ENVIRONMENTAL SENSITIVITY OF ARTERIAL ROADS

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ABSTRACT:

The development and application of arterial road management procedures utilises the full range of skills employed by the modern traffic engineer. For many years now, practitioners have attempted to include environmental issues in the decision matrix employed in this process. The Environmental Capacity concept was seen at one time as providing the basis for the logical selection of management procedures; more recently, the Victorian Road/Amenity Classification procedure has gained favour with some parties because of its simplicity of application.

This paper describes some recent work in the development of the concept of Environmental Sensitivity Measures and their application to road classification and arterial road management and monitoring tasks in N.S.W., Western Australia and Victoria. A simple methodology is outlined which combines ease of application with a quantitative basis; the procedure has been recently applied in Leichhardt, N.S.W. and the concept is illustrated by a description of this application.

INTRODUCTION

Arterial Road Management

The development of management plans for the arterial road network should ideally take place within an agreed framework of road classification as to function and management responsibility. Once all roads have been classified, traffic management strategies and implementation plans may be developed which take into account the function and characteristics of each road. These strategies will have as their general objectives the provision of adequate capacity and accessibility for "through" traffic demands and local access and egress. The road framework so developed will provide for the implementation of local area traffic management (LATM) strategies and for the appropriate location and orderly plannning of traffic generating land uses.

The development of a **road classification** or **road hierarchy** is therefore a fundamental pre-requisite to the application of arterial road management plans: the correct classification will assign road management responsibilities and provide guidance on appropriate traffic management strategies.

Road classification procedures require an agreed classification system and the application of a rational process for the identification of an appropriate main road network. It is to the latter that consideration of **environmental or amenity sensitivity** issues will make a contribution and, whilst it is not the intention of this paper to describe appropriate road classification methodologies, some brief comment is appropriate.

Figure 1 illustrates a road hierarchy or classification procedure adopted by Ove Arup Transportation Planning in studies in N.S.W., Western Australia and Victoria, in which the assessment of network environmental sensitivity to traffic plays an important part in the review of existing main road system or de facto road hierarchy.

This review and knowledge of future land development proposals and their access requirements enables a road hierarchy plan to be developed. Environmental effects assessments undertaken as an input to this plan ensure either that the plan is responsive to the environmental sensitivities of the road network or that the likely environmental effects, their locations and their relative intensities are identified.

ENVIRONMENTAL SENSITIVITY OF ARTERIAL ROADS

Environmental or Amenity Sensitivity

Investigations by various researchers have identified a number of potential effects of traffic on the surrounding environment:

- Traffic noise
- Traffic induced vibration
- Air pollution
- Reduced pedestrian safety
- Reduced pedestrian crossing opportunities
- Visual intrusion
- Social disruption/severance
- Reduced accessibility

The physical and land use characteristics of particular road links may be used to provide measures of the sensitivity of those links to traffic induced environmental effects of various types. These measures of link sensitivity may then be used to provide an important input to decision-making concerning the selection of primary and secondary arterial roads and the identification of environmental conflict points and their causes. This paper describes some recent work in the development of such measures, against a background of past initiatives in this field and illustrated by the description of their practical application in a Road Hierarchy Study for the Municipality of Leichhardt in New South Wales (Ove Arup Transportation Planning, 1983).

The objectives of such a methodology may be summarised as follows: "to provide a means for the simple and (to the greatest possible extent) objective assessment of the environmental effects of traffic or the sensitivity of the road network to such effects". It is proposed that measures of road link sensitivity be developed, in order that the effects of a range of traffic situations may be assessed. Rather than the environmental effects of particular traffic movements on a specified road link being determined, (and this analysis repeated for other levels of traffic activity), the sensitivity of the link to traffic is assessed in accordance with various criteria. This approach is similar to that used in the Environmental Capacity concept (see below) and, in situations where detailed quantitative analysis is warranted, this method may continue to be applied. However, in less demanding situations, application of the Environmental Sensitivity Methodology will be appropriate.

REVIEW OF THE STATE OF THE ART

Introduction

Research into the measurement of the environmental effects of traffic has been underway in several countries for many years. It is beyond the scope of this paper to thoroughly describe the significant features of this research but two key initiatives, the Environmental Capacity concept and the Road/Amenity Classification procedure may be briefly described.(1)

Road/Amenity Classification

This approach to the classification of roads was developed in the course of the Bayside Councils Corridor Traffic Study, Road Safety & Traffic Authority and Ministry of Transport, Victoria, 1978-80, (Chandler & Saggers, 1979).

The procedure takes account of the environmental effects of traffic by rating the sensitivity of the road system to such effects : the Amenity Classification. Initially developed simply on the basis of the potential level of conflict as indicated by frontage land use, the system was later refined to incorporate the determination of a Composite Sensitivity Index. This index represented the aggregation of measures of the:

a. Noise-Vibration Pollution Sensitivity of the frontage land use

b. Crossing Expectations and Requirements likely to exist along the road

Both sensitivities were scored on a scale of 1 to 5 and the scores combined to give a Sensitivity Index ranging from "insensitive" (1) to "highly sensitive" (10).

The scoring procedure is essentially judgemental, with roads being assessed in terms of their frontage land use: time and duration of sensitivity, number of activities and people affected etc., and in terms of their safety for pedestrians/cyclists and the level of such activity attracted by land use along the road.

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1 A comprehensive literature review and bibliography prepared in 1980 is contained in "Environmental Capacity", Ove Arup Transportation Planning and Planning Collaborative, 1980.

ENVIRONMENTAL SENSITIVITY OF ARTERIAL ROADS

Environmental Capacity

The concept of a street's Environmental Capacity (EC) was first developed by Colin Buchanan in 1963 and much of the research in the area has occurred in the United Kingdom.

In 1980, preliminary Australian research was further developed in a study undertaken for the Cities of Collingwood and Fitzroy, Victoria (Ove Arup Transportation Planning & Planning Collaborative, 1980). The extensive literature review undertaken at that time indicated that U.K. researchers had refined the "long list" of potential traffic effects to the following: traffic noise, pedestrian effects (delay, crossing and footpath density) and visual intrusion. The Melbourne work added air pollution to the "short list" of potential effects, a decision supported by the work of other researchers who had identified and ranked those traffic influences causing community concern: danger to pedestrians, difficulty in crossing the road, noise both inside and outside buildings, vibration, dust and dirt and the visual effect of parked and moving vehicles. Subsequently the Melbourne research identified **Traffic Noise** and **Effects on the Pedestrian Environment** as the primary assessement criteria.

The Environmental Capacity of a street was defined as "the maximum number of vehicles (and associated 50th percentile speed and proportion of heavy vehicles) that may pass along the street in a certain time period and under fixed physical conditions without causing environmental detriment". EC values were calculated in accordance with two criteria: traffic noise and effects on pedestrians and against two standards: critical and desirable.

Physical characteristics of the street were used to calculate those traffic volumes (and conditions of flow) or EC which would generate noise at the property line at a critical level or which would provide an unacceptable level of pedestrian conflict or crossing delay.

An Environmental Deficiency Index (EDI) was then calculated which related current or future traffic to the street's EC (EDI = Vol ÷ EC); where the EDI exceeded 1.0, environmental degradation existed.

The EC procedure is essentially quantitative, using predictive "models" and accepted measures of critical effects to calculate acceptable traffic volumes. The system is relatively "data hungry" and the calculation stages somewhat time consuming; the procedure would however be amenable to computerisation.

Comparison

Both procedures use traffic noise and effects on the pedestrian environment to assess the sensitivity of the road network to traffic. The Amenity Sensitivity Assessment component of the Road/ Amenity Classification is relatively easily applied, requiring little by way of data collection. However, the procedure is essentially judgemental in its application and does not lead to a detailed understanding of likely environmental influences of traffic on the subject network.

The EC approach, by comparison, is relatively rigorous in its application, requiring a detailed inventory of the street system and fairly lengthy numerical analysis. A more easily justified, quantified sensitivity assessment results but at the expense of considerable time and effort. Furthermore, the calculation of traffic volume limits (the street's Environmental Capacity) to a high level of numerical exactitude may imply a certainty of conclusion which is misplaced, given the wide range of community views on "acceptable" levels of the various criteria.

In approaching recent road classification studies, we have therefore sought to develop an environmental effects assessment procedure which lies somewhere between the ease of application of the Road Amenity Classification and the quantified rigour of the Environmental Capacity concept: the Environmental Sensitivity Method.

THE ENVIRONMENTAL SENSITIVITY METHOD

Introduction

The Environmental Sensitivity Method was developed by Ove Arup Transportation Planning in 1983 in response to the needs of road hierarchy planning studies being undertaken at that time. Our intention was to produce an objective but simply applied measure of the sensitivity of the road network to traffic effects.

Previous work on the Environmental Capacity concept was used as a starting point and knowledge gained in the development and application of that technique proved invaluable in providing information concerning the quantitative relationships between traffic volume and the various environmental effects. This was particularly useful when selecting the scales of measurement for the various environmental sensitivity measures.

Furthermore, experience with the EC research assisted in the identification of Environmental Sensitivity Variables or criteria, particularly in terms of their perceived "importance" and of their sensitivity to varying traffic conditions. (As the objective of the procedure was to provide a means of comparing alternative road links or

routes in terms of their environmental sensitivity or to assess the level of traffic effect on a particular route, the adoption of criteria having a low sensitivity to change in traffic volumes would have been unproductive).

The methodology developed is described below and represented in flow chart format in Figure 2. Each stage of the methodology is illustrated in terms of its recent application in the Leichhardt Road Hierarchy Study.

Selection of Environmental Sensitivity Variables and Sub-Variables

A number of possible effects of traffic on the surrounding environment have been identified above.

Previous experience indicates that noise sensitivity and pedestrian environment effects will be important in all applications of the method; in particular situations, additional criteria may be adopted.

The selection of appropriate Environmental Sensitivity Variables is dependent upon their appropriateness to the environment under study, their ease of measurement and their potential to encapsulate other relevant effects i.e. to act as a proxy for other criteria.

In the Leichhardt Study, the variables selected were:

- Difficulty of Access - difficulty of gaining access to the particular land use, considered a function of: land use, parking availability on road and availability of front or rear access to land use.

  In Leichhardt, the dense urban environment and the high intensity of control on car parking and vehicular access to frontages make Difficulty of Access an important measure of environmental sensitivity

- Pedestrian Safety - difficulty/danger for pedestrians using and crossing the road, considered a function of: width of footpath, walked road width (between pedestrian refuges) and availability of pedestrian facilities (median, islands, crossings, subways, etc).

  Pedestrian Safety may be considered a proxy for severance effects, as the degree of severance will be directly related to crossing difficulty or damage.

- Noise Sensitivity - sensitivity to traffic generated noise, considered a function of: existence of a building facade opposite, the grade of the road and the setback of the property.

  Noise Sensitivity may be considered a proxy for traffic induced vibration and air pollution effects.

Within each Sensitivity Variable, a number of sub-variables may be identified. Measurement of link sensitivity according to these sub-variables is carried out through the Road and Land Use Inventory and these assessments combined to provide an overall ranking of each link according to each of the three Sensitivity Criteria.

Sub-variables and their scales of measurement adopted in the Leichhardt Study are listed in Table 1. The latter were based on experience gained in previous research and a preliminary land use/road inventory of the area.

Division of Road Network into Links

The road network to be assessed is divided into links for the purposes of the inventory of physical characteristics. Links are identified on the basis of:

- the spacing and complexity of road junctions
- the homogeneity of frontage land use
- resultant link lengths by comparision to the total length of road to be studied

Within Leichhardt, only the major roads (arterial and sub-arterial status) were assessed; this road network is illustrated in Figure 3. The diversity of land use within the municipality led to the selection of relatively short links in some areas; in other locations, comparable land uses were recognised and a degree of averaging of land use sensitivity accepted such that longer links could be adopted. The Leichhardt network consisted of 51 links.

Road and Land Use Inventory

Each link of the network is inventoried in order to collect the data necessary to carry out environmental sensitivity assessment in accordance with the selected Variables and sub-variables. The inventory may be carried out by field staff, employed on a casual basis, who may also be required to collect information on traffic control devices and management systems of general interest to the study team.

Data collection is undertaken for each side of the road within each link and will include such items as:

- Frontage land uses
- Setback of properties from property boundary
- Parking availability and demand
- Type and arrangement of property access
- Building orientation - facing towards/away from road
- Road gradient
- Road width and lane configuration, footpath width
- Pedestrian facilities - crossings, light phases, overbridges, etc.
- Estimated speed of traffic
- Availability of public transport - bus stops, railway stations, etc.

In the Leichhardt Study, the inventory was undertaken so as to provide the data necessary to complete Table 1; the entire survey (of 51 links) took 8 man days to complete. A typical inventory sheet is illustrated in Figure 4.

Combination of Sub-Variable Sensitivity Assessments

The results of the sub-variable sensitivity assessments are combined (within each Sensitivity Variable) to provide an assessment of the environmental sensitivity of each link in accordance with the specified criteria. The allocation of sensitivity categories to particular combinations of sub-variable "scores" may be undertaken on an essentially judgemental basis or be the subject of extensive quantitative assessment. However, in general it is considered appropriate that the planner(s) provide a qualitative assessment based on knowledge of environmental sensitivity influences and the particular characteristics of the study area.

In Leichhardt, the combination of sub-variable scores was carried out in accordance with the system illustrated in Table 2. The composition of this table was independently reviewed by various members of the study team and the client's planning staff. Comparison of the various combination systems indicated only minor variations in judgement and a compromise assessment was agreed and used in the study. Valuable understanding of the environmental issues relevant to particular areas and types of road and effect was developed in the course of this process.

TABLE 1: ENVIRONMENTAL SENSITIVITY SUB-VARIABLE SCALES

Difficulty of Access

Access	1)	Frontage access generally available
	2)	Rear access available but frontage access restricted
	3)	No immediate access to site.
Parking Restrictions	Low	- limited areas of no-standing, generally no restrictions on on-street parking
	Medium	- some peak hour bans or limited duration parking controls
	High	- no standing or clearway controls at least 4 hrs/day
Land Use	1)	Residential/School/Hospital
	2)	Retail/Commercial/Office
	3)	Industrial- (light or heavy)

Pedestrian Safety

Pedestrian Facilities	No -	Non-provision generally assumed
	Yes -	Existence of some facilities: medians, islands, crossings, ped. phase at traffic signals etc.
'Walked' Road Width	Narrow	- < two traffic lanes
	Wide	- ≥ two traffic lanes
Footpath Width	Narrow	- < 3 m
	Wide	- ≥ 3 m

Noise Sensitivity

Opposite Facade	Yes -	Existence of opposite facade generally assumed
	No -	If park/open space opposite etc.
Grade	Low	- slight or flat < 5%
	High	- medium or steep ≥ 5%
Setback (of building from property boundary)	Small	< 2 m
	Medium	2 - 6 m
	Large	≥ 6 m
Land Use	1)	Residential/School/Hospital
	2)	Retail/Commercial/Office/Park
	3)	Industrial (light or heavy)/Railway

Sensitivity Assessment of Road Links

Following the development of the sub-variable scales of measurement (Table 1), the sensitivity combination system (Table 2) and the conduct of the road and land use inventory, the allocation of environmental sensitivities to each road link is a straight-forward process:

(Step 1) From inventory, note "value" of each sub-variable for each side of each road link

(Step 2) From Table 1, note "score" of each sub-variable

(Step 3) Using Table 2, record the combined environmental sensitivity in accordance with each criterion

In the Leichhardt Study, compatibility of land use and other characteristics on both sides of the road allowed the amalgamation of results to provide a single measure (against each criterion) for each link. A note of caution should however be sounded; amalgamation of land use characteristics may overlook the specific requirements of particular sites e.g. a kindergarten located in a residential street.

A review of these results should then be undertaken and reassessment may be required where environmental sensitivity predictions do not accord with reality. In the Leichhardt Study, such reassessment was necessary where the adoption of longer link lengths had obscured the effects of localised land use differences.

Plotting of Sensitivity Measures

On determination of the Environmental Sensitivities of the network, it is useful to prepare graphical plots indicating network sensitivity by link for each criterion.

Figures 5, 6 & 7 illustrate the plots of environmental sensitivity with respect to Difficulty of Access, Pedestrian Safety and Traffic-induced Noise for the Leichhardt main road network.

Applications of the Environmental Sensitivty Method

Measures of the relative environmental sensitivity of links in the main road network may be used to:

- compare alternative hierarchical road patterns and classifications, such that the optimum road hierarchy may be developed for an area

TABLE 2: COMBINATION OF ENVIRONMENTAL SENSITIVITY SUB-VARIABLE SCORES

Difficulty of Access

Access Availability	Parking Restrictions	Land Use 1	2	3
Front 1	Low	L	L	L
	Medium	L	M	L
	High	M	H	M
Rear 2	Low	M	M	L
	Med	M	M	M
	High	H	H	M
No Immediate Access 3	Low	M	M	H
	Med	H	H	H
	High	H	H	H

Pedestrian Safety

Walked Road Width	Footpath Width	Pedestrian Facilities: Yes	No
Wide	narrow	H	H
	wide	M	H
Narrow	narrow	M	M
	wide	L	M

Noise Sensitivity

		Road Gradient: LOW Setback			HIGH Setback		
	Land Use	Small	Med	Large	Small	Med	Large
Opposite Facade	1	H	H	M	H	H	H
	2	H	M	M	H	H	M
	3	M	L	L	M	L	L
No Opposite Facade	1	H	H	M	H	H	H
	2	H	M	L	H	M	M
	3	L	L	L	L	L	L

Legend

Sensitivity: L = Low, M = Medium, H = High

Land Use: 1 Residential/School/Hospital; 2 Retail/Commercial/Office/Park; 3 Industry/Railway

- provide traffic managers and planners with guidance as to the appropriate management measures to be applied to particular road links in the network. These management measures may range from short term actions, (e.g. the provision of a pedestrian crossing facilities) to longer term strategies involving changes in land use

In the Leichhardt Study, knowledge of the environmental sensitivities of the main road network enabled short, medium and long term road hierarchy plans and traffic management strategies to be developed.

CONCLUSIONS

The Environmental Sensitivity Method is considered a practical solution to the need for an environmental assessment technique for use in arterial road management and road hierarchy planning. The methodology lies midway in complexity between the simplicity of the Road/Amenity Classification procedure and the detailed analysis required by the Environmental Capacity concept and combines some of the advantages of the latter (in terms of comprehensiveness) with the ease of application of the former.

Data collection requirements are straightforward and generally involve information regularly used in traffic management studies (although not often comprehensively collected). It is therefore suggested that the additional resource costs involved in applying the methodology are relatively small and more than outweighed by the benefits resulting from the availability of environmental sensitivity assessments for the complete road network.

Application of the method allows the user to develop a thorough understanding of the sensitivity of the road network to traffic effects at a local level; the shorter the links used, the more detailed this understanding will be. Potential problem locations are identified and, by reference to the inventory, detailed information on the relevant physical characteristics of the area is available. In this way, the selection of the "correct" main road classification is assisted and the location of likely conflict points and appropriate types of management actions identified. Furthermore, the likely cause(s) of the environmental problem are known in relatively fine detail.

Experience with the use of the methodology indicates that the greatest benefits will be gained when it is applied in older street networks, particularly those of a grid pattern, where the selection of one street from many apparently similar routes is required. However, in newer areas knowledge of main road network environmental sensitivity will be useful in enabling future environmental conflict points to be identified.

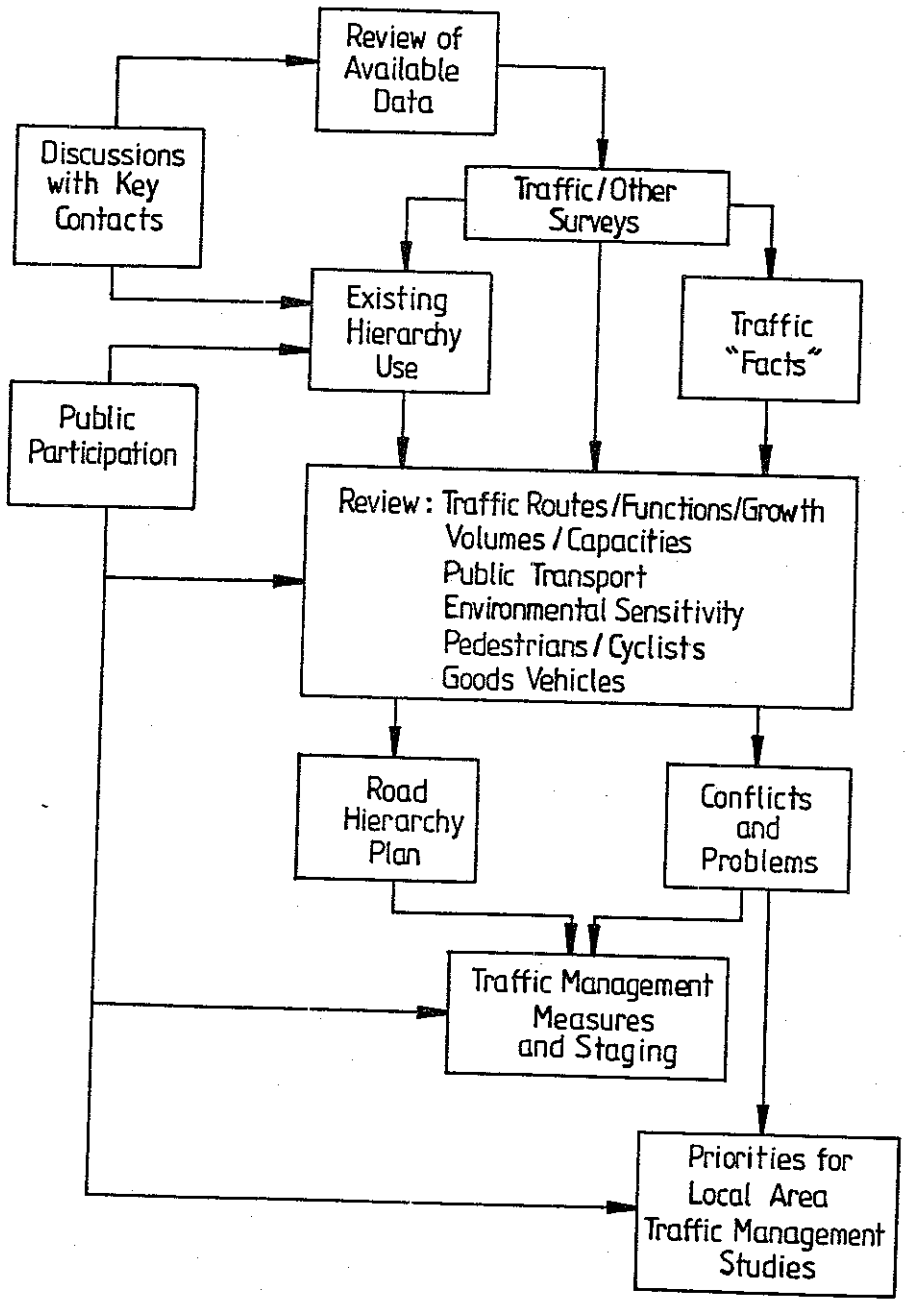


Figure 1: Road Classification Methodology

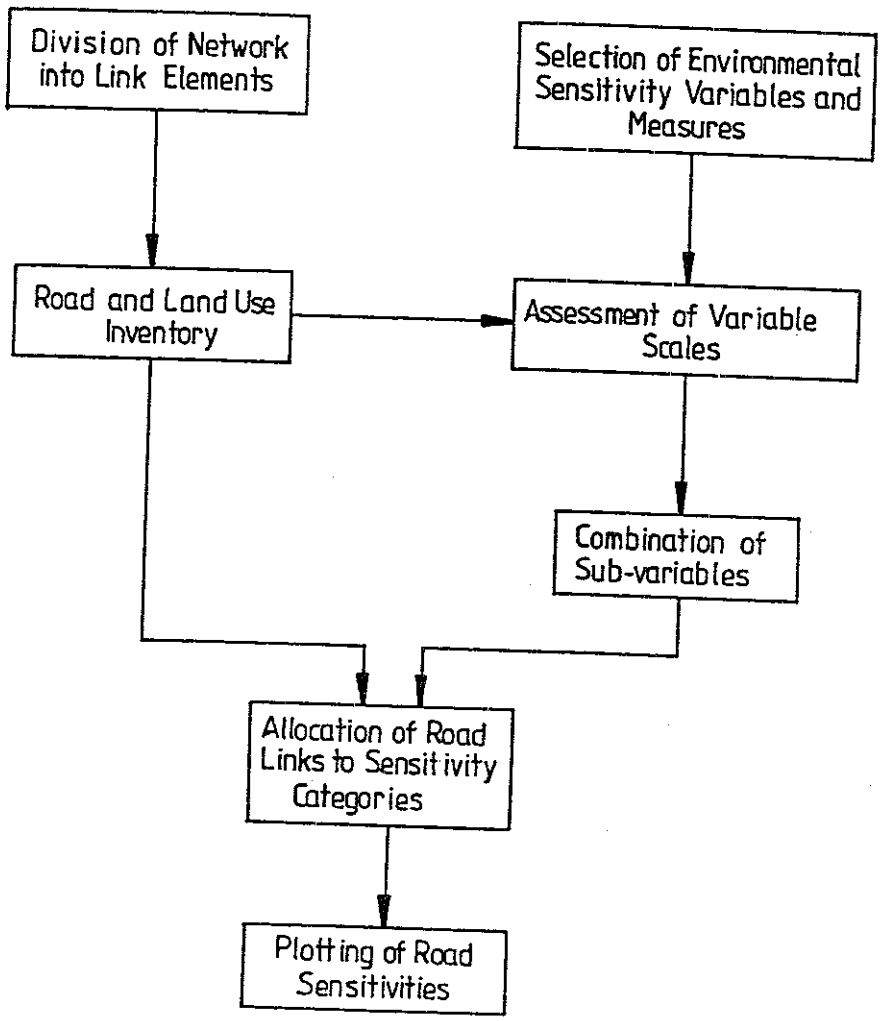
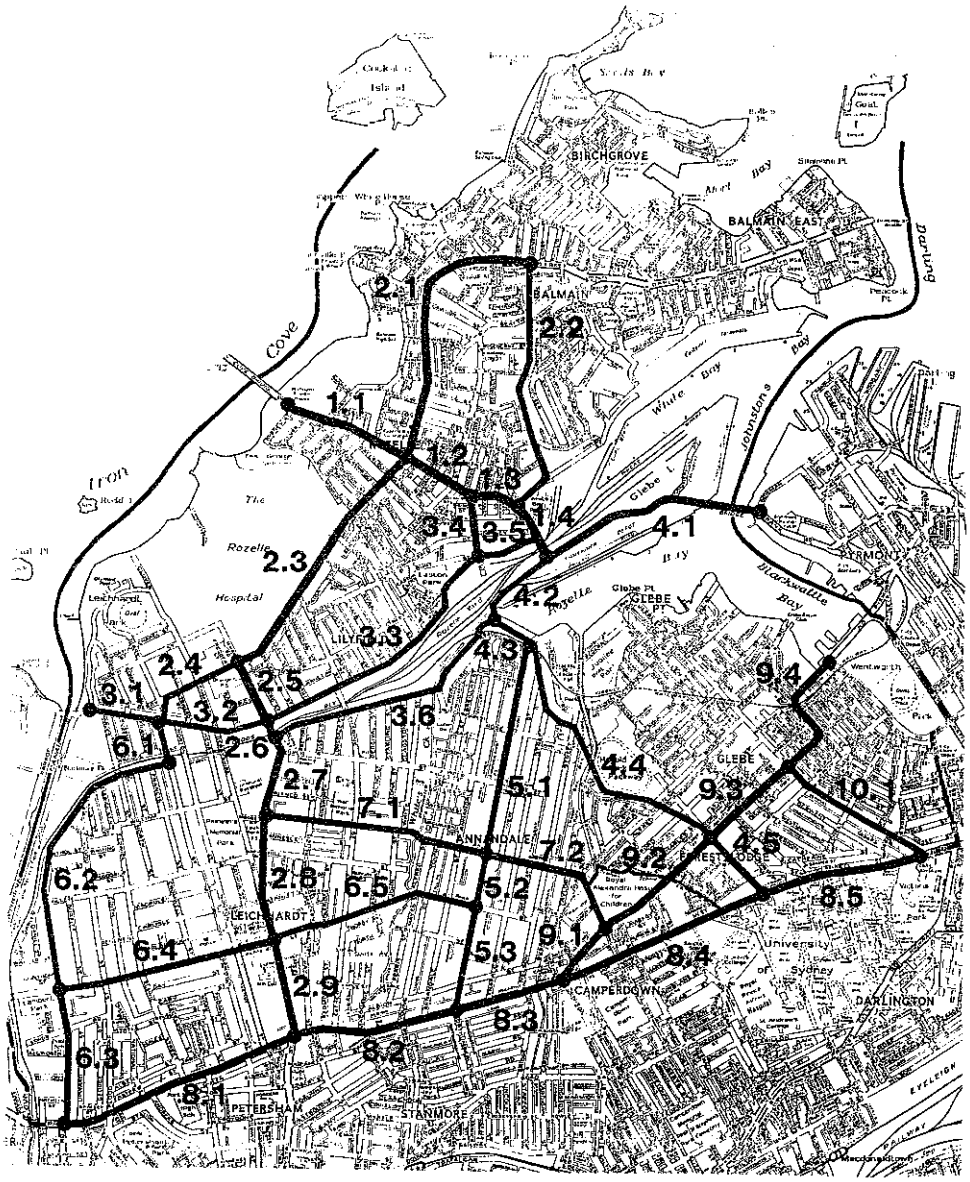
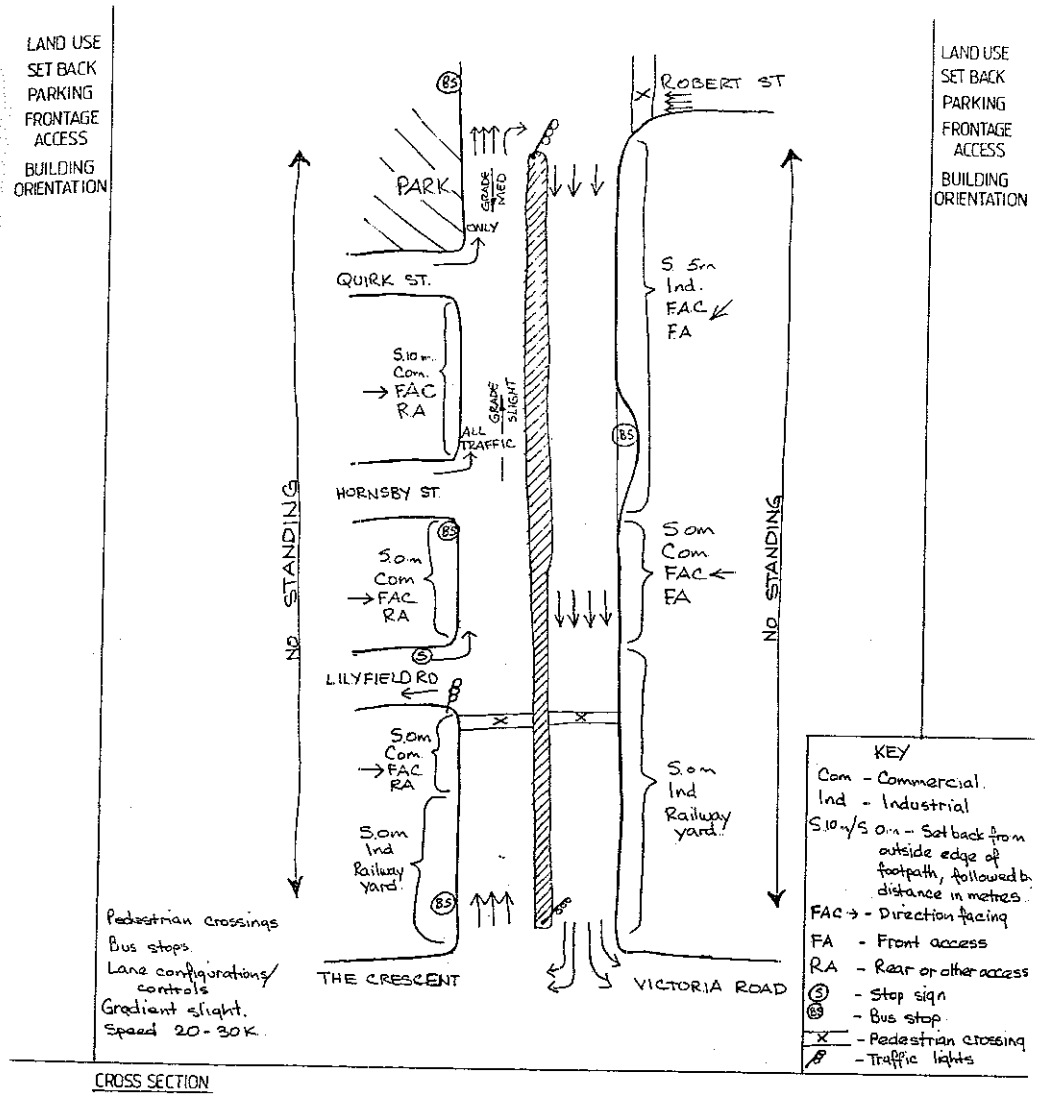


Figure 2: Environmental Sensitivity Methodology

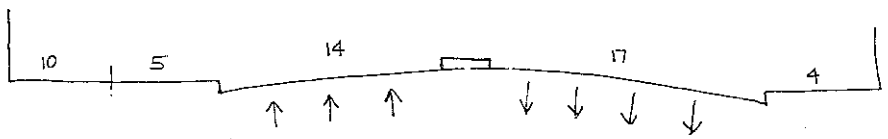


Legend: 3.6 Link Number

Figure 3: Leichhardt Main Road Network



CROSS SECTION



LEICHHARDT TRAFFIC STUDY

OVE ARUP TRANSPORTATION PLANNING

Road name: VICTORIA ROAD
Surveyor: NORM ERREY
Link number: 1·4
Date: 30/8/83 Time: 5.25

Figure 4: Typical Inventory Sheet

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