SOCIAL SEVERANCE

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CONTENTS

EXECUTIVE SUMMARY

Social severance is the term used to describe the effects that roads and traffic have on the social interaction within the "community". Impacts such as the reduction in walking trips that involve crossing busy roads have been observed by many researchers, and the existence and significance of social severance is well recognised by the public. However, in the analysis of transportation projects, and in particular roading projects, the impact has received little attention due to its complex nature.

From a review of selected literature the following definition of social severance has been developed:

> *"...the divisive effects that result from the provision and use of transport infrastructure".*

The definition is considered to encompass three key issues relating to social severance. Firstly, that the communities are far broader than those defined by geographic location and are formed around the activities that people take part in. Secondly, that the impact on activities within a community may be enhanced or reduced by the provision of and use of transport infrastructure and that some existing social severance may already be present. Thirdly, that social severance effects may be described in terms of two main mechanisms: physical severance, that relates to the direct effect on trips that encounter a barrier, and psychological severance, that stems from feelings of being cut off.

The study of social severance is inextricably linked to two other concepts: accessibility, which considers the opportunities to participate, and mobility, which is the ease of movement.

Research has shown that the burden of social severance falls most heavily on those groups of low mobility for whom walking is the principal form of transport. These groups include children, the elderly and people with disabilities.

Although no single measure of social severance effects has been identified, a number of measures or indicators have been considered. These tend to target particular aspects of social severance. Measures that assess community cohesion and stability are useful in identifying the potential for psychological severance. By considering aspects such as time spent living in a community, ethnic ties, and employment or other activities, it is possible to identify where a proposed road would sever a community and what psychological severance will result. In addition to these, measures such as delay and perceived danger consider the impact of specific barriers that cause physical severance. Measures of accessibility span both psychological and physical severance and consider the opportunities that are available for people to engage in activities. Such measures include the number of opportunities, such as employment, that may be accessed in a given travel time.

When using any of these measures, it is important that the scope of what is included and excluded be identified in order to reduce concerns over double or under counting.

Physical severance effects are identified as being most readily evaluated. The key components are increases in journey costs which result from having to make longer trips to go around a barrier or the increased delay associated with crossing a busy road. These effects are most likely to be felt by "able bodied" adults. However, the effects of perceived danger will impact more on sensitive groups such as children, the elderly and the mobility disadvantaged.

A pilot study undertaken in 1995 used the question *"would you allow your child to cross the road unaccompanied at this location"*, as a means of measuring the perception of danger. A model that relates the probability of a child being allowed to cross the road, unaccompanied, to the characteristic of the road and its traffic has been developed. It was found that parents knowledge about a site, the age of the child in question and the traffic volume and speed were the most significant variables. However, when considering only people who frequently passed a particular site the effect of traffic speed was reduced significantly. From this data a model which includes age and traffic volume effects has been developed. The model can be used to investigate the effect of perceived danger on the mobility of children and to assess potential severance effects.

A framework for assessing social severance suitable for use in New Zealand has been proposed. This follows the consideration of components of social severance, the available measures and a review of the assessment procedures developed in Denmark, Sweden and the United Kingdom. The key elements of this framework are the:

- Identification of social severance potential through the consideration of travel patterns and demands;
- Separation and valuation of the direct costs of social severance which result from increased journey distances and times, together with the suppression of trips due to perceived danger; and

- Use of proxy measures to indicate the significance of the intangible components.

This framework is recommended for adoption in New Zealand, and it can be used to calculate some of the direct costs associated with social severance.

There are further issues that if addressed would improve the assessment and evaluation of social severance effects.

ABSTRACT

Social severance is the general term applied to the negative effects that roads and their traffic have on social interaction. In particular it relates to the imposition of barriers that deter people's movements. This social severance has been identified as an important impact that requires consideration as part of the assessment of major roading schemes. From a review of selected literature a working definition of social severance has been developed and the key attributes of the impact have been identified.

The literature reviewed has shown that the burden of social severance falls most heavily on those with limited mobility. This includes groups such as children, the elderly and people with disabilities for whom walking is a particularly important form of transport.

A number of different severance effects have been identified. The principal components of social severance are physical severance which relates to the direct effect of a barrier on trips that are being undertaken, and psychological severance meaning the "feeling" of being cut off.

A number of possible indices and measures are outlined. These can be used to identify situations where severance impacts are likely, and to assist in the quantification and reporting of the impacts.

In addition to the direct effect of delay to pedestrians, as they cross a busy road, the feeling of danger that is associated with a road are an important "barrier" effect. In 1995 a pilot study was undertaken to develop a measure of the perceived danger. The resulting model is proposed as a tool to assess the direct effects of the perceived danger.

Using examples from Denmark, Sweden and the United Kingdom, a framework for the assessment of severance impacts has been developed for use in New Zealand.

1. INTRODUCTION

Social severance is the general term applied to the negative effects that roads and their traffic have on social interaction. In particular it relates to the imposition of a barrier that deters people from making trips. The effect of social severance has been identified as an important impact that requires consideration as part of the assessment of major roading schemes. It has, however, received insufficient attention due to its complexity.

The intention of this report is to provide those involved in the assessment of transport projects with an understanding of severance, guidance as to possible tools for use in identifying where the impact will be significant, and methods to assist in the quantification and reporting of the impacts.

Social severance as a phenomenon comprises a complex mixture of severing mechanisms. While a number of studies have considered the issue of social severance, generally termed severance, there has been a tendency for each to concentrate on a limited number of severing mechanisms. The result is that an incomplete picture of social severance is formed and questions are raised about the adequacy of the assessment.

Within this report a distinction has been made between the term "social severance", which is deemed to embrace the whole of this complex impact, and "severance", which is used, generally with an adjunct, to describe a part, such as physical, psychological or direct, of the impact.

Furthermore, this convention more readily accommodates the referencing of other work which generally use the term "severance" alone.

A framework for the assessment of severance impacts has been developed and it is proposed that this be included in the Transit New Zealand Project Evaluation Manual.

This report provides the background to that development and is intended as a users document providing amplification of important issues and further references for use by analysts.

Section 2 presents a review of selected literature, and develops a definition of the impact and identifies the components of severance. Section 3 looks at ways to identify the potential for social severance, measures that can be used to quantify the magnitude of the impact. The section has a list of selected case studies.

Examples of how three countries, Denmark, Sweden and the United Kingdom, incorporate severance effects with their respective Impact Assessment and Project Evaluation frameworks are outlined in Section 4. In the latter part of this section the key elements of each method are used to specify the attributes of a framework for use in New Zealand. The framework is built on the separation of components that have the potential for direct economic valuation and those which should remain within the non-monetary assessment.

Section 5 describes a pilot study into the effect of roads and their traffic on the independent mobility of children; and a model of the perception of the danger posed by a road is developed. This model may be used to estimate the potential for trip suppression or mode change that may result from the imposition of a barrier. A variation of the model is proposed as a part measure of the less tangible components of social severance.

Section 6 draws together the preceding material to develop an Evaluation Framework suitable for use in New Zealand. Sections 7 and 8 provide a summary of the findings and recommendations for future work, respectively.

2. THE PHENOMENON OF SEVERANCE

Social severance as an impact has been identified and developed over many decades. In the 1960s and 1970s, urban planning studies (Appleyard and Lintell 1969, Buchanan 1963) sought to investigate the phenomenon. The effect of increases in traffic volume on social interaction is shown in Figure 1 (Appleyard and Lintell 1969), which has formed the basis of many discussions of "severance".

Later studies (Lee and Tagg 1975 and 1976), considered the changing "shape" of a neighbourhood that results from the provision of major roads. The outcome of that study was the identification that traffic changed social interaction and that it should be possible to derive measures or indices which indicate the magnitude of the effect. Furthermore Lee and Tagg concluded:

> *"the effect is time dependent and existing severance may already be reflected in social activity".*

These studies showed that with increasing traffic volumes, either through "natural" increase or the provision of a new road, trips crossing the road/traffic barrier were decreased. Each concluded that "severance" was a real and observable phenomenon that disrupted social interaction.

2.1 Development of Social Severance as an Impact

The effect on social interaction that results from increases in traffic volumes on existing roads or the construction of major roads is observable. The translation of these observations into a definition of social severance is difficult. As a result the definition of severance has changed considerably over time. That a specific universally accepted definition has been difficult to identify is symptomatic of the observation (Clark et al 1992) that:

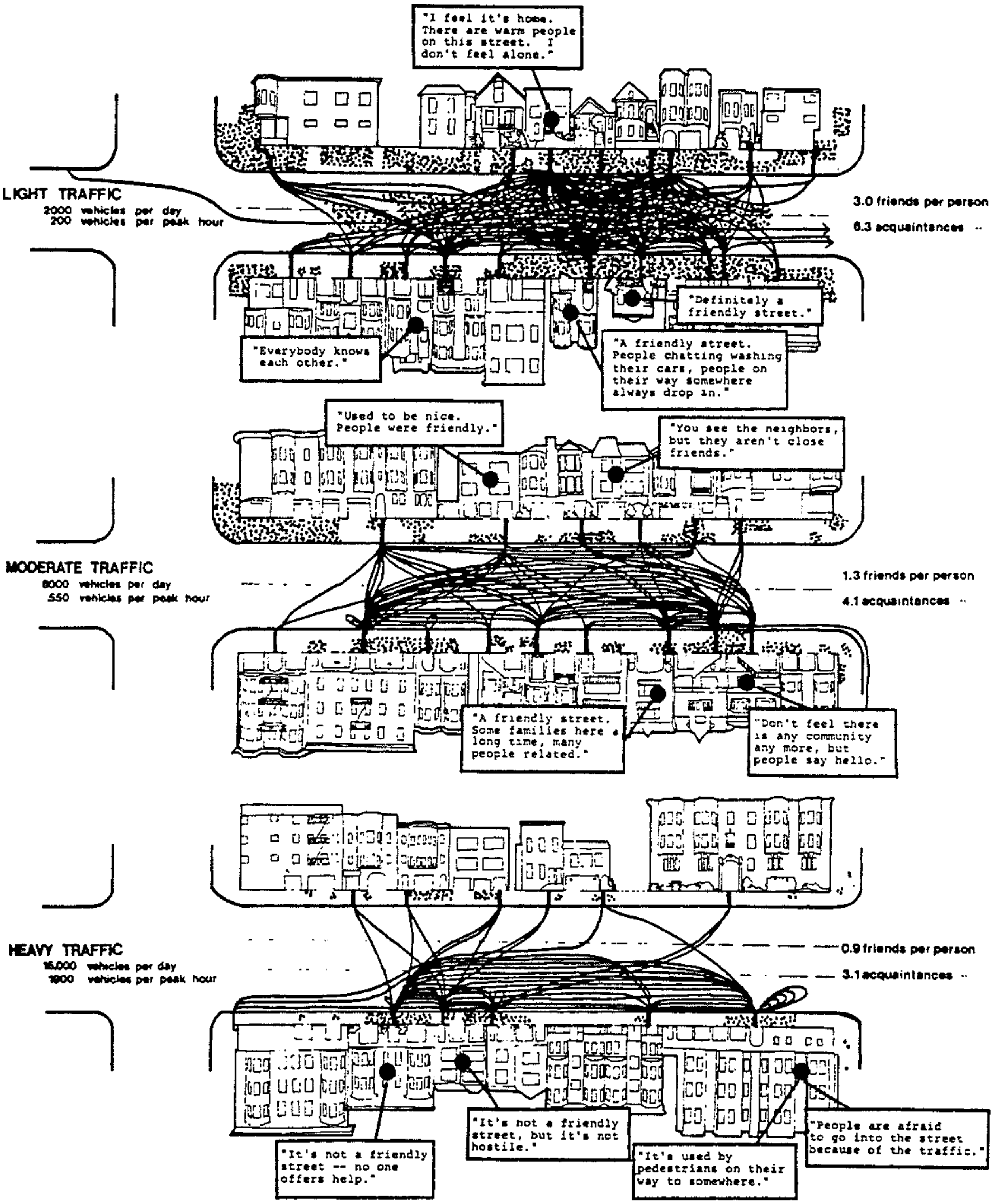
> *"... (severance) has received insufficient attention due to a lack of understanding of a complex issue"* .

Discussions of social severance abound and consequently so does the scope of any associated appraisal. It is worthwhile reviewing the historical development of discussions and social definitions of severance (Clark *et al* 1992) in order to identify the range of effects that are available for consideration.

Prior to the development of transport infrastructure, "severance" did not constitute a problem. With the arrival of canals and subsequently rail, the impact on farming units was identified and the need for mitigation measures developed.

As transport facilities increased, areas of land were divided and the usefulness of broken economic units, farms, etc was considered as severance. The early studies of the 1920-1940s considered the separation of activities, principally the work place and residential location. By the late 1960s and 1970s, the effect of traffic on social interaction had been identified and became known as "severance".

Figure 1. The effect of traffic on social interaction.
Taken from Appleyard and Lintell (1969).



"I feel it's home. There are warm people on this street. I don't feel alone."

"Definitely a friendly street."

"Everybody knows each other."

"A friendly street. People chatting washing their cars, people on their way somewhere always drop in."

"Used to be nice. People were friendly."

"You see the neighbors, but they aren't close friends."

"A friendly street. Some families here a long time, many people related."

"Don't feel there is any community any more, but people say hello."

"It's not a friendly street, but it's not hostile."

"People are afraid to go into the street because of the traffic."

"It's not a friendly street -- no one offers help."

"It's used by pedestrians on their way to somewhere."

The shift in emphasis from *land use* separation as a prime contributor to severance, to the imposition of a *barrier* is important and results in the consideration of social severance.

A separation within the definition of social severance occurred as a result of consideration of the mechanisms which were thought to effect interaction. Two distinct mechanisms were identified by researchers (Lassier 1976, Grigg and Ford 1983) and termed *physical* and *psychological severance.*

> *Physical severance* can be described as the direct effect, the need to travel additional distance, or the additional time to traverse a barrier, whilst
>
> *Psychological severance* considers the relationship of barrier effects and the feelings of being cut off.

Although quite different impacts are associated with each type of severance one study (Lee and Tagg 1976) suggested that a common methodology might be employed in evaluation of both mechanisms. Their investigations were based on an analysis of the changes in knowledge about one's neighbourhood that occurred following the construction of a major road in the study area. The assessment was based on the identification of landmarks and an analysis of trips, in order to define the boundaries of the "community". An important outcome of the study was that the effect of social severance decreased over time.

2.2 Communities

Typically studies of severance effects considered communities where the cohesion and function were disrupted. Prior to Lee and Tagg, early investigations (Jacobs 1961, Buchanan 1963, Appleyard and Lintell 1969) considered "street communities", a *population* which either by choice or circumstance sought a great deal of social interaction within a confined, defined physical environment. In contrast, the Urban Motorways Committee, established in the United Kingdom (Urban Motorways Committee 1972, Clark *et al* 1992), rejected the idea of a physically defined community. In reporting, the Committee concluded:

> *"Most urban communities are to some extent amorphous."*

The idea of a community, not necessarily a geographic entity, cannot be dismissed. It is most likely that within a high mobility population, such as New Zealand, people are members of more than one "community". These may not necessarily be based on a defined residential sub area having a single commercial focus. As an example a person may be a member of a particular group, such as a tramping club, church group, sports group, choir or cultural group. Their social interaction is a result of their mobility/accessibility as they travel to work, meetings and activities. At another level they are members of communities based on the street in which they "live", or the place where they work.

Given the demand for mobility, which can be seen through the levels of car ownership and the preference that people have for using private transport, it may be concluded that people value their ability to choose the communities that they are a part of. The Kyeemag-Chullora Road Inquiry in New South Wales (Kirby 1981) considered the extent to which a geographic community could be identified as an underlying measure of the susceptibility to social severance. This is consistent with the conclusion of others (Burt 1972, Kaplan 1972, Lee and Tagg 1976) that highly mobile communities are less susceptible to social severance.

It is the demand for mobility and associated choice that has given rise to social severance. The issue of choice is important, however, the desire to choose does not lessen the arguments of "livable streets".

For groups, such as children, the elderly or the mobility disadvantaged, communities are most likely to be geographically constrained and the "local" effects of traffic, which results from the mobility and accessibility others, may have a major impact on the "size", location or form of their community. It is obvious that increased mobility and accessibility for one group will impact on another and that groups of low mobility status, and in particular the young and elderly for whom walking is a prime mode of transport, will be most heavily impacted on.

2.3 Definitions of Social Severance

Possibly one of the most authoritative groups to consider the issue of social severance was the Urban Motorways Committee (1972). Having rejected the idea of a community, as a *geographically identifiable and socially cohesive group with strong interlinked activities*, the Motorways Committee adopted the following definition for social severance:

> *The sum of the divisive effects a major urban road scheme may have on the inhabitants of the previously linked areas either side of it.*

While more holistic in terms of the effects considered, the definition remains somewhat fixed both in terms of defining the impact groups and the facility. There is also an implied restriction on the locations that might suffer social severance. The definition also contains some assumption about the need for existing linkages, thus limiting the scope to increases in severance and not decreases, and may also be seen to preclude some elements of psychological severance.

To combine both physical and psychological severance into a definition of severance that was independent of the severing facility or "catchment" the following definition was developed (Tate 1993a). Severance:

> *"...the divisive effects that result from the provision and use of transport infrastructure".*

This definition is favoured because it not only encompasses the issues of existing severance and reduction in severance, but does not suggest a nett value relationship, nor does it imply only quantifiable or monetary components.

2.4 Discussion of Definition

Having specified a definition, the analyst is faced with the problem of establishing a methodology to determine the extent of "disruption" or divisive effects.

A "catch all" definition is not considered to be particularly useful when attempting to determine and compare the magnitude of severance issues. It is, however, possible to disaggregate the severance concept into more manageable parts and then identify possible impact measures, indices or proxy indicators that are appropriate for each component.

2.4.1 Physical Severance

The split between physical and psychological severance has been identified above. However, within the area of physical severance a further disaggregation of effects was proposed (Tate 1993b). This is outlined in Figure 2 for which the following definitions are provided:

(i) Mobility

"...the ability of an individual or type of individual to move about".

It is the ease of making a journey. Mobility relates to the *attributes of the individual*, as well as *the availability of facilities*. For example:

- Walking or cycling may not be available to the very young, the elderly, or to those with particular disabilities;
- For the young the "licence", or permission, that is held to undertake an activity (e.g. to cross the street or use public transport unaccompanied, or to drive) will affect mobility;
- A car may not be available to the person, either as driver or passenger;
- An individual may not be able to afford the fare of taxi, train or bus; and
- How knowledgeable a person is about the transport options available.

The second aspect of mobility relates to the *performance of the transport system*:

- How well does the transport system connect to the activities?
- Does it run at suitable times?
- Is it reliable?

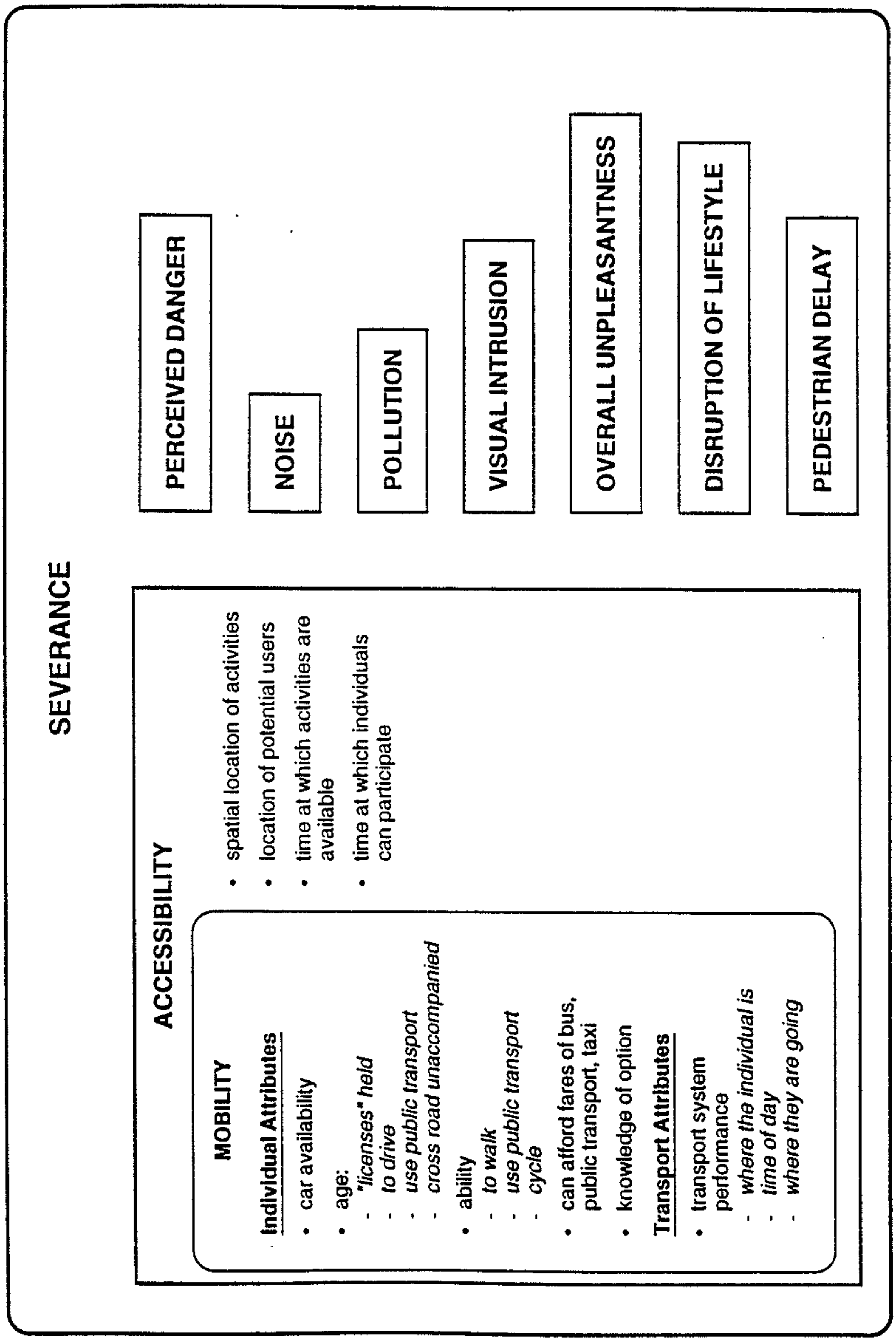
(ii) Accessibility

"...is concerned with the opportunity that an individual, or type of person, at a given location possesses to take part in a particular activity or set of activities".

It is the "ease of reaching", and is related to:

- The spatial and temporal distribution of the activity set relative to the starting point; and

Figure 2. The attributes of physical severance defined by Tate (1993b).



- The mobility of the individual.

(iii) Amenity Issues

Loss of amenity or the development of a feeling of general unease may result from real and perceived effects. These may include feelings of danger, traffic noise that makes conversation while walking difficult, the smell of exhaust fumes, rubbish and loss of a pleasant vista or other amenity value. In relation to children, it may be that parents do not consider the *length* of a walk to school, but they certainly consider the *number and type of roads* that will need to be crossed.

Research in the United Kingdom (Morton-Williams *et al* 1979, May *et al* 1985) identified that aspects of perceived danger were the most commonly cited concern related to roads and their traffic, followed by noise and then fumes and pollution.

2.4.2 Psychological Severance

Psychological severance is less easily defined and relates to the feeling of being "cut off". An individual may not necessarily need to access a particular facility to feel a sense of being "cut off" from it. The concepts of active and passive utility are useful in explaining this phenomenon.

> *Active utility* is the "benefit" or well-being that is attained from attending a facility, such as a swimming pool or shops. The resulting benefits can, in theory, be established through consideration of the supply and demand functions.
>
> *Passive utility* is the "benefit" or well-being from knowing that something exists without having to "use" it. For example, the fact that a hospital exists may provide someone with "security", without them necessarily having to visit it. The passive value has, to an extent, a relationship to "opportunity" rather than action.

In assessing psychological severance it appears that an assessment of the extent to which individuals feel they are part of a "community" will determine the extent to which they may feel "cut off".

2.5 Summary of the Definition of Severance

From a review of selected literature on the definition and components of social severance, the following key issues have been identified:

- Increased traffic provides a "barrier" to social interaction;
- Communities range widely in location and form, and the provision for one group may impact on another;
- There are two different severance mechanisms, termed physical and psychological severance;

- Physical severance relates to impact of a barrier on trips;
- Psychological severance results from a feeling of being cut off;
- The degree to which social severance is felt is related to the degree of cohesion within a "community" and level of mobility held by an individual or group; and
- The impact of social severance reduces with time.

3. POSSIBLE MEASURES FOR USE IN ASSESSMENT

As discussed above, the concept of social severance is very broad and may be considered to include the impacts of a number of effects. A literature search on the topic of social severance and various derivatives provided a number of articles and discussions of what purport to be studies of severance effects. From these, a wide range of measures and possible techniques have been identified, and are presented for possible use by practitioners. Although two severance impacts have been identified they do not occur in isolation from each other. The indicators reviewed may, however, be divided into two groups: those that consider the cohesiveness of communities, and those that consider the accessibility/mobility within the community.

3.1 "Community" Based Identification of Potential Problems

The concept of *community cohesion* is an important one given the discussion about the ability to define a community. While particular "communities" are identified on the basis of geographical location, employment, ethnic origin and the like, the key to how much they will be severed, or rather will fear severance, will depend on how cohesive the "community" was in the first place.

The Kyeemag-Chullora Road Inquiry (Kirby 1981) was critical of the efforts undertaken to identify the potential for social severance that may result from the project. The resulting report identified a number of possible measures by which the cohesion of a "community" could have been identified. The underlying theme was that a study of residential linkages and trip patterns would make it possible to determine the level of "community" interaction. These levels could then be related to key socio-economic indicators which would allow pre-estimates of the community cohesion from readily accessible data sources.

3.1.1 Stability and Cohesion

Kirby referred to (but did not reference) work in Washington and California, which considered *community stability* as a measure of cohesion. In those studies stability was measured by the proportion of owner occupied housing, single family residences and people resident in the same house for more than five years.

The stability measure is based on the assumption that the more stable a population the more likely it will be that strong linkages exist between the people and the community in which they reside. Such a measure may be useful when describing a situation or where differentiating between diverse alignments, e.g.

- Where alignment 1 would impact on a housing area with a lot of owner occupied housing and a stable population; while

- Alignment 2 would impact on an area of predominantly rental properties and a less stable population.

The method is only attractive if the linkages are established and the data on which the assessment is based is readily available.

Kirby concluded, however, that the stability measure did not equate to cohesion in that it did not consider the effects related to immigrant populations, common work place or mobility status that were thought to be important in the New South Wales context.

3.1.2 Social Feasibility

The social feasibility model (unknown 1974) was also referenced by Kirby. This model was considered to be a more suitable model. The model uses the following variables:

- Household size and income;
- Proportion of young and old;
- Car ownership;
- Length of time at current residence; and
- Ethnic composition.

The model considered physical constraints in the area under consideration, information on activity pattern and facilities and an examination of pedestrian dependency. In New Zealand consideration of the above variables is relatively simple as the data is readily available. As with the stability based measure, the base relationship that combines these variables into a "measure" capable of identifying sensitive areas would need to be developed for New Zealand. Such base relationships were lacking in New South Wales and as a first approximation Kirby considered how the study area differed from the surrounding areas in terms of the following personal attributes:

- Born overseas;
- Handicapped (disabled);
- Receiving a pension;
- Not in labour force;
- Unemployed;
- Income; and
- Car ownership.

This type of assessment has the potential to identify, from readily available data, areas where severance is likely to be more acute. If it were to be developed in New Zealand, a useful inclusion may be an indication of the population of below secondary school age, age 13, to represent the lower level of mobility disadvantaged.

3.1.3 Substitutability

The Kyeemag-Chullora Road Inquiry (Kirby 1981) also noted that psychological severance would result, despite the provision of crossing points, and drew a distinction between "land locked" and "bisected" communities. This formed the basis of a discussion on the "substitutability" of services and facilities. Where a community was "land locked" substitution was not possible and the barrier would need to be crossed on each occasion. Where a community was "bisected" alternative services would be available.

Although not discussed by Kirby, the implication is that the severance effects would be greater and less likely to reduce with time where a community was "land locked". In the case of a "bisected" community the users of a substitute facility, which is by definition second best, continue to suffer some physical severance and psychological severance. In either case the mapping of key facilities and identification of practical alternative destinations is very important.

3.1.4 Discussion of Methods to Identify Potential Problems

Each of the three methods principally consider the potential for psychological severance based on consideration of the linkages that define a community. The first two methods consider how such linkages may be related to other readily available data and emphasize the social interaction. Of these, the social feasibility model would appear the most useful in a New Zealand context.

In considering issues of demographic profile, ethnic composition, unemployment and mobility in addition to the length and type of residency, the assessment is more suitable to a highly mobile society. It is, however, suspected that in many cases the resulting assessment would state the obvious. For example, no two urban areas would be extremely different nor would two rural areas. The assessment would, however, be relatively inexpensive and could provide supporting evidence.

The third type of assessment is more targeted to physical severance and would identify the potential for specific barrier effects, as well as the need to change travel patterns, which does have a psychological impact. Closely related to the catchment analysis discussed below, the assessment of substitutability is seen as a key exercise in any assessment of social severance.

3.2 Accessibility Measures

Accessibility measures deal with the spatial separation of activities, and the ability of the transport system to link these. Accessibility measures are generally used in the context of land use and transport planning since they consider the potential to reach and take part in activities (Jones 1981). Accessibility measures consider the "opportunities" available and are measures of choice and substitutability.

3.2.1 Catchment Analysis

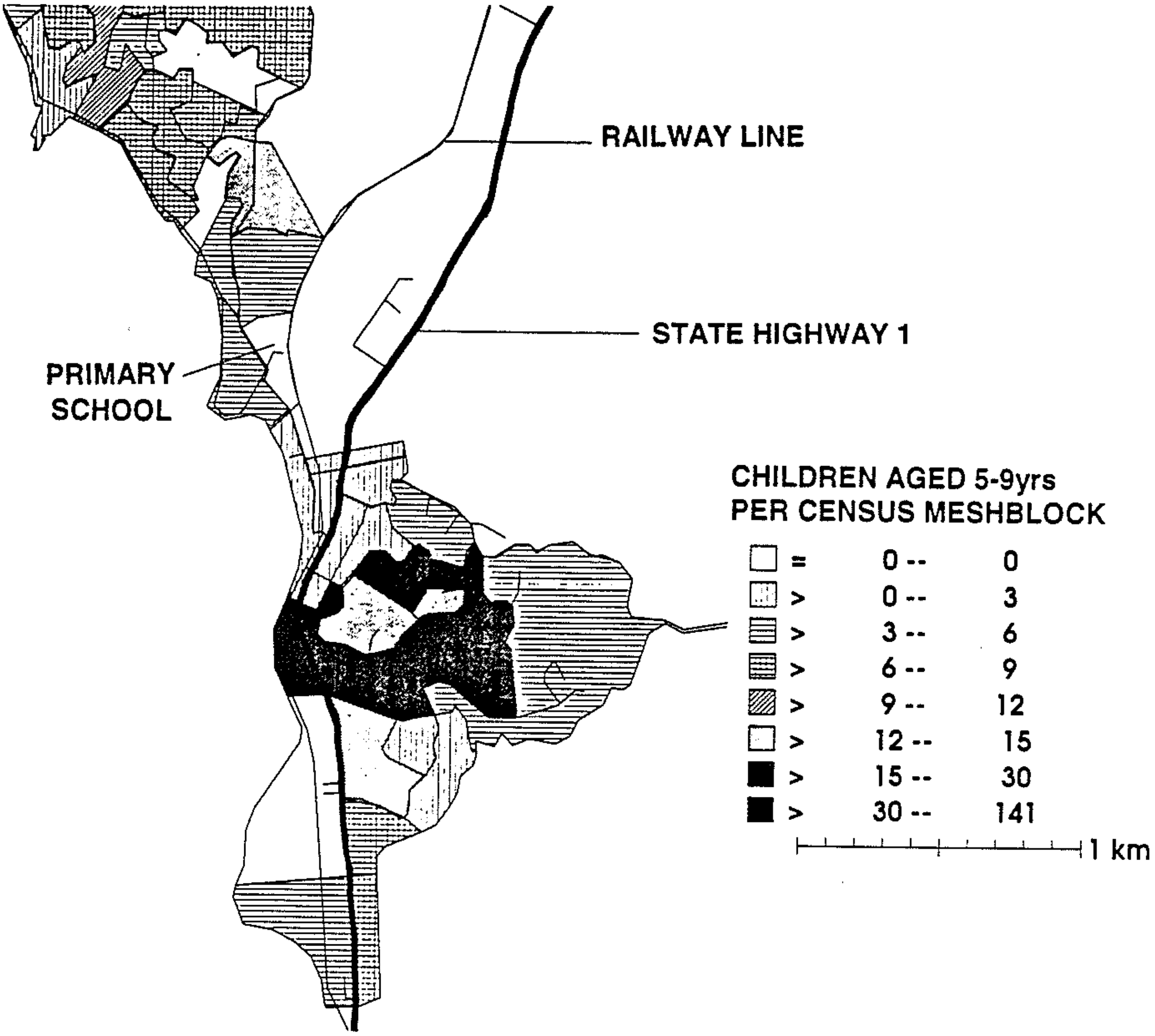
Catchment analysis is considered as the first step in identifying locations and the extent of potential severance. Catchment analysis may be undertaken from either the point of origin or destination.

3.2.1.1 Origin assessment

As a first step in any assessment, it is important to identify the characteristics of the population which will be impacted on. Using census data accessible through the New Zealand Department of Statistics computer software SUPERMAP, it is possible to identify the characteristics of the population. For example, mapping the distribution of particular groups of the population may indicate potential impacts. The distribution of children aged 5 to 9 years is given in Figure 3. In this example it can be seen that a concentration of school aged children exists to the east of the highway which separates these children from the local primary school.

Other plots may be generated to consider those of other important ages such as 0 to 5, representing the next group to begin school, or those over 65 years of age.

Figure 3. Example of origin-based assessment using SUPERMAP data on the number of children per meshblock aged 6 to 9 years.



3.2.1.2 Destination assessment

Key destinations within the study area may be identified and the catchments established from "surveys" of the users. This approach was promoted by Clark *et al* (1992) and forms the basis of the assessment framework used in the United Kingdom (Department of Transport 1993). In such surveys, it is important to identify any groups which are particularly vulnerable, the elderly or the young and other mobility disadvantaged. Of interest are the distances travelled, which define the catchment overall and the number of users, of each type.

Data from the household travel surveys can identify the relative importance of destinations. Other special destinations, including libraries, railway and bus stops, hospitals and churches, and medical centres, should also be identified (DTp 1993).

The type of facilities to which people travel, particularly by walking and cycling, are important and key trip indicators. Some, identified by a Perth study (Braddock 1979), include

- Shopping;
- School;
- Bus stop;
- Walking for pleasure; and
- Visiting friends.

Such data is available within New Zealand from sources such as the various regional transportation studies and the National Household Travel Survey (Ministry of Transport 1990).

These centres may be plotted, together with their catchments and the "barriers" in question to identify the areas of concern. The use of colour plots is considered to be a major advantage where catchments overlap.

3.2.1.3 Discussion of catchment analysis methods

Origin or destination assessments are considered the first step in the identification of the potential for social severance. Each looks at what trips are likely to be undertaken and may therefore be subject to severance effects. As such, they form the basis of many severance analyses. Origin assessment is somewhat simpler since most data can be drawn from readily available sources. It does, however, assume that certain trips are the most important, and without consultation some other important local trips or population groups may be missed.

Destination based assessments may be more useful when considering the impact on retail or other facilities that fear a drop in patronage or in situations where there are a number of competing facilities. Destination based assessments usually require some on-site data collection to determine the origins of user groups.

Neither assessment will account for dispersed journeys such as visiting friends or walking for pleasure. In order to consider these types of journeys it may be necessary to intercept "passers by" or interview people about their movements.

3.2.2 Transportation Planning Measures

Transportation planning measures are generally used to assess possible improvements in accessibility that may result from a proposed project or a range of strategies.

3.2.2.1 Contour measures

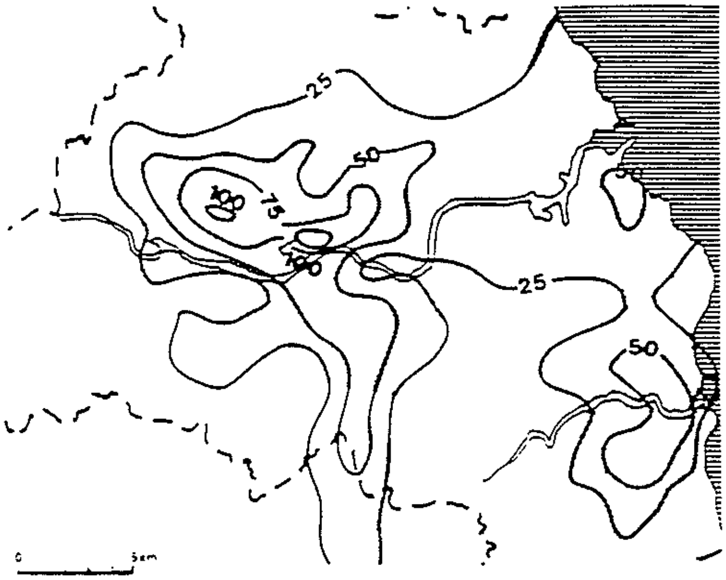
Contour measures describe the transport system from a user's point of view, considering:

- The number of opportunities for people to participate in an activity within a given travel time or cost, e.g. the number of jobs within 20 minutes travelling time from home; and

- The travel cost for people to reach a given number of activities, e.g. the average, or maximum, travel cost to reach two shopping centres.

The example in Figure 4 shows contours based on the population within 20 minutes travel time from a particular zone prior to the construction of the Tyne and Wear Metro (Jones 1986).

Figure 4. Accessibility index : thousands of people within 20 minutes.
Taken from Jones (1986).



In another example, the West Yorkshire Transportation Studies (Cooper *et al* 1979), accessibility problems were identified when the generalised cost of transport to a facility exceeded particular thresholds. From that point, it was possible to investigate the components of the particular problem and to recommend amelioration measures.

3.2.2.2 Hansen analysis

An alternative is to consider the number of origins within a particular "cost" of a destination. An example would be cumulative plots of an activity, such as the number of jobs within an increasing distance from a particular residential zone. This theme was extended to include the expression of the total accessibility of a particular zone to all others (Hansen 1959). It was proposed:

> *"that the accessibility at point 1 to a particular type of activity at area 2 is directly proportional to the size of that activity and inversely proportional to some function of the distance separating point 1 and area 2."*

$$A_o = \sum_d \frac{E_d}{t_{od}^{\alpha}}$$

where E_d *= the activity zone n, and* t_{od}^{α} *= the travel function.*

Based upon this type of analysis an overall index of accessibility could be generated for intra-project comparisons.

3.2.2.3 Potential change assessments

Potential change assessments are an extension of the contour analysis. One such study in Melbourne (King 1982) defined the likely employment catchments and using mode choice relationships developed from census data to determine the "potential" for changes in mode. A similar approach was adopted in the study of a Light Rail Transit (LRT) for Wellington City (Works Consultancy Services 1995). In that work, the catchments for a range of LRT routes were identified using employment opportunities and mode split relationships based on observed data. The coarse analysis shown in Figure 5, was used to screen possible route options prior to network modelling. The improved access to employment is obvious for some routes.

3.2.3 Discussion of Transportation Planning Measures

In order to produce contour measures or undertake a Hansen analysis, it is generally necessary to have a transportation model operating. The results are generally "broad brush" and need to assess strategic route or policy options.

The potential change assessments are more readily undertaken as "desk top" studies and use existing data and simplified relationships to make strategic decisions related to the improvements in accessibility that would result from a project or strategy.

In the final evaluation the accessibility benefits, or severance reductions, for one group are weighed against the more "local" impacts that may result from the provision of the infrastructure.

3.2.4 Mental Maps

The concept of *mental maps* (Gould and White 1986) follows the same lines as the landmark identification (Lee and Tagg 1976). The use of mental maps as a tool was based on the idea that the information people held, or received, about places, was related to the population, or level of activity, at that place and reduced with distance. On a macro scale the knowledge levels that people held about an area was derived by asking respondents to rate, or rank, locations in order of preference, or by asking them to perform a task such as naming the towns in an area. The researchers proposed that barriers limiting the flow of information about an area could be identified through discontinuities in the information rate function. The effect of these barriers might then be expressed in terms of an equivalent distance as shown in Figure 6. The observation that

> *"Most information surfaces are highly predictable but there is no way yet to clearly sort out the many different effects"* (Gould and White 1986)

is of interest since the same description has been applied to social severance. The concept of mental maps has an identified ability to account for a number of inter-related effects, such as fear and intimidation, excessive delay and psychological boundaries, while at the same time accounting for the power of attraction that may continue to draw people across a barrier. It is in essence a complete measure of social interaction and should therefore be available as a measure of social severance.

Figure 5. Analysis of catchment potential.
Taken from Works Consultancy Services (1995).

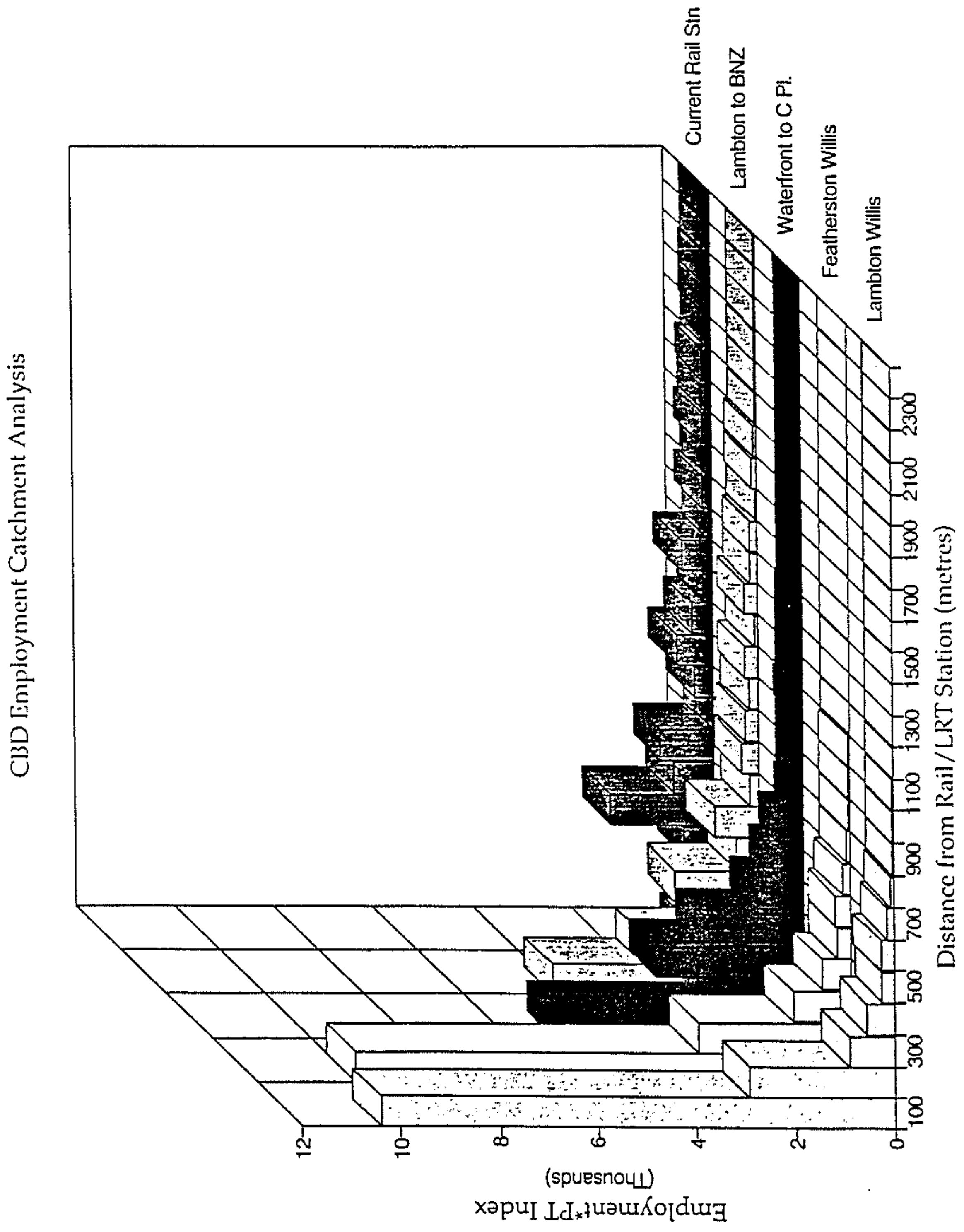
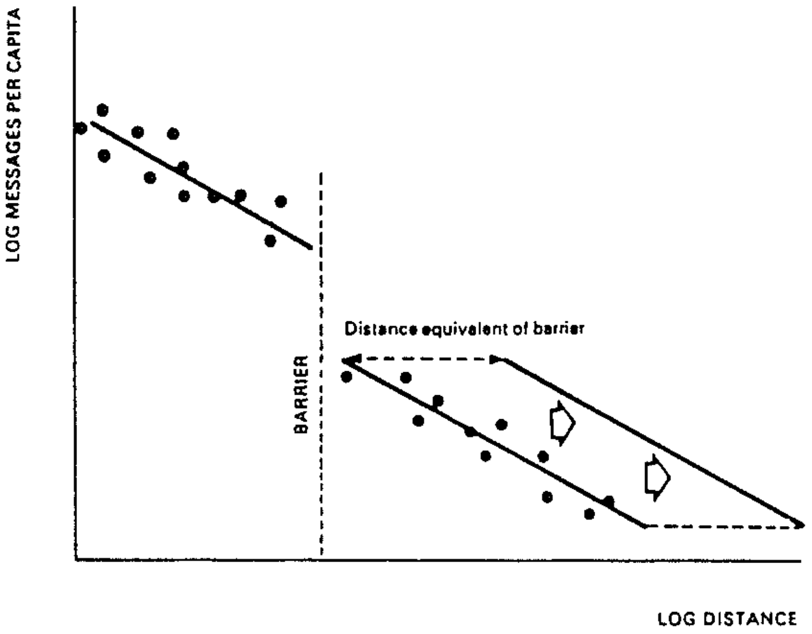


Figure 6. The identification of barriers to the flow of information.
Taken from Gould and White (1986).



If the mental maps approach could be applied at a local, or micro, level it would be a very powerful tool since it is a direct measure of the effect in which we are interested. Having expressed the barrier as an equivalent distance, reassignment of trips and economic evaluation may follow using standard techniques.

The technique is untried, and the project is considered to be both expensive to implement and complex to explain. However, the generation of mental maps could provide a great deal of knowledge about the mobility of various special groups, e.g. children. This could be fed into the investigation of potential for social severance and catchment analysis.

3.2.5 Other Measures

Possibly the most comprehensive review of accessibility measures was given by Jones (1981). Other measures identified include *revealed value* measures as well as *time-space geography* measures and *non sequential time-space measures.* These are considered to be more complex to implement and, in the context of studies of specific barriers, are less likely to provide much in the way of additional insight without considerable additional work.

3.3 Barrier Measures

As discussed above, the term social severance encompasses a wide range of effects which complicates impact assessment. A number of measures are available for use in the assessment of severing effects that result from a particular barrier. One approach (Tate 1993) was to obtain information on community concerns, about potentially severing effects, through public consultation. Indices or proxy measures that are in tune with the concerns of the community could then be developed. For example, if a particular community is concerned about the safety of children as they travel to school, an index that looked specifically at this, such as the *conflict index* discussed below, may be employed. Other measures, such as *pedestrian* *delay*, may in turn be used as a proxy for an overall effect. It may be that one measure is more suited to a particular group of people, while other measures better address activities.

3.3.1 Qualitative Measures

A number of publications suggested the use of descriptive measures of severing effects. The most readily referenced is that adopted in the United Kingdom (DTp 1993). Under this procedure the potential for new severance and the removal of existing severance are identified separately, both using a 3 point scale. For existing roads that may receive more, or less, traffic, an assumption is made that a 30% change in volume is required before a noticeable effect results. Increased journey lengths and the need to cross roads carrying increased traffic volumes are considered when assessing the impact, as are the effects of multiple events. Although the basis of the method is unclear, it is well documented and expected to be relatively easy to apply.

The background to this 30% change is unclear and a 30% change from 100 vpd to 133 vpd is be expected to have a different effect from a 300 vpd to 390 vpd or 6000 vpd to 7800 vpd change.

The system is descriptive and relatively simple to apply. It is, however, relatively subjective and therefore open to different interpretations.

3.3.2 Conflict Index

This simple measure is based on the number of trips crossing a particular road, or roads, and the volume of traffic on those roads. It was used in assessing the effects of possible network changes on the journey of children to school, (Works Consultancy Services 1989). The index does contain elements of risk arising from traffic volumes, and exposure using the number of journeys crossing each road. The data obtained from the school children, as part of a class exercise, was readily available at little cost.

$$\text{Index} = \sum \frac{[\text{AADT of Roads Crossed} \times \text{Number of Paths Crossing}]}{100}$$

where AADT is the average annual daily traffic.

An improved approach would be to estimate the risk by using existing accident data or the accident rate data.

The measure has an advantage that it is inexpensive and clearly addresses a specific concern, and is useful to rank options in terms of that concern. It is, however, of little use when comparing a range of projects.

3.3.3 Traffic Density

The traffic density reflects the amount of traffic contained in a length of road. The measure can be calculated from the traffic speed and volume using the equation:

$$k = \frac{q}{u_s}$$

where k = traffic density (vehicles/km)
q = traffic flow (vehicles/h)
u_s = space mean speed (km/h)

Although traffic density has been proposed as a possible severance measure (Clark *et al* 1992), no examples of its use have been located. Some doubts exist over the suitability of traffic density as a measure since the effects of increasing traffic volume and increasing speed will act in opposing directions in a manner which is counter intuitive.

3.3.4 Pedestrian Delay

A commonly proposed measure of the barrier effect has been pedestrian delay. Studies into the environmental capacity of residential roads (Buchanan 1963) concluded that when pedestrian delay criteria were met so would the criteria for other factors such as noise, the effect of fumes and disruption. Given that each relates to traffic volume in a similar non-linear manner this is not surprising. Pedestrian delay is, therefore, not only a measure of a physical severance effect, it also represents overall disruption.

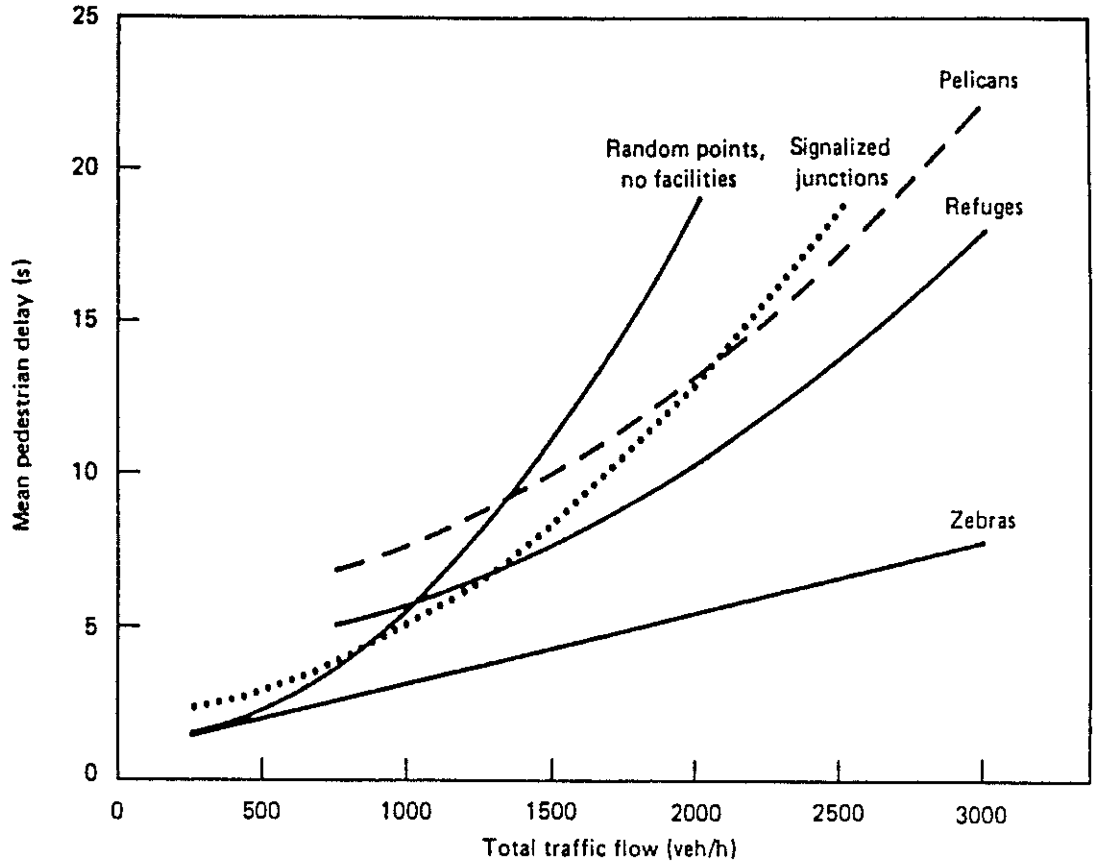
It is, however, generally accepted that the effect of increased travel time and delay should be accounted for within project evaluation in a similar manner to the vehicle journeys that may be catered for by the project (SACTRA 1986, Urban Motorways Committee 1972, Transit New Zealand 1995).

The measurement and prediction of pedestrian delay is, however, exceedingly difficult. Although a gap acceptance model may be utilised, the gap acceptance behaviour of pedestrians complicates the issue. It has been found (Hunt and Abduljabbar 1993) that pedestrians utilise a number of different road crossing strategies. These include looking for a gap in the combined stream, or accepting a gap in the near side stream and "waiting" on the centreline. Rather than waiting for a gap some pedestrians will "track" along the footpath, continuing their journey while searching for an acceptable gap.

As an alternative to probabilistic analysis of, an index of "pedestrian amenity" (Jerram 1993) and a crossing index (Hunt and Abduljabbar 1993) have been proposed. These indices are based on models of inter vehicle headways alone and consider the total available crossing time per unit time.

A series of relationships derived from observed crossing delays has been developed for a variety of crossing facilities in the United Kingdom (Goldschmidt 1977). These are presented in Figure 7.

Figure 7. Mean pedestrian delays associated with different road crossing situations. Taken from Goldschmidt (1977).

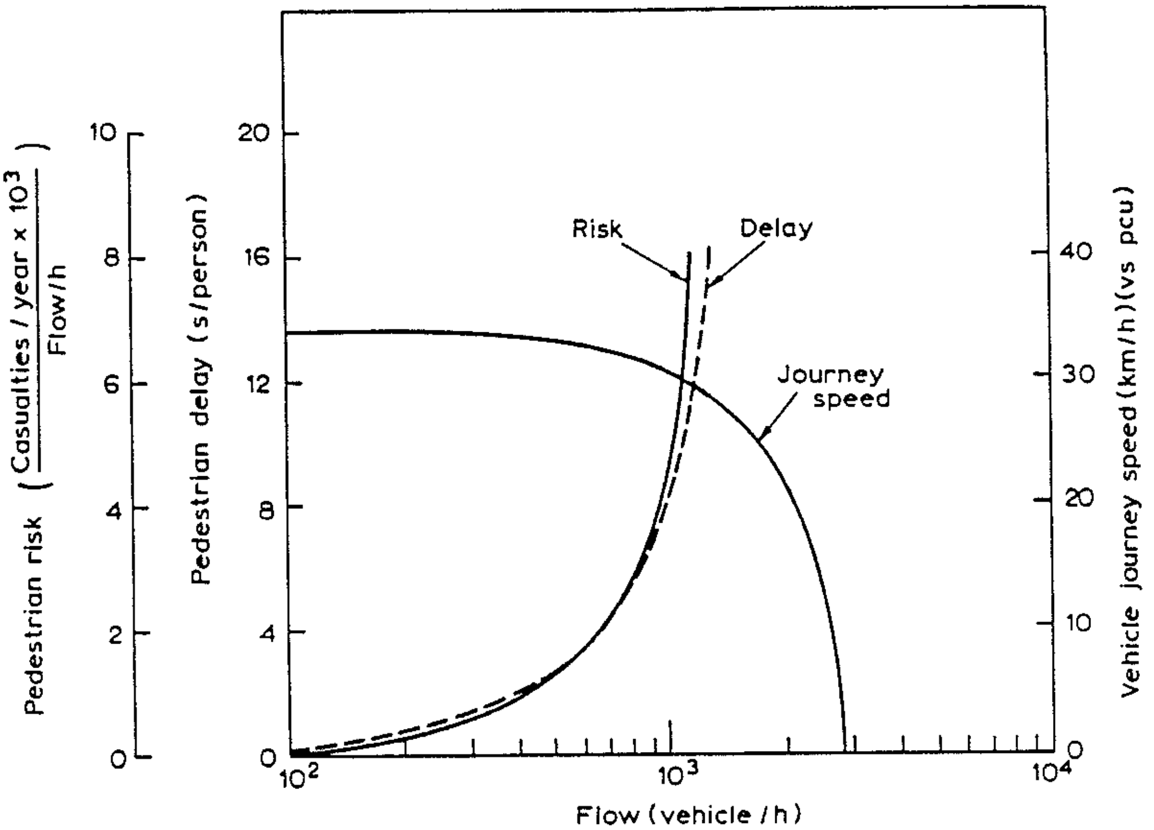


Although pedestrian delay may be valued, this does not, however, remove the value of pedestrian delay as a proxy measure that may be used to weight, rank or to represent in some other way the effect of disruption to trips or perceived danger. A relationship between pedestrian delay and danger, as measured by pedestrian risk, is given in Figure 8 (Burt 1972). This additional use of a delay as a proxy measure is often discounted because it is seen as "double counting" the effect. In practice, the monetary value of pedestrian delay is often found to be small. It is questionable whether it is worthwhile calculating it. It is likely that the measure is of more value when representing disruption than as an input to economic assessment.

The measure has an advantage in that time is a tangible concept that can be presented as a ranking criteria, and the data on traffic volumes and pedestrian flows are usually collected as part of any assessment.

The disadvantages are that the relationships used are from a study in the United Kingdom, and their relevance to New Zealand may be questioned when trying to cast doubt on the results and the strong belief that being a time-based measure the impact should only be valued and included in the economic evaluation.

Figure 8. Pedestrian delay and risk.
Taken from Burt (1972).



3.3.5 Trip Length Changes

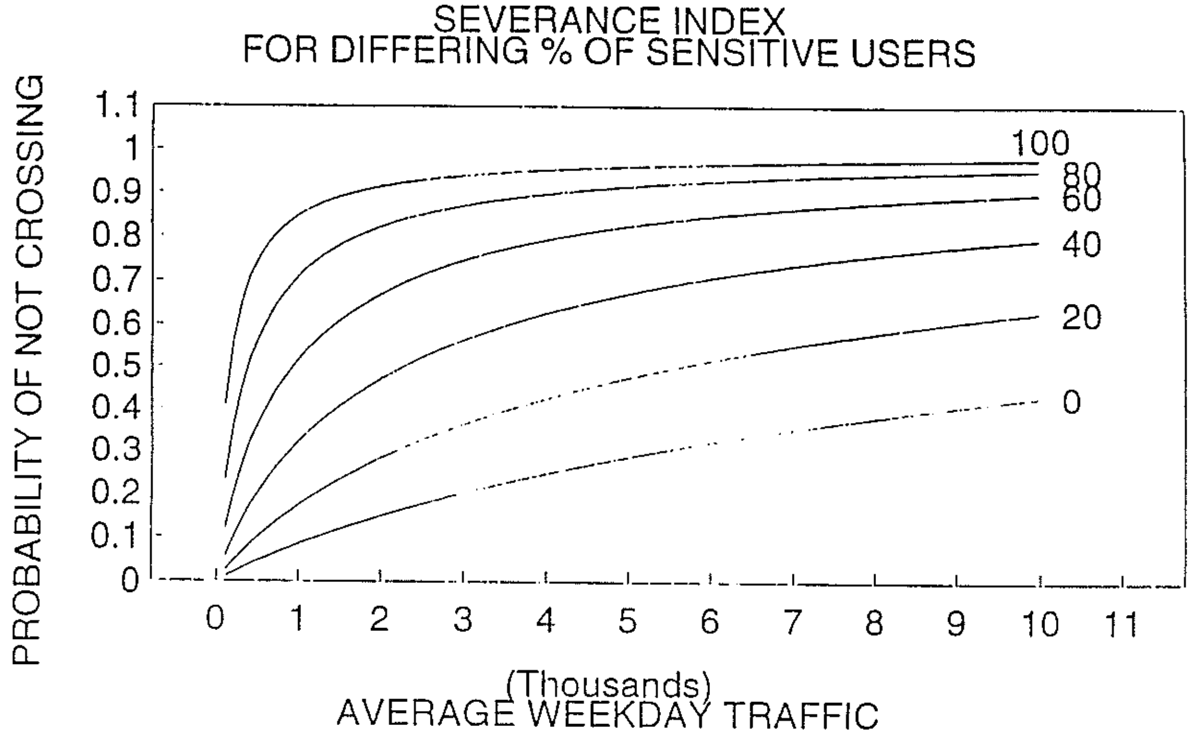
One assumption made when using pedestrian delay, or any index of amenity, is that no change to trip patterns will occur. Increases in travel time and trip length may be to suppress trips. It is possible to identify the likely reduction in the probability of making a particular walk trip from the trip length distribution for that trip. It should be noted that this approach only considers the propensity of physical severance to suppress trips. Highly mobile groups may avoid difficult situations through complex trip chaining thus minimising the physical severance effects, but not necessarily the psychological severance effects.

One problem with the approach is that data from which to construct trip length distributions for various age groups and trip purposes is not readily available in New Zealand.

3.3.6 Perceived Danger

A major concern among pedestrians is the danger that is posed by a road (Morton William *et all* 1972, May *et al* 1985). Comments such as "it is so dangerous that I won't let my children go that way", prompted research (Tate 1991) into the perception of the danger posed by road traffic. From an investigation into whether or not parents would allow their child to cross the road unaccompanied, the study developed an index of perceived danger. Shown in Figure 9, the index may be used to show the reduction in mobility that may result from changes in traffic volume.

Figure 9. Index of perceived danger (Tate 1991).



Having established the likely reduction in mobility, it should then be possible for an analyst to assess whether a change in location, mode or abandonment of the journey might result. Although the measure was developed in the United Kingdom using a sample of children aged 5 to 11 a pilot study using a similar methodology to produce a New Zealand model is discussed in Section 5 of this report.

The approach has advantages in that it addresses specific concerns voiced by parents, and the data is relatively simple to collect. The results of such an assessment could include the identification of losses in freedom by mapping areas that are now not available for children to travel to alone. Alternatively, for journeys that must take place, such as those to school, the cost of alternative transport may be used in the economic evaluation.

3.3.7 Discussion of Barrier Measures

Those barrier measures that address a specific concern and which can be defined concisely are seen as the most suitable. These include the conflict index, pedestrian delay, and perceived danger. The data for all measures is relatively inexpensive to collect and the measures may be used to supplement the catchment style analysis.

Care should be taken to use measures that encompass an important community concern. In addressing the "bulk" of a concern, the measures may also allow ranking, weighting, or scaling of a broader impact. Alternatively, for journeys that must take place, such as those to school, the cost of alternative transport may be calculated and used in the economic evaluation.

3.4 Case Studies and Selected Articles

Case studies and references for strategic and policy accessibility studies abound, and may be found in readily available publications, such as Traffic Engineering and Control, Transport and Road Research Laboratory and Australian Road Research Board reports. However, reports that consider the assessment of social interaction, are not readily available. Much of this case study work is contained in impact assessment reports and inquiry statements. While these may be referenced in texts and journals they have proved difficult to obtain.

Although a selection of studies is given below, it would appear there is a need to generate some specific examples of applications of the techniques identified. Such exercises would have the advantage of testing the data requirements and availability, as well as testing the significance of the factors and relationships that are used overseas.

3.4.1 A Review of Transportation Plans for Melbourne (King 1982)

This review of transportation decisions for Melbourne investigated the possible severance effects of changes to transport provision resulting from the proposed closure of urban railway lines and the change in road hierarchy. Commonly available data from the Australian census was used to establish the likely policy impacts.

By considering the current travel patterns, changes in accessibility were found to be readily identified and measurable. Other direct effects, such as increased danger, were not readily measurable, although their incidence was certainly seen as predictable. The paper is somewhat wordy and specific analysis was not covered. Readers will gain an idea as to what may be investigated from common data sources.

3.4.2 West Yorkshire Transportation Study (Cooper *et al* 1979, Headicar 1979)

This study is well reported in a series of papers that consider the development, and more particularly the evaluation of an overall transportation policy for West Yorkshire. The papers outline a number of criteria used for policy investigation and assessment. Of particular interest are the development of accessibility criteria for the evaluation of alternative scenarios to determine how the needs of the community may be met.

3.4.3 Tyne and Wear Metro (Jones 1981)

The paper describes the changes in accessibility that were investigated as part of the study into the Tyne and Wear Metro extension. Key indicators were seen to be the effect of the scheme on access to employment opportunities from residential locations and access to a labour force by employers. Some good example of the use of contour analysis are provided.

3.4.4 Adelaide (Braddock 1979)

This is possibly the best case study of the impacts of a specific barrier located in the literature search. The paper summarises the results of this study into the effect of building a transport facility along a designated but unused transport corridor. The study outline, presented in a paper to the Australian Transport Research Forum, considers the investigation of existing journey patterns and the effect of the barrier on these. In particular, the paper looks at how the key activities for that area can be defined and how the proposed barrier may affect travel to these activities.

3.5 Summary of Possible Measures

A number of measures are available for use in the identification and quantification of parts of the social severance impact:

- *Community measures* such as those that represent the stability and cohesion of the communities involved are suitable as tools for identifying where psychological severance may become an issue.
- *Accessibility measures* are available to investigate the loss, or gain, in opportunities to take part in activities or use facilities.
- *Barrier measures* allow the investigation of impacts on existing travel patterns that will result from the provision of a specific road.

Individually none provides a complete measure of possible severance, although some, such as pedestrian delay, may be used both as a direct measure as well as a proxy measure for other components of the impact.

4. IMPACT ASSESSMENT FRAMEWORKS

Sections 2 and 3 have provided discussion of social severance and outlined possible techniques by which some or all of the severance impacts may be assessed. This section looks at the procedures adopted elsewhere to incorporate severance effects within an assessment. Detailed procedures for the evaluation of severance effects were found for only three countries:

- United Kingdom;
- Denmark; and
- Sweden.

These procedures are outlined and form the basis of the subsequent discussions related to the attributes of the assessment and evaluation process.

4.1 Examples of Assessment and Evaluation Frameworks

Although three examples are discussed, these represent two distinct approaches to the issue of evaluation. The more qualitative approach adopted in the United Kingdom considers:

- Changes in journey length; and
- Changes in amenity.

separately. The method then considers the extent to which severance results from these effects and reporting is based on the number of persons affected by slight, moderate and severe severance.

Scandinavian practice is directed at obtaining a single monetary value of severance. Severance, or rather the barrier effect, as it is termed, is considered in two parts:

- Transverse barrier effects; and
- Longitudinal barrier effects.

For each effect the method considers the magnitude of the barrier in terms of the characteristics of the road traffic:

- Speed;
- Flow; and
- Composition.

and the demand for movement across or along the barrier. The demand is calculated from theoretical trip rates which are based on the adjacent land uses.

In the following sections each method is outlined in some detail. These examples are then used, in Section 4.2, to identify elements which are considered to be important and which should be included in a framework for use in New Zealand.

4.1.1 United Kingdom

In the United Kingdom the assessment of community effects is provided for in Chapter 2 of the Design Manual for Roads and Bridges Part II Environmental Assessment (DTp 1993). This chapter considers:

- Journey length and local travel patterns;
- Changes in amenity; and
- Severance.

The first step of the method is to establish current travel patterns. Two methods are described in Chapter 2. The first is based on identifying the catchments of key facilities, the other on measurement of travel via origin and destination surveys. In each case counts of pedestrian movements at important locations are to be undertaken. Particular attention is required to identify the movements of sensitive groups such as children, the elderly and other groups with reduced mobility.

Having established travel patterns, these are drawn on a map together with all roads for which the traffic volumes are to change by more than 30%. Changes in travel are assessed on a route by route basis assuming that people will minimise their travel costs by travelling to the nearest destination using "shortest" route.

The selection of the 30% change criteria is unsupported and a number of researchers (Burt 1972, Jerram 1993, Tate 1993) have identified the impacts as non-linear. Clearly a 30% change in a volume of 100 vehicles per day is not the same as a 30% change in a volume of 7000 vehicles per day. The use of such a simple criteria is therefore questioned.

Having identified travel patterns, any changes in amenity, or the general pleasantness that may be experienced by users of a route are described in subjective terms, e.g.

> *"Cavendish Road:*
>
> *Published Scheme: Some reduction in amenity for around 500 pedestrian and 10 cyclist journeys per day. AADT (1995, high growth) forecast to increase by 60%, to 5000 (HGVs by 50%, to 350), as some traffic diverts to this road to join the A28 at Redhill roundabout. Although pavements are typically 2m wide, they are adjacent to the carriageway. An alternative route is available for the cyclists using this road as a through route.*
>
> *Do Minimum: No change to existing good amenity."*

(Dtp 1993)

The changes in journey length and amenity may be such that a barrier is formed between residents and the facilities and services they use in their community. This separation is termed severance. Severance is then reported in terms of the number affected and the magnitude of the effect. The three categories of severance are outlined in Table 1 together with the criteria for relief and existing severance. With the exception of travel time and distance impacts which are valued directly, the overall approach is qualitative.

Table 1. Classification of severance effects Department of Transport UK.

Level		Slight	Moderate	Severe
New Severance	Description	In general the current journey pattern is likely to be maintained, but there will probably be some hindrance to movement.	Some residents, particularly children and elderly people, are likely to be dissuaded from making trips. Other trips will be made longer or less attractive.	People are likely to be deterred from making trips to an extent sufficient to induce a re-organisation of their habits. This would lead to a change in the location of centres of activity or in some cases to a permanent loss to a particular community. Alternatively, considerable hindrance will be caused to people trying to make their existing journeys.
	Example	- Pedestrian at-grade crossing of a new road carrying below 8000 vehicles per day (AADT); or - A new bridge will need to be climbed or a subway traversed; or - Journeys will be increased by up to 250 m.	- Two or more of the hindrances set out under 'slight' applying to single trips; or - Pedestrian at-grade crossing of a new road carrying between 8000 and 16 000 vehicles per day (AADT) in the opening year; or - Journeys will be increased by 250-500 m.	- Pedestrian at-grade crossing of a new road carrying over 16 000 vehicles per day (AADT) in the opening year; or - An increase in length of journeys of over 500 m; or - Three or more of the hindrances set out under 'slight' or two or more set out under 'moderate'.
Relief from Severance	Built up Area	Traffic volumes reduce 30%.	Traffic volumes reduce 30-60%.	Traffic volumes reduce 60+%.
	Rural Area	60-75% reduction in traffic volumes where road passes through a village or on the perimeter of a built up area 30%.	75-90% reduction in traffic volumes where road bisects a village or small town. This may be halved.	90+% reduction in traffic volumes where road bisects a small town or village. This figure may be reduced to 60%.

4.1.2 Denmark

In Denmark severance is described in terms of two effects, a Barrier Effect and a Risk Perception effect (Road Directorate 1992). The barrier effect considers the extent of crossing problems while the perceived risk effect considered the conditions for pedestrians and cyclists travelling along the road.

A single unit of measure, the BRBT, was used to quantify and aggregate the two effects as outlined in Figure 10 (T Larsen pers. comm.).

The Barrier Effect is the product of the Crossing Need and Barrier Impact. This is combined with the Perceived Risk Effect assessment which is undertaken for each side of the road and is the product of the Need and Risk Impact, calculated separately for each direction.

The **Barrier Impact** is determined by considering the traffic flow, speed, presence of heavy vehicles, and the availability of crossing points such that:

$$\text{Barrier} = 0.1\sqrt{ADT} \times (1.87\ L_o + 0.63) \times \left(1 - \frac{K}{20} \times L\right)$$

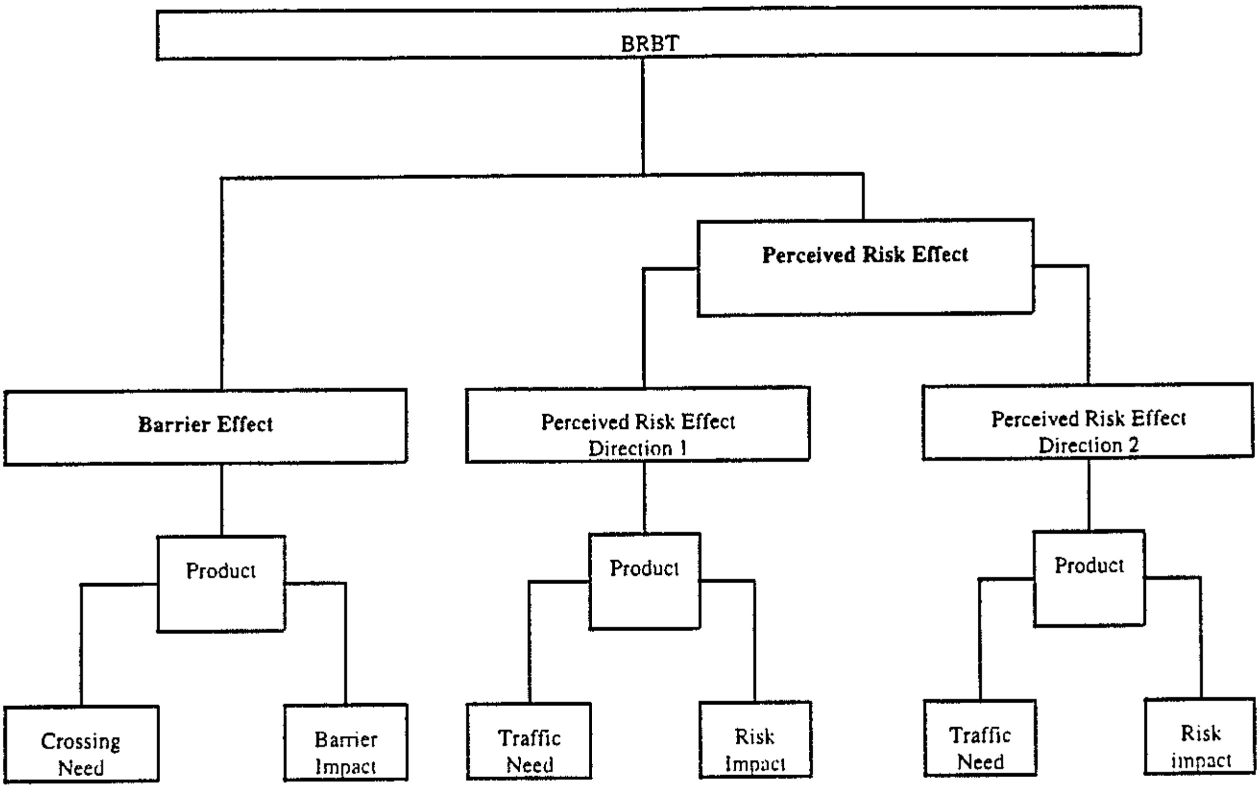
where ADT = average daily traffic (vpd)
L_o = proportion of heavy vehicles
K = number of pedestrian crossings, subways or other crossing facilities
L = length (km)
V = average traffic speed (km/h)

The **Crossing Need** is determined from the adjacent land use. The factors provided in Table 2 are used to weight the demand per kilometre. The crossing need is calculated separately for each side of the road and then summed.

Table 2. Crossing need factors.

Land Use	Housing Weight
Shops, public offices Schools and housing blocks	4
Low housing	2
Summer housing	1
Industrial and recreational city areas	1
Otherwise unbuilt	0

Figure 10. Danish assessment framework (Road Directorate Denmark 1992).



The **Risk Impact** is calculated separately for each side of the road using half the traffic flow term 0.1 $\sqrt{}$ADT $(V/50)^3$ which is corrected for heavy vehicles using 1.87 L_o + 0.63. As with the barrier effect, an adjustment for the facilities provided (C+F) is made based upon the factors of Table 3. The risk impact RI is then:

$$\text{Risk Impact} = \frac{1}{2}\,(0.1\,\sqrt{ADT}\,) \times (\frac{V}{50})\ 3 \times (1.87\ L_o + 0.63) \times (C + F)$$

where ADT = average daily traffic (vpd)
L_o = proportion of heavy vehicles
C,F = adjustment factors for cyclists and pedestrian facilities taken from Table 3
V = average traffic speed (km/h)

Table 3. Risk impact adjustment factors.

F factor		**C factor**	
no pavement/footpath	0.5	no bicycle path	0.5
only pavement/footpath on the opposite side	0.4	two-way bicycle path on the opposite side	0.4
shared bicycle path/footpath	0.3	shared bicycle path/footpath	0.3
pavement	0.1	cycle track/parking lane	0.2
		bicycle path	0.1

The **Traffic Need** is the same as the crossing need but calculated separately for each side of the road using the weights of Table 2. Once the BRBT units have been calculated these are monetorised. Although the basis for this is recognised as being inadequate:

> *"No appropriate method has yet been found to place a value on the barrier and risk effect. At present this effect is being valued at 50 percent of the value of the noise nuisance effect.*
>
> *On this basis the cost per BRBT-unit has been calculated to DKK[1] 8.500".* (Road Directorate Denmark 1992)

No distinction is made between more or less sensitive users, and the valuation is made over all groups and purposes. Not surprisingly in the example of a bypass (Road Directorate 1992), the valuation of severance effects were approximately half of the value of noise. What was of interest, however, was that severance effects were valued at a similar level to the distance component of car travel costs in that example.

4.1.3 Swedish Method

Details of the Swedish method for assessing barrier effects are outlined by the Swedish National Road Administration in part 15E Calculation Guide (Swedish National Roads Administration 1986). Although the part 15E Calculation Guide has been reviewed, it has not been possible to obtain the accompanying Effects Catalogue which it is believed contains a more detailed discussion.

In a similar manner to the Danish assessment, the Swedish method considers both:

- Transverse (B_T) effects; and
- Longitudinal (B_L) effects.

---

[1] DKK are Danish Krona

The transverse barrier assessment considers the effect on pedestrian journeys while the longitudinal barrier considers the impact of cars and trucks passing cyclists using the road. The approach is outlined in Figure 11.

The **transverse barrier** effect is made up of two parts, a disturbance term (C_1) and a delay term (C_2). The method considers the demand for movement based on an assessment of destinations and the potential need (P_i), which is determined from "trip rate" tables. The trip rates, such as those in Table 4, are established for three environment types:

Environment type 1	central part of town with 50 000 inhabitants
Environment type 2	suburban part of town with 50 000 inhabitants
Environment type 3	rural area, small village with no school, children travel by bus or cycle.

The table provides guidance on the potential need per age group (P_i) for walking and cycling.

Figure 11. Swedish barrier assessment framework.

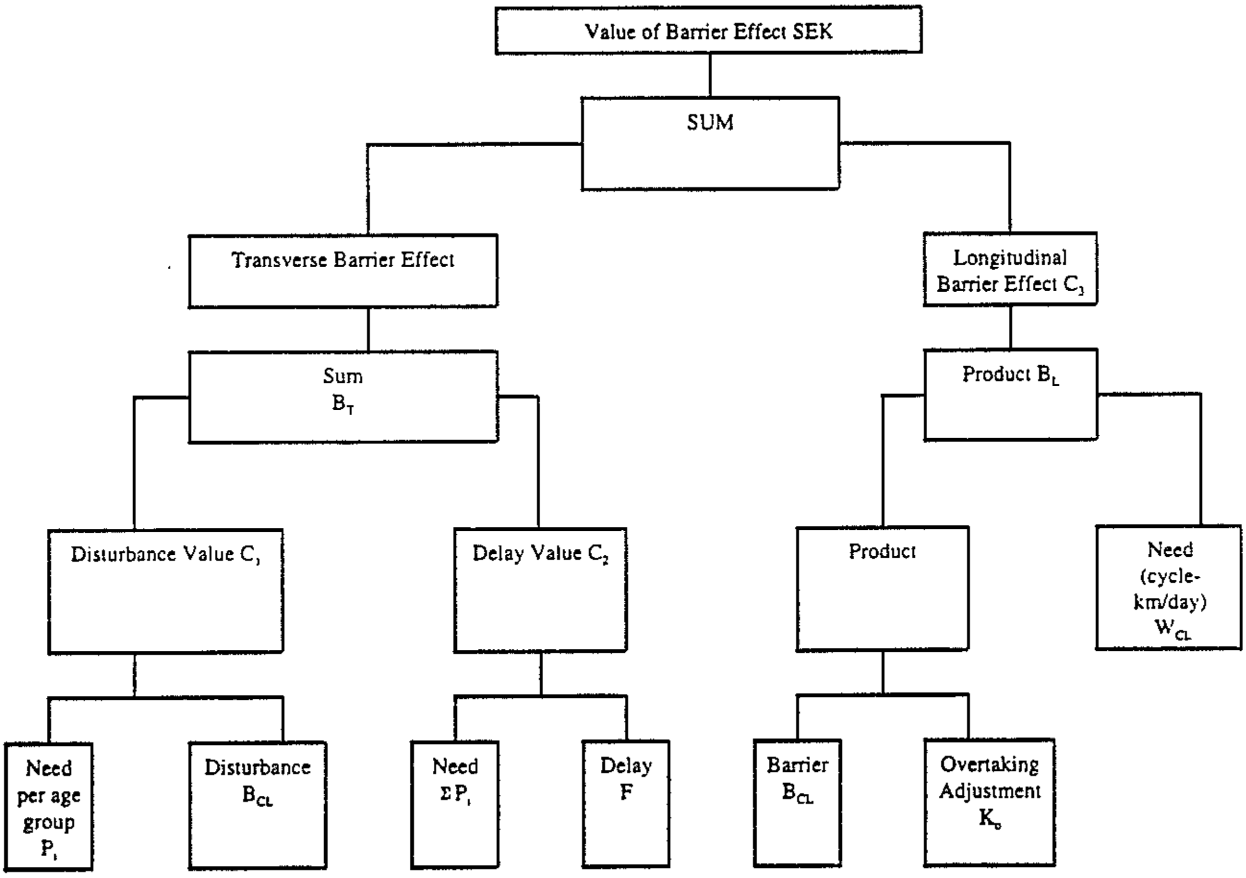


Table 4. Potential need assessment Swedish National Road Administration (1986).

Age group		**Bus stop**	**Service**	**School play work[2]**	**District play/recreation**			**Infant play**	**Other dwellings**			
					0* 400	400 800	> 800	0-400	0-400	400-800	> 800	Total
0-6[1]	Ped.	0	0	0	0	5	0	10	5	0	0	20
	Cyc.	0	0	0	0	0	0	0	0	0	0	0
7-9	Ped.	1	8	25	5	2	1	0	5	2	1	50
	Cyc.	0	2	5	0	1	1	0	0	1	1	11
10-12	Ped.	3	7	20	4	1	1	0	4	1	1	42
	Cyc.	0	3	10	1	1	2	0	1	1	2	10
13-65	Ped.	3	7	5	2	1	0	0	2	1	1	22
	Cyc.	0	1	3[3]	0	1	1	0	0	0	2	10
>65[3]	Ped.	3	6	0	12[4]	6	2	0	2	1	1	33
	Cyc.	0	1	0	0	1	2	0	0	0	2	6

Environment type: Central part of town with 50 000 inhabitants (bus increases in larger towns). Movement need on foot and by bicycle (each day per group of 10 people). Total number of outward movements and returns.

[1] 2-6 years old are assumed to be able (without parents, with and without traffic in the surroundings) to make an average of 3 movements a child per day outdoors (0-1 years old make no movements).

[2] Some play movements are connected with school surroundings.

[3] Assumed need magnified slightly in relation to real (observed) frequency.

[4] District recreation need magnified to an average of one walk (two movements) per pensioner each day, which is more than the real frequency (which is assumed to be depressed by the traffic situation).

* All figures in headings represent metres.

The first step is to calculate the disturbance term, C_1.

$$C_1 = 365 \times \sum_{i=1}^{i=5} S_i \times K_i$$

where C_1 = cost of disturbance (SEK/yr[1])
S_i = disturbance for age group i
= B x P_i
P_i = need (persons/day)
K_i = value of disturbance per age group (Table 5)

The Disturbance (B) that results from a barrier to transverse movement is calculated from a function of:

$$B = Q \times K_L \times K_H$$

where Q = average daily traffic (vpd)
K_L = correction for heavy vehicles
= $0.667 + 3.33\ a_i$
a_i = % of trucks
K_H = correction for speed = $(V / 50)^4$
V = average traffic speed (km/h)

The amount of disturbance is calculated as the product of B_{CL} and P_i, the potential need per age group. Where there is a crossing facility, such as a subway or a signal controlled pedestrian crossing, then P_i is reduced to reflect the use of that facility. In the case of a signalised facility no reduction is made for children under 13 years of age.

The monetorised value is calculated by age group using:

Table 5. Value of Severance per age band.

Age group	i = 1	i = 2	i = 3	i = 4	i = 5
Age band	0-6	7-9	10-12	13-65	>65
Value in SEK[2] K_i	$8x10^{-4}$	$4x10^{-4}$	$1x10^{-4}$	$0.25x10^{-4}$	$1x10^{-4}$

It is interesting to note that the effect on children is valued at a higher rate than for the adult age group 13-65 years. The value of delay C_2 is also calculated using the potential need and a constant value of time across all age groups:

---

[2] SEK is a unit of currency, Swedish Krona

$$C_2 = \frac{F \times P \times 365 \times 30}{3600}$$

where F = the delay
= $1.26 + 4.54 \times 10^{-6}q^2$
or the delay calculated at traffic signals
q = flow in vehicles per hour
30 = the value of waiting time in SEK per hour

The final **Transverse Barrier** B_T valuation is the sum of C $_1$and C .$_2$ **Longitudinal Barrier** (B_{CL}) effects are considered in terms of the effect on cyclists travelling down the road being passed by the moving traffic. The longitudinal barrier effect is calculated as:

$$B_{CL} = B \times K_O$$

where B = the barrier effect calculated above
K_O = 21 (0.07 – 1/V)
V = average traffic speed (km/h)

The factor K_o adjusts for the frequency of overtaking and accounts for the vehicles passing the cyclist. The monetorisation of the longitudinal barrier effect is then calculated from:

$$C_3 = 365 \times \sum_{j=1}^{j=4} S_{CL}^{j} K_j$$

where C_3 = the value of longitudinal effects, SEK/yr
S_{CL} = disturbance for age group j
K_j = value of disturbance for age group j from Table 6

Table 6. Swedish value of longitudinal severance.

Age group	j = 1	j = 2	j = 3	j = 4
Age band	7-9	10-12	13-65	>65
Value in SEK K_j	$2x10^{-4}$	$1x10^{-4}$	$0.5x10^{-4}$	$1x10^{-4}$

4.2 Identifying the Attributes of an Assessment Framework

Each of the three examples treats the assessment of severance in a different way. From these and the discussions of Section 2 it is clear that:

- The phenomenon of social severance is complex;
- No unique method of evaluation exists;
- A large number of proxy measures exist that to a greater or lesser extent may quantity one or more aspects of social severance; and
- A range of possible combinations are available that, while not completing the picture, will account for large portions of the issue.

In order to develop an appraisal framework for use in New Zealand, it is considered necessary to identify the objectives of such a framework. For this purpose the framework has been divided into three sections:

Impact Assessment -	the identification of the impacts of a project and the analysis of the distribution of these effects.
Project Assessment -	the summarising of nett impacts within a particular category.
Project Evaluation -	the process of establishing the worth of a project, typically in terms of some single nett variable.

4.2.1 Impact Assessment

The aims of an impact assessment are seen to be the presentation of information and processes in a concise manner to both decision makers, and the public in general, to:

(a) Ensure that they are aware of the issues involved,

(b) Properly identify the "needs" of various groups,

(c) Explain the effects of any decisions that are made about parts of the project. In particular, those related to the generation and mitigation of adverse effects.

The key in practical evaluation is one of *significance*. Assessment includes identifying which effects are significant, at what locations, to which groups, and in the case of multi-impact effects, where these impacts are recognised in the assessment and where they are not.

Community opinion or views are the first measure of significance and the concerns raised within the early rounds of community consultation will provide the initial insight into the likely impacts perceived by the community. Consideration of the distribution of the effects is important:

> *"Conflicts over the severity or otherwise of the effects and conflicts over priorities are rarely able to be resolved or removed. Debates over them can be however informed by comparisons of projected distributions of benefits and disbenefits, with present distributions as benchmarks. The key issue is therefore to identify what effect to which group has been assessed within which element of the impact assessment."* (King 1982)

Some existing social severance may be present within the "community" (Lee and Tagg 1976). A typical case within a New Zealand context is that of a heavily trafficked Main Street that may experience relief, a reduction in traffic volumes, as the result of a bypass. At the same time the Bypass may sever access for another area. Only the United Kingdom approach specifically requires that the impacts on individual groups be identified and discussed separately. This reflects the view that:

> *"The effects of reducing severance for one group and increases for another group should not be allowed to cancel each other out."* (Urban Motorways Committee 1972)

The methods used in the United Kingdom and Sweden require either existing journeys or potential journeys to be plotted on a plan. This allows explicit consideration of actual travel patterns.

Under the Scandinavian systems, it is possible to aggregate the gains and losses within a project. Although such summary statistics provide an overall measure of nett change, they do not differentiate between "winners" and "losers" nor the magnitude of the gains or losses. In New Zealand there is a requirement (Resource Management Act 1991) to identify adverse impacts and mitigation measures.

Aggregating such data may, however, raise discussions as to the relative effects and the principle of trade off. For example:

Project A	A road realignment will increase journey times for 500 local trips per day by 20 seconds but the travel time saving for the 10 000 vehicles using the road will be 25 seconds per vehicle and the resulting B/C ratio may be 4.8.
Project B	Changes to the traffic control at an intersection give a 30 second time saving to each of 10 000 vehicles per day on the main road, but results in an increased travel time of 5 minutes for 200 local trips.

In each case the total travel time savings are the same and although these are fictitious cases, they highlight that the local impact may be very significant and worthy of identification. In the latter case the increase may be such that the local trips become suppressed and incur a far greater economic cost. Under the current "fixed matrix" approach to traffic modelling, this effect would not be recognised.

4.2.2 Project Assessment

Measurements of the impacts and the distributional aspects, are of limited use when undertaking an intra-project comparison of possible options. In all but the simplest cases, it will be necessary to summarise the distributional effects in some way.

> *"Some analysts, while recognising that the impacts of transport may not lend themselves to objective aggregation, such as benefit/cost ratio or another index of single worth, do however aggregate the distributional elements in terms of a single index."* (Taggart *et al* 1979)

In the UK method, the travel time and distance changes may be valued consistently. Although the amenity and severance are not aggregated to a common base, the equivalence relationships of Table 1 would allow a conversion of slight impacts into an equivalent number of moderate or serious impacts.

In the Danish approach, a common unit of measure (the BRBT) is used to aggregate a variety of effects that impact on people. One assumption, within such summary statistics, is that the value of the impact is "constant". The value of time is considered constant and in terms of an overall evaluation it may be. However, small elements, such as 2 seconds, while not able to be "used" by some, may have value if it means the difference between catching a plane or not. As the level of disaggregation becomes greater, the validity of this assumption of constant value of time may become less tenable.

The Swedish method effectively skips the Project Assessment phase and proceeds directly to evaluation by applying monetary values early within the process. The principal reason for doing this is to allow significantly different "weights" to be applied using different costs for each effect and age group.

Of interest is that there is an almost constant relationship between the transverse barrier effects predicted by the Danish and Swedish methods as shown in Figures 12 and 13. This is even more noticeable given that the Swedish monetary values are provided to the power 10^{-4} while the Danes use a constant value of 8.5 currency units.

4.2.3 Project Evaluation

4.2.3.1 Direct costs

Within the Swedish and Danish methods impacts are *valued* directly. Once a summary measure or measures have been defined they are converted into monetary units, although the basis for the valuation is unclear. It has been noted that the Danish approach is a simple assumption of a constant value.

The Swedish approach however varies the cost by age. The effect of a barrier on adults, those aged 13-65 years, is reduced by the use of a very small disturbance cost for that group. The value of disturbance for children aged between 7 and 9 is 16 times larger than that for 13-65 years old, as can be seen from Table 5. One possible reason is that where a barrier is imposed, children in this age group must either abandon their journey or change mode.

Figure 12. A comparison between Swedish and Danish severance measures for 50 km/h.

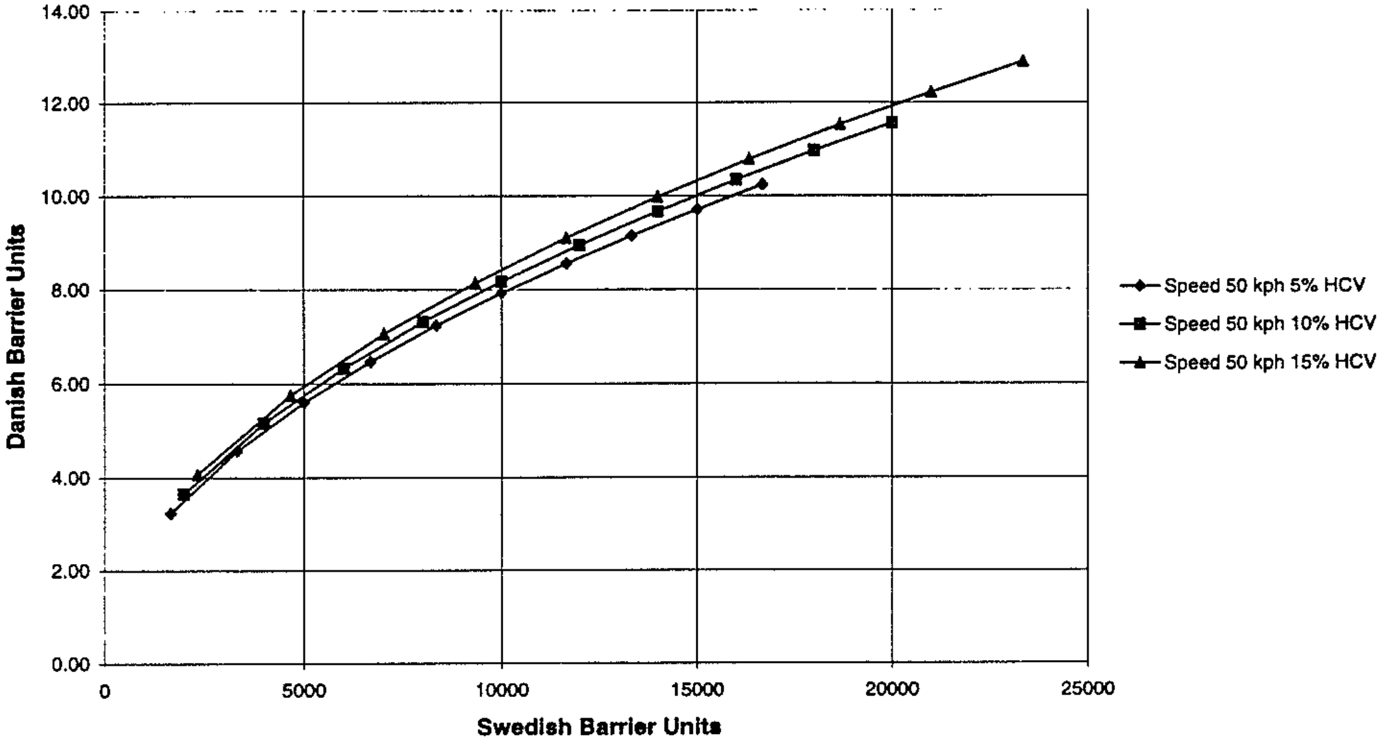
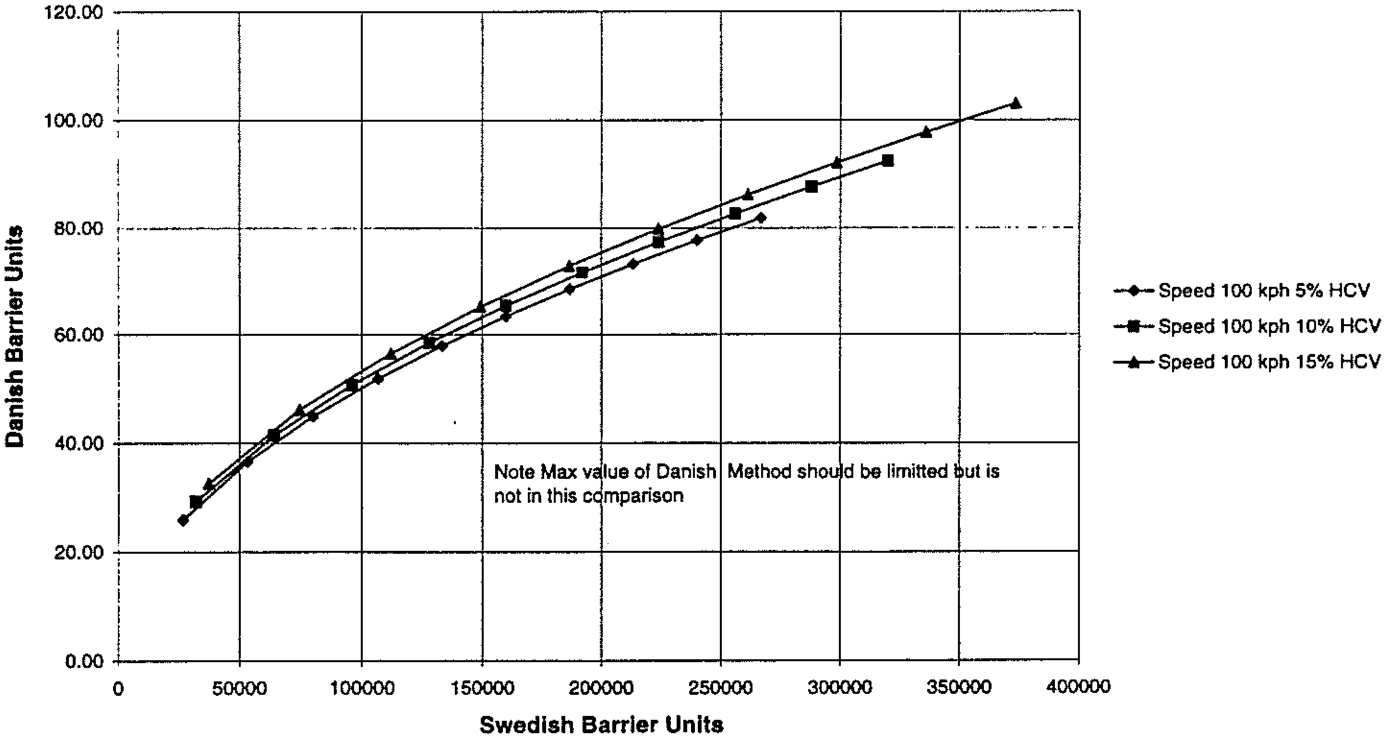


Figure 13. A comparison between Swedish and Danish severance measures for 100 km/h.



Note Max value of Danish Method should be limitted but is not in this comparison

A child's trip to school is essentially inelastic. If due to increased traffic volumes a child is not allowed to walk unaccompanied then the alternative is a change of mode to an escorted journey. If the journey is undertaken by car the minimum value will then be the cost of the two way car trip with occupant time and the additional congestion related to the additional trip. The "cost" in either case is obviously high. The demand for travel will vary significantly depending on the type of facility or activity that is being accessed. Trips to a local park may be very elastic and trips will increase markedly with the reduction of a barrier.

For other highly mobile groups trip making behaviour is more complex and may overcome such effects. In which case the costs of delay become a more significant component of the severance effect.

4.2.3.2 Indirect costs

While it is possible to establish the worth or value of a trip from considering the marginal utility there are costs which are less readily identified. These are associated with the "value" of social trips and the "value" of having "choice". A discussion of the sociological and psychological needs for interaction are beyond the scope of this review. However, a number of authors have looked at the role of social contacts. A study on the relationship between social contact and mortality undertaken by Berkman and Symes (Davis 1992) linked mortality risk increases with reduced social contact. Further references to this effect have been located (Kirby 1981), although it is suspected that the base reference may in fact be the same study. There is also anecdotal evidence that some elderly groups value the opportunity to view passers by and "the goings on in the street".

For children, another mobility disadvantaged group, the reduction in independent mobility through increases in traffic have been linked to reduced physical fitness and lost opportunities for skill development. A further consequence was the increase in escorted journeys which contributed to further traffic congestion and barriers (Hillman *et al* 1990).

4.2.3.3 Valuation experiments

Direct costs only represent a part of the assessed costs. Social severance, as an impact, includes a number of effects. As well as the physical barrier formed by a road, there may be a general dislike of the unpleasantness of a road, as well as psychological severance. One approach would be to use attitudinal surveys to:

- Assess what the public perceive as social severance; and
- Rank the relative magnitude of the components.

In New Zealand the Draft Project Evaluation Manual (PEM) (Transit New Zealand 1995) considers the use of valuation experiments such as willingness to pay, or willingness to receive compensation, as a means of evaluating an impact. Such experiments assume that the impacts under consideration may be defined.

The "public" is certainly aware of social severance as an impact but given the level of understanding to elicit a definition from the public as to what impact is being tested, would appear difficult (Clark et al 1992). Without an understanding of which costs, or impacts are

5.2.2 Road Sections

The aim of the study was to relate the perception of danger to the characteristics of the road traffic. Ten road sections were selected in the catchment of each school. While some were on the route to or from school, for some children they were not. This reduced the likelihood that parents would view the questions in the context of a particular journey purpose. From the studies reviewed, it was found that the most common traffic characteristics to be included in the discussion of severance were:

- Traffic flow,
- Traffic speed, and
- Traffic stream composition (% trucks).

A previous study (Tate 1991) had identified visibility as an important factor. However, the 5 point subjective rating scale used, in that study, may have been a danger ranking in its own right. To avoid such a problem, each road section was chosen to ensure adequate visibility within the section. This recognised the assumption that children should choose, either of their own accord or on instruction from their parents, their crossing location to minimise such effects.

Each of the road sections was a two laned urban road with a 50 km/h speed limit. Broadly the traffic volumes ranged between 100 and 13 000 vehicles per day of which between 2% and 14% were heavy vehicles. Mean traffic speeds were in the range of 32 km/h to 56 km/h.

A summary of the traffic characteristics at each site is contained in Appendix 2. The traffic count data was collected using VDAS tube counters. Unfortunately, vandalism of these counters and the road tubes was a major problem at some sites. As a result very few weekend surveys were completed . Consequently the Average Weekday Traffic (AWT) has been used instead of the preferred measure Average Annual Daily Traffic (AADT).

5.2.3 Response Rates

Determining the proportion of responses was difficult since some schools only provided questionnaires to the eldest child in the family while others provided questionnaires to all children. The intention had been to have the children complete their questionnaires in class, and to take the questionnaires home to parents that night. In some classes children completed their questionnaires for homework. Although some may have not completed this homework, it is assumed that the children's returns represented the total sample. Table 8 provides details of the response rate based on this assumption.

The survey was undertaken in the final weeks of the 1995 primary school year. This gave little lead time and meant that the survey could not be incorporated into curriculum activities. Indeed at Cannons Creek School it was only possible to distribute the survey to one class before the last week of school. A similar survey undertaken in the United Kingdom (Tate 1991) had a response rate of 76%.

Table 8. Parent response rate.

School	Redwood	Porirua East	Cannons Creek
Child returns	276	134	31
Parent returns[1]	181 (65.6%)	113 (84.3%)	29 (93.5%)
Usable parent returns[2]	172 (95%)	89 (78.9%)	10 (31.0%)
Overall response[3]	62.3%	66.4%	32.3%

[1] Calculated as a percentage of child return.

[2] The number of parent returns available following validity checking.

[3] Usable returns as a percentage of child return.

Table 8 clearly identifies two issues in the responses. Firstly, that parent responses at Redwood were considerably less than for the other two schools, possibly reflecting the instruction that parents need only complete the questionnaire of the eldest child. Secondly, the "error" rate for Cannons Creek, an area where many families have English as a second language, is considerably higher than for the other two schools.

On the whole, parents were found to be interested in improving road safety for their children and were willing to participate. The overall result was encouraging and it was clear that the method may be used with success. Table 9 outlines the profile of children for whom usable parent responses were received.

Table 9. Child profile of responses.

School	Age	Male	Female	Total
Porirua East	5	13	7	20
	6	5	5	10
	7	5	7	12
	8	6	9	15
	9	7	4	11
	10	5	8	13
	11	2	4	6
Redwood	5	16	12	28
	6	11	9	20
	7	14	24	38
	8	12	12	24
	9	15	19	34
	10	11	8	19
	11	4	2	6
Cannons Creek	8	0	1	1
	9	0	2	2
	10	1	3	4
	11	1	1	2

5.3 Analysis

5.3.1 Selection of Measures

While the measurement of traffic stream composition was relatively simple, a difficulty occurred as to which measure of speed or flow should be used. The parents' perception of speed could be influenced by a few higher speed vehicles on a street. If this is the case a higher percentile speed such as the 85%ile, may be a better measure than mean speed. Alternatively, it may be that the 10%ile speed, which represents the background or underlying speed environment may be a better description.

Similarly, for the measure of volume, the am or pm peak hour flows, the Average Annual Daily Traffic, or the weekday traffic may be the most "in tune" indicator. In order to test different measures the parents were asked to rate, on a 5 point scale, their perception of traffic speed and flow. The mean rating was then compared to the various measures available.

A complicating effect was, that the knowledge that each respondent held about a site would affect their perception. For this reason the level of knowledge each respondent held about the sites was tested. The knowledge levels were defined as shown in Table 10, and the effect of knowledge on the perceptions about traffic conditions at the sites is shown in Figure 14 which considers the relationship between the perceived traffic flow and the log of average weekday traffic. In keeping with other studies it was found that the Log_{10} of traffic flows was a better indicator than the flow alone. Log measures were, thus used in the investigation of possible flow measures.

Table 10. Knowledge levels.

Knowledge level	Rating	Description
1	Very Well	Pass it once a day or more
2	Well	Pass it once a week
3	Not Very Well	Pass it once a month
4	Do Not Know The Area	

Table 11 provides a summary of the relationships considered. From Table 11 it can be seen that parents had a better perception of traffic flow than they had of traffic speed. Furthermore, no one measure of flow or speed was clearly better than any other. This being the case the Mean Traffic Speed and Average Weekday Traffic volume were considered the most readily obtainable measures and were selected for use in the analysis.

Figure 14. The effect of knowledge on the perception of traffic volume.

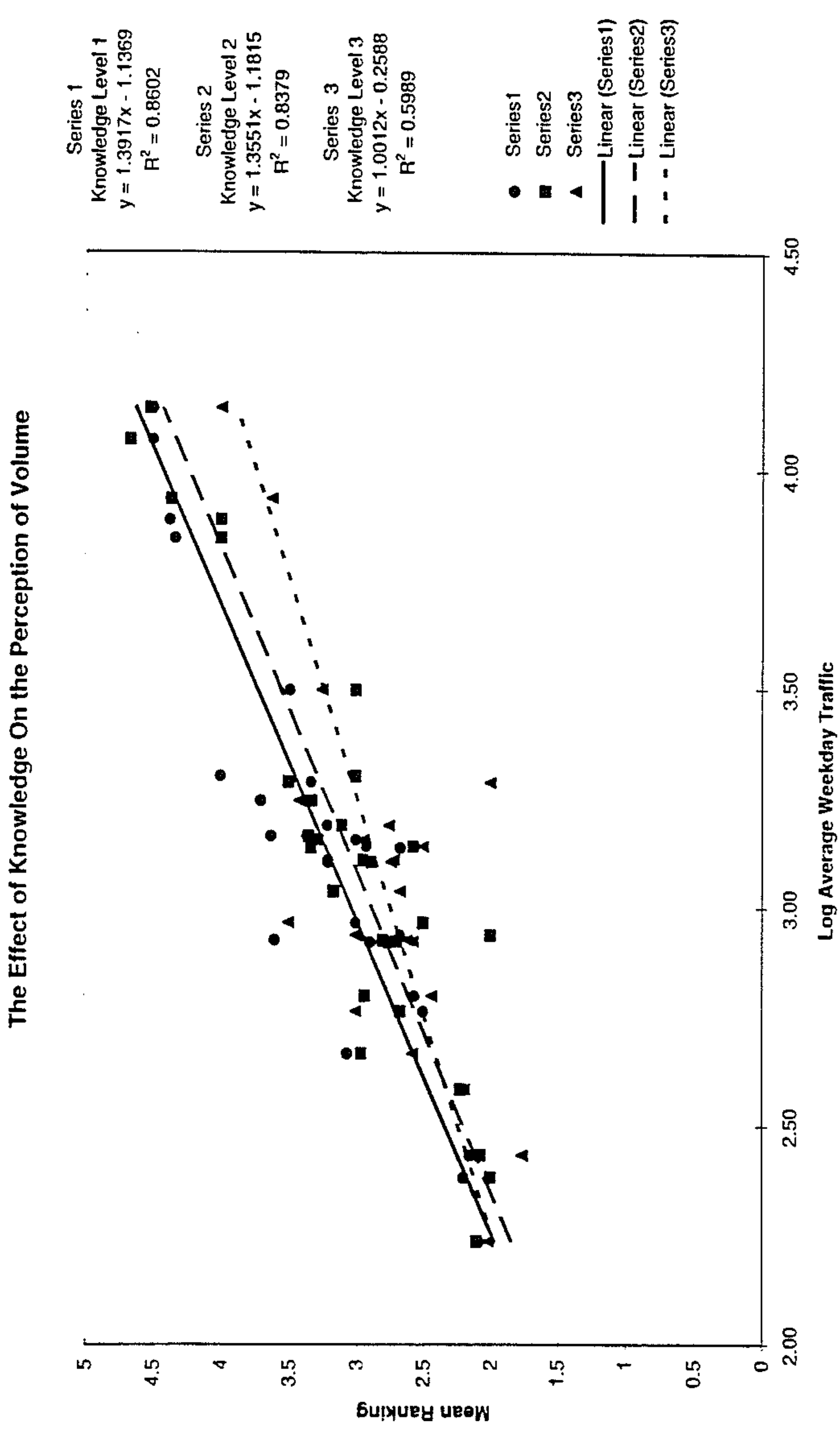


Table 11. Equations of average site weighting (y) for different levels of perceived knowledge.

Physical measure (x)	**Knowledge level**		
	Level 1 pass site daily	**Level 2 pass site weekly**	**Level 3 pass site monthly**
Mean Speed	$y = 0.041x + 1.327$ $R^2 = 0.3742$	$y = 0.050x + 0.916$ $R^2 = 0.3905$	$y = 0.053x + 1.493$ $R^2 = 0.4324$
Harmonic Mean Speed	$y = 0.041x + 1.465$ $R^2 = 0.3946$	$y = 0.049x + 1.117$ $R^2 = 0.3974$	$y = 0.053x + 0.688$ $R^2 = 0.4467$
20%ile Speed	$y = 0.039x + 1.666$ $R^2 = 0.3965$	$y = 0.046x + 1.372$ $R^2 = 0.3917$	$y = 0.051x + 0.965$ $R^2 = 0.4405$
80%ile Speed	$y = 0.039x + 1.119$ $R^2 = 0.3502$	$y = 0.047x + 0.690$ $R^2 = 0.3576$	$y = 0.053x + 0.135$ $R^2 = 0.4321$
90%ile Speed	$y = 0.039x + 0.994$ $R^2 = 0.3485$	$y = 0.044x + 1.647$ $R^2 = 0.327$	$y = 0.0543x - 0.125$ $R^2 = 0.4577$
Log_{10} Average Weekday Traffic	$y = 1.392x - 1.137$ $R^2 = 0.8602$	$y = 1.3551x - 1.182$ $R^2 = 0.8379$	$y = 1.001x - 0.2589$ $R^2 = 0.5989$
Log_{10} a.m. Peak	$y = 1.470x + 0.189$ $R^2 = 0.8734$	$y = 1.430x + 0.112$ $R^2 = 0.8489$	$y = 1.001x + 0.792$ $R^2 = 0.5745$
Log_{10} p.m. Peak	$y = 1.539x + 0.090$ $R^2 = 0.8795$	$y = 1.491x + 0.146$ $R^2 = 0.8478$	$y = 1.066x + 0.576$ $R^2 = 0.5778$

5.3.2 Development of a Model

The most appropriate measure of the traffic characteristics were established as:

- Percentage heavy commercial vehicles (hcv),
- Average weekday traffic (awt), and
- Mean spot speed (spd).

The road variables were attached to each crossing decision record for which the data of Table 12 was available.

Table 12. Child characteristics.

Variable	Description	Type
Allow	Whether or not the child was allowed to cross the road section unaccompanied	Binary 1 = yes 0 = no
Know	The parents knowledge level of the road	Category 1-4
Age	The age of the child in years	Integer
Older	Did the child have older siblings	Binary 1 = yes 0 = no
Ethnic	The ethnicity of the child	Category 1 = European/Pakeha 2 = NZ Maori 3 = Pacific Island 4 = Other
Own	Car ownership	Integer number of vehicles owned by the family. 0 = None 1 = One 2 = Two or more

This provided a total of 2676 separate records covering the 30 sites and 7 age groups. The data was then analysed using a logistic model of the form:

$$\log\left(\frac{\rho_{cross}}{1-\rho_{cross}}\right) = \beta_O + \beta_1 X_1 \ldots . \beta_K X_K$$

$$\rho_{cross} = \frac{e^{(\beta_0 + \beta_1 X_1 \ldots \beta_k X_K)}}{1 + e^{(\beta_o + \beta_1 X_1 \ldots \beta_k X_k)}}$$

A generalised linear model with a binomial error structure was employed to give the probability of a child being allowed to cross the road ρ_{cross}. The 'S' shaped function was considered suitable because at very high and very low traffic volumes the probability of a child being allowed to cross the road, would not alter significantly (Tate 1991). The analysis was undertaken using SPlus 3.3 for Windows, a product of Mathsoft.

All variables, for which data had been collected, were included in a preliminary model in order to assess the significance of each. The resulting coefficients and associated significance of the preliminary model is given in Table 13.

Table 13. Coefficients of the preliminary model.

Model Coefficients:

Variable	Value[1]	Std. Error[2]	t value[3]
(Intercept)	-2.2292691818	0.51444533601	-4.333
age	0.6750301392	0.03307181797	20.411
sex	-0.2395971808	0.10430584911	-2.297
awt	-0.0002449261	0.00002912307	-8.406
know	-0.2742980917	0.05053523457	-5.427
spd	-0.0576597332	0.00900149215	-6.405
hcv	3.5572009033	2.04129623757	1.742
older	0.4835931678	0.10702605754	4.518
ethnic	-0.0913366198	0.05772875191	-1.582
own	-0.0286684529	0.09180955471	-0.312

t values for significance	one sided test	two sided test
t_1, 0.10 significance	3.078	6.314
t_1, 0.05 significance	6.314	12.706

[1] The value of the coefficient β_k each variable X_k.

[2] The standard error associated with the estimate of the coefficient.

[3] The value of the students t test for significance. A variable is significant when the t value exceeds the value for a one sided test as given in the lower part of the table.

It can be seen from Table 13 that age, traffic volume, and traffic speed together with parent knowledge levels are all significant. In each case the direction of the coefficients are considered correct so that as a variable such as traffic flow (awt) increases, the probability of being allowed to cross unaccompanied decreases.

One problem that had been encountered in a previous study (Tate 1991) was correlation between the "independent" variables. In particular it was considered likely that flow and speed, ethnicity and car ownership, or age and older may be highly correlated. As can be seen in Table 14, this was not the case.

5.3.2.1 Community model

The preliminary community model is a modest description of what is going on in practical terms but is not particularly useful since data for many of the variables could not be easily obtained.

Table 14. Correlation coefficient of preliminary model.

Variables	**Intercept**	**Age**	**Sex**	**awt**	**Know**	**spd**	**hcv**	**Older**	**Ethnic**
Age	-0.3975								
Sex	-0.3137	-0.0725							
awt	0.2959	-0.1578	0.0155						
Know	-0.1300	-0.0448	0.0324	0.2275					
spd	-0.6578	-0.1182	0.0192	0.3597	0.1592				
hcv	-0.2734	0.0685	0.0012	-0.3991	0.1223	0.0742			
Older	-0.0916	0.0092	0.0100	-0.0355	0.0265	-0.0295	0.0160		
Ethnic	-0.2659	0.0154	0.0268	-0.0775	-0.0154	0.0669	0.0533	0.0061	
Own	-0.2509	0.0105	0.0434	0.1047	0.0492	-0.0587	-0.0937	-0.1039	0.1586

A second working model was constructed which included each significant effect except that of knowledge. Knowledge was discarded as the determination of knowledge levels in a field situation was considered impractical. By discounting the knowledge effect, the model represents the perception of the community as a whole. Table 15 provides the summary data for this community model.

Table 15. Community model.

Model coefficients			
Variable	Value	Std. Error	t value
Intercept	-2.50632	0.38470	-6.5154
age	0.603915	0.02899	20.8300
awt	-0.0001752	0.0000225	-7.7787
spd	0.0568145	0.007786	-7.2970

The working model of the probability (P_{cross}) of a child being allowed to cross a road unaccompanied is then:

$$p_{cross} = \frac{e^{(-2.5068+(0.6039\times age)-(0.1752\times awt/1000)-(0.0568\times spd))}}{1 + e^{(-2.5068+(0.6039\times age)-(0.1752\times awt/1000)-(0.0568\times spd))}}$$

where p_{cross} = probability of a child being allowed to cross the road unaccompanied as determined by the community model

age = the age of the child (years)

awt = the average weekday traffic (vehicles per day)

spd = the average traffic speed (km/h)

The model is considered a reasonable measure of overall community response, and feelings held by the community about the effects of speed and volume. It is not, however, a particularly good representation of the crossing responses. This is because the significant effect of site knowledge has been neglected. As such, the model may be used as a proxy measure of community responses. For example, where a number of alternative route options are being considered, the community model may be used to rank, weight or scale the community's concerns in this area.

5.3.3 Localised Model

The effect of varying levels of knowledge about a particular site were found to have a very noticeable effect on parent perception of traffic speed and flow. When a parent had "little" knowledge about a site they would view the decision, to let their child cross unaccompanied, differently. There was likely to be a greater consideration about the distance to the site and the circumstances that would lead their child to be in an area that they *"do not know"*. There was also, as shown in Figure 14, a reduced ability to assess the attributes of the site. When considering the impact of a particular barrier, it may be argued that the impact should only be related to the perceptions of those most likely to come into contact with the barrier.

On this basis a further Local Model was developed considering only those responses where the parent knew the site well or very well. That is the parents knowledge scores were 1 or 2, i.e. they passed the site once a week or more frequently.

Table 16. Local model using knowledge levels 1 and 2.

Model coefficients			
Variable	Value	Std. Error	t value
Intercept	-2.31039	0.62912	-3.6724
age	0.612614	0.03928	15.5939
sex	-0.482386	0.12613	-3.8244
awt	-0.0001977	0.0000269	-7.3550
older	0.388292	0.12881	3.0145
spd	0.0462795	0.012771	-3.6237

The initial model, detailed in Table 16, identifies only the child's age and traffic volume as being significant at the 5% level, using a one tailed t test. Although significant at the 10% level, the inclusion of the sex of the child as a variable would unnecessarily increase data collection for little practical benefit.

The sex of the child was therefore discarded as a variable. Given that the sex of the child had been discarded, it was difficult to justify the inclusion of the speed term when it was less significant. The resulting Simplified Local Model containing only two terms was then:

$$\rho_{cross} = \frac{e^{(-4.6884+(0.6073\times age)-(0.24637\times awt/1000))}}{1 + e^{(-4.6884+(0.6073\times age)-(0.24637\times awt/1000))}}$$

where age = child's age
awt = average weekday traffic

A comparison of the model predictions and parent responses, is shown in Figure 15. It can be seen that the Simplified Local Model is a reasonable predictor of the reported crossing decisions.

The Simplified Local Model provides a direct measure of the likely trip suppression for the groups in question. At the same time the model may be used as a proxy measure indicating the significance of the impact on other sensitive users.

Although the development of these models will allow a greater level of investigation to be undertaken, they are at best simple. The effects of multiple crossings, distance from the barrier, and possible mitigation measures are not included. Although the effect of traffic speed was not found to be very significant, all the roads surveyed were in residential areas and the average traffic speeds ranged from 32 km/h to 58 km/h. The extension of the model to four lane carriageways and roads with 100 km/h speed limits was not tested.

5.4 Application

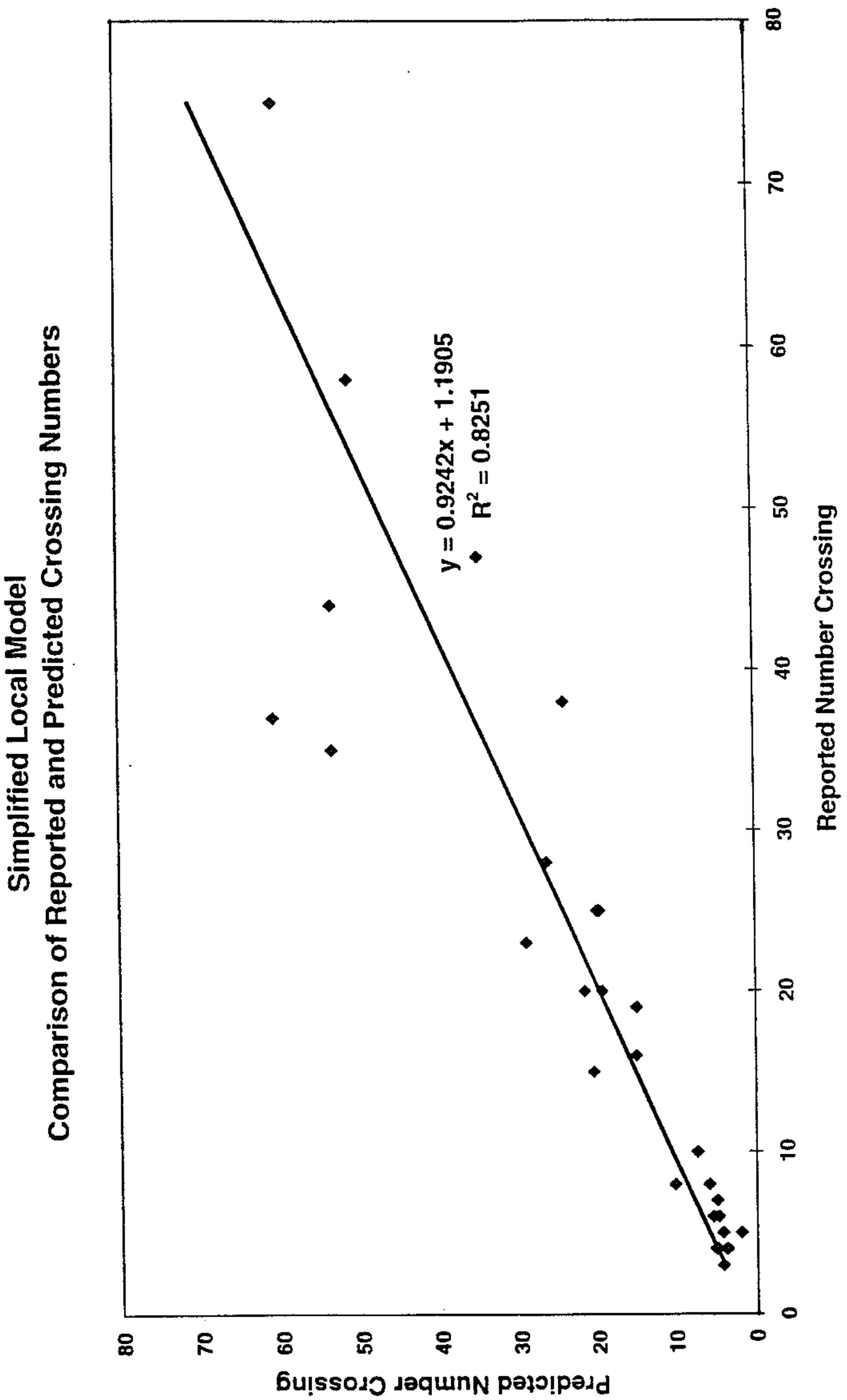
The perception of the danger posed by roads and their traffic is a significant barrier for some road users. Typically, this includes children and the elderly for whom walking is an important means of transport. Using the question "would you allow your child to cross this road unaccompanied" it is possible to determine the probability of a child being allowed to cross the road. This is therefore a measure of the perceived danger for a particular traffic barrier.

From this base it has been possible to develop a community model which may be used to identify those locations where changes to traffic characteristics are likely to generate concerns within the community.

When undertaking an assessment of the impacts of a project on the roading network, it is necessary to identify where significant changes occur. No guidance on what is significant has been located for the Scandinavian assessment methods. However, in the United Kingdom only roads on which traffic volumes change by ±30% or more are considered. The basis of the 30% threshold is not discussed, and should be questioned since a 30% change at 1500 vehicles per day is significantly different to a 30% change at 24 000 vehicles per day. Furthermore, traffic speed and the type of user being considered do not affect the threshold value.

The community model would provide a more rational basis for identifying areas where severance issues are likely to be significant.

Figure 15. Simplified local model comparison of observed and predicted results.



In order to remove a "double negative" it is useful to reformulate the community model in terms of a community concern rating which is a score in the range 1 to 100 such that:

$$\text{Community Concern Rating} = 100 \text{ x } [1 - \rho'_{\text{cross}}]$$

$$= 100 \text{ x } \left[1 - \left(\frac{e^{(-2.5068 + (0.6039 \times \text{age}) - (0.1752 \times \text{awt}/1000) - (0.0568 \times \text{spd}))}}{1 + e^{(-2.5068 + (0.6039 \times \text{age}) - (0.1752 \times \text{awt}/1000) - (0.0568 \times \text{spd}))}} \right) \right]$$

where ρ'_{cross} = probability of a child being allowed to cross the road unaccompanied as determined by the community model
age = the age of the child (years)
awt = the average weekday traffic (vehicles per day)
spd = the average traffic speed (km/h)

The results of such an assessment for a group with an average of 9 years is given in Figure 16.

Once the community concern rating has identified problem areas, these may then be investigated using the localised model which is presented graphically in Figure 17.

Figure 16.	Community concern rating.

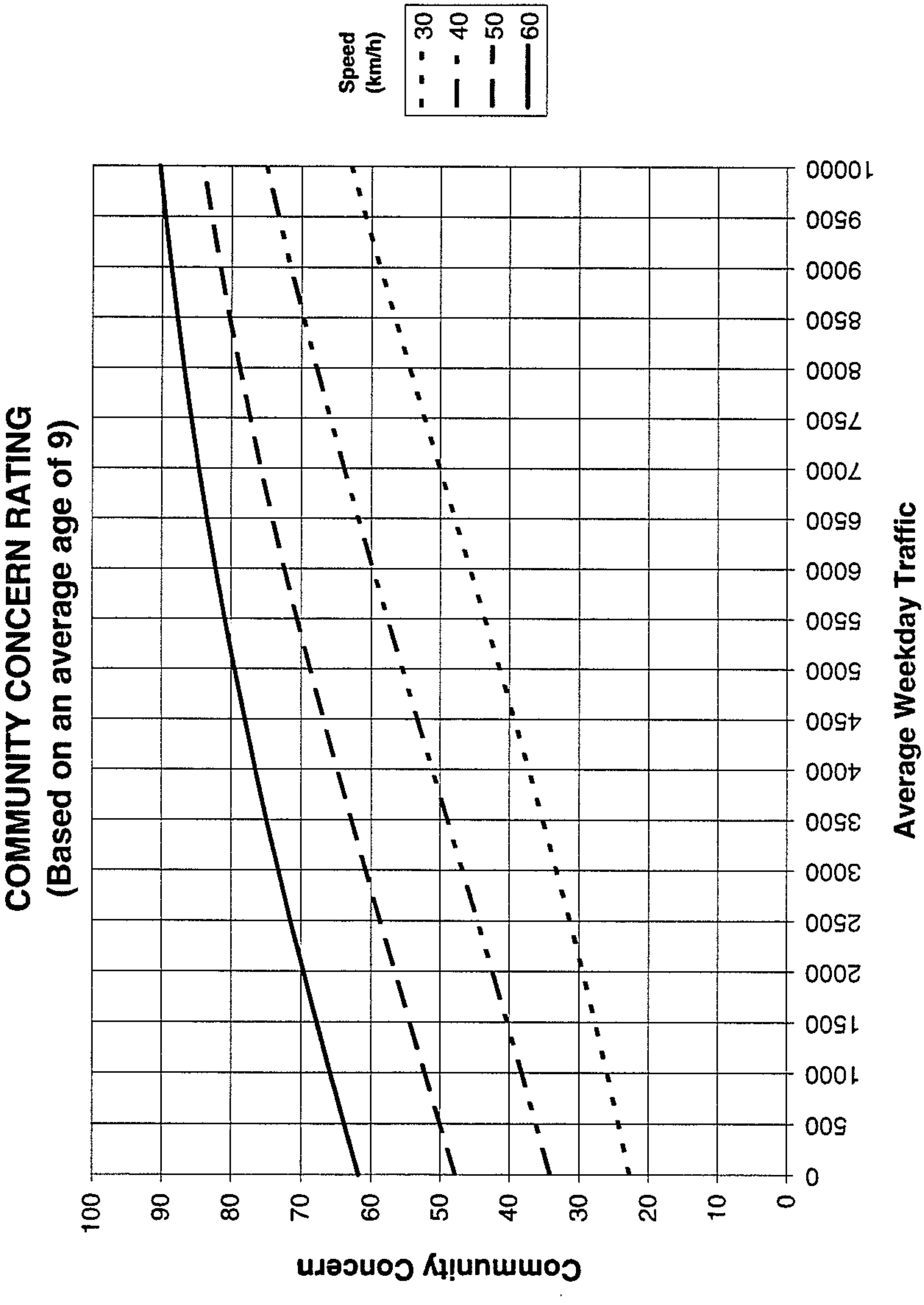
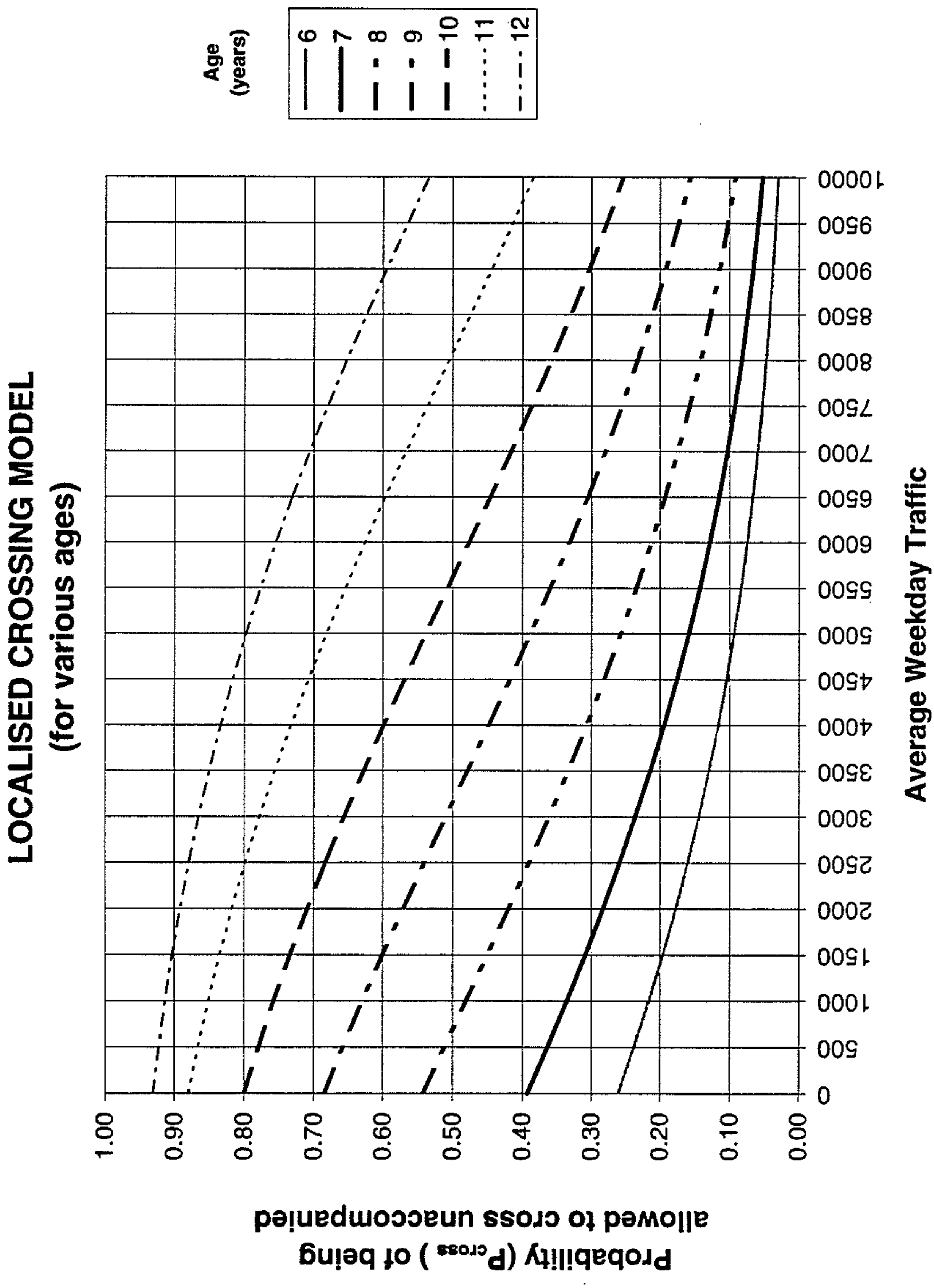


Figure 17. Localised model.



6. DEVELOPMENT OF A NEW ZEALAND EVALUATION FRAMEWORK

6.1 The Definition and Attributes of Social Severance

Social severance is the term used to describe the effects that road traffic has on the social interaction within the "Community". It is a complex effect the impact of which is felt in a number of ways, such as a reduction in walking trips that involve crossing busy roads, loss of social contact, the use of other less preferred facilities and the relocation of activities. The following definition of severance seeks to encompass the wide range of impacts:

> *"Social severance is the divisive effects that result from the provision and use of transport infrastructure".*

Three key issues relating to the investigation of severance that require recognition are:

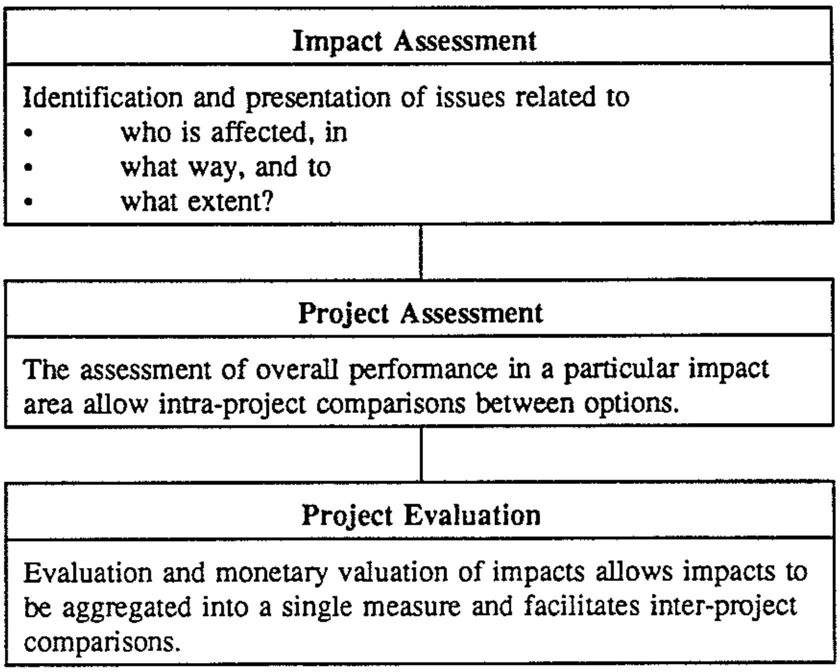
- That the communities that people are part of are far broader than those defined by geographic location and are formed around the activities that they take part in;
- That the impact on activities within a person's "community" may be enhanced or reduced by the provision of and use of transport infrastructure and that some existing severance may already be present in many situations;
- That severance effects may be described in terms of two main mechanisms:-
  - *physical severance* relating to the direct effect on trips that encounter a barrier, and
  - *psychological severance* stemming from feelings of being "cut off".

The burden of severance falls most heavily on those groups of low mobility for whom walking is the principal form of transport. These groups include children, the elderly and people with disabilities.

6.2 Outline

It is the desire of Transit New Zealand that as many impacts as possible be included within the tangible, Benefit/Cost analysis. It is also important to identify the differential impacts of a scheme. The three stage approach of Figure 18 is therefore proposed.

Figure 18. Proposed evaluation framework.



Impact Assessment

Identification and presentation of issues related to
- who is affected, in
- what way, and to
- what extent?

Project Assessment

The assessment of overall performance in a particular impact area allow intra-project comparisons between options.

Project Evaluation

Evaluation and monetary valuation of impacts allows impacts to be aggregated into a single measure and facilitates inter-project comparisons.

6.3 Impact Assessment

6.3.1 Identification

The approach adopted in the United Kingdom appears most useful for identifying where physical severance impacts should be considered. It is recommended that key destinations be identified on a map:

- Schools;
- Shops;
- Libraries;
- Playing fields and parks;
- Youth activity centres;
- Public transport stops (rail and bus stops);
- Shopping centres;
- Medical centres (including pharmacies but excluding hospitals); and
- Churches.

Catchment areas of facilities and concentrations of young children and the elderly should also be identified. Consultation with the community will identify additional walking patterns as well as specific concerns about the movement of any particular group, or for any particular purpose.

The review of this data, together with those roads experiencing significant changes in traffic volume, will identify those areas where social severance is likely to be a problem. The community concern rating developed in Section 5.4 together with any of the techniques or measures discussed within Section 3 of this report are useful in identifying those areas where barrier effects may be significant. While some will provide quantification of issues, such as travel time changes, their use at this stage in the assessment should be limited to identification.

6.3.2 Assessment

Each of the barrier assessment procedures discussed has been constructed from measures of:

- Impact; and
- Need.

The current trip pattern in the areas being considered should be established, either through observation or surveys, and the crossing movements should be classified by user group:

Children	-	accompanied
	-	unaccompanied
Adult	-	13-65 years
	-	mobility impaired
	-	elderly >65 years

The observation of existing travel does not recognise that some severance may already exist. This may be overcome using a potential need based assessment which is "constrained" to the observed movements such that:

observed crossings = barrier effect x potential need x adjustment for other conditions

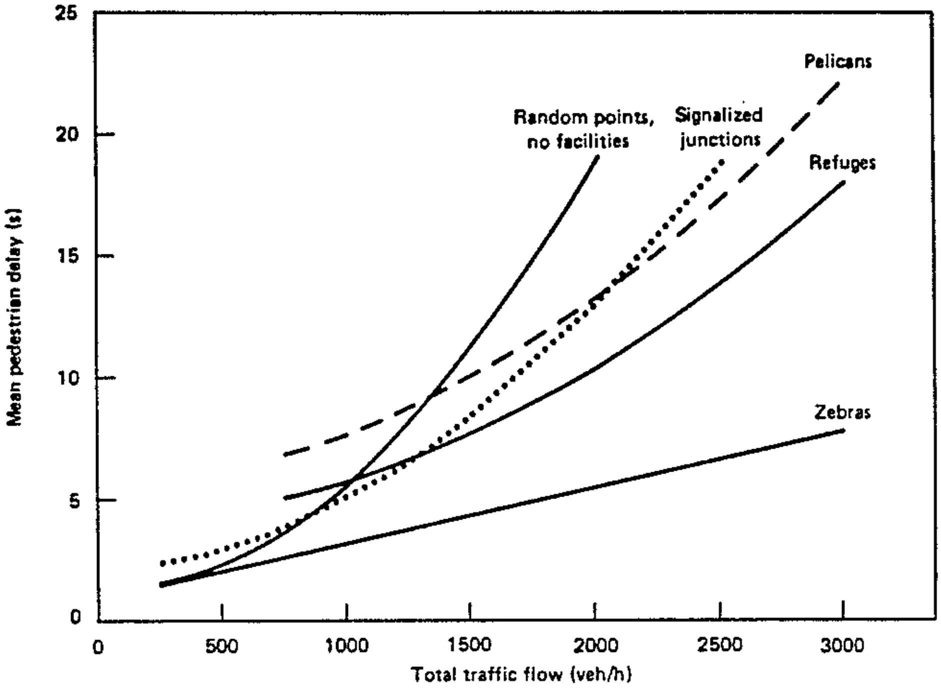
In this system the "change" in crossings or trips may be established from observed movements and the barrier effect from calculations. The alternative is to use an unconstrained model, such as the Danish model, which only considers need. This latter approach requires estimates of trip rates and the distribution of these trips to various destinations. These methods assume that destinations and to a lesser extent routes are fixed. Given the lesser data requirements, the observed movement approach is favoured for use in New Zealand, at this time.

6.4 Project Assessment

Ideally the impact assessment should take the form of a continuous function, rather than a series of categories. This then allows aggregation and overall performance assessment within the sector. Any number of measures may be "custom built" to assess a particular situation. It is however important to identify which components of severance are included, or excluded from any measures used. The advantage of "custom built" measures are that specific community concerns may be seen to be addressed. Such flexibility does not however allow inter, nor to a less extent, intra project comparisons. While this could be overcome by undertaking a study on the willingness to pay (or receive compensation), such an approach does appear to be fraught with sampling and bias problems.

It is considered important to separate the components of travel delay and increased travel distance from the overall barrier assessment. It should be noted that for the "able bodied" road crossing behaviour is very complex (Hunt and Abduljabbar 1993, Goldschmidt 1977). It is not appropriate to use models which consider the probability of accepting a gap in the traffic sufficient to allow a pedestrian to cross the whole road. In the absence of a New Zealand alternative the formulations of Figure 19 are proposed.

Figure 19. Mean pedestrian delay associated with different road crossing situations. Taken from Goldschmidt (1977).



Until such time as trip length distributions for different trip purposes are established, the implicit assumption is that the original destination pattern is fixed. Where specific information is available to suggest otherwise, the change in trip rates may be calculated.

While the changes in travel time and distance are considered to be the principal components of physical barrier effects for the adult group 13-65, it is not believed to be the case for unaccompanied children, the elderly, or the mobility disadvantaged. For these groups the perception of the danger posed by road traffic is the major impact on travel behaviour. The following model, developed in Section 5, predicts the probability P(cross) of a child being allowed to cross the road unaccompanied.

$$\rho_{cross} = \frac{e^{(-4.6884+(0.6073\times age)-(0.24637\times awt/1000))}}{1 + e^{(-4.6884+(0.6073\times age)-(0.24637\times awt/1000))}}$$

where ρ_{cross} = the probability of a child being allowed to cross the road unaccompanied
age = age of the child (or the average age of a group of children)
awt = the average weekday traffic
spd = mean spot speed of the traffic

Valid for children aged 5 to 9 years crossing residential streets.

It is proposed that this relationship be applied to observed crossing patterns to establish the potential suppression of trips by unaccompanied children. The elderly and mobility disadvantaged may also be considered using the same model. Using the above relationship together with observed number crossing the road, the method allows consideration of existing severance.

6.5 Project Evaluation

6.5.1 Direct Costs

Project evaluation results in the monetorisation of impacts and the subsequent inclusion of these within the tangible Benefit/Cost assessment. From the above description, it is clear that only part of the severance impact has been developed to allow quantification in this way. For the effects of increased distance the travel time, costs may be calculated using the data in Table 17.

Table 17. Data for assessing the cost of pedestrian journeys.

Group	Walk Speed	Time Cost
Adult 13-65	5 km/h	Separate on the basis of the proportions working and non-working[1]
Adult accompany children	3 km/h	Valued at work rate[2]
Elderly >65	3 km/h	Non-work rate[3]
Children 5-12	3 km/h	Unknown[4]

[1] The proportion of work to non-work journeys may be established globally from the National Household Travel Survey (Ministry of Transport 1990).

[2] Time spent on domestic duties is valued at the working rate in the Project Evaluation Manual (Transit New Zealand 1995).

[3] It is assumed that the elderly >65 are non-working.

[4] Definition of a child is not currently provided in the Project Evaluation Manual.

The PEM is unclear as to whether or not a child has a separate value of time. Where a child's trip is the subject of a barrier effect the following may occur:

(a) The journey becomes an accompanied trip;
(b) A change of mode results; or
(c) The journey is suppressed.

If the journey becomes an accompanied trip, ie an adult walks with the child, the value should include the return journey at the adult working rate of $19.80 per hour (Transit New Zealand 1995). In the absence of specific data, the average walk time for a child (5-9) is 10 minutes taken from the National Household travel survey, (Ministry of Transport 1990). On returning, the adult walk speed is increased. The resulting cost increase for an accompanied journey is thus:

10/60 x $19.8 = $3.30 taking children to a destination
10/60 x 3/5 x $19.8 = $1.98 returning at a higher walk speed

= $5.28

For a child's average walking trip, the distance is approximately 500-800 m (Ministry of Transport 1990). A change of mode to a car trip may not be realistic for such a short trip. However for a mean speed of 30 km/h the vehicle cost is $0.29 per km, neglecting the additional costs associated with speed changes, the increased cost associated with vehicle running is:

2 x 0.5 km x $0.29 = $0.29

The journey time would be approximately 2 minutes but the time to "load up the car and get underway" could be of the order of 3 minutes at each end. This would give a total cost of 8 minutes which would amount to a further $2.64 for an adult charged at the value of work time. The total cost would then be $2.93. It is unlikely that a trip of this distance would be undertaken by car but the method shows how longer trips may be valued.

Although these calculations are at best approximate, they provide a method to value part of the severance effect. If it is assumed that children from 10 families were each to be accompanied to and from school each day the increased cost for a walking journey of 10 minutes would be $5.28 per trip. For 200 days per year the discounted value (NPV)[3] over the life of a project would be approximately

(10 families x 2 trips x $5.28 x 200) / 0.1 = $211,200

Given that the impact may be greater than the 10 persons used in this example, and that some elements have not been valued the inclusion of severance in project evaluation may be significant. The direct valuation method does not include any allowance for the additional congestion that may result.

6.5.2 Intangible Assessment

While the project assessment and evaluation stages quantify some severance impacts, the psychological aspects of severance are not be dealt with. These must remain as intangible factors. This does not mean that they should be excluded from the analysis and it is possible to give an indication of the severity of these effects and the numbers of persons affected. Measures such as perceived danger, pedestrian delay, or changes in trip length may all be used as indicators to assess the significance of, or to rank or weight, the feelings of being cut off.

For this reason, it is considered acceptable to assess components of severance using similar methods or measures for both the tangible and intangible evaluations. For example, where the direct cost of a pedestrian delay is quantified in monetary terms, based on a value of time and summed for all observed journeys. The same delay measure may be used to rank the

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[3] Nett Present Value assuming a discount rate of 10%

relative feelings of "cut offness" that may be felt by those who do not necessarily make a particular journey but who value the fact that they may have had the opportunity to do so. In most cases this is not double counting.

6.6 Outstanding Issues

The proposed method for valuing some components of social severance has been constructed from a review of a number of systems in an attempt to use the "best parts of each". There are, however, a number of elements that cannot be included due to incomplete data. These include:

- Issues of trip rates by purpose;
- Improved valuation by age;
- Trip length distribution issues to define catchments;
- The role of multiple crossing impacts;
- Amenity issues related to the effects of noise and fumes on pedestrians; and
- The effectiveness of possible mitigation measures.

While the method has been proposed, a test of its usefulness is required.

7. SUMMARY

Social severance is the term used to describe the effects that road traffic has on the social interaction within the "Community". The impact has been observed by many researchers and the existence and significance of severance is well recognised by the public and analysts. In the analysis of transportation projects the impact has received little attention due to the complex nature of the impact.

From a review of selected literature the following definition of social severance has been developed:

> *"...the divisive effects that result from the provision and use of transport infrastructure".*

The definition is considered to encompass three issues relating to social severance. Firstly that the communities that people are part of are far broader than those defined by geographic location and are formed around the activities that they take part in. Secondly, that the impact on activities within their community may be enhanced or reduced by the provision of, and use of, transport infrastructure and that some existing social severance may already be present in many situations. Thirdly, that social severance effects may be described in terms of two main mechanisms. Physical severance relates to the direct effect on trips that encounter a barrier and psychological severance that stems from feelings of being cut off.

Research has shown that the burden of severance impacts falls most heavily on those groups of low mobility for whom walking is the principal form of transport. These groups include children, the elderly and people with disabilities.

Although no single measure of social severance has been identified, a number of measures or indicators have been reported. These tend to target particular aspects of the severance effect. Measures that assess community cohesion and stability identify the potential for psychological severance. Measures of accessibility span both psychological severance as they consider the change in the opportunities available to people and at the same time consider the direct impact on journeys, which is a part of physical severance. Measures such as delay and perceived danger consider the impact of specific barriers that cause physical severance. It is important that in any assessment, the scope of what is included and excluded be identified in order to reduce concerns over double or under counting.

Physical severance effects are identified as being those most readily evaluated and the key components are seen as increases in journey costs, which are most likely to impact on "able bodied" adults, and the effects of perceived danger that will impact on sensitive groups such as children, the elderly and the mobility disadvantaged.

A pilot study used the question *"would you allow your child to cross the road unaccompanied at this location?"* as a means of measuring the perception of danger.

Two models have been formulated using the probability of a child being allowed to cross the road, unaccompanied, to the characteristic of the road and its traffic. The first of these may be used to identify areas where there is the potential for significant community concerns to develop. The second looks at the social severance effects of specific barriers. This model includes the significant variables of:

- Traffic flow; and
- The child's age.

The model may be used to investigate the effect changes in traffic volumes have on the mobility of children and to assess potential social severance effects. A similar model could be applied to the elderly and adults who are mobility disadvantaged.

From a consideration of the components of social severance, the available measures and a review of the assessment frameworks developed in Denmark, Sweden and the United Kingdom a framework of assessing severance suitable for use in New Zealand has been proposed. The key elements of this framework are the:

- Identification of the potential of social severance through the consideration of travel patterns and demands;

- Separation and valuation of the direct costs of some severance impacts which result from increased journey distances and times, together with the suppression of trips due to perceived danger; and

- The use of proxy measures to assess the remaining intangible components.

8. RECOMMENDATIONS

A number of issues raised in this study are considered worthy of further investigation:

- A trial of the proposed methodology should be undertaken to assess the usability and significance of the outcomes.
- Development of a method to include mitigation measures.
- An extension of the relationship to include four lane roads and those with 70 km/h and 100 km/h speed limits.
- A more in-depth analysis of trip length distribution and suppression of pedestrian trips by age and purpose.
- Further investigation into the assessment of psychological severance factors.
- Further investigation into the use of mental maps as a possible evaluation technique.
- Extension of the current relationship to explicitly cover the elderly and the adult mobility disadvantaged.

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APPENDIX 1. QUESTIONNAIRES

18/11/95

DEAR PARENT

As part of research into road safety and traffic management undertaken at the request of Transit New Zealand, I would appreciate your completing the following questionnaire.

The questionnaire should only take a few minutes of your time and we would appreciate your returning it to school this week.

This work and an exercise undertaken by the children in class, forms part of an investigation into the perception of roads and the safety of children when crossing. It is hoped that these results will lead to improved child road safety through more effective traffic management.

While I would appreciate as many responses as possible, I realise your time is a scarce resource. If you have more than one child attending the school, and do not feel you are able to complete more than one questionnaire, please fill out that supplied by the oldest child.

Should you have any questions regarding this survey please do not hesitate to call me on (04) 4717-012.

Thank you for your time spent in answering this questionnaire.

Fergus Tate

A. THE CHILD WHO BROUGHT HOME THIS FORM IS: [✓ MALE]/FEMALE
(PLEASE CIRCLE)

AGE AT LAST BIRTHDAY 10 MONTH OF LAST BIRTHDAY Febuary

B. TO WHICH ETHNIC GROUPS DOES YOUR CHILD RELATE:
European

C. HOW MANY CHILDREN OLDER THAN THIS CHILD LIVE IN YOUR HOME 2

D. HOW MANY VEHICLES ARE AVAILABLE FOR USE BY YOUR FAMILY:

NONE/ONE/[✓ TWO] OR MORE
(PLEASE CIRCLE)

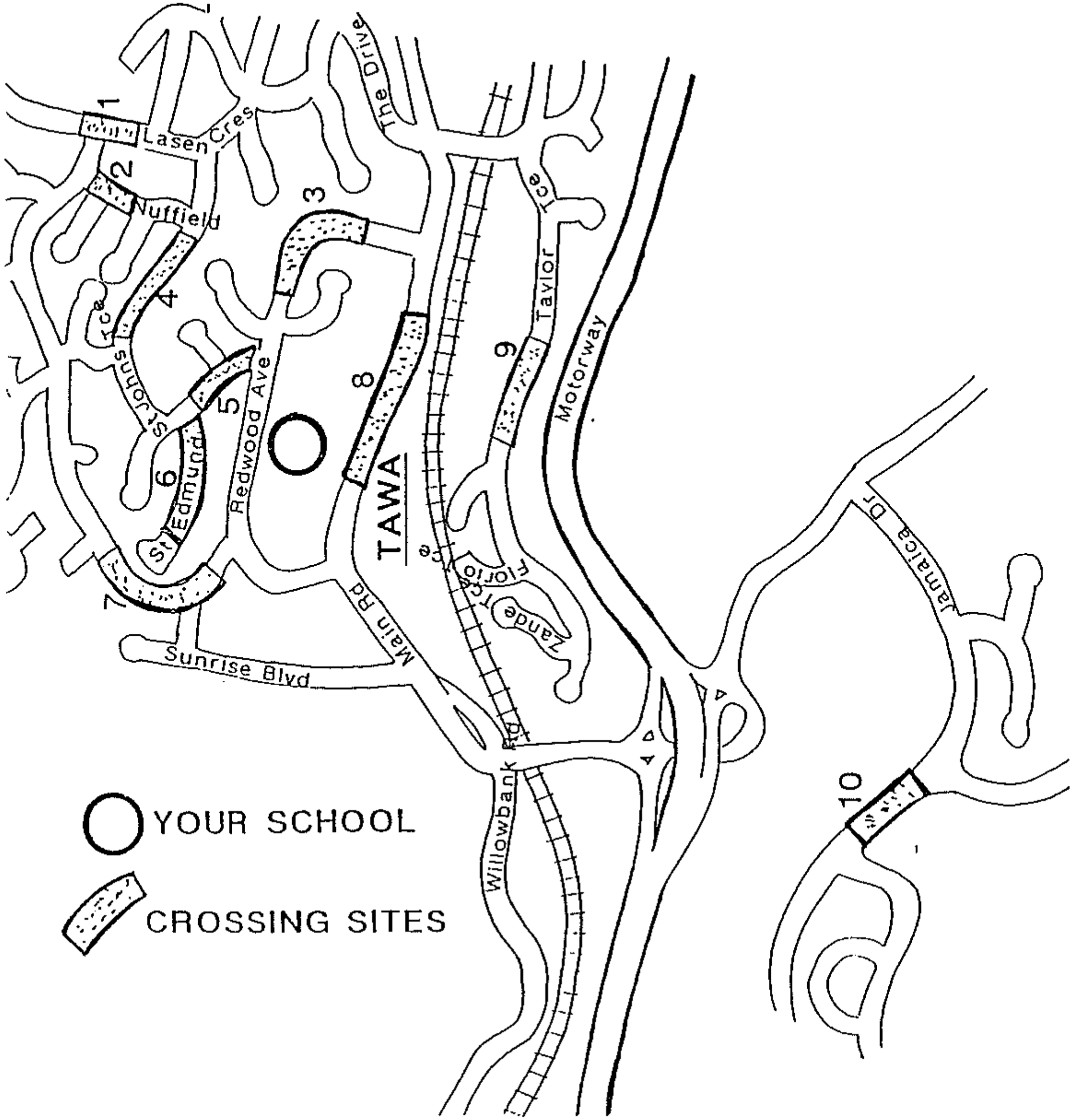
FOR EACH OF THE NUMBERED AREAS

PLEASE COMPLETE THE TABLE OVER THE PAGE

THANKS YOU FOR YOUR ASSISTANCE

PLEASE RETURN THIS TO SCHOOL WITH YOUR CHILD

20122



G. PLEASE COMPLETE THE FOLLOWING TABLE FOR EACH OF THE AREAS MARKED ON THE MAP OPPOSITE

AREA NUMBER	1	2	3	4	5	6	7	8	9	10
1. HOW WELL DO YOU KNOW EACH OF THESE AREAS (PLEASE TICK THE APPROPRIATE BOX)										
VERY WELL (PASS IT ONCE A DAY OR MORE)	✓						✓	✓		
WELL (PASS IT ONCE A WEEK OR MORE)			✓	✓	✓					
NOT VERY WELL (PASS IT ONCE A MONTH OR MORE)		✓			~~✓~~	✓		m	✓	
DO NOT KNOW THE AREA										✓

	1	2	3	4	5	6	7	8	9	10
2. ON THE SCALE 1 TO 5 WHAT DO YOU CONSIDER THE TRAFFIC SPEED IN THESE AREA TO BE: 1 VERY LIGHT 2 SLOW 3 MODERATE 4 FAST 5 VERY FAST	3	3	3	3	3	3	3	4	3	3
3. ON THE SCALE 1 TO 5 WHAT DO YOU CONSIDER THE TRAFFIC VOLUME IN THESE AREAS TO BE: 1 VERY LIGHT 2 LIGHT 3 MODERATE 4 HEAVY 5 VERY HEAVY	3	2	3	3	2.	2.	4	4		

	1	2	3	4	5	6	7	8	9	10
4A. WOULD YOU ALLOW YOUR CHILD TO CROSS THE ROAD WITHOUT BEING ACCOMPANIED BY AN ADULT IN THESE AREAS (Y/N)	Y	Y	Y	Y	Y	Y	Y	N	Y	
4B. IF NOT PLEASE WRITE THE NUMBER OF THE <u>ONE MAIN REASON WHY NOT</u> 1 TRAFFIC TOO FAST 2 TOO MUCH TRAFFIC 3 NOT ENOUGH VISIBILITY 4 TOO MANY HEAVY VEHICLES 5 OTHER (briefly note in box)								2		

THANK YOU FOR YOUR TIME ANSWERING THESE QUESTIONS

PLEASE RETURN THIS SURVEY TO THE SCHOOL

18/11/95

DEAR PARENT

As part of research into road safety and traffic management undertaken at the request of Transit New Zealand, I would appreciate your completing the following questionnaire.

The questionnaire should only take a few minutes of your time and we would appreciate your returning it to school this week.

This work and an exercise undertaken by the children in class, forms part of an investigation into the perception of roads and the safety of children when crossing. It is hoped that these results will lead to improved child road safety through more effective traffic management.

Should you have any questions regarding this survey please do not hesitate to call me on (04) 4717-012.

Thank you for your time spent in answering this questionnaire.

Fergus Tate

A. THE CHILD WHO BROUGHT HOME THIS FORM IS: [✓ MALE]/FEMALE
(PLEASE CIRCLE)

AGE AT LAST BIRTHDAY 10 MONTH OF LAST BIRTHDAY 9

B. TO WHICH ETHNIC GROUPS DOES YOUR CHILD RELATE:
Maori

C. HOW MANY CHILDREN OLDER THAN THIS CHILD LIVE IN YOUR HOME 3

D. HOW MANY VEHICLES ARE AVAILABLE FOR USE BY YOUR FAMILY:

NONE/[✓ ONE]/TWO OR MORE
(PLEASE CIRCLE)

FOR EACH OF THE NUMBERED AREAS

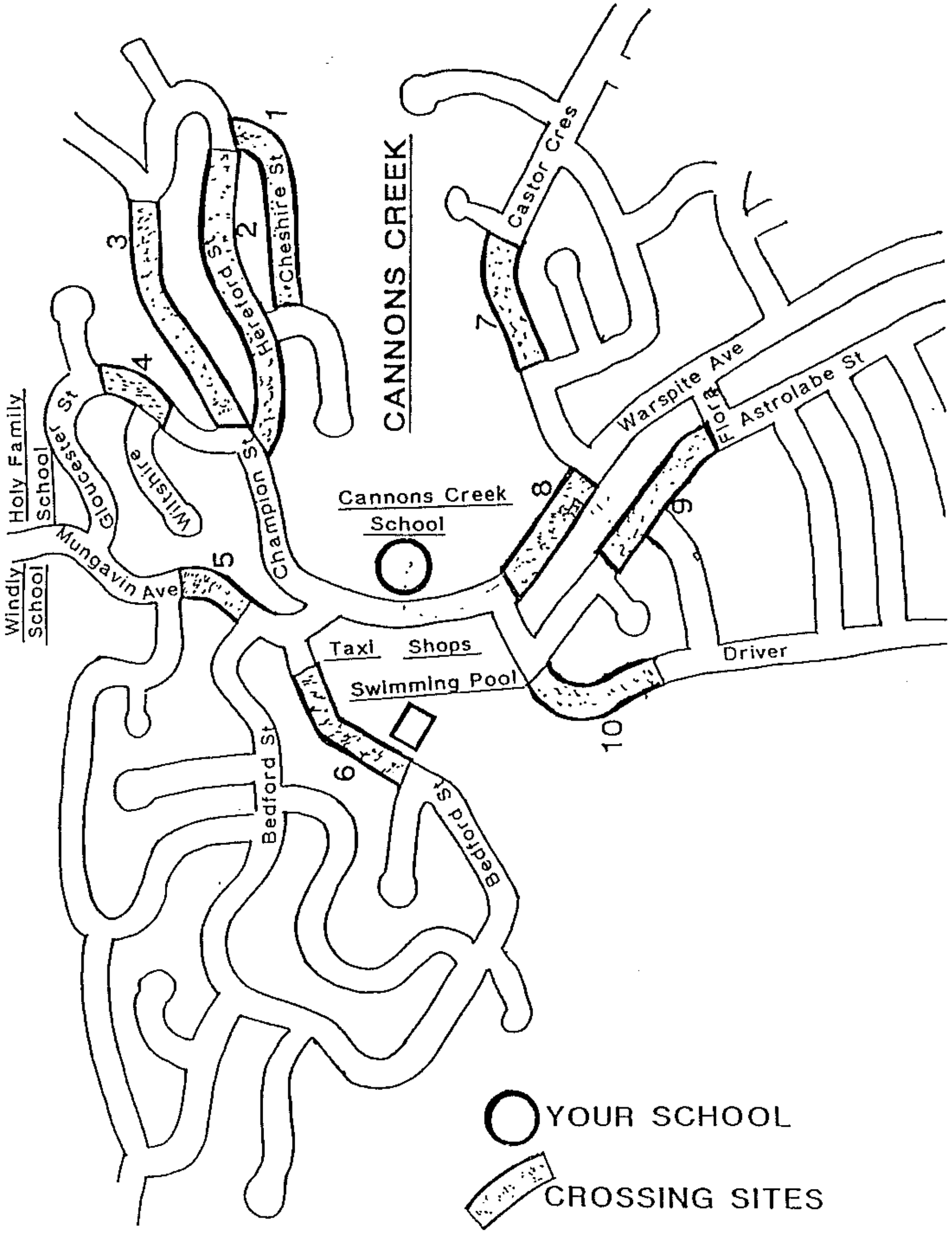
PLEASE COMPLETE THE TABLE OVER THE PAGE

THANKS YOU FOR YOUR ASSISTANCE

PLEASE RETURN THIS TO SCHOOL WITH YOUR CHILD

AS SOON AS POSSIBLE

30209



[illegible] COMPLETE THE FOLLOWING [illegible]
OPPOSITE

AREA NUMBER	1	2	3	4	5	6	7	8	9	10
1. HOW WELL DO YOU KNOW EACH OF THESE AREAS (PLEASE TICK THE APPROPRIATE BOX)										
VERY WELL (PASS IT ONCE A DAY OR MORE)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
WELL (PASS IT ONCE A WEEK OR MORE)										
NOT VERY WELL (PASS IT ONCE A MONTH OR MORE)										
DO NOT KNOW THE AREA										

2. ON THE SCALE 1 TO 5 WHAT DO YOU CONSIDER THE TRAFFIC SPEED IN THESE AREA TO BE: 1 VERY LIGHT, 2 SLOW, 3 MODERATE, 4 FAST, 5 VERY FAST	3	3	4	3	4	4	3	5	3	3
3. ON THE SCALE 1 TO 5 WHAT DO YOU CONSIDER THE TRAFFIC VOLUME IN THESE AREAS TO BE: 1 VERY LIGHT, 2 LIGHT, 3 MODERATE, 4 HEAVY, 5 VERY HEAVY	2	2	5	2	5	4	3	5	3	3

4A. WOULD YOU ALLOW YOUR CHILD TO CROSS THE ROAD WITHOUT BEING ACCOMPANIED BY AN ADULT IN THESE AREAS (Y/N)	Y	Y	N	Y	N	Y	Y	N	Y	Y
4B. IF NOT PLEASE WRITE THE NUMBER OF THE <u>ONE MAIN REASON WHY NOT</u> 1 TRAFFIC TOO FAST 2 TOO MUCH TRAFFIC 3 NOT ENOUGH VISIBILITY 4 TOO MANY HEAVY VEHICLES 5 OTHER (briefly note in box)	0	0	1 2 4	0	1 2 4	0	0	1 2 4	0	0

THANK YOU FOR YOUR TIME ANSWERING THESE QUESTIONS

PLEASE RETURN THIS SURVEY TO THE SCHOOL

18/11/95

DEAR PARENT

As part of research into road safety and traffic management undertaken at the request of Transit New Zealand, I would appreciate your completing the following questionnaire.

The questionnaire should only take a few minutes of your time and we would appreciate your returning it to school this week.

This work and an exercise undertaken by the children in class, forms part of an investigation into the perception of roads and the safety of children when crossing. It is hoped that these results will lead to improved child road safety through more effective traffic management.

Should you have any questions regarding this survey please do not hesitate to call me on (04) 4717-012.

Thank you for your time spent in answering this questionnaire.

Fergus Tate

A. THE CHILD WHO BROUGHT HOME THIS FORM IS: [✓ MALE]/FEMALE
(PLEASE CIRCLE)

AGE AT LAST BIRTHDAY 10 MONTH OF LAST BIRTHDAY 12

B. TO WHICH ETHNIC GROUPS DOES YOUR CHILD RELATE:
SAMOAN

C. HOW MANY CHILDREN OLDER THAN THIS CHILD LIVE IN YOUR HOME ONE

D. HOW MANY VEHICLES ARE AVAILABLE FOR USE BY YOUR FAMILY:

NONE/[✓ ONE]/TWO OR MORE
(PLEASE CIRCLE)

FOR EACH OF THE NUMBERED AREAS

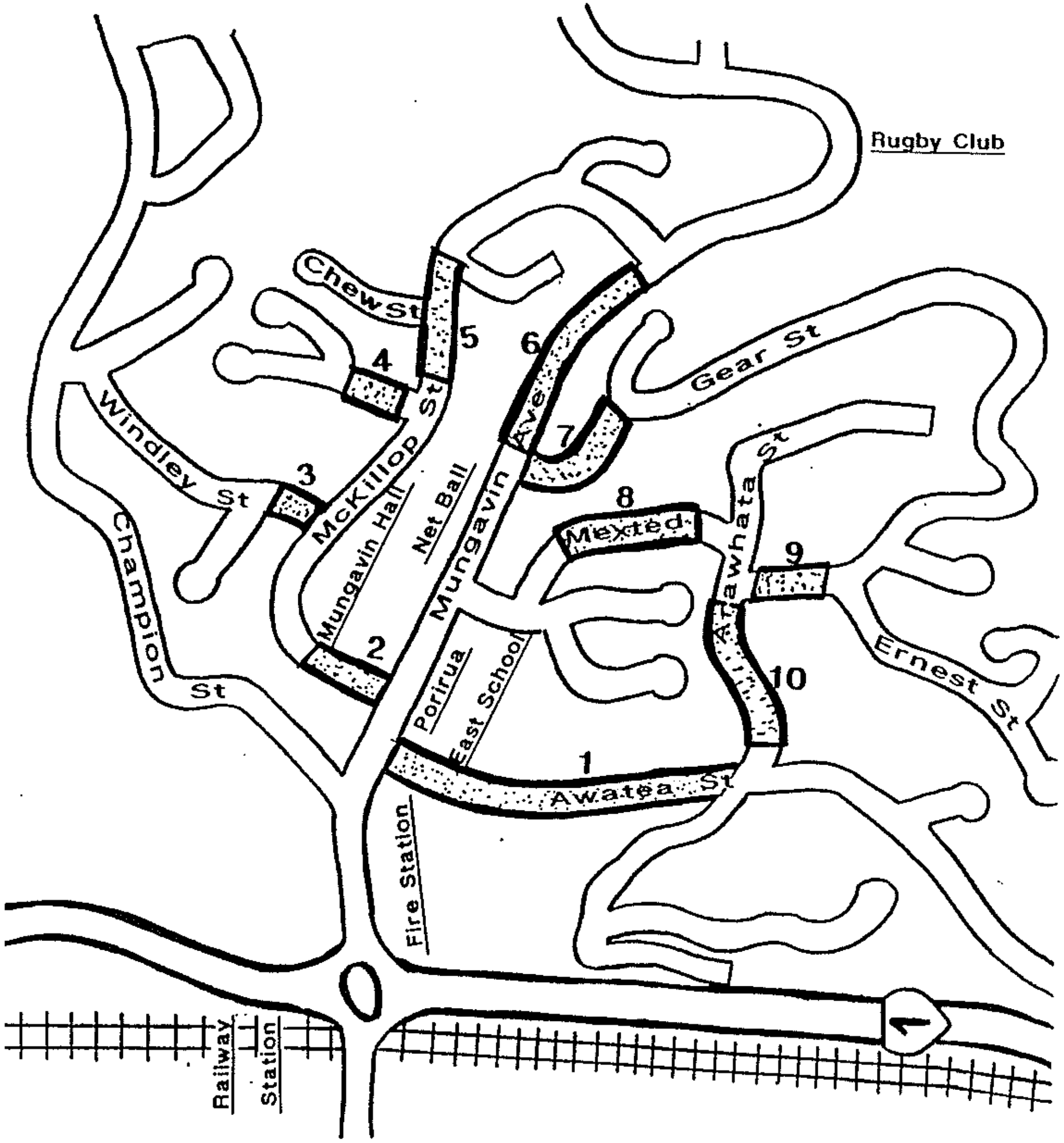
PLEASE COMPLETE THE TABLE OVER THE PAGE

THANKS YOU FOR YOUR ASSISTANCE

PLEASE RETURN THIS TO SCHOOL WITH YOUR CHILD

AS SOON AS POSSIBLE

10107



G. PLEASE COMPLETE THE FOLLOWING TABLE FOR EACH OF THE AREAS MARKED ON THE MAI OPPOSITE

AREA NUMBER	1	2	3	4	5	6	7	8	9	10
1. HOW WELL DO YOU KNOW EACH OF THESE AREAS (PLEASE TICK THE APPROPRIATE BOX)										
VERY WELL (PASS IT ONCE A DAY OR MORE)	✓	✓				✓	✓	✓		
WELL (PASS IT ONCE A WEEK OR MORE)									✓	✓
NOT VERY WELL (PASS IT ONCE A MONTH OR MORE)										
DO NOT KNOW THE AREA			✓	✓	✓					

2. ON THE SCALE 1 TO 5 WHAT DO YOU CONSIDER THE TRAFFIC SPEED IN THESE AREA TO BE: 1 VERY LIGHT 2 SLOW 3 MODERATE 4 FAST 5 VERY FAST	4	1				3	3	3	3	3
3. ON THE SCALE 1 TO 5 WHAT DO YOU CONSIDER THE TRAFFIC VOLUME IN THESE AREAS TO BE: 1 VERY LIGHT 2 LIGHT 3 MODERATE 4 HEAVY 5 VERY HEAVY	2	2				3	2	2	2	2

4A. WOULD YOU ALLOW YOUR CHILD TO CROSS THE ROAD WITHOUT BEING ACCOMPANIED BY AN ADULT IN THESE AREAS (Y/N)	Y	Y	DO NOT KNOW THE AREA →	→		Y	Y	Y	Y	Y
4B. IF NOT PLEASE WRITE THE NUMBER OF THE ONE MAIN REASON WHY NOT 1 TRAFFIC TOO FAST 2 TOO MUCH TRAFFIC 3 NOT ENOUGH VISIBILITY 4 TOO MANY HEAVY VEHICLES 5 OTHER (briefly note in box)										

THANK YOU FOR YOUR TIME ANSWERING THESE QUESTIONS

PLEASE RETURN THIS SURVEY TO THE SCHOOL

My child is almost 11 yrs old and aware of safety when crossing roads. Younger children however, depending on individual awareness and degree of responsibility may or may not feel confident crossing these roads. Particularly around Gear, Awatea, Arawhata, Mexted where traffic will come down hills quite fast sometimes and visibility is not always sufficient because traffic maybe coming around curves, children not being supervised by adults need to be particularly conscious of

APPENDIX 2.   SITE DATA

APPENDIX C **ROAD SECTION DATA**

SCHOOL	Site	Road 1	Road 2	Road 3	Road 4	Road 5	Road 6	Road 7	Road 8	Road 9	Road 10
Porirua East School	%HCV	3.82	9.34	2.70	4.02	2.89	7.63	3.47	2.51	4.07	3.69
	Speed %iles (kph)										
	10%	38.70	30.00	27.06	22.08	33.64	42.85	31.30	38.70	34.95	30.00
	20%	43.37	39.56	30.25	27.48	37.89	48.64	34.61	42.35	38.29	33.02
	30%	46.15	43.90	33.02	31.30	41.37	50.70	36.00	44.44	40.90	35.64
	40%	48.00	46.75	34.95	34.28	43.90	52.94	37.50	46.15	42.85	37.89
	50%	50.00	49.31	37.11	36.73	46.15	54.54	38.70	48.00	44.44	39.56
	60%	52.17	51.42	38.70	38.70	48.64	56.25	40.00	49.31	46.75	41.37
	70%	54.54	52.94	40.90	41.37	51.42	58.06	41.37	51.42	48.64	43.37
	80%	57.14	55.38	42.85	43.90	54.54	61.01	43.37	53.73	51.42	45.56
	90%	61.01	59.01	46.75	48.00	60.00	64.28	45.56	57.14	54.54	48.64
	100%	180.00	112.50	70.58	120.00	112.50	189.47	75.00	78.26	128.57	73.45
	Mean Speed	49.82	47.01	36.75	35.78	46.47	53.97	38.59	47.69	44.67	39.60
	Harmonic Mean Speed	46.20	40.56	34.31	31.59	42.98	51.37	37.34	45.75	42.95	37.85
	Average Weekday Traffic	3,137	1,536	627	384	836	8,591	1,086	832	1,376	1,425
	AM Peak	235	114	56	33	67	605	78	88	117	113
	PM Peak	336	146	63	40	85	719	111	84	145	149
Redwood School	%HCV	2.91	7.42	2.61	3.34	9.85	3.67	9.71	13.20	2.92	3.15
	Speed %iles (kph)										
	10%	25.17	21.95	38.70	28.12	28.34	26.47	29.26	37.89	37.50	44.44
	20%	27.27	27.06	42.85	33.64	37.50	32.72	40.00	48.00	44.44	48.64
	30%	29.03	30.25	45.00	37.50	40.44	36.36	44.44	51.42	48.00	51.42
	40%	30.50	33.02	46.75	40.44	42.85	38.70	47.36	53.73	50.70	54.54
	50%	32.14	35.64	48.64	43.37	45.00	40.90	49.31	55.38	52.94	56.25
	60%	33.64	37.89	50.70	45.56	46.75	43.37	51.42	57.14	55.38	59.01
	70%	37.11	40.44	52.17	47.36	48.64	45.56	53.73	59.01	58.06	61.01
	80%	44.44	43.37	54.54	50.00	51.42	48.64	56.25	61.01	61.01	64.29
	90%	52.17	47.36	59.01	54.54	54.54	52.17	59.01	64.28	66.66	67.92
	100%	128.57	69.23	156.52	102.85	92.30	87.80	133.33	189.47	150.00	100.00
	Mean Speed	35.37	35.19	48.52	42.05	43.27	40.08	47.44	53.72	52.19	56.12
	Harmonic Mean Speed	32.64	31.30	46.17	36.65	38.76	35.20	43.85	50.44	47.14	53.81
	Average Weekday Traffic	1,267	172	1,750	463	1,281	271	1,451	13,880	15	841
	AM Peak	74	19	210	46	143	24	157	1,206	6	105
	PM Peak	151	26	187	66	154	32	162	1,273	3	98
Cannon Creek School	%HCV	4.05	6.85	7.44	3.56	6.70	5.53	3.65	8.96	2.47	3.39
	Speed %iles (kph)										
	10%	20.45	21.30	45.00	25.35	33.02	30.00	35.29	36.73	30.25	35.64
	20%	26.86	25.35	50.70	29.03	36.73	34.61	41.86	42.35	35.64	39.56
	30%	32.43	27.48	52.94	31.85	39.13	37.50	45.00	45.56	36.70	41.86
	40%	35.29	29.50	54.54	33.96	40.90	40.00	48.00	47.36	41.37	43.90
	50%	37.89	31.57	56.25	35.64	42.85	41.86	50.70	49.31	43.37	45.56
	60%	40.00	33.96	58.06	37.50	44.44	43.37	52.94	51.42	45.56	47.36
	70%	42.35	37.11	60.00	39.13	46.15	45.56	55.38	52.94	48.00	49.31
	80%	45.00	40.90	62.06	41.37	48.00	48.00	58.06	55.38	50.70	51.42
	90%	48.00	45.56	65.45	44.44	51.42	50.70	62.06	59.01	55.38	54.54
	100%	67.92	97.29	144.00	64.28	171.42	83.72	189.47	189.47	100.00	156.52
	Mean Speed	36.11	32.70	55.51	35.27	42.53	40.91	49.40	48.71	42.99	45.41
	Harmonic Mean Speed	31.12	29.30	53.22	32.77	40.40	37.67	45.05	46.45	39.73	43.61
	Average Weekday Traffic	241	863	7,693	578	6,983	1,992	1,365	11,757	922	1,931
	AM Peak	20	66	576	60	541	127	90	805	71	228
	PM Peak	27	86	632	61	576	198	131	1,046	88	210