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Route Selection

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HIPAP 11: Route Selection

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Foreword

Since the 1980s, the New South Wales Department of Planning has promoted and implemented an integrated approach to the assessment and control of potentially hazardous development. The approach has been designed to ensure that safety issues are thoroughly assessed during the planning and design phases of a facility and that controls are put in place to give assurance that it can be operated safely throughout its life.

Over the years, a number of Hazardous Industry Advisory Papers and other guidelines have been issued by the Department to assist stakeholders in implementing this integrated assessment process. With the passing of time there have been a number of developments in risk assessment and management techniques, land use safety planning and industrial best practice.

In recognition of these changes, new guidelines have been introduced and all of the earlier guidelines have been updated and reissued in a common format.

I am pleased to be associated with the publication of this new series of Hazardous Industry Advisory Papers and associated guidelines. I am confident that the guidelines will be of value to developers, consultants, decision-makers and the community and that they will contribute to the protection of the people of New South Wales and their environment.

S Haddad

Director General

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Executive Summary

The orderly development of industry and the protection of community safety necessitate the assessment of hazards and risks. The Department of Planning has formulated and implemented risk assessment and land use safety planning processes that account for both the technical and the broader locational safety aspects of potentially hazardous industry. These processes are implemented as part of the environmental impact assessment procedures under the Environmental Planning and Assessment Act 1979.

The Department has developed an integrated assessment process for safety assurance of development proposals, which are potentially hazardous. The integrated hazards-related assessment process comprises:

- a preliminary hazard analysis undertaken to support the development application by demonstrating that risk levels do not preclude approval;
- a hazard and operability study, fire safety study, emergency plan and an updated hazard analysis undertaken during the design phase of the project;
- a construction safety study carried out to ensure facility safety during construction and commissioning, particularly when there is interaction with existing operations;
- implementation of a safety management system to give safety assurance during ongoing operation; and
- regular independent hazard audits to verify the integrity of the safety systems and that the facility is being operated in accordance with its hazards-related conditions of consent.

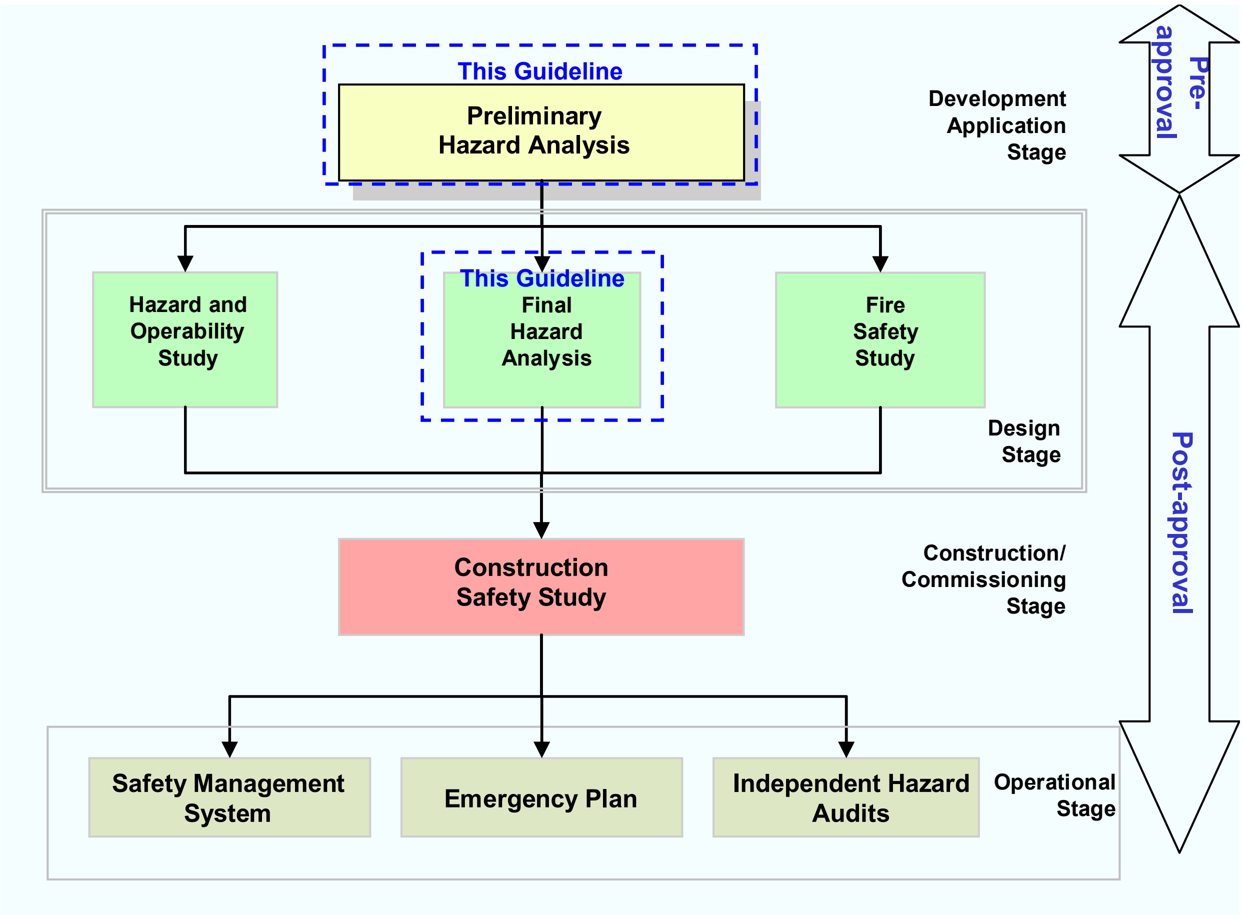
The process is shown diagrammatically in Figure 1.

A number *of Hazardous Industry Advisory Papers (HIPAPS)* and other guidelines have been published by the Department to assist stakeholders in implementing the process. All existing HIPAPs have been updated or completely rewritten and three new titles (HIPAPs 10 to12) have been added.

A full list of HIPAPs is found at the back of this document.

The part of the process covered by this guideline is highlighted in Figure 1.

Figure 1: The Hazards-Related Assessment Process



Route Selection

Where a development involves the transport of significant volumes of dangerous goods and/or hazardous materials, there may be a need to select preferred transport routes from a number of possible alternatives.

These guidelines provide an overall integrated framework for the assessment of road transport routes for the transportation of hazardous materials. They are based on the basic principles that land use safety planning should complement technical and operational safety management. Optimum transportation decisions can only be made when all relevant aspects of and use safety, traffic and economic elements are exposed and integrated into the decision making process.

While they were originally issued in 1995, the basic principles remain valid. Compared with the original edition, there have been some editorial changes and some tables in Appendix 5 have been removed, since experience has shown that they provided an unnecessary level of detail.

The guidelines provide state and local government agencies, industry and those involved or concerned with hazardous materials road transportation with the principles and basic tools for assessing routes on an area/regional/particular development basis.

Essentially, the study process includes:

- examination of the road hierarchy and identification of routes for heavy vehicle transportation;
- elimination of those routes where there are legal or physical constraints, special/sensitive land uses or where there is inadequate emergency access;

- rating the potential routes on the basis of environment and` land use risk factors, traffic factors and economic factors;
- a comparison of each of the route alternatives on the basis of their rating against each of the factors.

The guidelines cover each step of this process:

The ultimate decision is a balanced judgement considering each of the factors, since it is not possible to integrate them into a single indicator of acceptability because of their diversity.

The strength of the guidelines is that they provide a systematic approach to ensuring that decision makers have access to all relevant information.

The guidelines have been developed to help in land use safety planning. They are not intended to be used as a basis for preventing vehicles carrying hazardous materials from travelling on roads classified under the Roads Act 1993. Similarly, they should not be used as an argument for upgrading any roads classified under the Roads Act. These matters fall within the jurisdiction of the relevant NSW Government agencies.

It should be noted that the guidelines relate to road transportation only. Transport decisions should also consider the merits of alternative modes such as rail, sea or pipeline. The guidelines presuppose that such an evaluation has been done and that road has been identified as the preferred mode.

1 Introduction

SECTION SUMMARY

While hazard analysis techniques are commonly applied to fixed sites, they are also applicable to the transport of hazardous materials, particularly in the evaluation of alternative transport routes.

These guidelines present a holistic approach to the consideration of route options. They address such issues as:

- risks to people, property and the environment from hazardous material transport accidents on the various alternative route segments;
- road network capacity and level of service; and
- relative travel times and operating costs of the feasible route alternatives.

The guidelines may be used to assess routes on a regional basis or to evaluate individual projects.

KEY MESSAGE

- Route selection is more than simply identifying “least risk routes.” It requires a balancing of land use safety, road network capability and operational and economic factors.

1.1 Background

There has been a growing community concern in recent years over the hazards and risks associated with the production, storage and transportation of hazardous materials. In particular much attention has been focussed on accidents during the transport of such materials, particularly transport by road.

It is now recognized that the land use safety planning of transportation routes for hazardous materials, accounting for the type and nature of surrounding land uses, is an integral component of the safety management of hazardous materials transportation. Evaluating and selecting transportation routes is an essential complementary measure to technical and operational safety and environmental controls.

The New South Wales Department of Planning has developed and implemented a comprehensive approach to land use safety planning based on the assessment and management of risk. This approach involves systematic hazard analysis and risk quantification. It is applicable to transportation of hazardous materials as well as to fixed sites and is particularly useful for the identification of "least risk options" and cost effective risk reduction measures. In the transport case it is particularly effective in identifying "least risk routes".

In considering transport mode or route selection, there is currently typically little systematic analysis of the potential consequences or likelihood of impacts on sensitive uses such as residential areas, shopping centres, schools, and sensitive environmental areas. Furthermore, there are few examples, worldwide, of the use of formalised risk assessment studies to evaluate the hazard implications to people, property and the environment from the transport of hazardous materials.

More importantly, few attempts have been made to integrate the various factors that may influence the selection of routes for hazardous materials transportation. These factors include economic, environmental and land use safety, traffic and operational requirements. Consideration of any of these factors in isolation may result in inappropriate or sub-optimal decisions and practices, to the detriment of operators and the community.

This document addresses the framework, tools and techniques for an integrated planning approach to route planning and assessment for the transport by road of hazardous materials.

1.2 Purpose and Scope of the Guidelines

The purpose of this document is to provide guidance on the identification and assessment of transport routes suitable for hazardous materials, based on an integrated approach that accounts for traffic, environmental and land use safety, economic and other operational factors.

The guidelines' aim to provide a framework to:

- Identify, analyse and assess the traffic, economic and land use safety implications for routes currently in use;
- Enable the classification of the various possible routes;
- Assist relevant government agencies, Councils and developers to identify routes within each local government area (LGA) which are suitable (or otherwise) for the transport of hazardous materials;
- Assess the locations of designated developments requiring the transport of hazardous materials;
- Enable consent authorities (Councils) to impose conditions of consent-on any development that vehicles transporting hazardous materials shall use those routes which are least likely to result in adverse impacts to people, property and the natural environment;
- Provide a means for assuring consent authorities, developers and the public that all factors, including risk, have been adequately assessed and that routes are acceptable to the community; and
- Assist emergency organisations in responding to emergencies quickly and efficiently.

There are two main specific applications for the information, tools and techniques outlined in this document:

- Identification, analysis and assessment of the environmental and land use safety implications of existing or proposed routes used for transportation of hazardous materials on a regional scale, taking into account traffic and economic implications. The output is a relative ranking of each routing alternative for each of the factors (environment, safety, economic and traffic operational) thus enabling the selection of the most appropriate route(s).
- Provision of a basis for the assessment of road transport hazards and risks from individual development proposals (of a potentially hazardous nature).

1.3 Principles of Implementation

The integrated risk assessment and management approach to the safety of hazardous material transportation necessitates consideration of three main elements in an integrated manner:

- Capability of the existing road network and cumulative traffic implications including overall traffic movement, congestion and level of service on existing or potential routes, accident rates, and road conditions.
- Transportation risk and environmental and land use safety factors; including the identification and quantification of risks to people, property and the environment from the transport of hazardous materials, particularly as they relate to effects on land uses and various ecosystems along the transportation routes.
- Distribution considerations and operational requirements for practical transportation economics, including considerations of travel distance and time and the transportation costs of alternative route systems.

These guidelines are divided into sections, each tailored to meet a particular user need.

Section 2 is a broad introduction to the various factors that need to be taken into account in exploring possible routes for the transport of hazardous materials.

Section 3 describes the logical structure of a transport study, considering firstly the general approach and then its application to area transport studies and studies for specific developments.

Section 4 moves from the broad approach and discusses the study methodology in more detail.

Section 5 contains additional implementation notes.

The **Appendices** include supplementary technical and other information.

2 Process Elements

SECTION SUMMARY

This section discusses the various elements of the route selection process and categorises a number of factors that need to be considered. The main issues applying to the various factors are highlighted. These include:

- relevant codes and standards and mandatory considerations that must be observed, such as load limits and prohibited routes;
- subjective factors, which reflect community priorities and values;
- road and traffic factors, including the physical adequacy of the roads and carriageway levels of service;
- hazards and risks to people, property and the environment arising out of accidents involving hazardous materials;
- transport economics of the various route alternatives; and
- emergency response capability.

KEY MESSAGE

- Each of the process elements must be considered on its merits before eliminating a route or selecting a preferred route.

2.1 Overview

Factors that influence routing decisions may be grouped into the following interrelated categories:

- Mandatory factors, including statutory requirements and legal and physical constraints.
- Subjective factors that reflect community priorities and values which may not be easily quantified. Such factors include sensitive populations, special land uses and emergency response capability.
- Road and traffic factors including the identification of the most suitable routes.
- Environmental and land use risk, including the identification of hazards and the quantification of risk. These are location dependent.
- Operational factors including economics and operator's requirements.

In the first instance, mandatory and subjective factors should be considered to identify those routes which are clearly unsuitable for the road transport of hazardous materials. For the remaining routes, consideration of the other factors, individually or in combination, may preclude the use of any particular route for the transportation of hazardous materials or favour an alternative route. Table 1 is a generalised outline of the relevant considerations.

Table 1: Generalised Factors and Considerations

Traffic & Roads	Road Structure Volume & Composition Travel Time Level of Service Traffic Signals Alternative Routes
Environmental and Land Use Safety	Adjacent Land Use Population Levels Sensitivity of Ecosystems Accident and Incident Rates Potential Hazards Risk Level Drainage System Emergency Access Driver Training Vehicle Safety Design and Maintenance
Transport Economics	Distance Travel Time Operating Costs

2.2 Relevant Codes and Standards

A number of Australian Codes and Design Standards are used to cover technical safety matters. One of the most comprehensive codes is the Australian Code for the Australian Dangerous Goods Code (ADG Code), the 7th edition of which came into force in January 2009.

Additionally, the technical controls required by relevant Australian Codes and Design Standards cover the design, manufacture, testing and maintenance of road tank vehicles.

However, in addition to the operational and technical controls, it is now recognised that land use safety planning should be also considered as an integral part of the overall control process.

2.3 Mandatory Considerations

Physical considerations may preclude a routing alternative because of weight limitations on bridges, height restrictions on underpasses, inadequate shoulders for breakdowns, extensive construction activities or inadequate parking and turning spaces.

Laws and regulations may apply to any routing alternative, which would prohibit the transport of hazardous materials along certain roads or structures (e.g. tunnels, bridges). Local, state and national transport authorities should be consulted in all cases. Such prohibited roadways should be eliminated from consideration.

2.4 Subjective Routing Factors

Subjective routing factors in the consideration of routes for the transport of hazardous materials usually include:

- The location along the roadway or in its vicinity of extensive sensitive land uses such as major hospitals, schools, aged person housing, churches or items of heritage or cultural significance; or the location of sensitive ecosystems and natural landscape such as park reservations and wetlands.
- Emergency and evacuation planning and infrastructure, including: the availability of formalised emergency and evacuation procedures and plans, the location of

emergency response teams and their ability to respond to hazardous material release, access and ease of emergency evacuation.

Subjective factors should reflect community priorities and values and should ideally be arrived at through community discussion and consensus. These factors are particularly relevant in the assessment process when one alternative is not clearly superior to the others.

2.5 Road and Traffic Factors

These include the capability and level of service of the road system as measured by its physical characteristics, the volume of traffic and its composition, and congestion levels of existing and potential routes. The following traffic criteria reflect the ability of a route to effectively and safely move the traffic flows using it.

2.5.1 Structural and Geometric Adequacy of Roads

The structural and geometric adequacy of the routes under consideration should be assessed for their suitability to cater for heavy vehicles.

2.5.2 Level of Service

Level of service of the road network indicates its capability for moving the type and volume of traffic using it. The composition of vehicles by size and type is required to assess a road network's operating "Level of Service". Level of service is defined by the National Association of Australian State Road Authorities (NAASRA, 1988) as a "qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers". It describes these conditions in term of factors such as speed and travel time, traffic interruptions, safety, driving comfort and convenience. Levels of service are designated from A to F, with level of service A representing the best operating conditions and level of service F the worst. Three measures of level of service are presented below.

Carriageway Levels of Service

A service volume, as defined by the NAASRA (1988a), is "the maximum hourly rate at which vehicles can reasonably be expected to traverse a point or uniform section of a lane or roadway during a given time period under the prevailing roadway, traffic and control conditions while maintaining a designated level of service". Suggested one-way hourly volumes for interrupted traffic flow at different levels of service are summarised in Appendix 1.

Level of Service of Critical Intersections

The capacity of a street system is largely dependent on the capacity of critical intersections. The operational characteristics of an intersection are reflected by the intersection flow ratio (Y) and the intersection degree of saturation (X). These parameters, critical to the efficient operation of the road system, are defined in Appendix 2, together with suggested criteria for the evaluation of intersections controlled by signals or roundabout, and intersections controlled by signs or subject to the T-junction rule.

Travel Speed

Travel times for vehicles using a route indicate the congestion points as well as reflect the level of congestion.

2.5.3 Vehicle Crashes

The number, type and consequence of accidents along the potential routes are another pointer to the ability of a route to safely carry traffic flows.

2.6 Environmental and Land Use Safety Considerations

2.6.1 Hazards

An increasing variety of hazardous materials is now being transported by road, rail, pipeline and ships. These materials have the potential for incidents which may result in death or injury to people, property damage or damage to the biophysical environment through the effects of fire, explosion or toxicity.

A sound knowledge of the dangerous properties of these materials is essential in order to determine the level of interaction possible between them, the packaging of the material, and the environment surrounding their containment.

Appendix 3 gives a general classification of hazardous materials, based on the Australian Dangerous Goods Code. Whether or not a route evaluation may be desirable depends, in part, on the class of material being transported, the type of container, and the movement quantity and frequency. The Department's guideline *Applying SEPP 33* gives additional information.

2.6.2 Risk Objectives

The overall environmental and land use safety objective for route selection is that the route which presents the lowest risk to surrounding people, property and the natural environment should be selected. Risk is determined in terms of the cumulative combination of the probability of accidents and the consequences of such accidents.

2.6.3 Principles and Criteria

Principles

The classification and ranking of the various route options for the transport of hazardous materials, from an environmental land use safety planning viewpoint, should reflect a systematic identification of hazards, together with a qualitative and quantitative (as applicable) assessment of resultant risk levels.

The extent of the risk quantification process will vary depending on the purpose of the analysis. For example, in the case of large transportation area studies, the absolute level of risk is less relevant than the comparative risk assessment process. In these cases a simplified approach is appropriate. If, on the other hand, there are few alternative routes, more detailed risk quantification may be justified.

In general, the risk along a route used for the transportation of hazardous materials is a function of the population exposed (along that route) and the rate and severity of accidents. The population exposure along the route is dependent on the nature and extent of land use. Accident rates depend on the type of vehicles, traffic density and road condition and severity is linked to the nature and quantity of materials being carried.

An "intermediate" method of comparative risk assessment may be used to give a broad risk comparison (see Appendix 7). For more detailed risk quantification, the full range of accident scenarios should be explored, and the consequences and likelihood of each scenario estimated and then combined to derive quantitative risk levels along each route of interest.

Criteria

Routes that pass along sensitive population and associated land uses should be avoided wherever possible. Qualitative criteria may be used (e.g. avoid hospitals, schools, etc). Similarly, routes near sensitive environmental areas and ecosystems should be avoided, if possible, and alternative routes adopted. Some of the qualitative land use criteria that should be considered are set out in Appendix 4.

The emphasis in the Transportation Safety Study is on comparative risk assessment, rather than on absolute levels of risk along the route. The general principle should be that no significant increases to existing background risks should be permitted. While individual risk calculations may be appropriate in some circumstances, a societal risk approach is generally more appropriate in the transport risk assessment. It is appropriate to include the population of other road users in the societal risk calculation. Risk criteria are discussed in Hazardous Industry Planning Advisory Paper (HIPAP) No 4. It should be noted, however, that the individual risk criteria developed in the paper generally relate to risks from fixed installations and judgement should be used in applying them to transport risks.

2.7 Transport Economic Factors

Operating costs and distribution logistics should also be considered in the selection of preferred routes. Transport costs fall into two basic categories - fixed and variable costs. Generally the former costs do not vary significantly with the distance operated while the latter costs (usually referred to as operating costs) vary with distance and travel time.

Operating costs are based on two main components - a variable cost for operating the truck and cost for the driver's time.

The components of transport operational costs are distance travelled in $/km and time spent in distance travelled in $/hr. These factors are reflected by the travel distance and time along a route.

The main cost criterion when comparing alternative routes is the expected increase or decrease in distance and travel time if another route is used. An increase or decrease in operating costs exceeding 10 percent may have an effect on the overall transport economics and as such, may be used as a general guide for comparison purposes.

2.8 Emergency Response Capability

Another element influencing the selection of appropriate routes for the transportation of hazardous materials is the emergency response capability available for the routes considered. This may include such considerations as the speed of response of the emergency services, ease of access to the potential accident site and availability of emergency combat equipment.

In the case of an emergency which would require the closure of a route designated for the transport of hazardous materials, an alternative route should be available.

2.9 Other Factors

Other factors influencing transport safety include the design and maintenance of vehicles carrying hazardous materials, driver training, documentation and load containment. Many of these aspects are addressed in the ADG Code.

3 Approach

SECTION SUMMARY

Section 3 discusses how the approach to route selection varies between area studies and those carried out for specific developments or projects. Flowsheets are used to show the logical progression of each type of study and the interaction between the various process elements.

While the objective of both an area study and a specific development study may be to identify and rank suitable hazardous material transport routes, a study for a specific development also needs to demonstrate that the transport operations from the development do not pose unacceptable risk to surrounding land uses.

KEY MESSAGE

- The objectives of the study must be clearly defined since this will drive the approach adopted.

3.1 General

An area transport study addresses the evaluation of possible hazardous materials transport routes in a broad geographical area. The study may need to cover both existing and proposed developments in order to identify and evaluate all significant factors that contribute to the conclusion that particular routes are preferable to others from the perspective of safety and the prevention of land use conflicts. An area transport study is typically strategic in scope.

Assessment of a specific development's transportation risks is carried out at a more detailed level, usually as part of the assessment of the development application.

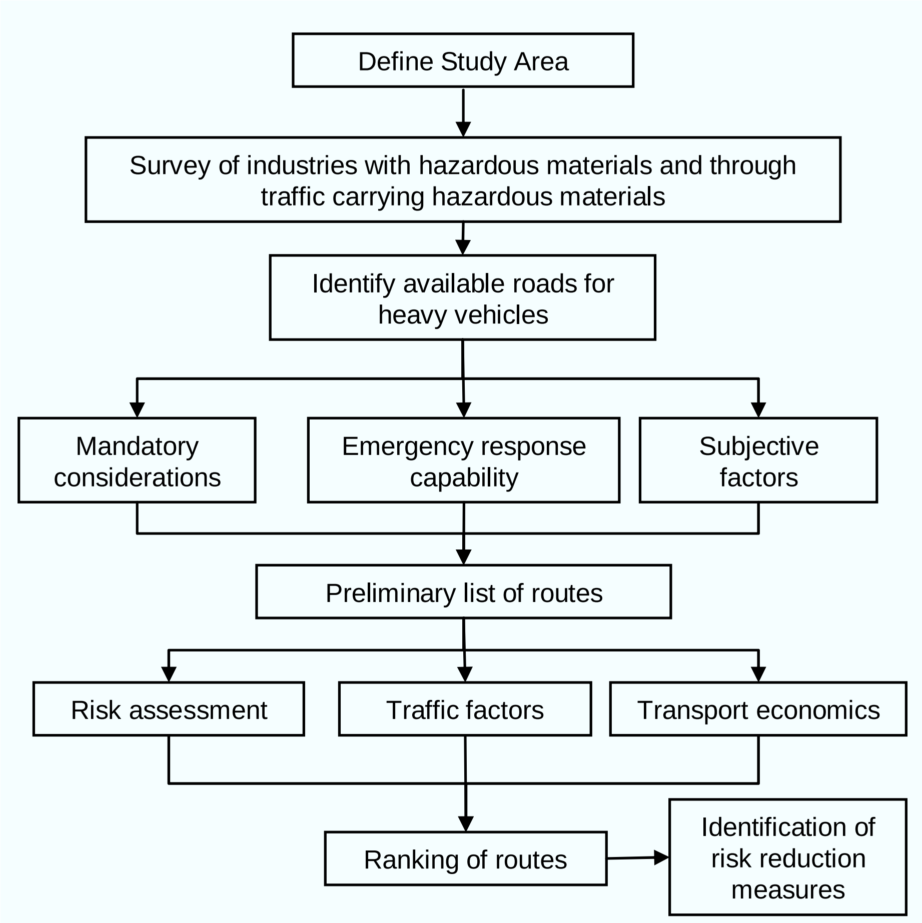
The various steps for both types of studies are discussed in this section, with a more detailed description of the methodology in Section 4.

3.2 Area Transport Studies

3.2.1 Approach

The objectives of the study will determine the amount of detail needed in the various parts of the study. The logical steps in the identification of suitable routes for the transport of hazardous materials are shown in Figure 2 and covered in more detail in Section 4. Any evaluation of routes which may be used for the road transport of hazardous materials through a local government area should be carried out in consultation with councils, relevant government agencies and industry.

Figure 2: Assessment Process for Area Transport Studies



A further explanation of Figure 2 follows.

- **Definition of the study area**. Usually the area would cover at least a full local government area. Ideally, the study area should be a region consisting of several local government areas. The study area could be extended if a joint study is undertaken by two or more adjoining Councils.
- **Survey of industries in the area**. The purpose of this is to identify generators or users of hazardous materials.
- **Identification of available routes** based on a review of the adopted road hierarchy for the Study area. If a road hierarchy has not been formulated then it should be developed. The identification of routes suitable for the movements of trucks will then follow from the road hierarchy.
- **Selection of a preliminary list of potential routes** suitable for the road transport of hazardous materials by testing the identified truck routes against
  - the mandatory considerations; and
  - the subjective factors including the emergency response capability of each route.
- **Comparison and ranking of potential routes** based on
  - a risk assessment of the potential routes using the "intermediate" method;
  - an evaluation of roads and traffic factors; and
  - an evaluation of the transportation costs associated with the potential routes.

- If the differences between the routes are insignificant and differentiation is still needed, then a "detailed" risk assessment should be undertaken.
- **Selection of suitable routes** for the road transport of hazardous materials based on the initial screening and the results of the ranking of the various factors for each of the route options.
- **Implementation of risk reduction measures** should be carried out where required.

3.3 Transport Studies for Specific Developments

3.3.1 Objectives

The objective of a transport risk study for a specific development is to ensure that a proposed or existing development does not generate traffic of a type and volume that would impose unacceptable risks on the community and that routes are chosen that will balance risk and economic considerations.

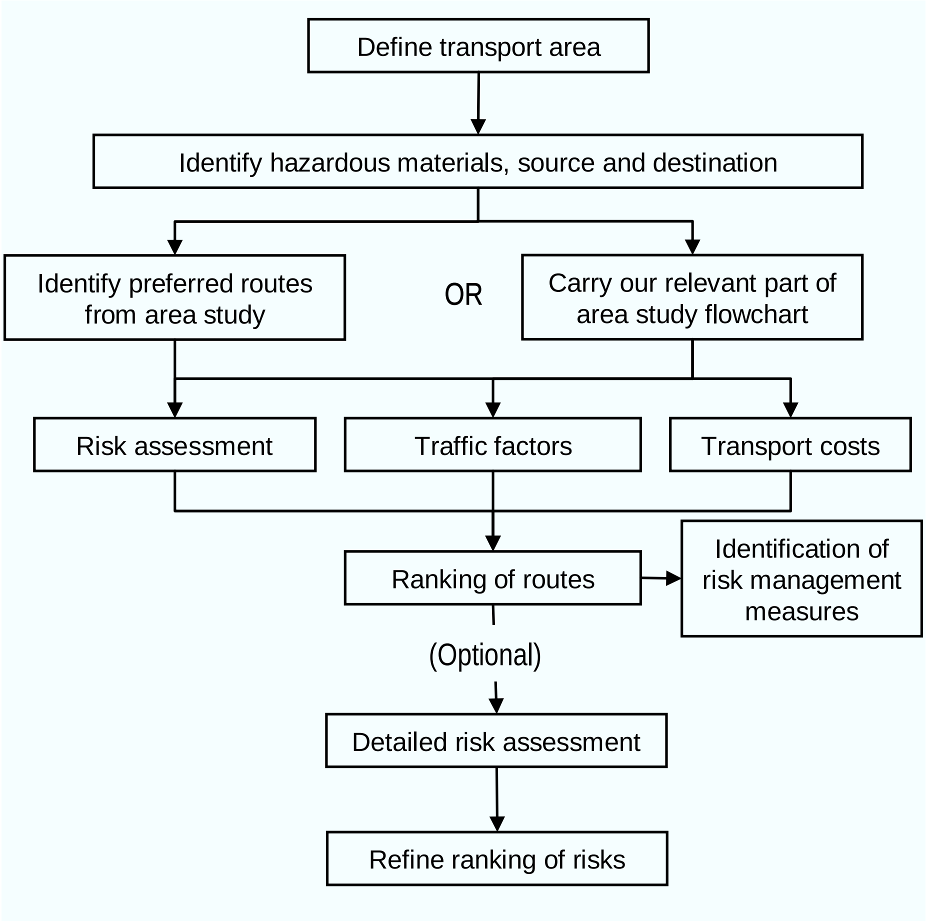
The requirement for a specific transport study may arise out of the need for a Preliminary Hazard Analysis (PHA) to support a development application for potentially hazardous industry (see Hazardous Industry Planning Advisory Paper No. 6). A study may also be requested at the stage of the preparation of an Environmental Impact Statement for Designated Development or an (Environmental Assessment for a Major Project), as one of the Director General's requirements. Further analysis may be required as part of a Final Hazard Analysis (FHA) specified as a condition of consent or approval.

3.3.2 Approach

The suggested procedure for the selection of suitable routes for the transport of hazardous materials associated with a specific development is shown in Figure 3.

This allows risk assessment to concentrate on those routes which are most likely to be acceptable on other grounds.

Figure 3: Assessment Process for Specific Development



The required steps are listed below and covered in more detail in Section 4.

- **Definition of the transport area** is carried out from a traffic perspective. It should include the area over which traffic to or from the development is likely to have a significant effect.
- **Identification of hazardous materials, source and destination** is required to allow specific risk calculations to be carried out. Volume of traffic for the various types of hazardous materials is also required.
- **Identification of the preferred hazardous goods routes** from the area study for the region of interest. If this does not exist, those elements of the area study which lead to the identification of a preliminary list of routes should be carried out.
- **Comparison and ranking of potential routes**. For each of the potential routes a comparison should be made of their relative strengths and weaknesses against each of the main factors considered. This may include.
  - an initial risk assessment of the potential routes;
  - an evaluation of the transportation costs associated with the potential routes;
  - an evaluation of the roads and traffic factors; and
  - the emergency response capability of each route.
- **Selection of suitable routes** for the road transport of hazardous materials is a balanced judgement taking into account both the qualitative and quantitative results of the comparison. This is further discussed in the implementation notes in Section 5.

- **Identification of risk management measures** should include opportunities for risk reduction where the evaluation shows undesirable levels of risk along the preferred routes, together with consideration of an appropriate safety management system (SMS). These are further discussed in Section 5.3;
- If the differences between the routes are small and differentiation is still needed, a **detailed risk assessment** may be undertaken and the route evaluation refined.

4 Study Methodology

SECTION SUMMARY

This section discusses in more detail the methodology used to evaluate the various process elements. A unified approach is used, recognising the broad similarity between many of the elements of area studies and those carried out for specific projects. Reference is also made to additional useful information in the appendices.

The suggested study sequence is:

- identification of potential routes using the road hierarchy, eliminating roads unsuitable for heavy vehicles, then applying the mandatory and subjective factors;
- assessment of the potential routes, comparing them on the basis of road and traffic factors, environmental and land use safety, and transport economics;
- selection of a preferred route or routes after reviewing all the factors; and
- implementation of the route(s), including making any necessary road or traffic management improvements.

KEY MESSAGE

- Numerical results of comparisons should not be regarded as absolute values. They are a guide to assist in forming an overall balanced judgement.

4.1 General

This section suggests a methodology for the two types of transport studies outlined in the previous section: an area transport study and a transport study for a specific development. Because of the similarities between many elements of both types of study, a unified approach has been taken to the methodology. Differences in application between area and specific studies are highlighted where appropriate.

Where a study for an individual development is being carried out, it should draw on information from relevant available area studies to avoid duplication of effort and promote consistency.

4.1.1 Types of Developments

Major Projects

Major projects which may require an assessment on the basis of hazardous materials truck movements generated could include:

- Oil refineries, processing and storage of Petrochemicals
- Bulk Fuel Depots
- LPG Extraction Plants
- Bulk LPG Storage
- Bulk Chemical Manufacturing including Chlorine, Ammonia or Hydrogen

Minor Developments

Smaller scale developments that could be approved directly by Local Councils, provided they met basic transport criteria, could include:

- Service stations (LPG Outlets)
- Dangerous Goods Warehouses
- Municipal swimming pools (chlorine dosing)
- Ammonia refrigeration (fish processing)

4.2 Detailed Methodology

The boundaries of the study area need to be carefully chosen in order to take into account natural boundaries, local government boundaries and other strategic features.

Contact should be made with adjoining Councils to ensure that a coordinated approach is used.

4.2.1 Identification of Potential Routes

The identification of potential available routes is based on

- a review of the road hierarchy for the Study Area; if a road hierarchy has not been formulated then it should be developed;
- the identification of routes suitable in general for the movements of trucks.

Road hierarchy

The development of a road hierarchy is the method by which the purpose of each road within a street system is determined, i.e. a road hierarchy is the basic recognition that, the purpose of a given road or street may range from being primarily for long range vehicular movements to primarily for pedestrian activity and local access.

The development of a road hierarchy in major urban areas is an essential element of a rational land use plan. The road network is intrinsic to land use planning both at the local and regional level. Thus, it is important that the function of roads in an area be identified and related to the existing and future adjacent land use.

The development of road hierarchies in New South Wales is based on the functional classification system of local streets, collectors, sub-arterial and arterial roads defined in Appendix 5.

Roads are classified as follows for administrative purposes.

- State Roads include Freeways and arterial roads
- Regional Roads include sub-arterial roads
- Collector and local roads

The development of a realistic road hierarchy requires a thorough evaluation of the physical characteristic of the street network, such as geometry of streets, network of connecting streets, constraints which control major road improvements and the existing function of the streets taking into account traffic volumes, capacity of roads and intersections, abutting land uses and the needs of local residents for access to properties.

Relevant factors and criteria for the development of a road hierarchy are presented in Appendix 5. The methodology to formulate a road hierarchy is outside the scope of these guidelines.

Identification of Truck Routes

The main purpose of a truck route network is to provide access to industrial areas and other major destinations as well as minimising the intrusion of through traffic in residential areas. When developing a truck route network the objectives should be that it

- adequately serves the needs of the industrial areas, and
- attracts heavy vehicles away from unsuitable residential streets without necessarily proclaiming certain streets "Light Traffic Routes".

All factors and criteria required for the development of a road hierarchy apply for the assessment of the suitability of routes to carry heavy vehicles. The travel time may also affect the selection of truck routes.

The routes used by heavy vehicles within and through the study area should be identified.

One of the major causes for heavy vehicles infiltrating residential streets are problems encountered along the major road system. From a traffic and planning point of view, it is important that wherever possible, a bypass route should be selected at major points of high population densities.

A basic premise of the identification process is that collector and local roads should not carry long distance traffic and are therefore not generally suitable as truck routes. Arterial and sub-arterial roads should be evaluated for their appropriateness to cater for heavy vehicles.

As an exception to the general rule, use of certain collector/local roads may in some circumstances be better suited for the road transport of hazardous materials because they are associated with lower traffic volumes, better levels of service, lower land use densities or lesser overall risk/exposure than available arterial/sub-arterial roads. It is accepted however that closer to the origin and/or destination, collector and local roads may be used for access.

In the short term, the objective should be to reduce as much as possible the impact of heavy vehicles along routes which traverse dense areas. In the longer term, the objective should be to completely divert heavy vehicles onto an alternative more suitable route.

Selection of Potential Routes

All the routes identified as suitable for heavy vehicles traffic are then assessed to establish their potential for the road transport of hazardous materials. These routes are tested against

- the mandatory factors (section 2.3);
- the subjective factors (section 2.4);

An area transportation study would require a comprehensive survey of all transportation activities taking place within the boundaries of the study area. The activities would not only include those with origin and destination in the area study but also those which handle loads in transit.

Some of the information required is listed below:

Mandatory Considerations

An inventory and identification of the physical and legal mandatory constraints of the identified routes should be carried out in the first instance. This will enable the removal of those routes which are the subjects of these constraints.

Subjective Routing Factors

An inventory of land use adjacent to the subject routes should be carried out. The criteria suggested in Appendix 4 will enable the subjective ranking of the routes.

Contact should be made with the emergency authorities to establish the availability of formalised emergency and evacuation procedures and plans and their ability to respond to hazardous material incidents.

4.2.2 Assessment of Potential Routes

4.2.2.1 Road and Traffic Factors

The assessment of the potential routes for suitability on road and traffic grounds will require the collection of the following information to establish the capability and level of service of the road system as measured by its physical characteristics, the volume of traffic and its composition, and congestion levels of existing and potential routes.

- Inventory of routes including the length, road width, number of lanes, traffic control and parking restrictions;
- Road structural condition;

- Present road usage, traffic volumes and composition, including the number of trucks carrying hazardous materials and the quantity and type of the materials, load size and frequency of transport. This is obtained from physical counts;
- Traffic movements at critical intersections along the routes;
- Travel time along the alternative routes;
- Origin and destination of trucks carrying hazardous materials, if the study area includes major developments generating significant hazardous materials traffic movements.

The following factors consider the ability of a route to effectively and safely handle the traffic using it.

Structural and Geometric Adequacy of Roads

Routes with good geometry (e.g. wide carriageway with minimum horizontal and vertical curves) and capable of carrying heavy vehicles should be selected in preference to routes of lesser quality.

Carriageway Levels of Service

One-way hourly volumes for interrupted traffic flow at different level of service are summarised in Appendix 1. The desirable standard is to achieve at least a level of service of C and not less than D. Therefore a level of service D is suggested as the minimum level for a road section.

Level of Service of Critical Intersections

The suggested criteria for the evaluation of intersections controlled by signals or roundabout, and intersections without signals are included in Appendix 2. Intersections with poor levels of service usually reflect congestions and delays.

Travel Speed

Travel speeds at or near 25km/hr indicate a road section experiencing congestion and delays (Level of Service E), while those under this speed reflect a congested situation (Level of Service F). The number of traffic signals can be used as a measure of delay along a route section. A route with a smaller number of signals would most likely be preferable as it would have the potential for fewer delays.

Accident Rates

The safety record of each route can be expressed as a crash rate (i.e. total vehicle and truck crashes per million kilometres of travel). These rates are derived from an analysis of reported crashes along the different sections of the route. Ideally, the crash rate should not exceed 0.7 crashes per million vehicle kilometres.

Availability of Alternative Emergency Routes

In case of an emergency which would require the short term closure of a route used for the transport of hazardous materials, an alternative route should be available.

4.2.2.2 Environmental and Land Use Safety Considerations

Approach

The routes which are found to be satisfactory on road and traffic grounds should be subjected to a risk assessment using the "intermediate" method summarised in Appendix 7. If the differences between the routes are small and differentiation is still needed, then a detailed risk assessment should be undertaken.

The study involves a thorough quantitative description, analysis and evaluation of the cumulative traffic impact. It should consider the movements of vehicles carrying hazardous materials having an origin or destination within the study area as well as those travelling through. This requires information on generation of heavy vehicle movements, roads used, traffic composition, land use frontage, accident statistics and quantities and types of hazardous materials being carried. This information is then used to evaluate:

- Risk Levels
  - Accident rates
  - Potential population exposed to effects
  - Identification of land use pattern, specially sensitive land use
  - Future land use in the area
- Safety Management
  - Emergency response capability
  - Operational guidelines used
  - Operational and organisational safeguards, including safety management systems
  - Documentation on past incidents (spills as well as traffic related accidents)

Environmental and Land Use Safety

The basic risk assessment methodology was originally developed principally for fixed installations but is equally applicable to transportation activities.

Four elements are involved: hazard identification, consequence analysis, probability (or frequency) estimation and quantified risk analysis.

The most common expression of the quantified results is in terms of individual human fatality risk, usually on an annual basis. The results can also be expressed in other terms such as levels of injury, property damage or environmental damage.

Human fatality risk results are commonly expressed in two forms, individual risk and societal risk. Individual risk is the risk of death of a person located at a particular point in relation to the source. Societal risk is the risk of a number of fatalities occurring. The societal risk concept is based on the premise that society reacts more strongly to incidents which kill several people than to incidents which kill smaller numbers.

The quantified risk result can be used for comparative purposes or judged against specific acceptable risk criteria, as discussed earlier, in Section 2.6.3.

Hazard Identification

Hazard identification is the first and most basic step in any hazard analysis and involves the identification of all possible conditions that could lead to a hazardous incident This should be done in a comprehensive and systematic way. More information on the technique is included in Hazardous Industry Planning Advisory Paper No. 6, *Guidelines for Hazard Analysis*. Typical results of hazard identification are shown in Appendix 6.

Assessment Techniques

The selection of route or mode of transport should be aimed at minimisation of risk to people, property and the natural environment. It will often be possible to classify and prioritise different risks for various routes or modes without necessarily going into extensive detail. In general the level of study detail required to rank routes for an area study will not involve a full quantified risk assessment. However, the cumulative probability and consequences of all hazardous materials accidents along each of the comparative routes should be considered.

The nature of risk assessment requires specialised technical expertise which is beyond the scope of these guidelines. It is, however possible to indicate general principles. In assessing the hazard implications of a route two distinct levels of detail may apply: a filter level and a detailed level. The result of this analysis leads to identification of suitable routes on a comparative risk basis.

At the filter level a broad assessment of land use and accident records would be required. This is imperative if the study area is large and the number of routes to be processed is large. For routes carrying relatively small volumes of hazardous materials the filter level alone may be sufficient.

At the detailed level, an evaluation of the major risk contributors along the route should be carried out, including a detailed quantification of risk levels.

In considering the relative risks of transport incidents involving hazardous materials, information is required on land use, changing population densities and accident history for the route selected for evaluation. Further each particular route can be broken down into manageable segments, for which the above information is available.

Simplifying assumptions can often be made:

- Use of representative loads. For example, rather than accounting for all flammable and combustible chemicals carried, a flammable material such as petrol could be used to represent all loads of flammable or combustible materials.
- Consequences of hazardous materials incidents are estimated in terms of fire, explosion and toxicity. Based on such estimates, the number of people potentially affected can be determined.
- Results can be expressed in terms of risk or exposure to enable comparison. While this method could be further refined and full quantified risk assessment techniques adopted, it is usually acceptable for comparative purposes

In the following section a possible method is presented to enable the analyst to differentiate between alternative routes. If use of this approach leads to clear-cut low risk alternatives, it may be possible to quickly identify the preferred routes. However, should the differences be small, a full and detailed assessment may need to be carried out in accordance with the Department's Hazardous Industry Planning Advisory Paper No. 6, *Guidelines for Hazard Analysis*.

Intermediate Method

This approach, set out in Appendix 7, estimates risk exposure for each road segment in terms of four components:

- Accident rates per vehicle kilometre
- Probability of loss of containment per accident and associated downstream effects
- Consequence effect area
- Population exposed within the effect area

Accident rates reflect the likelihood that a given load will be involved in an accident on the route being considered. For each accident, a fault-tree analysis can be used to estimate the probability of a loss of containment and downstream effects. For each potential occurrence impact propagation models estimate thy impact area involved on the number of people exposed

4.2.2.3 Economic Considerations

Transport Operational Costs

Travel distance, time and the transportation and operational costs of alternative routes must be taken into account when considering the various options available.

These have already been discussed in Section 2.7.

Other costs

In addition to direct freight costs, potential costs linked to the material's potential for fire, explosions or toxic releases may be significant. These can be described as incident costs, risk exposure costs and costs of safety measures. These may be evaluated as part of an area study or considered in conjunction with a specific development study.

Incident Costs

These are the costs of actual incidents in terms of loss of life, injury to people and property and environmental damage and the cost of control and clean up. These costs will vary from case to case and may be difficult to accurately quantify in advance.

Risk Exposure Costs

These are the less tangible costs of exposure to the risk of such incidents, such as loss of residential amenity, stress (and related health effects) and the effects on residential property values. The extent of these effects depends largely on perception. These may be accentuated where incidents have previously occurred or new developments are associated with unfamiliar risks.

Costs of Safety Measures

Measures designed to reduce the likelihood or severity of incidents, such as the requirement to use particular routes or to enhance vehicle or packaging design, impose additional costs. These costs would normally be borne as additional operating costs.

4.2.3 Selection of Routes

Experience and sound judgement is required in making decisions. The selection of routes may be based on an assessment of fine differences between alternatives and/or on weighing the relative importance of different types of criteria in a particular situation. An important purpose of these guidelines is to support consistent decision making.

All other things being equal, the routes which present the lowest overall risk to surrounding people, property and the natural environment should be preferred. In general, roadways with the smallest adjacent population combined with a low accident rate, will present the lowest risk.

In evaluating routes for the transportation of hazardous materials, the numerical values of the various factors are of limited practical use in absolute terms. It is the relative difference in the risk values that should mainly be considered when differentiating between the different route alternatives.

It should also be noted that selected routes should be subject to periodic review to monitor their ingoing acceptability as conditions change with time.

4.2.4 Implementation of Selected Routes

Short Term Improvements

In practice, identified hazardous materials routes may tend to be ignored in favour of more convenient routes, unless they are also acceptable to drivers on traffic grounds.

The major traffic problems that can result in some routes being less acceptable to drivers are:

- capacity problems, i.e. the number of traffic lanes in the direction of peak flows is not sufficient to cater for the traffic demands;
- congestion problems as a result of insufficient capacity at critical intersections along the routes.

The need for traffic improvements is usually related to a number of factors and not just the transport of hazardous materials. However, if traffic improvements are being considered, they might help to overcome the problems noted above. Typical short term improvements that could be of benefit to the implementation of identified routes include:

- **Improvements to carriageway capacity**
  - Ban right turn movements
  - Construct a full median between major intersections with signals
  - Initiate clearway restrictions and if necessary extend the times of the existing restrictions
  - Widen carriageway at critical locations.
- **Improvements at bottleneck intersections**
  - Provide exclusive right turn bay
  - Provide exclusive right turn phase at intersections with signals

- Widen carriageway to provide wider or more traffic lanes (some property acquisition maybe required
- Ban right turn movements
- Alter cycle/phase length so that priority is given to the appropriate traffic flow.

Long Term Improvements

In some circumstances, major costly and extensive works may be necessary to resolve certain problems. For example, while some measures would improve situations in the short term along a route traversing a highly populated area, the ultimate solution may be the provision of a by-pass route. Again, such improvements are likely to be required as a result of a number of factors and not just the transport of hazardous materials.

5 Application Notes

SECTION SUMMARY

This final section covers some miscellaneous issues, which do not warrant separate, stand-alone coverage. These are:

- references to information sources and part of the study to which they might be applied;
- presentation of results;
- safety management systems in a hazardous materials transport context; and
- the framing of conditions of consent or approval.

5.1 Source and Application of Factors

The factors relevant to the different stages of the identification of potential routes for the road transport of hazardous materials are listed in Appendix 8. Possible sources of information for each factor are also included.

5.2 Presentation of Results

The results of the study are generally best presented on a comparative basis, ranking and classifying the various route options under consideration.

Each section of the route (including alternative options) is ranked in terms of the three main factors: traffic, land use safety and economics. For each of these factors it is possible to rank routes using such terms as "acceptable routes," "least preferred," and "most preferred."

The interrelationship between the three factors will inevitably require value judgements to be made, since it is not possible to integrate the three factors into one indicator.

The most useful outcome is obtained by comparing and ranking each of the route options against each factor, so that there is a clear understanding of the traffic, land use safety and economic implications of each alternative, leading to a sound basis for decision making.

An example is given in Appendix 9.

5.3 Safety Management System

A good safety performance by an operator is only possible if there is a firm commitment to safety by every individual in the organisation. This requires leadership, and all levels of management must be made accountable for the safety performance in their area.

5.3.1 Assessment of Safeguards

Safeguards form an integral part of the process of preventing and mitigating the effects of incidents. The adequacy of a route depends very much on the safeguards available. The rote of the various people and equipment in use has to be understood. Some of the aspects to consider are:

Driver selection and training

The driver of a vehicle carrying hazardous goods potentially has the greatest influence on its safety from collection to delivery. He/she is often intimately involved with the loading and securing of the cargo at the start of the journey and the unloading or discharging at the end. The driver is responsible for the safe handling and security of the load during the journey and is often the only person available to initiate any immediate corrective action. It is essential that the driver fully understands what is required in an emergency and has the knowledge and ability to carry it out.

Placarding

One of the most common causes of delays and inappropriate action in dealing with hazardous materials incidents is the inability to determine the product involved. A compulsory placarding system compatible with the placarding system used worldwide with the international hazard pictogram and the UN product number should be enforced.

Emergency Response and Procedure

Prompt response by trained operators can be very important in avoiding injury to people or damage to property and the biophysical environment. Road and rail personnel working with hazardous materials need to be familiar with the nature and basic properties of the materials transported. In particular they should know the physical form of the material, its temperature and pressure, basic properties related to possible fire, explosion or toxic release, and the safeguards and first actions required to limit further damage.

Operators responsible for the transfer of loads to and from vehicles should also be trained to enable them to take appropriate actions with regard to the particular potential hazardous events associated with the material being loaded.

Reporting

A prerequisite for assessing the benefit from any new controlling measure, is to have access to sufficient incident data to enable comparisons to be made or problem areas to be identified. Some standardised form of incident reporting is necessary if accurate evaluation is to be made of the current situation and the effectiveness of controlling measures has to be monitored.

5.3.2 Risk Management Strategies

Risk management strategies have several aspects including

- choice of the best routes;
- identification of the main risk contributors;
- identification and implementation of risk reduction measures;
- measures to avoid avoidable risk;
- adoption of the most cost beneficial safeguards; and
- ensuring appropriate and comprehensive emergency plans.

The role of management at all levels in ensuring safety is crucial. Safety depends on management awareness, and management safety systems. Such systems should include:

- a complete commitment to safety by every level of management including the directors of the company;
- the assignment of clear responsibilities;
- proper access by relevant fine management to specialist safety and other technical advice from staff and management;
- ensuring of individual competence and adequate training;
- robust and comprehensive safety systems applying to all phases of activity; and
- auditing to ensure that all of this is in place and working.

These measures form part of a complete safety management system.

Identification of risk reduction options

A large range of risk reduction options exists. A cost benefit analysis may be undertaken to assist in identifying worthwhile improvements. Measures available can be classified as follows:

- Hardware improvements or other changes involving capital investment; and
- Operational improvements (e.g. operational scheduling, land use planning, routine operating procedures operation, driver selection, training and control, changed managerial practices, etc).

The following is a list of measures which may be of value.

Hardware Improvements

- Improvement to road tanker design to reduce both the likelihood of roll-over and the likelihood of puncture;
- Automatic devices to avoid overfilling;
- Radios or mobile telephones on vehicles to minimise emergency response delays;
- Protective measures for drivers of hazardous materials vehicles such as respiratory protective equipment and sealing of cabs; and
- Compartmentalising of tankers.

Driver Selection and Training

- Restricting the driving of road vehicles carrying hazardous materials to specified categories of drivers;
- Implementation of defensive driving courses for truck drivers of hazardous materials;
- Regular medical examinations for all hazardous materials vehicle drivers;
- Improved training in hazardous materials handling for drivers and the selection of particular drivers for hazardous materials work; and
- Strict selection procedures should apply to ensure the appropriate standard of recruits. Drivers should be required to have an understanding of a range of appropriate rules, regulations and procedures, including emergency response procedures for hazardous materials.

Operational Scheduling

- Voluntary or mandatory routing of vehicles to avoid areas of population, or particularly dangerous routes.;
- Scheduling of journeys to move certain materials by night only;
- Provision of fire-water hydrants and emergency telephone points on selected hazardous materials routes;
- Formalised vehicle and hardware checking schedules;

5.4 Conditions of Consent or Approval

Control measures available to a consent authority include restricting hours of operation, load limits on collector and local roads, signposting and designation of preferred routes.

When dealing with an application for a development which is likely to require the road transport of hazardous materials, the consent authority could give consideration to imposing conditions of approval in relation to the following:

- hours of operation;
- routes to be used through the affected local government area(s); and
- the clear identification of the quantity and type of hazardous goods transported.

The final section and implementation of routes for the road transport of hazardous materials should be carried out in consultation with Local Government, the Department of Planning and the Roads And Traffic Authority.

6 References

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Appendix 1

Carriageway Levels of Service

The capacity of major streets within an urban area can be based on an assessment of their operating level of service.

Level of service is defined by the National Association of Australian State Road Authorities (NAASRA 1988a) as a "qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers". It describes these conditions in terms of factors such as speed and travel time, traffic interruptions, safety, driving comfort and convenience. Levels of service are designated from A to F, with level of service A representing the best operating conditions (i.e. free flow) and level of service F the worst (i.e. forced or break down flow).

A service volume, as defined by the NAASRA (1988a), is "the maximum hourly rate at which vehicles can reasonably be expected to traverse a point or uniform section of a lane or roadway during a given time period under the prevailing roadway, traffic and control conditions while maintaining a designated level of service". Suggested one-way hourly volumes for interrupted traffic flow at different level of service, obtained from the NAASRA document (1988a), are summarised in Table 1.

It is suggested that ideally, arterial and sub-arterial roads should not exceed service volumes at level of service C. At this level, whilst most drivers are restricted in their freedom to manoeuvre, operating speeds are still reasonable and acceptable delays experienced. However, in urban situations, arterial and sub-arterial roads operating at Level of Service D, are still considered adequate.

Table 2: Suggested One-way Traffic Volumes (PCU)[1] for Urban Roads at Different Levels of Service – Interrupted Flow Conditions

Type of Road	**Level of Service[2]**					
Carriageway	**A**	**B**	**C**	**D**	**E**	**F**
2 Lane Undivided	540	630	720	810	900	FORCED FLOWS
4 Lane Undivided	900	1050	1200	1350	1500	
4 Lane. Undivided with Clearways	1080	1260	1440	1620	1800	
4 Lane Divided with Clearways	1140	1330	1520	1710	1900	
6 Lane Undivided	1440	1680	1920	2160	2400	
6 Lane Divided with Clearways	1740	2030	2320	2610	2900	

[1] PCU Passenger car unit, i.e. heavy vehicles volumes are converted into passenger car equivalent.

[2] The levels of service are defined as:

A - Free flow (almost no delays)
B - Stable flow (slight delays) .
C - Stable flow (acceptable delays)
D - Approaching unstable flow (tolerable delays)
E - Unstable flow (congestion; intolerable delays)
F - Forced flow (jammed)

Note: The Service Volumes and Capacity in Table 2 can increase by 20 to 40 percent where, among other factors, the absence of significant traffic movements entering /crossing the major roadway from minor streets or major developments, and where these movements are restricted by major road priority controls.

Appendix 2

Operational Characteristics of Intersections

For a detailed explanation of the calculation of these parameters, reference could be made to the publications on this subject by the National Association of Australian State Road Authorities (NAASRA 1988b).

The capacity of a signalised intersection depends on the volumes of traffic entering the intersection, the physical characteristics of the intersection and the cycle lengths and phase splits of the signals. The factors are reflected by the intersection flow ratio (Y) and the degree of saturation (X). The degree of saturation "X" for a signalised intersection is defined as the largest movement degree of saturation which is the ratio of arrival flow to capacity for a movement approach and is given by

$X = Y \cdot C/(C - L)$ where

Y = Ratio of arrival flow to saturation flow for the intersection

C = Cycle length (seconds)

L = Loss time (sum of intergreen time between each phase of cycle; i.e., amber and "all red" times).

Suggested criteria for the evaluation of signalised intersection operation and unsignalised intersections are summarised in Table 3 and Table 4, respectively.

Level of service at critical intersections

The capacity of a street system is largely dependent on the capacity of critical intersections. The operational characteristics of an intersection are reflected by the intersection flow ratio (Y) and the intersection degree of saturation (X), as defined above.

Suggested criteria for signalised intersections, together with their associated Level of Service are included in Table 3

Unsignalised Intersections

The evaluation of the operational characteristics of intersections can be based on the average delay "D" (secs) per vehicle entering the intersection. The delay is a combination of Geometric Delay, Uniform Delay and Overflow Delay.

Suggested criteria, together with their associated Level of Service are included in Table 4. Criteria for assessment of give way/stop signs are given in Table 5.

Roundabouts

An evaluation of the operational characteristics of roundabouts is based on the average delay of the movement with the highest average delay in seconds per vehicle. The delay is a combination of Geometric Delay, Uniform Delay and Overflow Delay. Table 6 shows the criteria range for each Level of Service.

Table 3: Criteria for Evaluating the Capacity of Signalised Intersections

Level of Service		Optimum Cycle Length (Secs) (CO)	Volume/ Saturation Y	Intersection Degree of Saturation X	Average Delays Per Vehicle (secs)
A	Very good operation	<90	<0.5	<0.6	<14
B	Good operation	<90	<0.70	<0.80	15-2
C	Satisfactory	90-120	0.70-0.80	0.80-0.85	29-42
D	Poor but manageable	120-140	0.80-0.85	0.85-0.90	43-56
E	Bad, extra capacity required	>140	>0.85	> 0.90	57-70

Table 4: Criteria for Evaluating the Capacity of Unsignalised Intersections

Level Of Service		Optimum Cycle Length (Secs) (CO)	Volume/ Saturation Y	Intersection Degree of Saturation X	Average Delays Per Vehicle (secs)
A	Very good operation	<30	<0.3	<0.5	<14
B	Good operation	<30	<0.4	<0.6	15 to 28
C	Satisfactory	30 to 60	0.4 to 0.55	0.6 To 0.65	29 to 42
D	Alternative control (roundabout) or more capacity may be reqd.	43 to 51 > 60	0.55 to 0.60	0.65 To 0.75	43 to 51
E	Roundabout, traffic signals or other major treatment should be considered	> 60	> 0.60	> 0.75	57 to70

Table 5: Criteria for Assessment of Give Way/Stop Signs

Level of Service		Average Delays per Vehicle[3] (secs)
A	Very good operation	<14
B	Acceptable delays and spare capacity	15 to 28
C	Satisfactory with spare capacity	29 to 42
D	Poor operation and accident study required	43 to 56
E	At near capacity and requires roundabout or alternative treatment	57 to 70
F	At capacity and requires roundabout, traffic signal or major treatment	> 70

[3] On worst approach.

Table 6: Criteria for Assessment of Roundabouts

Level of Service		Average Delays per Vehicle[4] (secs)
A	Very good operation	< 14
B	Acceptable delays and spare capacity	15 to 28
C	Satisfactory with spare capacity	29 to 42
D	Poor operation and accident study required	43 to 56
E	At near capacity and requires alternative treatment	57 to 70
F	At capacity and requires traffic signal or alternative major treatment	> 70

[4] On worst approach

Appendix 3

Summary of the ADG Code Classifications

Dangerous goods are substances or articles that pose a risk to people, property or the environment, due to their chemical or physical properties. Dangerous goods are usually classified with reference to the immediate hazard they pose rather than the long-term health effects.

In Australia, dangerous goods are defined by the Australian Dangerous Goods Code (ADG). Classifications are based on the 7th Edition of the ADG.

Packing groups are used to indicate the degree of danger associated with the transport of dangerous goods of a given class:

packing group I	Substances presenting high danger
packing group II	Substances presenting medium danger
packing group III	Substances presenting low danger

It should be noted that packing groups are not assigned to classes 1, 2 and 7 or to Divisions 5.2, 6.2 or self reactive substances of Division 4.1

Readers are referred to the ADG Code for a more detailed explanation of the classes.

Table 7: Summary Classification of Dangerous Goods

Class/ Division	Packing Group	Description
1.1	N/A	Substances and articles which have a mass explosion hazard.
1.2	N/A	Substances and articles which have a projection hazard but not a mass explosion hazard.
1.3	N/A	Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both but not a mass explosion hazard
1.4	N/A	Substances and articles which present no significant hazard.
1.5	N/A	Very insensitive substances which have a mass explosion hazard.
1.6	N/A	Extremely insensitive articles which do not have a mass explosion hazard.
2.1	N/A	Flammable gases
2.2	N/A	Non-flammable, non-toxic gases
2.3	N/A	Toxic gases
3	I, II or III	Flammable liquids
4.1	I, II or III	Flammable solids, self-reactive substances and solid desensitised explosives
4.2	I, II or III	Substances liable to spontaneous combustion
4.3	I, II or III	Substances which in contact with water emit flammable gases

Class/ Division	Packing Group	Description
5.1	I, II or III	Oxidising Substances
5.2	I, II or III	Organic peroxides
6.1	I, II or III	Toxic substances
6.2	I, II or III	Infectious substances
7	N/A	Radioactive material
8	I, II or III	Corrosive substances
9	I, II or III	Miscellaneous dangerous goods and articles

Note that C1 combustible liquids are not a dangerous good under UN (United Nations) classification. They are defined as dangerous goods under workplace legislation. This also applies to goods too dangerous to be transported.

Note also that where materials to be transported are of Class/Division 1, 6.2 or 7, the Department of Planning, DECC, WorkCover NSW and/or the RTA should be contacted for advice.

Appendix 4

Schedule of Land Use Categories and Criteria

In the event of an incident involving hazardous materials occurring as a result of a transport accident most people attempt to respond by moving quickly away from the source of the incident. However in the case of children and the sick and infirm this may not be possible. The young and infirm are therefore considered to be at greater risk than the general population, and allowance needs to be made for routes with sensitive land uses which include kindergartens, schools hospitals and nursing homes. Building setbacks should also be considered.

The types of criteria that could be used to compare alternative routes are included in Table 8. It should be noted that these criteria are not absolute. They are a relative guide, all other things being equal. They should be applied in conjunction with other factors discussed in Section 2.

Table 8: Land Use Criteria

Land Use	Unit of Measurement	Ranked Criteria
Schools	number of people	smallest
Hospitals	number of beds	smallest
Residential	number of residents/ dwellings	lowest density
Commercial	fronting length	shortest length
Industrial	fronting length	highest length
Open Space	fronting length	highest length
Other	fronting length	highest length

The ranked criteria selected for comparison of alternative routes from a traffic safety point of view are as follows:

a) The smallest number of pupils at educational institutions or beds in hospitals.

b) The lowest density of residential population;

c) The shortest length of fronting commercial development;

d) The highest length of fronting industrial development or open space.

Appendix 5

Road Hierarchy

Introduction

Background

The development of criteria for the functional classification of roads and the preparation of road hierarchies in the large urban areas was generally initiated in Australia in the 1960s and 1970s. In the 1980s, the preparation of road hierarchies was actively pursued and the process refined and detailed.

The establishment of road hierarchies allows the pursuit of environmental objectives in planning of new residential areas and in modifying and protecting existing residential areas.

A functional hierarchy of roads defines the basic purpose of each road in an urban area. It shows whether a road is inter-regional in importance (serving vehicles travelling longer distances at higher speeds); of local importance (providing land use access and serving slower speed traffic); or a combination of both functions. In practice, a road serves more than one class of traffic movement, but the predominant use can be determined and then the appropriate design standards can be selected.

In the basic form, NAASRA ("Guide to traffic Engineering Practice, Arterial Road Traffic Management." Part 9) emphasises that the classification of roads should give recognition to two competing goals for urban areas which are the provision of reasonable living and environmental conditions and mobility for movement of people and goods in road vehicles.

Objectives of a Road Hierarchy

A road hierarchy study sets down a functional classification in hierarchical order for all streets within a Study Area, so that it:

a) can accommodate both regional and local traffic demands;

b) is capable of implementation;

c) achieves consensus acceptance by State and Local Government Authorities; and

d) identifies routes for special classes of traffic, e.g. trucks, bicycles.

Benefit of a Road Hierarchy

The adoption of a road hierarchy:

a) provides State and Local Government Authorities with a sound basis for future traffic, transport and land use planning, as well as:
   - providing a logical basis for the operation of the road network;
   - assisting local traffic committees to consider the effect of their decisions on the surrounding local area;
   - enabling appropriate and efficient traffic management schemes to be implemented in local residential precincts, shopping centres and industrial zones; and
   - providing input to Local Environment Plans which now have to be prepared by Councils in accordance with the Environmental Planning and Assessment Act 1979;

b) enables the adoption of appropriate standards of construction for the various streets in the area; and

c) enables the preparation of a priority programme of works to implement the hierarchy.

Road Classification Terms

The development of Road Hierarchies in the Sydney Metropolitan Area is based on an hierarchical concept of the street network, that is, that there is a basic framework of streets which is fed by streets of lesser importance.

The concept of functional classification does not deal with roads merely as channels for vehicular traffic, but seeks to relate the type of traffic which each road is expected to carry to land use and environmental objectives. It is an endeavour to match the class of road to its use and the environmental needs of the community.

The terms relevant to functional classification of roads, used in this document, are defined as follows:

ROAD HIERARCHY - is the basic recognition that the prime purpose of a road or street may range from vehicular movements to pedestrian activity and local access.

ARTERIAL ROADS - predominantly carry through traffic from one region to another, forming principal avenues of communication for metropolitan traffic movements.

SUB-ARTERIAL ROADS - connect the arterial roads to areas of development or carry traffic directly from one part of a region to another. They may also relieve traffic on arterial roads in exceptional circumstances.

COLLECTOR ROADS - connect the sub-arterial roads to the local road system in developed areas.

LOCAL ROADS - are the subdivisional roads within a particular developed area. These are used solely as local access roads.

Purpose of a Road Hierarchy

The main reasons for the development of a road hierarchy are:

a) to establish a logical, integrated network which brings together all roads and streets under one classification because of their traffic service;

b) to group together those roads and streets which require the same general level of design and operation;

c) to assign responsibility for each class of road and street to the level of government having the greatest basic interest; and

d) to provide a rational basis for longer term works programming, improvement priorities and financial planning.

It must be remembered that the road itself is not classified, but rather the character of the traffic proposed to use it.

Some roads today may have a future year classification of collector with a planned low type design, but they presently function at a sub-arterial level because the arterial road in the travel corridor has not as yet been upgraded. It is necessary, when classifying the road network, to consider all future roads and reservations.

Criteria for Functional Classification of Roads

The criteria for functional classification of roads for the road hierarchy should simply be based on the premise that the place of a road in the hierarchy is defined by its role in the traffic network and in the urban structure it serves; that is on the type of traffic being served and its interaction with adjacent land uses. The classification selected for the road then helps to define the characteristics required for its implementation, such as road cross-section, geometric design and traffic management treatments.

The factors considered for the functional classification of roads for inclusion in a road hierarchy should fall in the following areas for each road class:

a) the length of trip of traffic served by each road class;

b) the effect on the urban structure being served; and

c) the interconnections required in the road network.

Traffic Served

The arterial/sub-arterial roads should be accorded the primary function of movement of through traffic - longer distance trips for movement of people and goods. Access to land uses adjacent to these roads should be limited or made secondary to the primary function.

The local streets should mainly provide for vehicle access to abutting land uses, as well as for pedestrians, bicycles, parking and service vehicles. The traffic use of collector roads should be restricted to access for each local precinct and for local traffic moving across the precinct.

Arterial and sub-arterial roads normally serve through traffic, where the average trip length is greater than that of traffic using collector or local roads. Local traffic should be discouraged from using arterial and sub-arterial roads.

Heavy and commercial traffic should be limited to arterial and sub-arterial roads, except that collector and local roads in areas zoned "industrial" or "commercial" may carry heavy or commercial vehicles. It is desirable from a residential amenity point of view to deter heavy vehicles (i.e. over 3 tonnes from using collector roads in residential areas, but obviously those with destinations which lie on collector or local roads must be granted access).

The emphasis should be on the trip length of traffic served, not the traffic volumes even in urban areas experiencing large seasonal variations of recreational or tourist traffic. The form of the classified road implemented for such seasonal traffic will then depend on its characteristics including variations in traffic flows on weekends or during peak seasons.

Effect on Urban Structure

The spacing of roads needs to consider:

a) the spatial requirements for reasonable residential, commercial, industrial and recreational precincts in the urban structure;

b) their location in the present and future urban structure to adequately service the travel demands generated by the various land uses; and

c) the conflict between integration of urban land use functions and the accessibility provided for those land uses.

An important aspect requiring consideration is the location and size of major traffic generators. All urban areas contain a Central Business District (CBD), which is usually located at about its centre depending on topographical and waterway constraints. The arterial roads mainly focus on the CBD.

Furthermore, the larger urban areas are more likely to have other large traffic generators located away from the CBD thus creating a need for arterial roads (or at least sub-arterial roads) linking them.

Interconnections of Roads

It is desirable for the road system to be fully hierarchical i.e. all intersections should be between roads of identical or adjacent classification - for example local roads should not connect directly to arterials. Since one has to deal largely with existing situations, this cannot always be achieved. Traffic management is therefore essential for both movement and safety reasons. This often imposes severe limitations on accessibility from the lower to the higher class of road; wherever possible, it is essential that reasonable access is available.

Implementation

Criteria

Following adoption of a road hierarchy, actions will need to be planned so that the functionally classified roads will safely and efficiently carry the expected traffic movement and fulfil the access needs of properties without undue impacts on the adjacent land uses. The actions proposed will depend on whether the classified road exists or has to be designed and built.

The following factors should be considered for the design, operation and control of each road class in the hierarchy:

a) Control of vehicle speeds for safety reasons

b) Limitation of the traffic volume carried on lower order roads

c) Control of cross street interference on arterials/sub arterials by spacing of intersections

d) Design of road elements to encourage the safe and efficient movement of vehicles

e) Restriction of heavy vehicles to higher order roads to minimise impacts

f) Safe and efficient management and control of traffic movements

g) Provision for safe crossings of roads by pedestrians and cyclists

Appendix 6

Example Hazard Identification Table

Functional/ Operational Area	Possible Initiating Events	Possible Consequences	Prevention/ Protection Measures
Road tankers containing toxic gas	• Valve failure • Catastrophic tanker failure • Impact leading to loss of containment • Loss of control of vehicle • Collision with vehicle	• Loss of containment leading to formation of cloud of toxic gas – Effect distance to 1 km or more	• Tanker/vehicle design standards • Excess flow valves • Remote shut-down valves • Driver training
Road tankers containing flammables	• Valve failure • Catastrophic tanker failure • Impact leading to loss of containment • Loss of control of vehicle • Collision with vehicle	• Upon ignition: flash fire, vapour cloud, explosion or pool fire – Effect distance typically up to 100m • Pollution of water courses or water tables	• Tanker/vehicle design standards • Excess flow valves • Remote shut-down valves • Driver training
LPG road tankers	• Valve failure • Catastrophic tanker failure • Impact leading to loss of containment • Loss of control of vehicle • Collision with vehicle	• Upon ignition: jet fire, BLEVE, flash fire or vapour cloud, explosion, pool fire – Effect distance typically up to 250m	• Tanker/vehicle design standards • Excess flow valves • Remote shut-down valves • Driver training
Tanker/truck carrying corrosive or toxic liquids	• Valve failure • Catastrophic tanker failure • Impact leading to loss of containment • Loss of control of vehicle • collision with vehicle	• Pollution of water courses or water tables	• Tanker/vehicle design standards • Securing of load • Excess flow valves • Remote shut-down valves • Driver training

Appendix 7

Intermediate Risk Quantification Method

This method provides a simplified approach to risk quantification for each route alternative identified. For each road segment, accident rates for vehicles carrying the hazardous material of interest are obtained or estimated. The probability that this will lead to personal, property or environmental damage is then estimated, together with the consequences of each accident scenario. Based on these estimates and the population densities along each route, the number of people affected by the accidents can also be estimated. The relative safety of alternative routes can be evaluated by comparing the product of population density along the route and probability of an accident for each route segment.

Accident Probability

The probability of a hazardous material accident is related to the likelihood that a vehicle carrying hazardous materials will be involved in a roadway accident. If specific accident rate data is available it should be used directly in the probability calculation. In many cases, however, such information is not readily available. It is then necessary to rely on accident rates statistics for all vehicles and then to adjust these to reflect the proportion of hazardous materials traffic in the overall vehicle population.

The steps involved in the probability calculation would be as follows:

1. Obtain statistics from historical records of the annual number of accidents for all vehicles, **N**. To obtain the accident rate, divide **N** by the distance, **D**, travelled by vehicles for which the data have been obtained.
2. Calculate the probability of a vehicle accident occurring in a particular segment by multiplying the rate (**N/D**) by the road segment length, **L**.
3. Adjust the probability obtained in 2 to allow for the proportion of hazardous materials vehicles in the traffic stream by multiplying (**N/D • L**) by the ratio of hazardous materials transport accidents to all vehicle accidents (**A/N**).

The probability of an accident involving a hazardous material is given by,

$$Pa_i = N/D \cdot L \ A/N \cdot F$$
$$= A/D \cdot L \cdot F$$

Where

A = No of hazardous materials accidents

D = No of km travelled by all vehicles for which accident statistics are available

N = Total No. of vehicle accidents per year

L = Length of road segment

F = Correction factor reflecting physical characteristics of the road segment.

Probability of Loss of Containment Damage

Several methods are available for obtaining the probabilities associated with system failures for various types of loads. These can be obtained from historical statistical data. Very often these data are not readily available and a fault tree analysis may be used instead. A fault tree uses a logic diagram which starts with an undesirable event and works downwards until the range of possible causes has been identified. The end result of a fault tree is a list of combinations of equipment and procedural failures, for which appropriate failure rate data exist or can be generated, that would lead to the 'top event'.

Consequence Effect Area

For each incident scenario the size of the affected area is estimated, taking into account such factors as release rate, duration of release, fire and explosion effects, wind speed, material toxicity and concentration. An estimate of the number of people exposed is derived by multiplying this estimated impact area by the relevant population density.

Generic consequence distances for different classes of hazardous materials can be calculated. If more accurate values are required, impact distances can be calculated using consequence models as described in the Department of Planning's Hazardous Industry Planning Advisory Paper No. 6. Whatever generic consequence distance is chosen, this must be consistently applied in each alternative analysis for an objective evaluation.

In considering the movement of a road tanker, carrying hazardous materials along a route, for each sub-segment (i) of the route, there is a probability of the tanker being involved in an accident $\mathbf{Pa_i}$

For each accident there are a number of possible accident scenarios $\mathbf{S_j}$ each of which may be considered to be fatal to all individuals present within a radius $\mathbf{r_j}$ of the accident, with a probability $\mathbf{Ps_j}$ of that scenario arising from the accident.

The consequence effect area is

$$\boldsymbol{\pi}\, \mathbf{r_j}^{\mathbf{2}}$$

The number of people affected by each hazardous material accident scenario depends on the consequence effect area and the population density $\mathbf{P_i}$ and is

$$\boldsymbol{\pi} \bullet \mathbf{r_j}^{\mathbf{2}} \bullet \mathbf{P_i}$$

Fatality Probability

Considering the passage of the tanker along a route segment **i**, the probable number of people killed per annum for scenario **j** is

$$\mathbf{Pa_i} \bullet \mathbf{Ps_j} \bullet \boldsymbol{\pi} \bullet \mathbf{r_j}^{\mathbf{2}} \bullet \mathbf{P_i}$$

The probable number of people killed per annum from all scenarios is

$$\boldsymbol{\Sigma}_{\mathbf{j}}\, \mathbf{Pa_i} \bullet \mathbf{P_i} \bullet \mathbf{Ps_j} \bullet \boldsymbol{\pi} \bullet \mathbf{r_j}^{\mathbf{2}} \bullet \mathbf{P_i}$$

which simplifies to

$$\mathbf{Pa_i} \bullet \mathbf{P_i} \bullet \boldsymbol{\Sigma}_{\mathbf{j}}\, \boldsymbol{\pi} \bullet \mathbf{r_j}^{\mathbf{2}} \bullet \mathbf{Ps_j}$$

For any one type of load, the term $\boldsymbol{\pi}\, \mathbf{r_j}^{\mathbf{2}}\, \mathbf{Ps_j}$ is a constant, independent of the route. This term can be termed the Severity Index for the load **SI**.

Thus the probable annual number of fatalities from the passage of a truck carrying load **X** along sub-segment i is

$$\mathbf{Pa_i} \bullet \mathbf{P_i} \bullet \mathbf{(SI)_X}$$

and for the entire length of the route

$$\mathbf{(SI)_X} \bullet \boldsymbol{\Sigma}_{\mathbf{j}}\, \mathbf{Pa_i} \bullet \mathbf{P_i}$$

For any one given load, it is possible to compare the relative safety of two alternate routes by comparing the term $\boldsymbol{\Sigma}_{\mathbf{j}}\, \mathbf{Pa_i} \bullet \mathbf{P_i}$ i.e. the population density along the route multiplied by the probability of a hazardous substance accident.

Appendix 8

Source and Application of Factors

FACTORS	SOURCE	Road Hierarchy	Truck Routes	Hazardous Material Routes
TRAFFIC & ROADS				
Physical characteristics	Field inventory	x	x	x
Traffic Volumes	RTA. Council Field counts	x	x	x
Travel Time	RTA (major roads - Sydney) Field surveys		x	x
No of Traffic Signals	Field inventory/RTA		x	x
Road Structure	RTA Council Field testing		x	x
Alternative Routes	Field inventory			x
SAFETY/RISKS				
Adjacent Land Use	Land use maps Field observation	x	x	x
Population levels	ABS Council			x
Accidents	Police RTA			x
Risk Levels	DoP			x
Heat Radiation	DoP			x
Toxicity	DoP			x
OPERATIONAL COSTS				
Distance	Maps Field survey		x	x
Travel time			x	x
ENVIRONMENTAL				
Drainage System	Field survey Council Water Supply Authorities			x
Prevailing Winds	Bureau of Meteorology			x

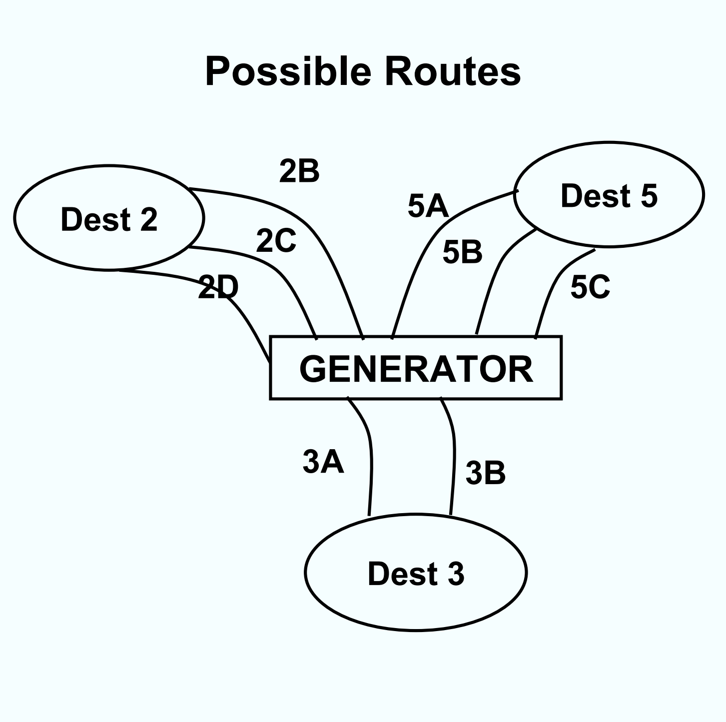
Appendix 9

Example

The following example illustrates one way in which results can be presented and a ranking of routes carried out. In the interests of space, the selected results only are shown, rather than the detailed working.

It assumes a single generator and five destinations, three of which are shown in Figure 4, numbered 2, 3, and 5.

Figure 4: Route Example



It is assumed that a preliminary screening shows two potential routes for destination 3 and three potential routes for each of the other two destinations.

Table 9 to Table 14 show the results of evaluation against a number of individual factors, while Table 15 shows the overall conclusions for three materials: chlorine, petrol and LPG.

The approach used could be applied to area studies and individual studies.

Table 9 illustrates the approach to traffic factors. Each alternative has been compared on the basis of factors such as route length, travel speed and time, number of traffic signals, accident rates and level of service. This shows that route 5C generally shows less favourable characteristics that 5A or 5B.

Land use (Table 10) favours option 5C because it does not generally pass through sensitive use areas.

In the case of operating costs (Table 11) there is little to choose between 5A and 5B and 5C is again the least preferred.

When risk analysis is taken into account (Table 12 to Table 14), Option 5A is significantly more hazardous than the other alternatives for all three classes of materials studied.

On the basis of a balanced judgement considering all factors, option 5A has been excluded as an acceptable route (Table 15). Option 5B has been nominated as the preferred route, with 5C also being acceptable.

This does not necessarily mean that risk should always be given a higher relative weighting than the other factors but rather, that in this particular analysis, there was a much greater differentiation between the risk results and those arising out of the other factors considered.

The example demonstrates the importance of individually examining the various factors and making a balanced judgement, rather than attempting to arrive at a single suitability "score" which could tend to mask significant issues.

The required factors and their derivation are described in more detail, below, for each of the Tables.

Table 9: Alternative Route Comparison – Traffic Service/Accidents

It is recommended, in the first instance, to divide each route into homogeneous sections. The following information is then obtained for each section:

(i) The length of each section along the route (in km) is determined from a scaled map.

(ii) Traffic volumes, both daily and peak hourly volumes, and composition are obtained from available counts (RTA, Council) or field surveys.

(iii) The product of distance by traffic volumes is then calculated in M.veh.km of travel. It is a parameter which provide a common base for comparing routes of different length and traffic volumes.

(iv) Travel time information could be obtained from the RTA which has been conducting surveys of travel time along most major routes within the Sydney Metropolitan area. If not available then field surveys are required.

(v) Travel speed (km/hr) is derived from the travel time information; the overall travel time and speed for the full route are then calculated.

(vi) The desired level of service target must be selected. In the example, a minimum level of service C has been adopted. The necessary physical characteristics of the route could be obtained from field surveys or areal photographs. Levels of service along each section of route are derived from Appendix 1.

(vii) The proportion of route with speed not exceeding 25 km/hr is derived from (v) above.

(viii) The number of traffic signals could be used as a surrogate measure of delay.

(ix) The number and type of total and accidents involving trucks should then be estimated: divide the number of total accidents and accident involving trucks by M.veh.km of travel calculated in (iii) above; sum up for the whole route.

Table 10: Alternative Route Comparison – Land Use

Land use factors include population levels and type of land use along the route:

(i) For each land use, determine the proportion of its length fronting the route to the total route length.

(ii) Population is normally considered in terms of people located within 100 metres of either side of the route.

(iii) The number of pupils in schools with frontage to the route or within 100 metres either side of the route should be obtained.

(iv) The number of beds in hospitals with frontage to the route or within 100 metres either side of the route should also be obtained.

Table 11: Alternative Route Comparison – Operating Costs

Travel time and distance along a route are surrogate measures of operational costs. These are used to determine vehicle operating costs from costs associated with travel distance ($/km) and travel time ($/hr).

Table 12: Alternative Route Comparison – Fatality Frequency – Petrol Tankers

The derivation of this measure per million trips for petrol tankers is described in Appendix 7.

In the example, this information has been calculated for different time period, namely day, evening and night.

Table 13: Alternative Route Comparison - Fatality Frequency – LPG Tankers

This is calculated in the same way as Table 12.

Table 14: Alternative Route Comparison - Fatality Frequency – Vehicles Carrying Chlorine

This is calculated in the same way as Table 12.

Table 15: Alternative Route Comparison – All Factors

This table summarises the conclusions based on all factors. From an assessment of each factor, a route is categorised as preferred, acceptable or to be excluded. An overall assessment of each potential routes between each origin-destination pairs is then made. A comparative assessment of all factors' results in the selection of the most suitable routes, as well as the identification of routes which should not be used for the road transport of hazardous material.

Table 9: Alternative Route Comparison – Traffic Service/Accidents

Alternative Routes	Length (Km)	Yearly Veh km Travel (M)	Avg Travel Speed (Km/h)	Avg Travel Time (min)	% of Route With Level of Service D to F	% of Route With Speed 25 km/or less	No of Traffic Signals	Truck Accident (per Veh.km)	Total Veh Accident (per Veh.Km)
2B	17.94	171.1	42.2	25.49	21.8	6.1	14	0.25	2.91
2C	18.00	159.4	41.9	25.78	21.7	6.1	15	0.33	2.90
2D	19.58	181.8	39.2	29.96	7.1	11.6	15	0.19	2.65
Routes with Best Characteristics	2B, 2C	2C	2B	All	2D	2B, 2C	2B	2D	2D
3A	18.70	167.8	33.8	33.18	9.8	16.3	26	0.21	2.55
3B	17.39	147.0	33.7	30.96	23.9	17.5	20	0.20	1.88
Routes with Best Characteristics	3B, 3B	3B	3B	3A	3A	3A, 3B	3B	3B	3B
5A	8.93	65.6	31.5	17.00	4.5	25.8	14	0.88	7.23
5B	10.06	106.9	41.7	14.48	28.0	15.5	6	0.20	2.64
5C	11.38	95.9	30.9	22.09	16.3	39.1	12	0.41	3.69
Routes with Best Characteristics	5A	5A	5A, 5C	5B	5A	5B	5B	5B	5B

Table 10: Alternative Route Comparison – Land Use

Alt Rts	Length	Resid Pop'l	No. of School Pupils	No. of Hosp Beds	% of Total Length of Land Use Fronting Route					
					Res	Sch	Hosp	Bus	Ind	Open Space
2B	17.94	8215	236	210	32.4	1.0	I.5	5.5	41.6	17.9
2C	18.00	7863	2037	0	31.9	2.2	0.7	7.2	42.5	15.4
2D	19.58	9498	283	279	33.1	0.4	2.6	5.0	40.3	18.4
3A	18.70	5564	631	210	22.1	0.4	1.4	16.5	47.1	12.4
3B	17.39	9350	527	0	33.5	1.8	0.3	8.0	40.5	15.7
5A	8.93	2814	1276	0	23.3	3.0	0.3	15.9	45.7	9.1
5B	10.06	2854	0	0	19.8	0.8	8.0	5.2	28.9	33.8
5C	11.38	112	0	0	0.7	0.4	0.1	6.6	73.6	17.9

Table 11: Alternative Route Comparison – Operating Costs

Alternative Routes	Length (Km)	Average Speed (Km/h)	Average Travel Time (min)	Dist* $	Time $	Total $
28	19.74	43.0	27.5	9.87	11.46	21.33
2C	18.00	41.8	25.8	9.00	10.75	19.75
2D	17.10	39.5	26.0	8.55	10.83	19.38
3A	21.38	40.1	32.0	10.69	13.33	24.02
3B	17.39	33.7	31.0	8.70	12.92	21.62
5A	8.93	31.5	17.0	4.46	7.08	11.54
5B	10.06	41.7	14.5	5.03	6.04	11.07
5C	11.38	30.9	22.1	5.69	9.21	14.90

* Based on distance (km) x $0,50/km and time (min) x $25/hr.
Congestion delay costs are not included.

Table 12: Alternative Route Comparison – Fatality Frequency – Petrol Tankers

Route	Day	Evening	Night	24 Hr Mean	Remarks
2B	11.56	5.26	3.59	7.10	
2C	21.67	5.54	3.43	10.75	
2D	8.51	6.25	4.64	6.51	
3A	26.30	15.73	11.78	18.13	
3B	17.27	10.11	9.54	12.45	
5A	24.42	12.03	8.08	15.25	
5B	7.95	4.18	3.13	5.20	
5C	10.82	6.36	4.56	7.30	

Table 13: Alternative Route Comparison - Fatality Frequency – LPG Tankers

Route	Day	Evening	Night	24 Hr Mean	Remarks
28	9.17	5.41	3.49	6.36	
2C	14.94	6.30	3.87	8.99	
2D	8.06	6.28	4.43	6.31	
3A	27.01	17.37	12.81	19.29	
3B	17.73	11.64	10.98	13.62	
5A	24.35	13.86	9.31	16.31	
58	7.9.7	4.82	3.60	5.59	
5C	12.25	7.33	5.25	8.34	

Table 14: Alternative Route Comparison - Fatality Frequency – Vehicles Carrying Chlorine

Route	Day	Evening	Night	24 Hr Mean	Remarks
2B	2.60	1.48	0.96	1.77	
2C	4.34	1.70	1.04	2.53	
2D	2.23	1.72	1.22	1.74	
3A	7.38	4.70	3.47	5.25	
3B	4.84	3.14	2.96	3.69	
5A	6.68	3.73	2.51	4.43	
5B	2.18	1.30	0.97	1.52	
5C	3.31	1.97	1.41	2.25	

Table 15: Alternative Route Comparison – All Factors

	Traffic Service/ Accident Factors			Land Use Factors			Operating Cost Factors			Hazard Analysis Factors: Petrol			Hazard Analysis Factors: LPG			Hazard Analysis Factors: Chlorine			Comparative Assessment All Factors		
Alt Rte	**Pref Rte**	**Accep Rte**	**Excl Rte**	**Pref Rte**	**Accep Rte**	**Excl Rte**	**Pref Rte**	**Accep Rte**	**Excl Rte**	**Pref Rte**	**Accep Rte**	**Excl Rte**	**Pref Rte**	**Accep Rte**	**Excl Rte**	**Pref Rte**	**Accep Rte**	**Excl Rte**	**Pref Rte**	**Accep Rte**	**Excl Rte**
2B	2B				2B			2B		2B			2B			2B			2B		
2C		2C				2C	2C					2C		2C			2C			2C	
2D			2D			2D	2D			2D			2D			2D					2D
3A		3A		3A				3A			3A				3A			3A		3A	
3B	3B				3B		3B			3B				3B			3B		3B		
5A		5A			5A		5A					5A			5A			5A			5A
58	5B			5B			5B			5B			5B			5B			5B		
5C		5C		5C				5C.			5C			5C			5C			5C	

Additional Information

Relevant DoP Publications

Hazardous Industry Planning Advisory Papers (HIPAPs):

No. 1 - Emergency Planning
No. 2 - Fire Safety Study Guidelines
No. 3 - Risk Assessment
No. 4 - Risk Criteria for Land Use Safety Planning
No. 5 - Hazard Audit Guidelines
No. 6 - Hazard Analysis
No. 7 - Construction Safety
No. 8 - HAZOP Guidelines
No. 9 - Safety Management
No. 10 - Land Use Safety Planning
No. 11 - Route Selection
No. 12 - Hazards-Related Conditions of Consent

Other Publications:

Applying SEPP 33: Hazardous and Offensive Development Application Guidelines

Multi-level Risk Assessment

Locational Guideline: Liquefied Petroleum Gas Automotive Retail Outlets

Locational Guideline: Development in the Vicinity of Operating Coal Seam Methane Wells

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