certain types of large warehouses.

Under the proposed regulations, operators of a major hazard facility must:

- Notify the authority that they are a major hazard site and apply for a licence.
- Identify all major hazards.
- Assess the risk of these hazards causing a major incident.
- Adopt control measures to eliminate the likelihood of a major incident.
- Establish and implement a safety management system.
- Prepare on-site and off-site emergency plans in consultation with local emergency services.
- Consult and involve workers and health and safety representatives regarding any major incident hazard.
- Provide safety information to the local community.

These regulations also require that a "*Safety Case*" be prepared. The Safety Case is a document in which the operator presents information that demonstrates to a range of stakeholders (regulatory agencies, employees, community) that it has adequate measures in place to prevent a major incident and to mitigate the consequences. The Safety Case can only be written after the operator has systematically examined all operations; the potential for major incidents, and defined and justified the adequacy of controls in place to reduce the risks as far as practicable.

Again, storage thresholds are used to determine major hazard facilities. These thresholds are generally larger in comparison to those used by the USEPA. Table 4.1 shows a comparison for some arbitrarily selected materials.

- **Table 4-1 Comparison of Thresholds from U.S. and Australia**

Substance	USEPA (Part 68) Threshold (tonnes	NOHSC Threshold (tonnes)
Acrolein	2.2	200
Ammonia (anhydrous)	4.5	200
Arsine	0.45	0.01
Chlorine	1.1	25
Fluorine	0.45	25
Formaldehyde	6.8	50

5. Potentially Applicable Activities

As discussed earlier in this report, at the time of writing the Auckland Regional Council has yet to draft the Proposed Regional Plan, so rules for discretionary activities have not been developed. However, it is understood that the Council envisages reversing the presumption of the RMA and designating all activities as permitted unless specifically identified as controlled, discretionary or prohibited. Those activities likely to be discretionary will be based to some extent on the Second Schedule of the Clean Air Act 1972. These in turn are based on process types rather than quantities of material used. The broad groupings of these activities are as follows:

- Combustion processes,
- Waste processes
- Animal or vegetable products and food processing
- Metallurgical processes
- Factory farming
- Wood products industry
- Surface coating processes
- Mineral processing
- Chemical manufacturing and processing industry
- Miscellaneous

Clearly, not all the facilities at which the above activities are carried out will have the potential for accidents that could cause air discharges. Conversely, other activities that do not normally lead to discharges may have the potential to cause discharges under unplanned conditions. It will therefore be important to establish a clear and logical set of criteria by which the requirement for a risk study is identified.

A number of examples of threshold criteria used in both New Zealand and overseas were discussed in section 4. Most of these are based on the quantity of hazardous material stored or used on site. However, the Approved Code of Practice developed under the Health and Safety in Employment Act includes a list of process operations and therefore identifies hazardous activities.

It is suggested that the Regional Council should consider encouraging use of the threshold criteria developed for the Hazardous Facility Screening Procedure (HSFP) currently operated by Territorial Local Authorities in the Auckland Region. This means that hazardous facilities are identified in a consistent manner in respect to land use planning, hazardous substance management and discharge consents. Using the HSFP as a basis would avoid unnecessary repetition, since many activities applying for an air discharge permit may already be required to undertaken a form of risk-based study as part of their duty under the District Plan.

As discussed earlier, the HSFP will not address all activities that have a potential to discharge significant quantities of contaminants in an industrial incident. These procedures apply only to new facilities or significant changes to existing facilities and the focus is on the quantity of certain materials stored or used on site. Many activities that require air discharge consents, on the other hand, are hazardous principally because of the nature of the processes that are involved It is not considered appropriate to rely on these procedures alone to identify activities that should undertake a risk study as part of an application for an air discharge consent.

Consideration must be given to those activities that are hazardous by virtue of the types of operations they employ. There are a number of activities, involving operations such as distillation, oxidation and chemical reactions, which could discharge air contaminants but would not be classified as hazardous under the HSFP.

A potential guide to identifying hazardous processes is described in the Health and Safety in Employment Act Approved Code of Practice (ACPO) discussed in section 4.3 (and listed in Appendix B). The guidelines in this code are very general and are also not specifically relevant to discharges to air, but they may provide a starting point for identifying activities considered hazardous. Some of the process descriptions identified in this code may be useful for complementing the HFSP in identifying those activities that should undertake a risk study as part of an application for an air discharge consent.

Activities that rely heavily on air pollution control equipment to mitigate a hazardous or major discharge to air should also be considered, particularly if the control equipment is technically complex. With some activities the air pollution risk of an incident within the process itself may not be as significant as a failure in the control equipment.

By using the HFSP, part of the ACOP guide and knowledge of potential causes of air pollution, a list of general activities likely to require a risk study can be compiled as follows:

- All activities with an 'effects-ratio' above the relevant trigger levels identified by the HFSP in District Plans and where the hazard is likely to give rise to a discharge to air.
- Activities involving distillation, refining or other processing of petroleum products,
- Waste disposal activities involving incineration or chemical decomposition.
- Metallurgical activities.
- Chemical production, processing or treatment activities where reactions or other processes occur at elevated temperatures, pressures or under vacuum.
- Activities involving cryogenic processes.
- Activities relying to a large extent on air pollution control equipment to mitigate a potentially hazardous discharge.

More work is necessary to precisely define those activities of concern, and this should be considered as the Regional Plan rules become closer to being formed. When the rules are finalised, it may be possible to identify exactly, those activities that must report on a risk study as part of their application for consent.

6. What should be Included in an AEE?

6.1 General Requirements

Section 88(6) of the RMA specifies the methods for making an application for a Resource Consent. These matters have been discussed many times elsewhere. Suffice it to say that an application should include a description of the proposal, the scale and significance of the activity's effect, the sensitivity of the local environment, mitigation measures and monitoring. Of particular note in the context of this report is s1(e) of the fourth schedule, which states that an AEE should include "*where the activity includes the use of hazardous substances and installations, an assessment of any risks to the environment which are likely to arise from such use*".

An assessment of "*risks to the environment*" for an air discharge consent should at least include:

- An analysis of what can happen and how,
- An estimate of the likelihood,
- An account of the likely consequences, and
- A description of what controls are in place to mitigate the risk.

It will also be necessary to rank scenarios or at least identify the worst case, and the AEE should describe how this was undertaken. A preliminary risk analysis will therefore be necessary that categorises all potential risks and separates those considered minor from those that may require detailed study.

The consequence of an air discharge incident can be analysed by a variety of methods and to a varying degree of analytical precision. In the context of this discussion, which concentrates on the release of contaminants to air, it may be necessary to investigate the dispersion and/or rate of deposition of released contaminants downwind using appropriate modelling tools. Some tools for this are discussed in section 7. The overall tolerability of the risk may also be related the likely frequency of the event of concern. Thus, the risk may need to be evaluated in probabilistic terms in relation to suitable criteria as discussed in section 8.

When describing the risk mitigation methods, the AEE should address three elements. Firstly, it should describe how key operating procedures have been developed or evaluated with respect to minimising the risk in question. Second, engineering controls should be described in appropriate detail. Finally, emergency response or contingency plans should also be described. Obviously not all incidents can be avoided, so the emergency response plans form an important part of any risk management process. Specific methods and procedures are described in more detail in section 7.

6.2 Depth of Study

Obviously there is a range of tools available for undertaking a risk study and many of these are very complex and expensive to undertake. It is important however that the amount of effort that is put into a study of this kind is consistent with the scale and nature of the activity in question. A guide should therefore be provided as to the level of work suitable for groups of activities.

There are a number of formal methods of identifying the appropriate depth of study. The simplest are those similar to that given in AS/NZS3931. A list of factors that might be considered is given in the example shown in Figure 6.1.

Figure 6-1 Factors Involved in Identifying an Appropriate Depth of Study

GENERAL CONSIDERATIONS FOR IDENTIFYING THE DEPTH OF STUDY

What is the status of the proposed change?	• minor change proposed	2
	• conceptual	4
	• detailed investigation	9
What is the objective of the study?	• comparison between alternatives	2
	• identification of risk reduction measures	3
	• comparison to risk target	5
How extensive are the changes and hazard being analysed?	• simple	1
	• technological hazards	2
	• complex/ human behaviour	4
What is the potential severity?	• minor	0
	• economic implications	4
	• environmental damage	4
	• single injury or fatality	8
	• large number of fatalities	10
What level of resources is available?	• limited time and expertise	1
	• extensive time and opportunity to to acquire expertise	3
What information is available about the effects?	• estimation	1
	• operational	2
	• historical	2
	• detailed research	3
Will the study need to be updated in the future?	• one-time activity	1
	• on-going activity	2

7. Tools and Methods for Assessing and Air Discharges from Industrial Incidents

The following discussion provides a description some tools and methods used for identifying and analysing risk from industrial incidents. It is not a comprehensive guide and provides a general introduction to some methods that may be relevant to air discharge assessments.

The Regional Council may wish to provide specific guidance as to the most appropriate tools for particular circumstances, with a view to achieving consistency. However, this will require further work.

The tools are described in logical order and cover the areas that should be reported in an AEE.

7.1 Hazard Identification

The first stage in a risk analysis is to identify the potential hazards at a facility and a range of methods can be used. In all instances the approach must be systematic to ensure all potential hazards are identified. Consideration should be given to internal and external influences, human error, accident sequences (domino effects), and the components of the processes. In the context of an air discharge consent application, the hazards identified should relate specifically to events that discharge contaminants to air.

Methods may include external specialists, reviews of incident reports and reviews of operational procedures of key equipment (e.g. bagfilter, scrubbers, etc.). A range of methods is applicable depending on the nature of the activity in question, those suitable for most air discharge applications are unlikely to be substantially different from other hazards. Indeed, it is probable that any hazard identification step associated with an AEE should be seen as part of a more general risk and hazard study.

The two essential approaches to risk and hazard identification are a 'top down' approach and a 'bottom up' approach. The top down starts with a clear listing of those events that it is known must be avoided, while the bottom up looks at the sources of risk (hazards) and investigates how these could lead to an event or incident. Each approach has its strengths and weaknesses, and it is often appropriate to use a combination of both.

7.2 Consequence Analysis

7.2.1 Event Size and Likelihood

The consequence of an event is dependant on both the size of a hazardous event, and its likelihood. Both can be calculated analytically or assessed qualitatively but for air many discharge incidents it is common to at least quantity the size of the release scenario.

In general terms, the size of an air discharge event is a function of the quantity of material likely to escape and the mode of release. Discharge quantities can be calculated by using the appropriate equations, based on fluid dynamics, chemical characteristics and thermodynamic properties etc. There are however, a number of factors that can effect the significance of a release event, and the following lists those that may need to be assessed:

- The nature, composition and quantity of chemicals being stored or processed
- Contaminants generated in the course of an incident (such as combustion products)
- Potential chemical reactions between substances
- Potential for effects of substances to interact
- Release duration, particularly before any mitigation measures act.
- The physical nature of contaminants released (gas, liquid, solid or multi-phase)
- The type of leak or spill (pressurised jet, rupture or explosion)
- Whether the release is in an enclosed space or unmitigated

Guidance documents and computer models are available, which can be used to estimate both the quantity of material discharged during a particular scenario and how long this may last. Some models can also automatically determine the correct algorithms or equations based on information on the type of incident identified. These models are often associated with dispersion models and some are described in section 7.2.4 below.

The event likelihood may be determined by the following techniques.

- Use of historical data on previous accidents or incidents.
- Literature on other processes of similar type.
- Expert judgement.
- Technical methods, such as a fault tree analysis

In most circumstances the event likelihood will be classified in qualitative terms, such as ‘likely’ or ‘improbable’. Detailed calculations using fault tree techniques or similar are only likely to be appropriate in cases where the hazards are perceived as having a very high potential impact and where the nature of the activity is conducive to such an approach. Even then, the reliability of such calculations can be very low and are best used when order of magnitude estimates are suitable or for categorising or ranking activities.

7.2.2 Receiving Environment

It is important to account for the nature of the receiving environment when assessing the consequence of an incident. Key points in determining the sensitivity of the receiving environment in relation to the risks from an air discharge incident include:

- Land use in the surrounding areas
- Population density (potential number of persons exposed)
- Local biota and habitat
- Heritage and built environments, waahi tapu and urupu sites

These are no different to the features that need to be considered when assessing the effects of a normal discharge. There may be a different emphasis however. For example, the population density in the immediate location of an activity may be an important factor in determining the potential consequence of a release incident.

7.2.3 Potential Effects

Clearly a large range of potential effects can result from an unintended discharge to air. As a guide, it is considered the following issues may need to be considered or determined:

- The distance to a level identified as being safe (based on the 'toxic endpoint' discussed below).
- The potential significance of meteorological conditions or time of year
- Likelihood for contaminants to bio-accumulate or enter the food chains
- The potential for damage to biota, their habitat or ecosystems
- How much habitat may be effected
- How long the effects could last
- Potential for ecological damage to be repaired
- How many people could be killed or injured.
- The significance of any long-term health effects

7.2.4 Modelling Tools

Atmospheric dispersion modelling is probably the most common method for assessing the effects of normal discharges to air. It is also appropriate to apply similar tools to estimate the consequences of incident scenarios. A variety of computer models are available. As discussed previously, some of these can be used to estimate the quantity of material likely to escape in addition to the subsequent dispersion downwind. Other models will only estimate dispersion. The United States Environmental Protection Agency (USEPA) is a useful source of suitable models. While many of these are the same models used to determine adverse effects from normal discharges, accidental releases can have features that require special treatment.

The commonly used Gaussian dispersion models are not always appropriate for accident situations because they are designed for continuous discharges of a neutrally buoyant gas. Accidental releases may be more complex. For example, a release from a vessel holding liquid under pressure could be in several different forms, including:

- a two phase vapour cloud,
- an instantaneous puff of gas or liquid,
- evaporation from spills of volatile material.

If an incident causes a two-phase vapour cloud to release, the latent heat from evaporating liquid droplets will cool the cloud and cause it to become denser then air. Such a release will dramatically slump due to gravity and cause very high concentrations close to the source. A specific denser-than-air model is required for these circumstances.

The mode of release will have a significant bearing on both the quantity of material discharged and how it will disperse downwind. It is therefore important that the correct model or algorithm is chosen for the circumstance in question.

Some of the models provide assistance with the appropriate choice of model but expert input is advised. Examples of models specifically designed for discharges from industrial incidents include:

ALOHA

TSCREEN
DEGADIS
AFTOX
AUSTOX
WHAZAN
SLAB

In addition, the commonly used Gaussian models such as AUSPLUME, ISC and SCREEN can also be used. A detailed description of the models is beyond the scope of this report, but Appendix C gives more information on some of the models in the above list.

The outputs of the dispersion models can be compared with exposure limits, which allow the assessor to determine at what distance downwind from the release point, humans and the environment will not suffer adverse effects. This allows the modelling to determine the area that could be effected by an unintended release and allow the degree of harm it could cause to be evaluated.

Unfortunately, modelling is not accurate, because the models cannot account for all variables involved in a real-world situation. They only approximate a given physical situation. This applies especially to the calculation of the safe threshold concentrations or endpoints resulting from the release of toxic materials. The results should be used with caution.

7.2.5 Toxic Endpoints

A useful concept for emergency releases to air is the *'toxic endpoint'*. This is a human health criterion developed by the USEPA as part of their risk Management Program. Toxic endpoints are based on guideline values adopted by the American Industrial Hygiene Association specifically for emergency response and planning. They are defined as the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects, or symptoms that could impair an individual's ability to take protective action.

The toxic endpoint criteria can be used to assess potential effects on human health from industrial incidents with the use of appropriate dispersion models as described above. A list of the USEPA toxic endpoints for 77 substances is presented in the Appendix D.

The toxic endpoint criteria should be distinguished from the commonly understood 'Immediately Dangerous to Life and Health"(IDLH) criteria, which are sometimes used for assessing effects accidental releases. Toxic endpoints are considered more appropriate criteria for these assessments. However, toxic endpoints are sometimes calculated by dividing the IDLH by a factor of ten.

Similarly, these criteria are considered more appropriate for assessing accident scenarios than Ambient Air Quality Guideline values. The ambient air guidelines are designed for continuous releases or normal discharges and as such assume a potential for long-term or frequent exposure to the public. The Ambient Air Quality Guidelines are not suitable for assessing the potential effects from infrequent incidents that may produce a short term discharge.

Endpoints have also been derived for flammable and explosive mixtures.

7.2.6 Environmental Endpoints

Along similar principles to the endpoints discussed above, environmental end points aim to provide a defined and measurable goal by which environmental change or ecological damage can be assessed in the event of an accident.

Unfortunately such criteria are very difficult to develop. Ecological risk assessments are complex because they typically involve large numbers of inter-linked factors. Analysis of risks from air discharge incidents are therefore more commonly applied to the assessment of human health concerns even though levels lower than those that result in human health effects may produce more significant responses in other species.

In practical terms an environmental endpoint may identify a few indicator species as part of the criteria, but the selection of these species often has more to do with current knowledge than what species might be at risk. As a starting point the identification of the resources (ecosystems) at risk and the definition of their current state or condition (health) with in the study area is important. Defining the "health" of an ecosystem or species provides a basis by which to evaluate the potential changes in that condition over time in response to a stress.

In order to be able to determine what is a significant ecological risk a specific dose-response relationship needs to be understood for those species and contaminants of concern. Also the temporal and spatial effects of the exposure event need to be considered.

Ecosystems are generally resilient to short term effects, or those that cause only temporary ecological changes. Nature has a substantial capacity for healing itself. However some changes are either permanent or semi-permanent, for example the complete destruction of a unique species or habitat.

Two factors must be considered when developing endpoint criteria:

- the time that it takes for an ecosystem to recover and
- the extent of the area likely to be damaged.

Generic criteria and thresholds have been developed in the Unitied Kingdom under the COMAH regulations to help determine whether there is potential for a major impact on the environment. For example, an incident is considered a major accident if it causes the death of 1 % or more (or sub-lethal effects within 1% or more) of a population of common fauna species. Similarly the death of (or sub-lethal effects within) 5% or more of the ground cover for common vegetation species would be considered a major accident.

The setting of environmental endpoints or threshold criteria is an area where further research is required to determine what type of approach is a suitable to the Auckland Regional Council and if there is sufficient data to support the preferred approach.

7.3 Controls to Reduce Risk or Effects

In reporting the results of a risk study in an AEE, the applicant for a discharge consent must show the controls that have been considered and those that are in place to treat the risks, that is to reduce or mitigate the risk of an industrial incident. Aside from the first option of eliminating particular risks where possible, these could include:

- Operating Procedures and Practices
- Engineering Controls
- Emergency Contingency Plans

7.3.1 Operating Procedures and Practices

Good practice with respect to risk management requires the development of comprehensive operating procedures. These should be readily accessible to all employees who work or maintain the processes. They needed to be reviewed and updated to take into account changes in the processes, or changes imposed by the result of safety audits. As part of a risk study the operator should evaluate the adequacy of process operating procedures in terms of minimising or avoiding risk.

7.3.2 Engineering Controls

Engineering controls offer the most effective risk reduction option as, if designed and implemented well they offer a reliable risk control option. In is of note however, that they should normally be seen as additional to operating procedures and practices. There are many existing regulations that require equipment to be designed so as to be safe, most resulting from previous accidents. Examples include the fitting of relief valves to pressure vessels, and annual inspections and testing of potentially lethal equipment. However, despite these accepted regulatory methods more plant specific controls are invariably appropriate. The level of additional control should be proportionate to the level of individual and societal risk.

7.3.3 Emergency or Contingency Plans

A suitable Emergency Response Plan may consist of the following elements:

- Procedures for informing the public and emergency services about releases.
- Documentation of proper first aid and emergency medical treatment necessary to treat human exposures, etc.
- Procedures and measures for emergency response.
- Procedures for using inspections, testing and maintaining emergency response equipment.
- Training for all employees in relevant procedures.
- Procedures to review and update the Plan as appropriate.

The Emergency Response Plans should be developed in consultation with emergency services and they should be provided with a copy and all updates. The plan should be tested to see that employees are aware of contents and to see if it functions as intended. If not, changes should be made to correct the faults detected during the exercise.

8. Risk Evaluation – When is Risk Tolerable?

Good risk management practices should reduce the risk of an accident to a low level, but it does not eliminate the hazard completely. There remains some residual risk. The key question, particularly for those making decisions on Consent applications, is: ‘how much risk is tolerable?’ Therefore, once the risk has been analysed the result must be compared against criteria that provide a measure of acceptability.

General guidelines for setting risk tolerability limits are as follows:

- Whether a given risk is so great or the outcome so unacceptable that it must be refused altogether;
- Whether the risk, is or has been made so small that no further precaution is necessary;
- If a risk falls between these two states, it must be reduced so far as reasonably practicable, or to a level that is ‘As Low as Reasonably Practicable’.

While some risk evaluations may be relatively clear cut, there are many situations where the risk may lie in the broad region between what is clearly acceptable or negligible, and what is clearly intolerable. Figure 8.1 illustrates this region in relation to the likelihood and potential severity of risks in the form of a matrix. It demonstrates the relative boundaries between tolerable and negligible risks.

The ‘As Low as Reasonably Practicable’ (ALARP) principle was developed by the United Kingdom’s Health and Safety Executive and this approach to the identification of a tolerable level of risk is now used extensively across the world. Indeed a similar principle underpins New Zealand Health and Safety in Employment legislation.

Figure 8-1 Qualitative Risk Matrix showing the ALARP Region

	Insignificant	Minor	Major	Catastrophic
Frequent	*ALARP*	*ALARP*	*Intolerable*	*Intolerable*
Reasonably Probable	*ALARP*	*ALARP*	*ALARP*	*Intolerable*
Remote	*Tolerable*	*ALARP*	*ALARP*	*ALARP*
Extremely Remote	*Tolerable*	*Tolerable*	*ALARP*	*ALARP*

A similar visualisation of the ALARP region is provided in Figure 8.2. This gives a “*risk profile”* in quantitative terms. It is a logarithmic plot that compares these parameters to produce a likelihood-severity curve. An example of such a presentation is a “F-N plot”, where F is the cumulative frequency of killing N or more people.

Figure 8-2 Quantitative Risk Profile

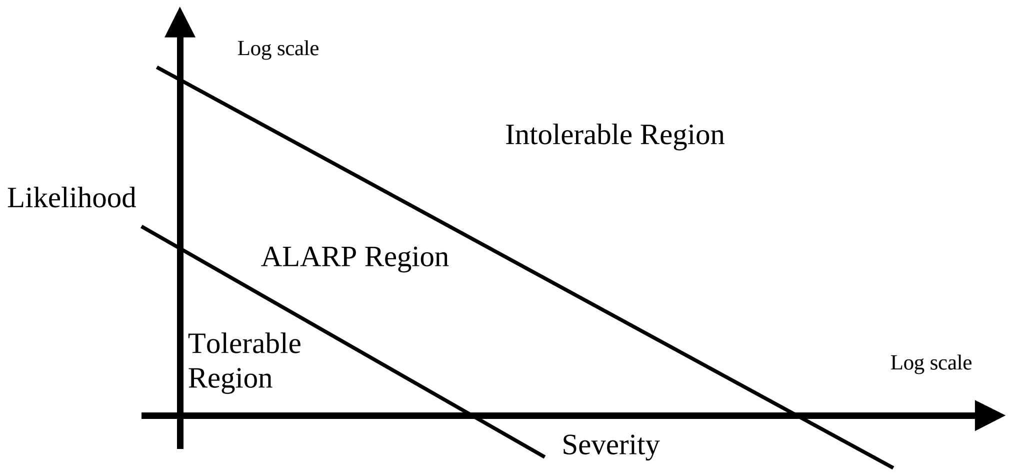

Figure 8.2 illustrates how the relationship between the potential size of events and likelihood can be expressed mathematically. It demonstrates that risk cannot always be evaluated in terms of a single probability figure (as with individual risk), as it is necessary to consider the size of the disaster as well as the probability (societal risk). As discussed in section 3.3, the risks from major hazards are of direct concern to both individuals and to society at large since there is a potential for small and large-scale disasters. These concerns must be taken into account in any evaluation criteria, and if quantitative criteria are developed they could ultimately involve a statistical or probabilistic element based on community values.

One relatively simple level of risk evaluation for discharges to air is to assess the consequence distance relative to the location of nearby sensitive development. As discussed earlier in this report, the US Clean Air Act accident release provisions require public receptors to be located beyond the estimated distance to toxic or flammable endpoints for a worse case release. This provides an assumption that the risk is acceptable beyond this distance, based on the definition of the toxic endpoint. It is possibly a method for identifying the lower tolerability range for air discharge applications (below the ALARP region described above) without having to undertake a detailed analysis of probability.

There are a variety of views on the use of probabilistic risk criteria. A review of a number of recent documents indicates some degree of consistency with respect to the acceptable level of individual risk, being in the range 10^{-6} to 10^{-4} deaths per annum. Views on societal risk criteria are more complex however, with some authors advocating a particular curve on F-N plots. For example, it is suggested the tolerable probability of events should be directly proportional to the expected number of fatalities (slope of –1 on the logarithmic scale plot). In other words, if one death in 10^4 years is tolerable, 100 deaths in 10^6 years is equally tolerable. Other authors however, have suggested the risk of death is an inadequate concept and the risk of injury or other damage should be taken into account. Some authors argue for more subjective criteria for societal risk. For example, the U.K. Health and Safety Executive states: "*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 it.*"

Clearly a significant amount of work may be necessary for the Auckland Regional Council to develop general criteria for evaluating the risk from air discharge incidents. At this stage these should be determined on a case by case basis taking into account the true level of risk, the worst case scenario, the value of the surrounding environment, and the general benefit to the local community that stems from having the facility nearby (work, income etc.).

Finally, it is important to understand that whatever criteria may be used to assess the tolerability of risk, it should not be assumed that because those risks that are within the prescribed limits they can be dispensed with or forgotten. To quote the U.K. Health and Safety Executive again: "*Tolerability does not mean acceptability. It refers to a willingness to live with risk so as to secure certain benefits and in the confidence that it is being properly controlled. To tolerate a risk means … something we need to keep under review and reduce still further if and as we can*".

Refereces

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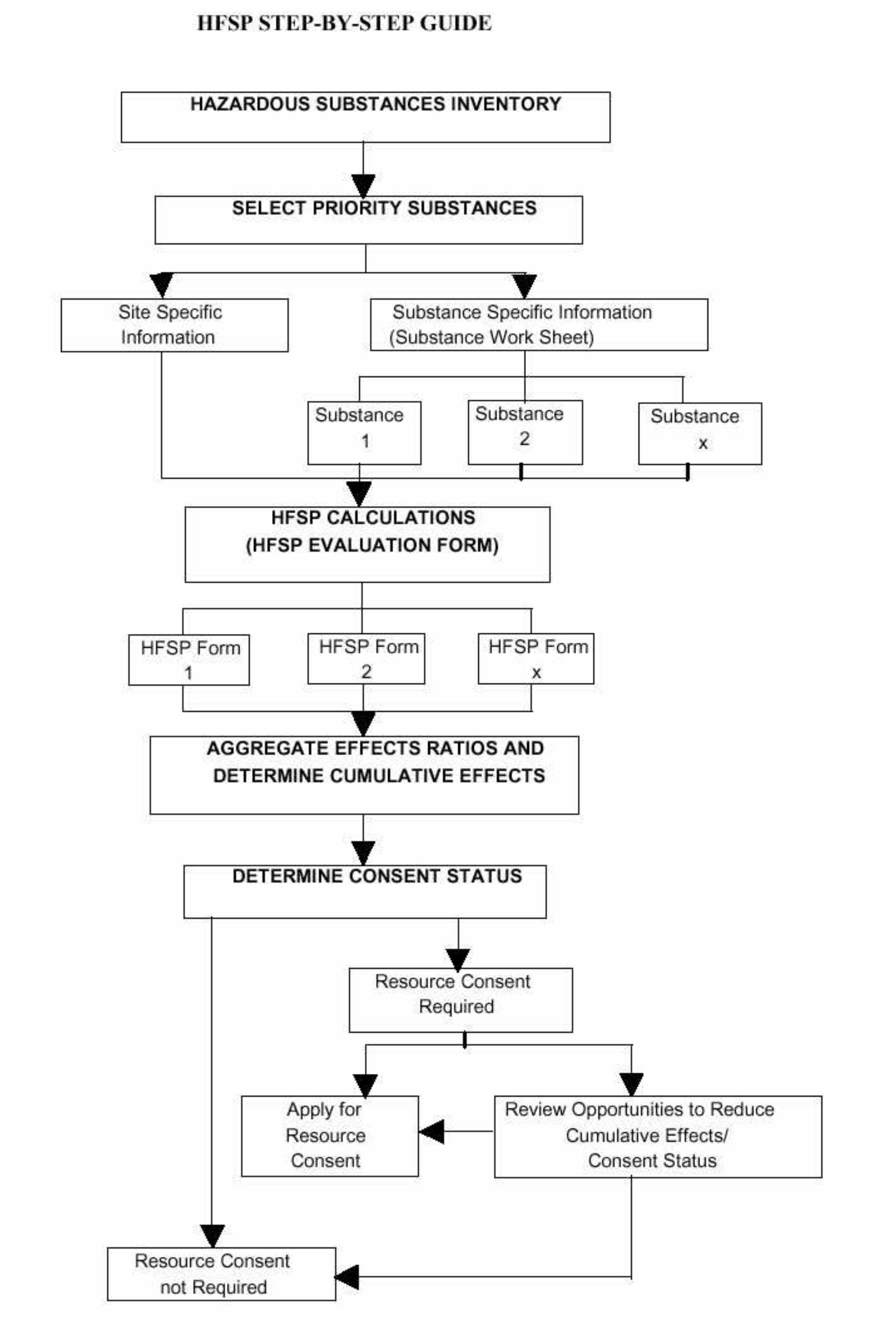
Appendix A Guide to the HFSP from the Auckland District Plan



Appendix B. Guidelines on Coverage from the HSE Approved Code of Practice

The following is an extract from the Approved Code of Practice for Managing Hazards to Prevent Major Industrial Accidents, Appendix 2: Guidelines on Coverage:

"This code may apply, but is not limited, to installations where the following activities are carried out"

1) *Installations that use or have on site sufficient quantities of the following hazardous substances to cause, generate, promote or contribute to a major industrial accident.*
   a) *Explosive substances (solid, liquid or gaseous)*
   b) *Flammable substances (solid, liquid or gaseous)*
   c) *Toxic, poisonous or infectious substances*
   d) *Radioactive substances*
   e) *Corrosives*
   f) *Oxidising substances*
   g) *Ecotoxic substances*
1) *Installations for storage, distillation, refining or other processing of petroleum or petrol products.*
2) *Installations for the total or partial disposal of solid or liquid substances by incineration or chemical decomposition.*
3) *Installations for the dry distillation of coal or lignite.*
4) *Installations for the production of metals or nonmetals by a we process or by means of electrical or mechanical energy*
5) *Installations for the production of pulp and paper, and similar processing plants*
6) *Installations for the production, processing or treatment or organic or inorganic chemicals using for this purpose, among others:*
   - *Alkylation*
   - *Amination by ammonolyisis*
   - *Carbonylation*
   - *Condensation*
   - *Dehydrogenation*
   - *Esterification*
   - *Isomerisation*
   - *Halogenation and manufacture of halogens*
   - *Hydrogenation*
   - *Hydrolysis*
   - *Oxidation*
   - *Polymerisation*
   - *Sulphonation*
   - *Desulphurisation, manufacture and transformation of sulphur-containing compounds*
   - *Nitration and manufacture of nitrogen-containing compounds*
   - *Manufacture of phosphorus-containing compounds*
   - *Manufacture of pesticides and pharmaceutical products*
7) *Installations for the processing of organic and inorganic chemical substances, using for this purpose, in particular, but not limited to:*

- *Adsorption*
- *Distillation*
- *Extraction*
- *Solvation*
- *Mixing*

8) *Installations where:*
   - *Chemical reactions occur at elevated temperatures, pressures or are under vacuum*
   - *Cryogenic processes take place*
   - *Other activities are carried out at extreme temperatures or pressures, eg steam generation."*

Appendix C. USEPA Models for Emergency Release Situations

F.1. DEGADIS

The Dense Gas Dispersion Model (DEGADIS+) combines the features of two models: the Shell HEDADAS model and a box model proposed by van Ulden. It is used to predict toxic pollutant concentrations regardless of plume buoyancy. The model is applicable to a wide variety of scenarios including: gas and aerosol releases; continuous, instantaneous, finite duration, and time-varying releases; ground-level low-momentum area releases; and ground-level or elevated vertical jet releases. DEGADIS+ is recommended for estimating the spatial and temporal distribution of short-term concentrations (typically 1-hour or less averaging times). It is a relatively complex and time consuming model to use, but is especially useful for heavier-than-air releases where screening estimates exceed levels of concerns.

DEGADIS+ is a versatile tool for performing off-site consequence modelling and emergency response planning under Section 112(r) of the U.S. EPA Clean Air Act. This provision requires facilities that manufacture, process, use, store, or otherwise handle certain amounts of toxic substances to submit Risk Management Plans (RMP) to the local emergency management authorities. An important component of the RMP is the determination of consequence distances for worst-case and alternative release scenarios using an applicable accidental release model. The model can also be used to meet requirements within the Occupational Safety and Health (OSHA) Process Safety Management (PSM) guideline, European Economic Commission (EEC) Seveso Directive, and Chemical Manufacturer Association (CMA) Responsible Care Program, among others.

DEGADIS+ provides a non-isothermal (heat transfer) option, which uses an energy balance approach to determine cloud temperature (density) as air is mixed into the dense cloud. This approach provides options for overland and overwater heat transfer. Alternatively, DEGADIS+ provides an isothermal option, which uses adiabatic (no heat transfer) calculations to determine the liquid and vapor contents of an aerosol mixture.

The model internally calculates the downwind receptor distances. The number of receptors and length of model run depend upon the time and distance until the plume centerline concentration is one-half the lowest concentration of interest.

DEGADIS+ provides tools to: 1) determine whether to model the release as a dense or neutrally-buoyant gas; 2) determine the fraction of a liquid, by mass, that flashes to a gas during an instantaneous depressurization event; and, 3) define the density profile for a two-phase (aerosol) mixture.

DEGADIS+ includes a database of over 200 chemicals commonly released as a dense gas into the atmosphere. It also includes the capability to add and store new chemicals or modify existing data. The database includes IDLH (Immediately Dangerous to Life and Health), TLV-TWA (Threshold Limit Value – Time Weighted

Average), and TLV-STEL (Threshold Limit Value - Short Term Exposure Limit) values where available for each chemical.

Meteorological Data is handled in DEGADIS+ by an expandable database of site characteristics for over 700 meteorological stations throughout the U.S. The model estimates stability using site characteristics, date and time of release, and user-specified cloud cover, cloud type, and wind speed observations. It is possible to also enter stability directly. The model simulates only one set of meteorological conditions, and is applicable for averaging periods of 1-hour or less. Chemical property, toxicity, and meteorological station databases can be modified or expanded as necessary.

F.2. TSCREEN

TSCREEN is a model developed for screening toxic air pollutant concentrations, should and designed to be used in conjunction with the USEPA's "Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants (Revised)". With the use of these tools one can determine the type of release and the steps to be followed to simulate the release via an applicable computer model.

A variety of models are imbedded in TSCREEN and can be used for various scenarios are, they are: SCREEN2, RVD, PUFF, and the Britter-McQuaid model.

SCREEN2 is an early version of the well-known Gaussian screening model used often for continuous neutrally buoyant discharges. The RVD model provides short-term ambient concentration estimates for screening pollutant sources emitting denser-than-air gases and aerosols through vertically-directed jet releases. The model is based on empirical equations derived from wind tunnel tests and estimates the maximum ground level concentration at plume touchdown at up to 30 downwind receptor locations. The PUFF model is used where the release is finite but smaller than the travel time (i.e., an instantaneous release.) This model is based on the Gaussian instantaneous puff equation and is applicable for neutrally buoyant non-reactive toxic air releases. The Britter-McQuaid model provides an estimate of dispersion of denser-than-air gases from area sources for continuous (plume) and instantaneous (puff) releases.

Using TSCREEN, a particular release scenario is selected via input parameters, and the model automatically selects and executes the appropriate dispersion model to simulate that scenario. The worst case meteorological conditions are also automatically selected based on criteria given in the workbook. TSCREEN has a front-end control program to the models that also provides, by use of interactive menus and data entry screen, the same steps as the workbook. The correct release scenario and associated characteristics of a toxic emissions release are selected with the help of on-screen text and graphics and data input is performed in a full-screen edit mode. TSCREEN saves the input data for each release scenario to a file that can be retrieved and later edited or executed.

A chemical look-up database and an on-line calculator are also available in the model. Once the nature of the release is determined, the user must specify the emission rate. For some scenarios, extensive references to EPA methods are provided, while for others, a specific method for calculating the emission rate is given. Density checks for the release are performed to determine which dispersion model is selected. Data necessary to execute that particular model is then requested in a logical format. Once the model is executed, the concentrations are calculated and then tabulated.

F.3. SLAB

SLAB is not a USEPA model but is available from the USEPA modelling support centre (SCRAM). This model simulates the atmospheric dispersion of denser-than-air releases. The types of releases treated by the model include:

- A ground-level evaporating pool
- An elevated horizontal jet
- A stack or elevated vertical jet
- An instantaneous volume source

Except for the evaporating pool source, which is assumed to be all vapour, all of the remaining sources are either pure vapour or a mixture of vapour and liquid droplets. Atmospheric dispersion of the release is calculated by solving the conservation equations of mass, momentum, energy, and species. The conservation equations are spatially averaged so that the cloud is treated as either a steady-state plume, transient puff, or a combination of the two depending upon the duration of the release. A continuous release is treated as a steady-state plume. In the case of a finite duration release, cloud dispersion is initially described using the steady-state plume mode and remains in the plume mode as long as the source is active. When the source is shut off, the cloud is treated as a puff and subsequent dispersion is calculated using the transient puff mode. For an instantaneous release, the transient puff dispersion mode is used for the entire calculation.

SLAB was developed specifically to model heavier-than-air gaseous (dense gas) releases. A cloud from a dense gas release behaves very differently than a plume from a lighter-than-air release. Since the gas is heavier than air, the cloud characteristics are primarily gravity-driven. Negative buoyancy and stable density stratification are among the factors that prevent the application of a Gaussian dispersion model from accurately simulating a dense gas release.

To determine whether a scenario must be run using a dense gas model like SLAB, it is recommended that the Richardson number is calculated. The Richardson number applies to three types of releases.

- Instantaneous (that is, occurring over a few seconds)
- Continuous ground level (that is, lasting several minutes with little or no variation in emission rate)
- Continuous jet releases

For an instantaneous release, a Richardson number greater than 700 indicates a dense gas. For a continuous dense gas release, the Richardson number is greater than 32. If the Richardson number does not fall within these parameters, consideration should be given to using another model (for example, SCREEN3, ISC3, AUSPLUME, INPUFF) for a passive release (neutrally-buoyant).

Appendix D. Table of Toxic Endpoints

CAS No.	Chemical Name	Toxic Endpoint(mg/L)
107-02-8	Acrolein [2-Propenal]	0.0011
107-13-1	Acrylonitrile [2-Propenenitrile]	0.076
814-68-6	Acrylyl chloride [2-Propenoyl chloride]	0.00090
107-18-6	Allyl alcohol [2-Propen-1-ol]	0.036
107-11-9	Allylamine [2-Propen-1-amine]	0.0032
7664-41-7	Ammonia (anhydrous)	0.14
7664-41-7	Ammonia (conc 20% or greater)	0.14
7784-34-1	Arsenous trichloride	0.010
7784-42-1	Arsine	0.0019
10294-34-5	Boron trichloride [Borane, trichloro-]	0.010
7637-07-2	Boron trifluoride [Borane, trifluoro-]	0.028
353-42-4	Boron trifluoride compound with methyl ether (1:1) [Boron, trifluoro[oxybis[methane]]-, T-4	0.023
7726-95-6	Bromine	0.0065
75-15-0	Carbon disulfide	0.16
7782-50-5	Chlorine	0.0087
10049-04-4	Chlorine dioxide [Chlorine oxide (ClO2)]	0.0028
67-66-3	Chloroform [Methane, trichloro-]	0.49
542-88-1	Chloromethyl ether [Methane, oxybis[chloro-]	0.00025
107-30-2	Chloromethyl methyl ether [Methane, chloromethoxy-]	0.0018
4170-30-3	Crotonaldehyde [2-Butenal]	0.029
123-73-9	Crotonaldehyde, (E)- [2-Butenal, (E)-]	0.029
506-77-4	Cyanogen chloride	0.030
108-91-8	Cyclohexylamine [Cyclohexanamine]	0.16
19287-45-7	Diborane	0.0011
75-78-5	Dimethyldichlorosilane [Silane, dichlorodimethyl-]	0.026
57-14-7	1,1-Dimethylhydrazine [Hydrazine, 1,1-dimethyl-]	0.012
106-89-8	Epichlorohydrin [Oxirane, (chloromethyl)-]	0.076
107-15-3	Ethylenediamine [1,2-Ethanediamine]	0.49
151-56-4	Ethyleneimine [Aziridine]	0.018
75-21-8	Ethylene oxide [Oxirane]	0.090
7782-41-4	Fluorine	0.0039
50-00-0	Formaldehyde (solution)	0.012
110-00-9	Furan	0.0012
302-01-2	Hydrazine	0.011
7647-01-0	Hydrochloric acid (conc 30% or greater)	0.030
74-90-8	Hydrocyanic acid	0.011
7647-01-0	Hydrogen chloride (anhydrous) [Hydrochloric acid]	0.030
7664-39-3	Hydrogen fluoride/Hydrofluoric acid (conc 50% or greater)	0.016
7783-07-5	Hydrogen selenide	0.00066
7783-06-4	Hydrogen sulfide	0.042
13463-40-6	Iron, pentacarbonyl- [Iron carbonyl (Fe(CO)5), (TB-5-11)-]	0.00044
78-82-0	Isobutyronitrile [Propanenitrile, 2-methyl-]	0.14
108-23-6	Isopropyl chloroformate [Carbonochloridic acid, 1-methylethyl ester]	0.10
126-98-7	Methacrylonitrile [2-Propenenitrile, 2-methyl-]	0.0027
74-87-3	Methyl chloride [Methane, chloro-]	0.82
79-22-1	Methyl chloroformate [Carbonochloridic acid, methylester]	0.0019
60-34-4	Methyl hydrazine [Hydrazine, methyl-]	0.0094
624-83-9	Methyl isocyanate [Methane, isocyanato-]	0.0012

74-93-1	Methyl mercaptan [Methanethiol]	0.049
556-64-9	Methyl thiocyanate [Thiocyanic acid, methyl ester]	0.085
75-79-6	Methyltrichlorosilane [Silane, trichloromethyl-]	0.018
13463-39-3	Nickel carbonyl	0.00067
7697-37-2	Nitric acid (conc 80% or greater)	0.026
10102-43-9	Nitric oxide [Nitrogen oxide (NO)]	0.031
8014-95-7	Oleum (Fuming Sulfuric acid) [Sulfuric acid, mixture with sulfur trioxide]	0.010
79-21-0	Peracetic acid [Ethaneperoxoic acid]	0.0045
594-42-3	Perchloromethylmercaptan [Methanesulfenyl chloride, trichloro-]	0.0076
75-44-5	Phosgene [Carbonic dichloride]	0.00081
7803-51-2	Phosphine	0.0035
10025-87-3	Phosphorus oxychloride [Phosphoryl chloride]	0.0030
7719-12-2	Phosphorus trichloride [Phosphorous trichloride]	0.028
110-89-4	Piperidine	0.022
107-12-0	Propionitrile [Propanenitrile]	0.0037
109-61-5	Propyl chloroformate [Carbonochloridic acid, propylester]	0.010
75-55-8	Propyleneimine [Aziridine, 2-methyl-]	0.12
75-56-9	Propylene oxide [Oxirane, methyl-]	0.59
7446-09-5	Sulfur dioxide (anhydrous)	0.0078
7783-60-0	Sulfur tetrafluoride [Sulfur fluoride (SF4), (T-4)-]	0.0092
7446-11-9	Sulfur trioxide	0.010
75-74-1	Tetramethyllead [Plumbane, tetramethyl-]	0.0040
509-14-8	Tetranitromethane [Methane, tetranitro-]	0.0040
7550-45-0	Titanium tetrachloride [Titanium chloride (TiCl4) (T-4)-]	0.020
584-84-9	Toluene 2,4-diisocyanate [Benzene, 2,4-diisocyanato-1-methyl-]	0.0070
91-08-7	Toluene 2,6-diisocyanate [Benzene, 1,3-diisocyanato-2-methyl-]	0.0070
26471-62-5	Toluene diisocyanate (unspecified isomer) [Benzene, 1,3-diisocyanatomethyl-]	0.0070
75-77-4	Trimethylchlorosilane [Silane, chlorotrimethyl-]	0.050
108-05-4	Vinyl acetate monomer [Acetic acid ethenyl ester]	0.26