A METHODOLOGY FOR THE ASSESSMENT OF THE ENVIRONMENTAL EFFECTS OF TRAFFIC IN DISTRICT SHOPPING CENTRES

PETER RONALD HILLS

A Thesis submitted in partial fulfillment
of the degree of

DOCTOR OF PHILOSOPHY

The Department of Architectural, Planning
and Urban Studies

The University of Aston in Birmingham

SEPTEMBER 1975

SUMMARY

This thesis has its origins in an applied research problem identified by the West Midlands Transportation Study Group, a team of local authority officers responsible for the development of transportation policy in the West Midlands Conurbation.

The Study Group were aware of environmental problems arising in district shopping centres located on heavily trafficked links in the strategic highway network. The need to evaluate the environmental implications of alternative policies for these important shopping links was recognised. The research work carried out by the author was directed to the development of an environmental evaluation methodology applicable to this particular type of environmentally sensitive location.

The general, disciplinary and operational contexts of the project are discussed. Alternative methodologies for environmental evaluation are examined. An environmental impact statement approach is postulated as the feasible methodology responding to the research problem identified by the Study Group.

Existing evidence regarding the nature of subjective responses to traffic environments is examined to determine environmental variables for inclusion in the impact statement. Techniques for the prediction of these environmental variables are presented and discussed. The key issue of pedestrian exposure to traffic effects is reviewed and the thesis seeks to make an original contribution to this area through the development of a disaggregated technique of exposure accounting.

The components of the methodology are presented in the form of a manual. A range of policy options for shopping links based on various levels of vehicle access restriction are defined for test purposes. The proposed manual is then tested, using these policy options, in a sample of district shopping centres drawn from the West Midlands Transportation Study Area. Conclusions relating to the applicability and effectiveness of the methodology are presented.

Key words: 'Environmental, Evaluation, Methodology'

ACKNOWLEDGEMENTS

There are a number of people to whom I would like to extend my sincerest thanks for the part which they played in helping me to bring this thesis to fruition.

I would like to thank Mr Frank Joyce, my academic supervisor, for his many valuable comments on various parts of my research and the encouragement which he provided. Dr David Van Rest, my IHD Tutor, also provided many useful observations on the research project.

Particular thanks go to the members of the West Midlands Transportation Study Group, Mr John Williams, Mr Ian Hobbs and Mr George Morran. They had the formidable task of introducing the author to some of the practicalities of transportation planning and did so with considerable understanding and the requisite patience.

I would like to thank members of the Joint Unit, especially Hugh Williams and David Johnson, for numerous valuable discussions, and also the staff of the Department of Architectural, Planning and Urban Studies.

The technical staff of the Department and Joint Unit - Mrs Lynda Bloy, Tony Charman and Geoff Taylor provided valuable services at various stages in the project.

Last, but by no means least, I would like to thank my wife whose constant aid and encouragement made the preparation of this thesis possible.

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

1.1. The Study

In recent years there has been a marked increase in public sensitivity to issues of urban environmental quality. At the same time, and largely in response to changes in public opinion, both central and local government have placed far greater emphasis on such issues within the planning context. The maintenance and improvement of environmental quality is increasingly articulated as a distinct objective rather than as an adjunct to various planning or, in certain cases, public health issues.

Within this general context of growing disquiet about the quality of urban life, environmental issues arising from from the planning, management and operation of the urban transportation system represent one of the most significant and sensitive areas of public and governmental concern.

This concern has, as Weiner and Deak (1972) note:

> .....intensified the need for the rational identification, measurement and evaluation of environmental "impacts" which appear as a result of transportation planning.

It is within this particular problem area of environmental evaluation in transportation planning that the present study is set.

This thesis reports on the development of an evaluation methodology for assessing the environmental implications of policy options for shopping links in the highway network.

An environmental impact statement approach is formulated. The levels of specified traffic impacts and disaggregated pedestrian exposure estimates are displayed in matrix form against the traffic parameters of policy options.

The research described in this thesis is essentially methodological in nature. However, some examples of the application of the methodology are presented using illustrative policy options for shopping links in the secondary road network. These policy options reflect in part the range of conditions over which it may be necessary to evaluate traffic impacts on shopping links in the real world policy making context. Where possible, an attempt is also made to give some indication of the related costs of these policies.

1.2. The Organizational Context of the Research Project

The work which forms the basis of this thesis responds to an applied research problem identified by the West Midlands Transportation Study Group, a team of local authority officers responsible for the development of a transportation policy for the Conurbation and a recommended transport plan for 1981.

The activities of the Study Group represented the second stage of the West Midlands Transportation Study (WMTS) and were carried out over the period 1968 - 1974. Stage 1 of WMTS comprised of a detailed land use/transportation survey in the Conurbation and was undertaken by a firm of Consultants; Freeman, Fox, Wilbur Smith and Associates.

The Consultants commenced work in September 1964 and submitted their Final Report (WMTS, 1968) in January 1968.

The Study Group (WMTSG) then commenced work on Stage 2, their terms of reference being:

> ....to produce an overall plan for transportation including a main highway network, and the public transport systems with a parking policy to balance their use. (WMTS, Stage 2 Report, 1974)

WMTS, in both its stages, represents an exercise in strategic urban transportation planning. It was, in fact, the forerunner of a number of similar studies which were to be initiated during the 1960's.

The strategic nature of WMTS, coupled with its temporal context, are factors which should be emphasised. They were to have considerable implications for the author's research project, not the least of which were the absence of existing data concerning the environmental implications of WMTS proposals and the constraints on data availability imposed by the nature of the peak period modelling exercise which formed the basis of Stage 2 analysis.

The Study Group, although cognizant of environmental factors in transportation planning had not actually undertaken an environmental evaluation of the highway network proposals embodied in the plan which they produced. They had, however, developed an understanding of the various traffic impacts and through their discussions with members of the Technical Committee, the supervisory body for WMTS, were aware of local environmental issues arising on the highway network.

The reasons why environmental evaluation was not undertaken in WMTS are clearly stated in the Stage 2 Report. Two basic reasons are given. First, the formidable difficulties associated with defining community objectives for the environment. Second, technical issues reflecting the then current sparsity of impact measurement and prediction techniques and evaluation methods.

To a large extent the omission of environmental evaluation from Stage 2 must be seen as reflecting on the temporal context of WMTS in general and the work of the Study Group in particular. WMTS spanned a ten year period during which there have been many changes in both transportation planning practice and the broad policy framework within which the transportation planner operates.

However, it is only recently that environmental considerations have figured explicitly in transportation policy and even more recently that techniques and methodological frameworks for evaluating the environmental implications of alternative policies have been available. Indeed, environmental evaluation is a developing field and the pace of development has accelerated significantly during the life-span of the author's project.

Thus, there was an explicit recognition of environmental considerations on the part of the Study Group, although at a generalised and non-operational level. At the same time, there appears to have been a certain scepticism, perhaps well founded, about both the effectiveness and sensitivity of environmental evaluation methods applicable to the strategic scale.

Given the temporal context of WMTS there were, in fact, few methodological options available to the Study Group. The problems which arise in attempting to link accessibility and environment at the strategic scale are in any case formidable. Furthermore, the scale of WMTS as a strategic transportation planning exercise, the credibility of the traffic assignment data and the difficulties associated with the integration of environmental considerations into the modelling process compounded the problem of developing any type of suitable analytical framework for environmental evaulation.

1.3. Identification of the Research Problem

The research project has its origins in the Study Group's awareness of environmental problems associated with heavily trafficked shopping links in the proposed strategic highway network.

The particular shopping links in question relate to district centres, the second tier in the urban hierarchy of retail centres, and locations typically characterised by high levels of traffic and pedestrian activity. The environmental sensitivity of such links may be attributed primarily to the exposure of large numbers of pedestrians to potentially intense traffic impacts.

The Study Group prepared a list of some twenty centres in the WMTS Study Area which they believed were subjected to adverse environmental impacts resulting from traffic activity. A small number of centres from this list were subsequently selected for consideration in the methodology application examples, the results of which are presented in

Chapter 9.

As the Study Group had little practical experience in the field of environmental evaluation their interest in the research project was initially expressed in terms of identifying the environmental impacts to which these centres were subjected, and indicating how these impacts might be measured and predicted.

The research project was therefore established with these objectives in mind, However, it also appeared that the project might go somewhat further and attempt to develop a method of evaluation which could be used to assess the environmental performance of alternative traffic policies for shopping links.

The stages in the development of this evaluation methodology and some worked examples illustrating its application are described in this thesis.

1.4. The Thesis

In order to develop this evaluation methodology, the project passed through a number of distinct phases and these are described in the following chapters.

Initially, however, the contextual setting of the project is discussed in greater detail in the following chapter. Chapter

3 is directed to the definition of the research problem and the specification of the project approach to environmental evaluation.

Chapter 4 considers environmental policies for shopping centres and the environmental and accessibility implications thereof.

In Chapter 5 theoretical and conceptual issues relating to the definition of environmental quality are examined. Existing evidence regarding subjective responses to traffic environments is reviewed in order to establish socially relevant impacts for inclusion in the impact statement.

Chapter 6 considers the means by which the selected traffic impacts may be predicted.

The issue of pedestrian exposure is examined in Chapter 7. An analytical framework for exposure measurement based on the concept of stress is postulated. The exposure measurement procedures developed in the research project are described.

Chapter 8 is devoted to a discussion of evaluation methodologies. In the following chapter (9) the proposed methodology is presented in the form of a manual. Chapter 10 is devoted to a concluding statement.

CHAPTER TWO

THE CONTEXTUAL FRAMEWORK OF THE PROJECT

2.1. Traffic and the Urban Environment

The urban transportation problem has, until recently, been viewed primarily as a traffic problem, or more precisely, a traffic movement problem. Planning for peak hour traffic conditions related to journey-to-work movements has represented the fundamental dimension of the problem as perceived by planners and decision makers. (Starkie, 1973).

The publication of the Buchanan Report (HMSO, 1963) represents a watershed in the development of transportation thinking in this country. The arguments presented in "Traffic in Towns" did much to stimulate awareness of the inherent conflict between accessibility and environment in transportation planning. The period since its publication has been characterised by increasing public disquiet about the various environmental impacts of road traffic and its requirements.

At a general level the nature of the traffic-environment problem is widely appreciated. There exist a variety of impacts associated with both traffic (dynamic) and highway (static) components of the system.

These impacts have been variously categorised (for example,(Burt, 1972)(Radcliffe, 1973)(Vass, 1972)) but it is generally accepted that they include the following:

(a) traffic noise,
(b) atmospheric pollution,
(c) pedestrian vehicle conflict,
(d) visual intrusion,
(e) vibration,
(f) community disruption through severance or land-take.

This general synopsis of the problem may be extended by the suggestion that the significance and meaning of these various impacts finds expression in the extent to which they detract from the quality of the environment within which the individual operates.

There is evidence, albeit limited and fragmentary, which indicates that people exposed to such impacts may well find certain of them unpleasant and objectionable. The existence of imperceptible traffic impacts must however also be recognised. These may induce detrimental physiological effects, as for example, in the case of carbon monoxide and lead emissions.

However, a more realistic formulation of the problem recognises that it presents a choice situation. Increasing levels of traffic activity resulting from a desire for greater mobility and accessibility in urban areas implies a choice between these desirable objects and environmental quality (Gwilliam, 1973).

Furthermore, to extend what is essentially the transport economics formulation of the problem, it must be recognised that the traffic-environment issue is itself representative of the fundamental economic problem of allocating scarce resources between a variety of competing ends.

While this view of the problem may be regarded as both realistic and meaningful, economic analysis of the relationship between road traffic and environmental quality is not without its complications.

To the transport economist the environmental impacts of traffic activity represent externalities in production; the unpriced consequences of such activity. The accepted economic approach to the problem of externalities has been to seek to internalise such costs by using fiscal means; taxation and subsidy (Seneca and Taussig, 1974).

However, in the case of road traffic activity it is far from clear how complex environmental externalities might be internalised. This has led certain transport economists to regard such effects as imponderables within the context of transport investment appraisal (Gwilliam, 1970).

Economic analysis of the problem is further complicated by the issue of jointness in consumption which means, essentially, that environmental quality is not amenable to production in the form of predetermined discreet units for individual consumption.

The implications of these two issues are clearly considerable for they suggest that the problem is not susceptible to the market mechanism; hence the view of traffic impacts as imponderable externalities.

It is now clearly recognised, however, that the constraints imposed on the economic analysis of the problem do not justify avoidance of the environmental issues raised by the planning and management of the urban transportation system. Indeed, the pressures on both central and local government to examine the environmental implications of alternative policies have necessitated the adoption of an essentially pragmatic approach to the problem in the applied policy making and evaluation context. The research project described herein is itself representative of this approach.

2.2. The Scale and Incidence of the Traffic-Environment Problem

The potential scale and intensity of the problem is clearly reflected in the significance of road transport as a means of movement for both people and goods in this country.

Approximately 97% of journeys and 86% of freight tonnage used this mode of transport in 1972. Traffic activity in urban areas accounts for approximately half the total road vehicle mileage (Lassiere, 1974).

Despite somewhat more cautious estimates of future traffic activity levels (DOE, 1975) a continued growth in car usage and commercial vehicle activity may be expected over the next two decades. It therefore appears likely that there will be an intensification in the use of available road space, both within urban areas and elsewhere.

Thus, the environmental impact of road traffic activity will continue to be an issue of considerable concern to the general public and government for some time to come. In particular, the established relationships between the highway network and land uses in urban areas almost inevitably produces a situation in which large numbers of people reside or are employed in locations adjacent to the network.

Given this situation and the continued growth in the level of urban road traffic activity, the environmental impact of traffic and its requirements may well be both more intense and extensive in the future.

Much of the existing and ongoing research into aspects of the traffic-environment problem has concentrated on the issues raised by urban motorways. This is perhaps only to be expected bearing in mind the public disquiet which has arisen in recent years in connection with the impact of motorways in urban areas.

The work of the Urban Motorways Committee and and their subsequent report, "New Roads in Towns" (HMSO, 1972), reflects a concern with the problems of integrating motorways into the urban fabric. The actual extent of existing or proposed urban motorway provision suggests that these primary network problems may perhaps have received a rather disproportionate amount of attention on the part of planners, decision makers, academics and the general public.

More recently, there has been a growing realisation that the environmental issues arising on the secondary and local road networks present possibly a more serious and certainly more widespread problem. Clearly, in terms of environmental improvement it is at the local level that the formulation and achievement of environmental objectives becomes a realistic proposition (Joyce and Williams, 1973).

Local network issues, such as heavily trafficked residential streets ("rat-runs") should not, however, be allowed to detract from the potentially severe environmental problems existing on the secondary road network.

Secondary roads are clearly key links in the urban road network, and particularly so in those cases where they function a major radial routes. Not only do such links carry high volumes of traffic but urban growth patterns have frequently produced a situation in which they are straddled by environmentally sensitive land uses; residential areas and shopping centres, for example.

In the case of London alone there exists approximately 1000 miles of secondary road network (GLC, 1971), much of which is associated with such land uses.

The secondary road network is of fundamental importance in the achievement of strategic accessibility objectives. More recently, however, secondary roads have played a vital role in the achievement of local environmental objectives.

Environmental improvements at the local area level have frequently been achieved by redistributing local network through traffic to secondary roads. As a result of both accessibility and environmental considerations, the secondary road network has itself been subjected to environmental disbenefits in order that such objectives might be achieved.

There exists then a situation of intensive and extensive vehicular use of urban space with the potential for considerable environmental disbenefits across all levels of the urban road network hierarchy.

2.3. Transportation Planning: The Policy Framework and Investment Appraisal

There have clearly been many changes in transportation planning practice over the past two decades. Changes have taken place in both the methods employed in this field of planning and in the broad policy framework within which it is conducted. In order to identify the macro-context within which environmental evaluation in general, and the project in particular, is set, it is necessary to briefly consider the development of transport policy and investment appraisal methods.

Strategic transportation planning has only recently emerged as a discreet process. It has been suggested, fruthermore,that the use of the term "transportation planning" be reserved specifically for recent developments which involve the comprehensive planning of both private and public mode requirements (see (HMSO, 1970)).

Kirwan (1969) suggests that there are a number of basic differences between the traditional piecemeal traffic planning approach and the contemporary systems approach. Among these differences is the aim of comprehensiveness in the new approach, an emphasis on transportation planning as a process and a fundamental concern with the formulation and evaluation of alternative policies.

This concern with policy alternatives is itself a significant development. Starkie (1973) has suggested that until the early 1960's it was by no means uncommon for:

> ....an undisputed best plan to emerge from the unrecorded deliberations of the transport planners.

Such a situation arose, he argues, due to a policy of evaluating schemes on the basis of technical design considerations, and a lack of guidance regarding the financial constraints within which the transport planner was operating.

From the late 1950's there began a trend towards the development of expenditure programmes for transport investment, coupled with the development of methods of economic evaluation for transport investment.

Thus, while it had previously been feasible, and acceptable, to assess and justify highway investment on traffic flow criteria, the adoption of economic evaluation criteria necessarily involved the evaluation of at least two options, even if one was simply the "do-nothing" situation.

This change in perspective may be viewed as a transitional phase between limited technical evaluation procedures and the development and application of cost-benefit analysis in transportation planning. With the incorporation of environmental evaluation procedures there has clearly been a further broadening in the range of criteria for transport investment appraisal.

Changes in the approach to policy evaluation are inextricably linked to changes in the macro-policy framework within which the planning and management of the urban transportation system is conducted.

It must be emphasised that the policy framework, which is essentially synonymous with the manner in which the urban transportation problem is perceived, determines both approaches to the problem and viable solutions. In the case of evaluation, it also gives the techniques and methods their meaning and significance, and determines which costs and benefits shall be examined and the manner in which they are examined.

The macro-policy framework has changed markedly over the past twenty years or so as Plowden (1970) has shown in his extensive review of the subject. The most significant change has been the shift from the so-called "laissez-faire" approach to an explicit recognition of the need to formulate and implement traffic restraint policies.

During the 1960's the emphasis changed from an attempt to build the problem away to a policy directed to improving the technical efficiency of the system by means of comprehensive traffic management. Only in the latter part of the 1960's were traffic management techniques more widely viewed as a means of achieving environmental objectives.

At a similar point in time the implications of the laissez-faire approach were receiving greater attention. The Smeed Report (HMSO, 1964) considered approaches to road pricing as a means of restraint. A later report entitled "Better Use of Town Roads" (HMSO, 1967) examined various means of restraint, accepting the proposition that sufficient road space could not be provided and that the choice lay between increasing congestion or the control of demand.

Discrimination in favour of public transport also assumed a more prominent role in the 1960's, reflecting a growing awareness of the need for balance in transport planning. Special facilities for public transport (for example, bus lanes and turning priority) have been provided on an increasing scale over the past ten years (TRRL, 1972).

Towards the end of the 1960's traffic management techniques were increasingly viewed as a means of reconciling the conflict between accessibility and environment ((Collins, 1972) (Dimond, 1972)(Buchanan and Crompton, 1968)).

Circular 1/68 Roads, Traffic and Transport Plans (MOT, 1968) clearly reflects this growing interest in environmental traffic management.

There now exists an emerging legislative framework which provides various opportunities for local authorities to exploit discretionary or mandatory powers directed to the amelioration of the environmental impact of traffic and roads.

For example, the 1968 and 1971 Town and Country Planning Acts have provided powers to restrict vehicle access to roads and streets on environmental grounds. These powers have been exploited in numerous pedestrianization schemes for shopping streets, primarily in central areas.

The Heavy Commercial Vehicles (Controls and Regulations) Act of 1973, more commonly known as the "Dykes Act", places a statutory obligation on local authorities to produce, by January 1977, plans for the control of heavy goods vehicle movement on the basis of environmental considerations.

The Land Compensation Act of 1973 is a particularly significant piece of legislation. This places a statutory obligation on local authorities to examine the environmental implications of new or improved roads. The Act includes various provisions designed to ameliorate the direct environmental effects of new roads, particularly traffic noise, as well as providing for compensation in the case of property depreciation and loss of amenity.

Given the contemporary policy framework for transportation planning it is clear that environmental considerations will be apparent in the formulation and evaluation of policy options. Inevitably, then, we arrive at the transport planner's long established dilemma; the conflict between accessibility and environment.

The research problem itself clearly reflects this dilemma. Significant environmental issues arise at that local level on shopping links as a result of policies directed to the achievment of strategic accessibility objectives. These issues arise because of the technical linkages which exist between accessibility and environment.

These linkages find expression in the technical relationships between capacity, traffic flow parameters and environmental variables. Thus, under different traffic management regimes there will be alternative mixes of accessibility and environmental quality levels, within, of course, the overall technical limits of the system.

The implications of the changes in the policy framework examined above are that the combination of accessibility and environmental quality which is acceptable to the community has shifted in favour of the environment at the expense of accessibility.

If this proposition is valid, and it is implicit in many environmental traffic management schemes, then accessibility is consciously being traded off for environmental quality.

Pedestrianization schemes, for example, result in a loss of capacity at both the network and local scales, unless, of course, terminal restraint policies are operative. Under such conditions evaluation is essential in order to establish that the environmental benefits accruing to the link in question outweigh the losses incurred on the links to which traffic is diverted. Similarly, some indication of the resource costs which such schemes impose is necessary if planners are to be able to establish whether net scheme benefits do indeed justify the costs involved (Williams, 1975a).

The perception of the urban transportation problem now reflects a much broader perspective than was apparent some twenty years ago. Both the nature of, and feasible solutions to, the problem have been redefined over the period. This broadening in perspective requires a package of evaluation procedures; a package in which environmental evaluation supplements the operational and economic approaches.

2.5. Environmental Evaluation in Transportation Planning

The development of environmental evaluation procedures in transportation planning may be regarded as a response to pressures of public opinion, professional needs and statutory obligations. It has been argued (Lassiere, 1973) that the most immediate stimulus to such developments has come from the "new context" provided by the Urban Motorways Committee Report and the Land Compensation Act. It should be noted, however, that the UMC was itself established as a result of pressure following the Westway controversy.

There has obviously been a growing demand for techniques and methods of evaluation which enable the planner to generate systematic quantitative statements of amenity which may be used to indicate the performance of options against a range of environmental criteria.

Part of the necessary research has been directed to the development of techniques for the measurement and prediction of physical environmental variables: traffic noise, atmospheric pollution and pedestrian delay, for example.

However, there has clearly been a need for the development of methodological frameworks within which the output of environmental modelling procedures may be set, and which can be used as an aid in the decision making process.

Considerable progress has been made in both the measurement and prediction of certain traffic impacts. However, the development and application of the necessary evaluation procedures, that is to say, the means of choosing between options, has raised some formidable theoretical and practical problems. These problems, it may be argued, are constraining developments in other areas.

The significance of environmental evaluation does not rest solely on the demands created by the Land Compensation Act. Evaluation necessarily attempts to trade off one particular element against another and this attempt to balance elements may be regarded as an implicit part of urban planning objectives.

The implementation of environmental traffic management policies, be they lorry routing or shopping centre pedestrianization, requires that the environmental benefits to be derived are set against the various costs of scheme implementation. The definition of problem situations also requires some quantitative measure of disamenity in order that resource allocation priorities may be established and policy implementation rationalised on an objective basis.

Although statutory obligations may indeed have been responsible for stimulating certain developments in environmental evaluation, the interplay between legislation and method is emphasised in situations where the same methods may be applied to discretionary environmental policies (pedestrianization), or where local authorities must produce proposals from a wide range of options under a statutory obligation ("Dykes" Act).

Clearly, the development and application of environmental evaluation methods does not remove or negate the need for judgement, nor indeed does it necessarily make the decision making process easier or more effective. The option finally selected can only be the optimum from among the range of alternatives selected for evaluation. The design process is itself of critical importance and both objectives and policy proposals must be examined in great detail.

2.6. Disciplinary Perspectives in Transportation Planning

In concluding this general discussion of the contextual framework of the research project reference should be made to the various disciplinary perspectives and value systems which must be reconciled and utilised in contemporary transportation planning.

To begin with, it is useful to distinguish between academic and professional disciplines. It has been suggested by Wilson, et al (1970), that academic disciplines are primarily associated with analysis whereas professional disciplines are concerned with design and policy making issues. In transportation planning it is necessary to draw upon and reconcile a variety of concepts and approaches derived from both academic and professional disciplines.

Transportation planning has until recently been dominated by two basic disciplinary inputs: engineering and economics.

Engineering inputs may be viewed in terms of both academic analytical contributions reflecting a concern with operational characteristics of the system, as well as the professional design contribution. Economic inputs have typically taken the form of an analysis of system or scheme performance, usually within a cost-benefit analysis framework.

The traffic engineering approach has not unnaturally been pre-eminent until recently bearing in mind the general acceptance of the transportation problem as being one of providing accessibility for road traffic. Given this formulation of the problem, the engineer's role was, and still is, to design a satisfactory system and to test its operational efficiency. But as Antoniou (1971) comments:

> Hardly any attention was paid to the environmental implications. The technical standards adopted by the engineer were also considered by implication to be acceptable levels of quality.

The engineering value system is one dominated by a concern with technical issues such as road capacity and traffic flow. At the same time, the traffic engineer is extremely sensitive to the cost implications of alternative highway construction or improvement schemes.

The economic evaluation of transport plans and proposals has been closely associated with operational evaluation. Prior to the recent developments in environmental evaluation the two have represented the basis of the highway investment appraisal process. The economic performance of plans and proposals has typically been measured against the rate of return afforded by alternative options.

At the interface between physical planning and transportation planning it is important to recognise the professional disciplinary input provided by the physical planner. Like the highway engineer the physical planner is sensitive to design issues but his perspective must of necessity be somewhat broader. Although the physical planner is clearly concerned with accessibility in the city he is at the same time presented with a great variety of conflicting issues, which are, of course, competing for resources.

Environmental objectives have found increasing expression in physical planning policies (for example, GIA policy and central area planning). It can be argued that the physical planner has a longer and more comprehensive experience of environmental quality issues than the transport planner.

There is some evidence which suggests that physical planners have for some time been conscious of the adverse environmental impact of road traffic, and, in certain types of development, have taken positive steps to ameliorate such impacts.

The most striking example of this is the policy of pedestrianization and the development of purpose-built pedestrian precinct areas. Such policies may be regarded as a manifestation of a long established concern on the part of physical planners and urban designers with the segregation of people and traffic (Ritter, 1964).

Finally, there exists a need to draw upon certain social science disciplines, most notably, psychology and sociology and possibly geography, for concepts and methods relevant to the development and application of environmental evaluation procedures.

At this point we move into an area which is perhaps a good deal less clear, both conceptually and operationally. We are concerned here, essentially, with the environmental value system of individuals, groups and the community in general. The value system reflects, and determines, responses to the environment.

Public attitudes to the environment have clearly undergone some considerable changes in recent years. Environmental values are finding increasing expression in the public response to a variety of planning issues.

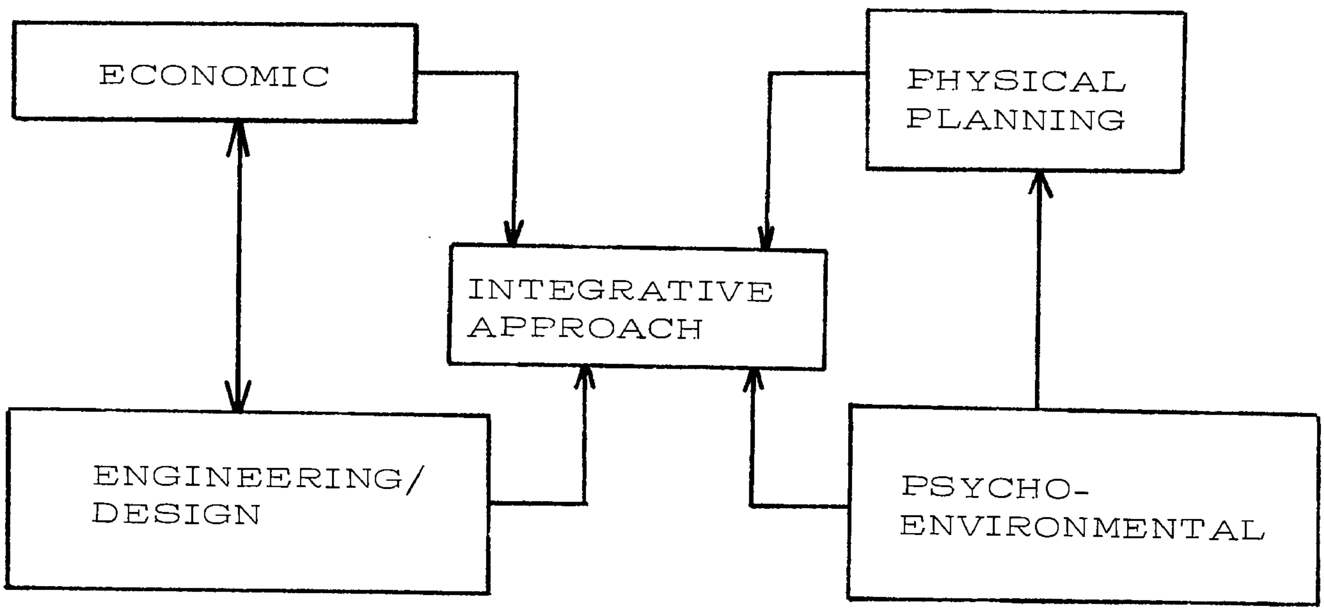
In some cases public opposition to planning policies is based on perceived threats to environmental quality, while in other situations public dissatisfaction with specific environmental issues has itself stimulated a response in the planning/decision making context. Whatever the context for the articulation of public attitudes might be, the essential element involved is the subjective, personalised response of the individual to the environment within which he operates.

The implications of this psycho-environmental value system are considerable. Environmental evaluation requires that socially relevant impacts be identified, their relative significance determined and socially acceptable environmental trade offs established.

Research in this area is however in its infancy and as yet we cannot make definitive statements concerning these components of the value system. Our inability to make such statements imposes a number of fundamental constraints on the feasibility of alternative methodological approaches to evaluation.

Figure 2.1. displays in diagrammatic form the linkages between the perspectives and value systems described above.

Figure 2.1. Disciplinary Perspectives and Value Systems in Transportation Planning



Various issues have been raised in the discussion above which imply that an integrative perspective in transportation planning is now required. The importance of both design-engineering and economic perspectives is recognised. The physical planning perspective may well be responsive to certain issues arising from the interaction between traffic and environment. The psycho-environmental perspective is of course the most recent addition to this framework. It may be argued that it is through the use of concepts and techniques drawn from various social science disciplines that we may find a way of defining the environment which corresponds to the individual's perception of that environment and thus be better able to respond to relevant environmental issues.

Recent developments which have stimulated a greater concern with the environmental implications of alternative policies do,therefore, require a broadening in the disciplinary inputs on which the process of transportation planning is based.

CHAPTER THREE

DEFINING THE RESEARCH PROBLEM

3.1. Introduction

The discussion so far has centred on the contextual setting of the research project. Its organisational and general problem area contexts have been discussed in order to establish some of the relevant constraints on the research work that was carried out, as well as the areas where it might seek to make a useful contribution to existing knowledge.

The present chapter is devoted to a more detailed and specific discussion of the research problem. Almost inevitably, however, it will be necessary to expand on certain points which, in a sense, may be regarded as contextual issues. These points are, nonetheless, of considerable significance and bear more directly on the development of the methodology presented at a later stage in this thesis.

The first section of the chapter briefly considers the conflict between environment and accessibility at the strategic scale, and in particular the methodological problems which arise in evaluation at this level. In the following section discussion centres on the particular problems of district shopping centres and seeks to give some indication of the scale of the traffic-environment problem in such locations. Reference is also made to local authority responses to such problems.

Having established the nature and scale of the problem the issue then to be resolved is the selection of a suitable methodological approach to evaluation. A number of basic issues in environmental evaluation are considered and alternative methodological options for evaluation examined. An impact statement approach is proposed as the feasible option responding to the requirements of the author's "terms of reference".

The final section of the chapter comprises of a formal definition of the research problem and its various components.

3.2. Accessibility and Environment at the Strategic Level: Some Issues and Methodological Problems

The environmental problems which arise on shopping links in the secondary road network may be regarded as particular manifestations of the conflict between environment and accessibility which may arise at the strategic scale.

In the case of WMTS highway network proposals the emphasis is clearly on the provision of private vehicle accessibility subject to the budgetary constraints imposed on highway investment and thereby the operational capability of the network. It is worth noting here that the public transport component of the WMTS strategic policy, designed primarily to balance the use of the system in conjunction with parking restraint policies, is very much geared to shopping centres as focal points in public transport trip making.

The conflict between accessibility and environment at the strategic scale reflects on the technical linkages which exist between the two. It is worth reiterating the point made in the previous chapter that these linkages find expression in the relationships between capacity, traffic flow parameters and environmental quality. The pre-eminence of accessibility objectives in strategic transportation planning exercises of the WMTS type necessarily implies trading off environment for accessibility. It is perhaps worth emphasising, however, that given the temporal context of WMTS this was by means an unrealistic proposition. As the Study Group noted in the Stage 2 Report it was not possible to establish community objectives for the environment and thereby socially acceptable trade offs between accessibility and environment.

There exist in any case some quite formidable problems which are associated with attempts to link accessibility and environment at the strategic scale. The two clearly cannot be linked within a welfare economics framework due to the problems inherent in the economic analysis of environmental quality issues. It should ,of course, be emphasised that the two are intangibles and that this seriously complicates any attempts to link them together.

Strategic environmental evaluation has typically been based on a disaggregated approach in which individual impacts are considered from option to option (CTS, 1973).

However, this disaggregated approach does itself raise a number of problems when cross-network comparisons are made. One may, in fact, question whether it is indeed meaningful to examine environmental impacts at the strategic scale, when in reality accessibility-environment issues are most likely to manifest themselves at the local level. It might be argued that if environmental issues are purely local then solutions should be sought through the use of remedial measures, but, on the other hand, the strategic impact may be of such an intensity that changes in proposals at that level are required.

What has become clear, however, in the limited number of strategic environmental evaluation exercises which have been reported is that it is quite likely that there will be only relatively small differences between options. This reflects to a large extent the implications of the investment assumption for strategic transportation planning (Pickering, 1975). It is quite likely that there will be relatively small changes in traffic distribution on the strategic network. In consequence, as Pickering notes:

> ......when comparing total noise impacts, for example, it is often found the distributions of noise impact show relatively small differences between the options. The areas of difference have become diluted in the overall network assessment.

This, of course, is precisely the problem of environmental evaluation at the network level. At the general level of strategic environmental evaluation distributional issues cannot be dealt with in any meaningful fashion. In contrast to local traffic management schemes where direct environmental trade offs may be established between the link (s) which experience improved environmental conditions and those to which traffic is redistributed, at the network level changes in environmental impact as between options are most likely to distributed across a large number of links. Bilateral trade offs may, therefore, be extremely difficult to establish. Environmental improvement on one particular link may reflect incremental changes on a great many others.

Joyce, Williams and Johnson (1975b) describe what is essentially a two stage methodology for environmental evaluation at the network level. The first stage is based on comparisons between networks at the same level of the impact under consideration. This technique, therefore, reconciles the conflicting demands made on network evaluation, namely, the desirability of considering network options at the aggregate level, initially at least, and the constraints imposed by the use of ordinal scales which preclude the adding together of different levels of the same effect.

The second stage of the methodology is based on the disaggregation of the network impact requiring consideration of changes in impact levels on individual links in the network. The methodology, therefore, seeks to establish the number and size of the changes in environmental impact between options. Impact level change criteria are proposed as a means of isolating those individual links on which significant changes occur as between options.

The approach summarised above is essentially an impact statement formulation but one which recognises the constraints imposed on evaluation by the nature of ordinal measures of response . The implications of such measures for evaluation are considered in more detail in subsequent chapters.

The environmental issues associated with shopping centre locations cannot be effectively handled within the context of overall network assessment. The issues themselves are representative of the conflict between accessibility and environment at the strategic scale but are clearly experienced at the local level.

In order to explore the particular traffic-environment issues which arise at the spatial scale of the shopping centre it is therefore necessary to disaggregate the strategic issues involved. The methodology presented herein seeks therefore to provide a means of evaluating the environmental implications of policy options at a local level.

3.3 Traffic-Environment Problems in District Shopping Centres

Shopping centres are, by their very nature, pedestrian environments of considerable significance. Pedestrian activity on the part of shoppers and other users of the centre will result in their exposure to various traffic impacts. The concept of pedestrian exposure, considered in some detail in Chapter 7, must incorporate both the time duration of exposure to traffic impacts and the intensity of those impacts if it is to be meaningful in terms of environmental annoyance.

This exposure issue is inextricably linked with the

the significance of the highway links on which district centres are typically located. The high levels of traffic activity characteristic of both the peak and off-peak "shopping day" periods reflect on the significance of the secondary road network, and particularly radial routes, in terms of both strategic and local accessibility considerations.

Radial routes are of special significance within the context of formulating policies for the achievement of strategic accessibility objectives and, more recently, local environmental objectives. Almost inevitably, shopping links on such routes have been subjected to environmental disbenefits in order that such objectives might be achieved.

However, it is only recently that the nature and extent of these disbenefits has been appreciated.

On this point concerning radial routes it is interesting to note that in the case of the City of Birmingham there exists a long established committment to radial routing in the context of transportation planning which has extended over a period of more than sixty years.

The linear spatial configuration of many traditional High-Street district shopping centres is grossly inefficient from the pedestrian movement viewpoint. It may often produce a situation in which extended pedestrian trips are required to link together the retail and service outlets which the pedestrian shopper desires to visit. Clearly, the precinct concept in its purpose-built form, with a pronounced tendency to nucleation of facilities, is more efficient in trip length requirement terms and has the obvious advantages of a traffic free environment.

It is perhaps worth noting at this point that data derived from pedestrian surveys undertaken by the author indicate that in the centres studied up to approximately 10,000 people per day may be exposed to traffic impacts for periods ranging in duration from a matter of seconds to in excess of 30 minutes. Although little is yet known about subjective responses to traffic in externalised activity settings, one suspects that exposure rates are of considerable importance in the creation of stress situations experienced by individuals and, by implication, in their subjective responses to traffic environments.

Pedestrians on shopping frontages will be potentially exposed to unmediated traffic impacts at the kerbside. Under high traffic flow conditions the resulting impact may well be considerable. The duration of exposure experienced by pedestrians in shopping centres will clearly vary according to the characteristics of the shopping trip undertaken and such factors as the age or physical condition of the individual. Young children accompanying adults and the need to carry heavy shopping loads may act as additional constraints on walking speed and, therefore, extend the duration of exposure.

While pedestrians are clearly the numerically dominant group exposed to disamenity effects in shopping locations, workers in shops and offices may also experience exposure to traffic impacts which they may find objectionable or stressful. Similarly, the limited resident population of shopping links may also be subjected to exposure, most notably in the case of traffic noise. The physical fabric of buildings will, however, serve to ameliorate certain impacts.

To summarise, therefore, it is suggested that the environmental sensitivity of district shopping centre links reflects primarily the interaction between high levels of pedestrian and vehicular activity.

When the research project commenced there existed virtually no information concerning environmental conditions in district shopping centres located on the secondary road network. As a result, there was no substantive data on which to assess, initially at least, either the potential scale or intensity of the problem. More significantly, there was very little information regarding the nature of the environmental issues which might arise in association with heavily trafficked shopping links.

It has been suggested that much of the existing research into traffic-environment issues has focused on residential environments. Furthermore the discretionary powers provided by the Town and Country Planning Acts, which might be exploited to improve environmental quality in shopping streets have been primarily applied in town and city centre locations. The environmental problems of district shopping centres have received very little attention. Thus, the research project developed from a situation in which little was known about the nature of the environmental issues involved or the scale and intensity of the problem.

In order to illustrate the scale of the problem in the locational context within which the author operated reference will be made to shopping provision in the City of Birmingham. This may be justified on the grounds that Birmingham itself constitutes the primary urban component within the WMTS Study Area and has by far the greatest number of district centres.

A recent survey of shopping facilities in the City (City of Birmingham, 1973a) defines some 26 district shopping centres within the local authority area. These centres generally range in size from approximately 50 - 150 establishments, providing both convenience and comparison goods, as well as a variety of service functions. These centres typically cater for user populations in the order of

35, 000 to 60,000 persons. The spatial distribution of these centres is shown in Figure 3.1..

This map is also useful as it clearly reveals the relationship between these centres and the secondary road network in Birmingham. Few of the centres are located away from secondary roads, and it is evident that many are located adjacent to radial routes.

Some district shopping centres in Birmingham have been extensively redeveloped in recent years and now mainly take the form of pedestrianized areas. Residual pockets of older linear shopping development do, however, remain in most cases. The majority of centres do,nonetheless,conform to the linear configuration typical of the High-Street district centre.

In the City of Birmingham there are some 20 "typical" district shopping centres. The author's measurements of district centre link lengths suggest that figures of 500-700 metres are by no means uncommon, and may well be exceeded in certain cases. If we assume an average link length of 600 metres and apply this to the 20 centres, we arrive at the total figure of 12 Km of potentially affected shopping links. For shopping frontages, which usually straddle both sides of a link, we can think in terms of some 24 Km (15 miles) of affected frontages characteristically associated with high concentrations of pedestrians.

THE CENTRES

1 City Centre
2 Small Heath
3 North Yardley
4 Sheldon
5 Acocks Green
6 Hall Green
7 Springfield
8 Sparkhill
9 Ladypool Road
10 Moseley
11 King's Heath
12 Stirchley
13 Selly Oak
14 Northfield
15 Harborne
16 Five Ways
17 Soho Road
18 Villa Road
19 Aston
20 Perry Barr
21 Hawthorn Road
22 The Circle
23 Erdington
24 Castle Vale
25 Saltley
26 Alum Rock
27 King's Norton

SPATIAL DISTRIBUTION OF DISTRICT SHOPPING CENTRES - BIRMINGHAM.

BASED ON THE CITY OF BIRMINGHAM
SHOPPING SURVEY - 1972.

NOISE LEVELS IN DISTRICT SHOPPING CENTRES - Some Birmingham examples.

Even allowing for the rough calculations involved in the generation of these data, the problem does appear to be significant in scale.

As stated above, very little data concerning the intensity of physical impacts in district shopping centres was available when the study commenced. However, subsequently, the City of Birmingham Structure Plan documents were released. The report concerning transportation (City of Birmingham, 1973b) did include some limited data on district centres and environmental conditions therein. Figure 3.2. is derived from this report and gives some indication of the noise levels in a small number of centres. It is interesting to note the effect on noise levels of the bypass at Erdington.

It has been indicated that the Study Group were aware of the relationship between straegic policy proposals and their implications at the local level in district centres. However, the nature of the issues involved was far from clear and little was known about the scale and intensity of the problem.

The purpose of theproject was, therefore, to respond to this concern and explore what was feasible in terms of environmental evaluation at the disaggregated scale of the district shopping centre; to bridge the gap between strategic transportation planning considerations expressed primarily in accessibility terms, and local environmental issues.

It is interesting to note that the City of Birmingham has been well aware of these particular local environmental issues. In a report published some seven years ago, (City of Birmingham, 1968) a detailed account is given of a number of shopping centre redevelopment schemes carried out during the 1960's. Completion dates for the schemes spanned the period 1963-68. With one exception, the seven schemes described in the report are explicitly based on the principle of segregating people and traffic through the provision of pedestrian precinct areas.

Such a policy approach, which was clearly carried out in a systematic fashion, indicates a recognition of the interrelationships between traffic and environment. It may be seen, therefore, as a purposive attempt to "design out" the potential conflict between accessibility and environment in shopping areas.

A number of these schemes were, in fact, implemented in district centres. Here the local authority concerned was able to exploit redevelopment to achieve environmental objectives. However, only recently have policies been formulated for centres where redevelopment is not a feasible policy option.

The City of Birmingham is clearly conscious of the environmental problems existing in High-Street district centres. In particular, there has been a clear expression of concern about the pedestrian exposure issue (City of Birmingham, 1973a). This Structure Plan document expresses a clear committment to extend environmental policies to High-Street centres.

It should be noted, however, that the policy approach suggested by the City is closely linked with certain of the highway investment assumptions embodied in WMTS. The suggested bypassing policy for certain district centres is dependent on investment in key secondary network links in order to achieve the 1981 network specification. The likelihood of such investment is now open to question.

Nonetheless, the point remains that bypassing, which is a necessary condition for the proposed pedestrianization schemes in some centres, raises fundamental questions concerning the relationship between highway investment in key strategic links and local environmental quality issues.

There is some evidence the local authorities may be more aware of environmental problems in district centres and may be moving towards the formulation and implementation of environmental policies for such locations. In this context, mention may also be made of the extensive programme of pedestrianization proposed by the Greater London Council for district centres within that local authority area (GLC, 1973).

It must be recognised, however, that such policies are closely related to the planning and management of the urban transportation system and cannot, therefore, be viewed in isolation from the transportation planning process. Similarly, it would certainly not seem realistic to adopt a narrowly based transportation policy approach to the problems of district centres. Rather, the technical linkages between traffic and environment, as well as linkages between physical planning policies, traffic and environment, suggest that we must think in terms of broader policy packages with which to tackle the environmental problems of district shopping centres.

3.4. Some Issues in Environmental Evaluation: Exploring the Feasibility of Alternative Approaches to Evaluation

In the previous chapter an attempt was made to indicate some of the implications of the links between approaches to transportation planning, investment appraisal methods and the policy framework within which the planning and management of the urban transportation system has been conducted over the past twenty five years or so.

The trend away from a purely design oriented approach was stressed. The development of economic appraisal methods was briefly considered, as were some of the implications of this development. It was also suggested the environmental evaluation should now be regarded as an integral component of plan or project appraisal.

The present discussion briefly considers some of the key theoretical issues in environmental evaluation and seeks to provide a rationale for the selection of the impact statement approach used in the research project. A more detailed examination of theoretical issues and evaluation methodologies is undertaken in Chapter 8.

Two fundamental theoretical issues arise in environmental evaluation; the definition of the environment and the valuation of environmental quality. It may be argued that the problems inherent in the definition of the environment and its valuation, be it attitudinal or monetary, impose severe constraints on the current feasibility of various methodological approaches to environmental evaluation.

The two issues are themselves closely related. This appears to be particularly so in those research situations where a behavioural analytic framework is adopted, and little distinction made between the cognitive and affective components of attitude.

As the discussion in Chapter 5 will indicate, those who work in the field of environmental evaluation must face the basic problem of operating with a multi-dimensional construct which remains for the most part poorly defined. In fact, we know very little about the cognitive structures pertaining to the environment in general, or semi-discreet forms such as traffic environments. Thus, we know little about the composition of such environments as the individual is aware of them.

Such statements clearly reflect one particular perspective on the definition of the environment, namely, that which is based on the application of social psychological concepts and techniques. Such an approach seeks, essentially, to elicit the cognitive structure of the environment at the level of the individual. However, other approaches to the definition of the environment do exist.

One approach is based on a generalised, holistic perspective and is used frequently in political discussion of environmental issues. Another approach is based on the use of environmental indicators, while yet another is based on the concept of a bundle of environmental goods, representing, therefore, a disaggregated perspective on the environment. These various approaches are considered in Chapter 5.

Regardless of the approach adopted, the fact remains that little is known about the way in individuals, or the community, structure the environment within which they behave. This factor, coupled with the difficulties, both theoretical and practical, inherent in the derivation of meaningful values for the environment means that it is not yet feasible to construct an objective function for the environment (Williams, 1975c).

The valuation of environmental quality presents the researcher with a great many difficulties. With regard to values derived through mechanisms such as "hypothetical compensation exercises", "willingness to pay" and the "house price differential", there is as yet no clear indication of the validity of the values so obtained. The "house price differential" approach has proved confusing to say the least, while values derived through the other mechanisms have yet to be validated by proven replication in a behavioural (market) context. This latter point is essential if, as Joyce and Johnson (1975) comment, "the money values have any meaning".

Attitudinal valuation of environmental quality must inevitably raise the problem of the scale properties of response data. Is the response data of interval or ordinal nature?

If the data is indeed of interval scale then responses to impacts may be measured on a common scale and aggregated.

If we accept the proposition that responses are of an ordinal rather than interval scale nature then we must acknowledge that this imposes some fundamental constraints on the approaches to evaluation that we can use and the comparisons we can make. It is not feasible to weight different impacts in terms of their relative significance, nor to say that changes in a particular impact are of greater value than changes in another. We do not know, therefore, how impacts are valued either individually or one against another.

The situation may be summarised thus. We are as yet unclear as to the nature of the environment as a cognitive structure. Monetary valuation of the environment has so far produced results of questionable validity. Attitudinal valuation of the environment is dependent on the assumption of interval scale properties of response data; again, as yet not validated.

What then does this mean in terms of the potential application of various evaluation methodologies in the context of the research project?

Clearly, we may conceive of a range of evaluation methodologies varying in their complexity and degree of sophistication. On the one hand, we may think in terms of single sum cardinal evaluation of the cost-benefit analysis type. The advantages of such an approach are obvious. Environmental considerations could be readily incorporated within the existing economic evaluation format.

However, the problems associated with the derivation of money values for components of environmental quality, coupled with problems of interpersonal comparisons, make it extremely difficult to operationalise this approach in a meaningful and effective manner. It is also worth emphasising that existing examples of environmental cost-benefit analysis (for example,the Urban Motorways Project Team Approach (HMSO, 1972;1973)) have been related to residential environments. It is at present difficult to see how such an approach might be made operational in the context of shopping centres.

The weighted matrix method is a common approach to evaluation. Examples include the Goals Achievement Matrix (Hill, 1968) and the UMPT Environmental Evaluation Index. The former requires a numerical weighting of objectives to reflect their relative importance to various groups within the community. The latter approach is based on the weighting of individual impacts to reflect their significance in response terms.

Both methods of evaluation are dependent on the valuation of the environment, but as suggested above, we are not yet in the position to be able to assign weights, either to objectives or to individual environmental impacts. Similarly, the approach proposed by Cassidy (1975), which incorporates some dubious annoyance curves unsubstantiated by any social response data, was not regarded as a feasible methodological option in the context of the research project.

Approaches to evaluation based on standard setting were also rejected as impracticable. Such approaches include cost-effectiveness and cost-minimisation. The assumptions to be met in cost-effectiveness evaluation (Flowerdew, 1975) cannot be validated operationally given the current level of our knowledge regarding environmental values and valid standards are themselves difficult to establish. Again, it should be emphasised that existing research in the field of traffic-environment problems has focused for the most part on residential areas. Although it may appear that we have the beginnings of a system of residential area noise standards (through the mechanism of the Land Compensation Act, and admittedly in a very limited way) such standards for external activity locations would seem a long way off.

Finally, we arrive at evaluation methodologies which are based on the use of unweighted display matrices of the environmental impact statement type (see (Lassiere, 1973), for example)). Such approaches come under the rubric of what Williams (1975c) has termed "design" methods of evaluation. The impact statement approach seeks to display relevant impacts associated with alternative courses of action. The relevance of impacts may be established with respect to policy objectives and whatever evidence exists concerning the significance of impacts expressed through the mechanism of subjective responses to the environment.

The compilation of such impact statements, or display matrices, is not dependent on the attitudinal or monetary valuation of the environment and no attempt is made to weight impacts or objectives. Such an approach is essentially descriptive but can obviously exploit the availability of techniques by which impacts can be displayed in terms of objective physical units.

It is important to note that the environmental impact statement approach has found increasing expression in recent years, particularly in the United States . The National Environmental Policy Act (1970) requires that an impact statement be prepared for:

> .....every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. (Section 102)

Such statements should include the identification of " unavoidable adverse environmental impacts", possible alternative courses of action and the balance between short term gains and long term damage.[1]

The recent Review of the Development Control System (HMSO, 1975) in this country included among its recommendations the proposal that impact analysis be incorporated within the system (Planning, 1975).

In the context of the research project, the impact statement approach to evaluation was viewed as having certain distinct advantages. The use of an unweighted display matrix clearly does not depend on some possibly untenable assumptions concerning the way in which either objectives or impacts are valued. Furthermore, the form of impact statement adopted - the display matrix - is flexible in that as more data concerning impacts and responses to impacts become available, these may be readily incorporated.

The method is practicable in an operational sense

---

[1] For a general discussion of the Act's requirements and implications see White (1972). For a critique of the NEPA see Greenberg and Horden (1974). Guidelines on impact statement preparation under NEPA obligations have been issues by the US Council on Environmental Quality (1973). Other useful readings on impact statement preparation include those of Leopold, et al (1971) and Peterson, et al (1974). The former has been heavily criticised by many for the simplicity of its approach.

and is almost certainly going to be cheaper to operate at the small project level in particular, than approaches based on attitudinal or monetary valuation requiring extensive and costly social survey inputs.

One might argue that the appeal of the method is associated partly with its apparent simplicitly. This is, of course, a danger and much of the criticism levelled at the Leopold approach has stemmed from a feeling that the type of impact statement produced in indeed too simplistic. Considerable care must, therefore, be exercised in the compilation and presentation of impact statements.

The approach to evaluation adopted in the research project, therefore, takes the form of an unweighted impact display matrix.

3.5. The Research Problem Defined

The discussion above has hopefully provided a rationale for the methodological approach which the author adopted. Given that a specific evaluation method has now been selected as the basis of the project, the research problem may itself be defined in the following way:

To explore what was feasible in terms of

> environmental evaluation methodology, with reference to the specific spatial scale of the district shopping centre.

Given the constraints on the selection of a suitable methodology described in the previous section, the fundamental objective of the project became:

> The development of a systematic environmental impact statement methodology suitable for the evaluation of alternative policy options for district shopping centre links in the highway network.

The methodology represents a systematic synthesis of inputs from various existing research areas, coupled with the development of a key area; the conceptualisation and measurement of pedestrian exposure.

An attempt was also made to develop a procedure to determine the trade off costs, in monetary terms, between accessibility and environment on shopping links. Certain conceptual and practical problems precluded the use of this procedure in a realistic manner within the proposed methodology presented in Chapter 9. However, it was felt that the procedures should be presented and discussed, primarily to give some indication of the potentialities and problems of the costing method used. The relevant details, together with some derived costs, are presented in Technical Appendix 1.

Although it was not feasible to use the costing method described in the Technical Appendix, an attempt has been made to isolate and specify policy costs incurred in the worked examples presented in Chapter 9.

There exist a number of dimensions of the research problem which, in effect, summarise the various components of the project and the interrelationships between these components. These dimensions are as follows:

(a) Examine existing approaches to the environmental problems of shopping locations as a background to the study.

(b) Determine the environmental impacts to be included in the impact statement by reference to existing evidence regarding the nature of subjective responses to traffic environments.

(c) Indicate the methods by which the selected impacts might be predicted in relation to policy options.

(d) Establish the nature and composition of the activity groups exposed to traffic impacts in district shopping centres.

(e) Develop a meaningful conceptual framework for exposure measurement and determine, where relevant, the exposure characteristics of activity groups.

(f) Integrate these components to produce a systematic environmental impact statement which incorporates:

(i) changes in the level of impacts in relation to policy options,

(ii) measures of pedestrian exposure, and, where relevant, other activity groups.

(g) Apply the proposed methodology to a small sample of district shopping centres in the WMTS Study Area using some illustrative test policies, specifying associated policy costs where possible.

To summarise, therefore, the project represented an exploration into the methodology of the environmental impact statement at the specific spatial scale of the district shopping centre.

The sequence of the following chapters does, for the most part, reflect the sequence of the dimensions isolated above. However, as will be noted, Chapter 8 is devoted to an extended review of problems and issues in evaluation and evaluation methodologies, and may be regarded as setting the scene for the presentation of the proposed methodology in Chapter 9.

CHAPTER FOUR

ENVIRONMENTAL POLICIES FOR SHOPPING CENTRES

4.1. Introduction

Certain environmental policies for shopping centres have already been mentioned briefly in preceding chapters. The purpose of the present chapter is to examine the relevant policy framework in somewhat greater detail in order to isolate current approaches to the problem of resolving the conflict between road traffic activity and pedestrians in shopping locations. The development of environmental policies for shopping centres will be described and their objectives, implications and environmental performance considered.

At the outset it should be emphasised that such policies have found expression primarily within the spatial context of urban central areas (Ritter, 1964). The pedestrianization of major shopping streets, or more extensive shopping areas, has proved to be one of the most effective and popular policy approaches to the environmental quality problems of central area shopping locations (OECD, 1974)

The pedestrianization of existing shopping streets through the exploitation of discretionary powers to restrict vehicle access is, however, one of the two current policy approaches to pedestrianization. The second approach is based on the implementation of specific design criteria which provide for the spatial segregation of pedestrians and vehicles in purpose built precinct areas ((Binks, 1974) (Harris, 1961)(Liekerman and Wilcock, 1970)(Multiple Shops Federation, 1964)).

The recent history of pedestrianization policies has its origins in the plans for the redevelopment of Coventry City Centre which were prepared in the late 1940's. When opened, Coventry became the first completely pedestrianized area in Europe (Dalby, 1973).

The implementation of such policies, and particularly those involving existing shopping streets, raises a variety of significant issues, not the least of which are problems of goods vehicle servicing, public transport access, car parking and capacity for through traffic (Richards, 1974).

It is evident that the fundamental issue of reconciling environmental and accessibility considerations is central to the formulation and evaluation of pedestrianization policies. Furthermore, they are clearly indicative of the need to integrate the planning of the built environment and transport facilities (Mills, 1974).

4.2. Segregating People and Traffic in Shopping Centres

It would be useful to clarify the terminology of traffic management schemes. Dalby (1973) has presented a definition of terms and this is presented in Table 4.1..

As Dalby notes, the "British Standards" Glossary of Highway Engineering Terms provides a definition for only one of the terms included in Table 4.1.: pedestrian precinct. Such a precinct is defined as "an area reserved exclusively for pedestrians".

The term "pedestrianization" does, however, have a more general applicability to situations ranging from the complete segregation of pedestrians , in both time and space, to the implementation of selective time constraints on vehicle access and access restrictions on designated vehicle types.

The Coventry scheme represents a land mark in the development of pedestrianization policy in Britain. Over the twenty five years since the introduction of the pedestrian precinct concept in this country, the benefits of this essentially design oriented approach have been widely recognised by the general public, retailers, planners and local authorities.

The early developments in the field were primarily associated with those situations in which local authorities were able to exploit the opportunities afforded by new shopping

Aston University

developments or redevelopment schemes. In such cases it was possible to provide for pedestrian-vehicle segregation at the design stage.

The initial period of pedestrianization in Britain was thus geared very much to the specific opportunities to design out the potential conflict between traffic and the pedestrian.

This relationship between new or redeveloped shopping areas and pedestrianization reflects primarily a situation in which local authorities lacked the necessary powers to exclude traffic from existing shopping streets in order to improve environmental quality. Even when such powers did ultimately become available they were initially linked explicitly to accessibility considerations (at the local level) or the one environmental dimension of pedestrian safety. Only in the latter part of the 1960's was there a clear shift in emphasis to the use of vehicle access restrictions on broader based environmental grounds.

It was not until 1960 that the first powers to restrict vehicle access to any road or street became available to local authorities.

The provisions of Section 26 of the Road Traffic Act (1960) empowered local authorities to restrict vehicle access to any street or road for periods up to six hours in twenty four. However, these provisions permitted such restrictions only in cases where pedestrian safety and traffic circulation required improvement. As Dalby (1973) notes, the most deserving locations for the implementation of such powers tended to be characterised by low pedestrian accident rates, with the result that such powers were only rarely used to improve this one particular aspect of the pedestrian's environment.

Later legislative developments did, however, give local authorities far greater opportunities to implement policies with specific pedestrian environment objectives in mind.

The Road Traffic Regulation Act (1967), later amended by Section 126 of the 1968 Transport Act, provided powers for the prohibition of vehicular access for periods up to eight hours in twenty four.

The legislation also provided for the planning of the needs of any type of traffic, including pedestrians, without this necessarily being construed as a prevention of reasonable access. With the Secretary of State's approval, access to streets or roads could be prohibited for longer periods, up to and including twenty four hour restrictions. Such proposals were, however, generally approved only in cases where pedestrian safety was again a prime consideration.

Traffic segregation on explicit environmental grounds was made possible with the powers provided by the 1968 Town and Country Planning Act (Section 92). The relevant provisions remained basically unchanged in the 1971 Act.

These powers are clearly much more appropriate to the achievement of environmental objectives in shopping streets and local authorities are afforded a more comprehensive framework within which to articulate such objectives.

The Act provides for the conversion of traffic streets into footpaths, with access only for specified vehicle types. Streetworks may be undertaken to improve pedestrian amenity, even at the expense of permitted traffic.

The use of the powers outlined above constitutes the basis of recent developments in pedestrianization in this country. The provisions of the 1968 Town and Country Planning Act were widely used to initiate schemes in various twons and cities. Some examples of existing pedestrianization schemes are provided in Table 4.2., classified according to type.

The trend towards the pedestrianization of shopping streets in central areas is by no means confined to Britain. As recent OECD reports indicate (OECD, 1975) a large number of cities in the member countries have ongoing

Table 4.2. Examples of Pedestrianization Schemes

y, 1975, p45

programmes of pedestrianization.

There now exist a number of quite detailed surveys of pedestrianized shopping areas in Europe and North America, and a certain amount of information on schemes in Japan.

Gray (1965) has provided a review of the design and layout characteristics of a number of pedestrianized streets in Western Europe. More recently, the GLC Study Tour Report "Pedestrianized Streets" (GLC, 1973) provides a considerable amount of detailed information regarding schemes in some fifteen cities. The OECD report "Streets for People" (OECD, 1974) also includes details of specific schemes in Europe, North America and Japan, as well as discussions of pedestrian policies and strategies.

It is interesting to note that the countries which have implemented the greatest number of pedestrianized street schemes - West Germany and Denmark - have been able to carry out such policies without recourse to statutory powers of the type required in Britain (Richards, 1974).

4.3. Dimensions of Pedestrianization

A variety of factors must be considered when pedestrian-vehicle segregation policies are applied to shopping areas. Antoniou (1971) has produced a schematic breakdown of these factors and the schema itself is presented in Figure 4.1..

Clearly, the complete segregation of pedestrians and traffic, although the most environmentally beneficial in the immediate area of the shopping centre, may only be viewed as a feasible option in those situations where it does not excessively disrupt the functional activities of the centre or community.

Particular emphasis must obviously be placed on the provision of suitable goods vehicle access, bus access, car parking and capacity for through traffic. As has been suggested, this type of scheme may be best suited to those situations in which shopping areas have either been developed or redeveloped in the context of town plans.

Three other degrees of traffic restraint are considered in Antoniou's schema; time segregation, hired transport and limited vehicle access.

Time segregation of vehicles and pedestrians may be achieved by exploitation of the powers described in the previous section. Pedestrians have priority use of the street(s) involved for specified periods of the day. Such policies do, however, frequently present severe problems of goods vehicle access. It has been suggested (FTA, 1974)

Aston University

that the regular delivery of fresh foods to such pedestrianized areas is becoming an uneconomic proposition, and that there is evidence that shop use in pedestrianized streets may be changing to low servicing demand types. Furthermore, the same report suggests that servicing concentrated in particular time periods may result in a higher accident rate.

The hired transport approach to pedestrianization exists on only a limited scale at the present time. The provision of shopper buses in pedestrianized central areas, for example, the Centrebus scheme in Birmingham, represents an attempt to reconcile the demand for public transport access to the central area with environmental considerations. The goods transhipment approach to shop servicing has similarly yet to be tested on an extensive scale.

Limited vehicle access may in some cases be associated with selective time constraints on access for particular vehicle types. The provision of adequate capacity on the local network for through trips is again a prime consideration, as are the issues of goods vehicle servicing, bus access and parking.

The goods vehicle servicing issue is one which can have a profound effect on the overall success of schemes. An increasing amount of research is being conducted into the problems of urban freight movement, due primarily to increasing public concern about the impact of heavy goods vehicles on the environment. There exist some general reviews of the goods vehicle problem (for example,(Sharp, 1973)(HMSO, 1974)) but reported studies of goods vehicle servicing in shopping areas are limited.

A study by the Metra Consulting Group (Metra, 1970) examined the generation of goods vehicle movement in two shopping centres in London; Hammersmith and Wembley. Jennings, et al (1972) have studied the operation of the Watford precinct from the servicing viewpoint. More recently, studies of urban freight distribution in relation to shopping streets have been carried out by the Transport and Road Research Laboratory (Christie, et al 1973a; 1973b). Reference will be made to these TRRL studies in a subsequent chapter.

Thorpe (1970), drawing on the results of the Metra survey, has presented a comparison of data concerning goods vehicle generation in Hammersmith and Wembley. The primary emphasis of this paper is on the goods traffic generated by supermarkets but nonetheless the data presented give some indication of the relationships between shopping centre characteristics and goods vehicle attractions.

It should be stressed, however, that both Wembley and Hammersmith are more in the order of district shopping centres, and certain of their structural and functional features clearly differ from those generally associated with central shopping areas.

The data presented by Thorpe indicate that approximately 20% of all goods vehicle deliveries to the two centres are to grocery outlets. The exclusion of this particular retail function, together with variety and department stores would, it is estimated, reduce the number of deliveries by 45%.

Estimates of the numbers of deliveries to individual establishments present a somewhat complex picture. Whereas there appear to be economies of scale expressed in terms of the number of deliveries to establishments of different sizes, the actual time requirements for delivery shown little overall difference. Furthermore, with increasing store size the frequency and duration of delay increased, as did the overall size of delivery vehicle.

Clearly, the functional characteristics of individual shopping areas will have a considerable impact on the demand for goods vehicle access to pedestrianized areas. Whereas central shopping areas might be expected to have fewer grocery outlets this would to some extent be counteracted by the presence of large variety stores and department stores generating goods vehicle traffic, both in terms of deliveries to the shops and deliveries of goods to customers.

Attention must obviously be paid to the functional characteristics of proposed pedestrian shopping areas and also to the likely size of goods vehicles requiring access after scheme implementation. Both the Multiple Shops Federation and the Freight Transport Association have incorporated recommendations for turning radii provision in their proposals for servicing standards ((MSF, 1968) (Hatfield, 1972)).

The public transport access factor is clearly an issue to which the public, transport operators and planners are sensitive. Shopping trips are a very significant element of bus passenger traffic (Vickerman, 1972). From the public viewpoint it is desirable that access to shopping areas be maintained at a satisfactory level. Transport operators are not unreasonably sensitive to standards of service and operating costs.

The key issue is essentially one of the proximity to, or penetration of, pedestrianized shopping streets or areas by bus services, and various policy approaches are in evidence. In some cases, bus services operate adjacent to the pedestrianized area, in others traffic streets bisect the primary pedestrian streets, while another approach has been to classify buses as permitted traffic (TRRL, 1972).

The mixing of vehicles and pedestrians in shopping streets with limited access constraints on the former is an approach which has been widely adopted in this country.

Such an approach does, however, raise certain issues concerning the layout of shopping streets and in particular the choice between providing a formal carriageway for vehicles or resurfacing existing carriageways to pavement height. The latter is regarded by some as a key element in establishing the priority of pedestrian activity over that of vehicles (OECD, 1974).

The problem of maintaining bus operating speeds has, in some cases, necessitated the retention of existing carriageways, but in periods of high pedestrian activity this objective is difficult to achieve even with carriageway provision (Dalby, 1973). Furthermore, the issue of bus access to pedestrianized areas does raise the possibility of the substitution of general environmental disamenity through traffic activity with a specific agent of environmental nuisance.

The policy approaches to pedestrianization in this country have been described. The factors which must be considered in applying traffic restraint to shopping streets have been briefly examined, with particular emphasis being placed on issues of goods vehicle servicing and bus access. The preceding discussion has clearly been centred on the implementation of pedestrianization policies in central areas, but this, of course, reflects the primary locational emphasis in current policy approaches.

4.4. Pedestrianization: The Rationalization and Articulation of Policy Objectives

The trend towards the pedestrianization of shopping streets or areas was initiated at a time when traffic problems per se were not perceived as the fundamental environmental issue which they are today. Until quite recently the basic means of achieving environmental improvements in shopping centres revolved around an essentially design oriented approach. Both built-form and transportation elements of the shopping environment are manipulated in order to design out pedestrian vehicle conflicts and other environmental disbenefits. Such precinct schemes appear for the most part to have been evaluated purely on a design basis.

Since the late 1960's attention has been directed to the possibilities afforded by environmental traffic management in shopping streets. Such a development is clearly in keeping with the changes in the broader transportation policy framework described in Chapter 2.

Until the recently, the motives behind pedestrianization proposals have generally been none too clear. Political and economic factors have undoubtedly been prominent in many local authority schemes. Civic pride and a desire to strengthen the competitive position of the central area vis-a-vis new shopping developments in peripheral areas have played a significant role in encouraging some local authorities to invest in or stimulate the development of pedestrianized shopping areas.

Evidence from 32 German cities (Kuhnemann and Witherspoon, 1974) shows that traffic flow and economic objectives figured more prominently in the creation of traffic free shopping areas than did environmental factors. As the authors comment:

> These findings strongly suggest that decision makers were concerned only secondarily with environmental considerations.

Whether similar objectives underlay pedestrianization schemes in this country - even those based on environmental traffic management - is not easily established.

What is apparent, however, is that there is very little evidence on which to evaluate the environmental performance of such schemes. This is particularly so in the case of environmental traffic management schemes, which have for the most part been associated with a much clearer articulation of environmental objectives.

This lack of data relating to scheme performance does in part reflect the lack of available techniques for environmental measurement and prediction, and, of course, evaluation methodologies. However, to return to a point made in Chapter 2, the implementation of environmental traffic management policies for shopping streets clearly necessitates evaluation of the environmental benefits and losses involved, as well as the monetary costs incurred.

It is argued, therefore, that the rationalisation of early pedestrianization schemes reflected a subjective design-oriented response to issues of conflict between traffic and pedestrians. Pedestrian safety considerations and traffic flow factors were undoubtedly primary constraints on the selection of early pedestrianization schemes based on traffic management techniques. The emergence of environmental traffic management has been associated with a rapid expansion in the number of pedestrianization schemes related to existing shopping streets. In such cases, environmental objectives are clearly in evidence, although detailed evaluation of scheme performance has rarely been undertaken.

4.5. The Benefits Derived from Pedestrianization

Data relating to the environmental benefits resulting from pedestrianization are somewhat fragmentary and in many cases take the form of subjective estimates of environmental variables and changes in their level of intensity.

However, it is useful to examine such data as does exist because it at least gives some indication of the environmental performance of pedestrianized street schemes.

Data relating to a number of schemes in various countries has been assembled and are presented in Table 4.3.. Figure 4.2. illustrates the differences in noise levels recorded in Birmingham City Centre between the various types of pedestrianized area.

The data in Table 4.3. clearly reveal that considerable reductions in noise levels and carbon monoxide levels may be achieved by pedestrianization. One would not unnaturally expect reductions in smoke and pedestrian delay impacts although no quantitative data on changes in these impacts appears to be available. There is a marked tendency to arrive at subjective conclusions about these factors as well as general amenity benefits such as visual quality.

There is also evidence which suggests that the number of pedestrians using pedestrianized shopping streets shows an increase after scheme implementation, and that retail sales may increase.

In Copenhagen's Strøget shopping area, the volume

Table 4.3. Environmental Changes in Pedestrianized Shopping Streets: Some Examples

CENTRE	NOISE LEVELS	CO LEVELS	OTHER IMPACTS
Ginza, Tokyo	----	reduced from 14.2-2.9 ppm.	------
Copenhagen	reduced from 75-65 dB(A)	----	
Gothenburg	reduced from 74-67 dB(A)	reduced from 65-5 ppm	pedestrian accidents reduced by 20%
Cologne	reduced from 70-45 dB(A)	reduced from 8-1ppm	-----
Leeds	reduced from 65-75 to 60-65 dB(A)	----	-----
New York	reduced from 75-65 dB(A)	reduced from 23-8ppm	-----
Southampton	reduced from 80-70 dB(A)	----	-----

COMPARATIVE NOISE LEVELS - Birmingham City Centre.

FIG. 4.2.

100

90

75

50

25

10

0

85

Source CITY OF BIRMINGHAM STRUCTURE PLAN

TRANSPORTATION STUDY 1973

of pedestrian traffic increased by 20-48% one year after scheme implementation. In Norwich, the number of pedestrians increased by some 45% (Richards, 1974).

Despite the customary opposition to pedestrianization from retailers, data from a number of centres indicates that retail sales frequently show an increase after pedestrianization.

In Vienna, an increase in business in the order of 25-50% was reported. In Norwich, sales increases of up to 10% were reported with only two shops in the pedestrianized area reporting a drop in business (Wood, 1974). In Rouen, sales increased by 10-15% and in Essen by 15-35%, depending on shop type (Orski, 1974).

However, the retailers' fear of pedestrianization may well be vindicated in situations such as that which occured in Eccles. All vehicles, including buses, were removed from the High-Street. A total of 121 shops out of 141 reported a decline in business (Richards, 1974).

Clearly, the pedestrianization of central area shopping streets necessitates some redistribution of vehicle trips. Available evidence suggests that by no means all of the displaced trips need reappear on adjoining roads. After implementation of the Strøget scheme in Copenhagen, only 72% of its former traffic reappeared on parallel streets and this figure fell to 38% during peak periods. In Norwich, following the closure of London Street, 60% of the traffic previously using this street did not appear in the adjacent areas. Only a 20% increase was noted in the levels of traffic on the adjoining streets ((Richards, 1974)(Wood, 1974).

4.6. The Implications of Pedestrianization Policies for District Shopping Centres

The emphasis placed on the pedestrianization of central area locations was established earlier in this chapter. However, it was also suggested in Chapter 3 that the City of Birmingham had, during the latter part of the 1960's, exploited schemes for the redevelopment of existing district shopping centres in order to implement pedestrianization policies.

Over the past few years, some local authorities have turned their attention to High-Street centres and have started to examine the feasibility and implications of pedestrianization schemes for these locations. This thinking is apparent in both the City of Birmingham Structure Plan (City of Birmingham, 1973a) and the concluding sections of the GLC report (GLC, 1973).

In environmental quality terms, it is clear that very real problems do exist in a great many High-Street district centres. Pedestrianization of all , or part of, such shopping locations could undoubtedly produce significant environmental benefits. The implications of such policies at this level are, however, considerable.

The primary issue is clearly that of resolving environmental considerations at the local level with accessibility requirements on the strategic highway network. The removal of capacity from this network will necessitate displacement of traffic to links in the local network, unless, of course, trip end restraint is operative. Thus, the examination of the environmental predicament of these centres is undoubtedly going to raise fundamental trade off issues associated with environmental disamenity.

The close proximity of most district centres to residential areas implies that if traffic is to be restrained on the shopping link it will have to be redistributed over a local network which either totally, or in part. is associated with the residential environment.

The problem clearly becomes one of trading off environmental benefits to one type of environmentally sensitive location against possible losses in another.

Certain of these problems may be resolved by the construction of bypasses around sensitive shopping locations, thereby deriving both environmental and accessibility benefits. However, the current limitations on highway investment imply that this solution may only rarely represent a feasible option. Environmental policies for district shopping centres will, therefore, have to be examined in the context of local environmental traffic management.

Given the present climate of opinion concerning highway construction and traffic impacts in residential areas it would not seem unreasonable to suggest that opportunities for environmental improvement in district shopping centres are somewhat limited.

However , although such problems exist, it may also be argued that there remains a need to evaluate all feasible opportunities to improve environmental quality in these locations. Similarly, there is a need for a logical and coherent methodology which will permit the planner to evaluate the environmental implications of such policies. It is to this particular purpose that the present study is directed.

CHAPTER FIVE

SUBJECTIVE RESPONSES TO TRAFFIC ENVIRONMENTS

5.1. The Need to Define the Environment

The definition of the environment represents a fundamental theoretical issue in environmental evaluation. The need to define the environment is clearly linked to the critical issue of establishing relevant environmental impacts which should be accounted for in the evaluation process. Essentially, the problem is one of determining how much of an "environmental good" should be provided, and how components of the environment may be traded off against one another. However, although policy should obviously seek to respond to community values pertaining to the environment, little is currently known about the way in which individuals and groups exposed to traffic impacts perceive, and respond to, the components of this semi-discreet environment.

Stringer (1973) commenting on the growing interest in environmental perception and evaluation in geography and planning suggests that various motives may be detected in studies where "lay people" are invited to "evaluate parts of their physical environment".

There exists a justificatory approach in which planners seek to rationalise their actions in the environmental context. A related approach seeks to ascertain the extent to which planning goals have been achieved. The purpose may be proleptic, reflecting a desire to determine what people currently value and assuming that a replication of valued elements will maximise future satisfaction. Finally, this interest may reflect a general concern with the nature and structure of environmental value systems.

Stringer's comments would appear to be directed primarily to approaches involving the examination of the affective component of attitude (Upshaw, 1968). This relates to value systems and the degree of positive or negative feeling towards an attitude object.

Initially, however, it may be argued that we are primarily concerned with the cognitive dimension of attitude, that is, with experience, information levels and expectations of and about the environment. We are seeking to determine those attributes of traffic environments which are represented in the individual's knowledge structure, or "image" (Boulding, 1956) Nonetheless, we cannot ignore the affective component of attitude completely. Environmental evaluation inevitably raises questions about the relative significance of environmental variables and the valuations, both attitudinal and monetary, ascribed to them.

5.2. Approaches to the Definition of the Environment

The discussion above was framed essentially in terms of the social psychological approach to the definition of the environment. This is, however, just one of a number of approaches to the problem.

Theoretical approaches to the definition of the environment are reviewed by Williams (1975a). Four approaches are identified:

(a) the general or holistic approach

(b) the environmental indicator approach

(c) the bundle of"environmental goods" approach

(d) the social psychological approach

5.2.1. The General Approach

In this approach a broad perspective on environmental quality is adopted. This may also be associated with general statements regarding the components of environmental quality to which policy should respond.

Not unnaturally perhaps, this approach has been widely adopted in the political sphere, as well as in much of the public debate concerning environmental quality issues. In a sense, it may be argued that such an approach, frequently embodying the articulation of broad resource allocation priorities, is well suited to the public debating context. It would appear to provide a useful common ground, free from technical complexities, from which debates about issues of environmental quality may develop between decision makers, planners, designers and the public.

Furthermore, as Williams suggests, the framing of environmental quality objectives in such broad and general terms may well be seen to provide planners and designers with a framework within which professional standards might constitute the basis for defining environmental quality. Alternative standards and definitions might also be derived from elected members and the public through participation exercises.

The approach does, however, beg many questions about the nature of environmental quality and the manner in which highly generalised definitions of the environment may be translated into policy options directed to the achievement of environmental objectives. Furthermore, acceptance of such an approach may well imply acceptance of professional values regarding the environment. If professional and public values are not in accord then there exists the possibility that policy responses to the issues may generate dissonance between the various "actors".

5.2.2. The Environmental Indicator Approach

This approach again seeks to generate a broad definition of environmental quality. Such an approach does, however, imply a change in the criterion employed in the articulation of environmental policies. The typical binary form of environmental indicators directs attention away from attribute specific policy criteria to location specific focii. Thus, policy seeks to respond to measurements of the number of locations, or environments, classified according to the two categories representing the indicator rather than the environmental quality attributes in a specific area.

If the definitions employed in such an approach are seen to reflect a community consensus, a dubious proposition without detailed validation, then the approach, with its advantage of drawing attention away from the heterogeneity of urban areas, might prove useful in broad policy option appraisal. However, the degree of generality inherent in this approach implies that the indicators themselves may well remain poorly defined. Furthermore, in common with aggregate definitions of environmental quality the actual components of that quality are unlikely to be presented in a form to which the professional planner or designer can respond.

5.2.3. The Bundle of "Environmental Goods" Approach

This approach contrasts markedly with both the general and indicator-oriented definitions of environmental quality, in that a disaggregated view of the environment is adopted. The environment is defined in terms of various distinct elements, for example, noise, fumes and so. These elements are regarded as "environmental goods", and environmental quality is deemed to comprise of a bundle of such goods. Effects are examined independently even though little may be known about what each effect means to the individual exposed to it, and how that effect is itself defined by the individual.

These fragmentary, pragmatic approaches to the definition of the environment again raise the critical issue of the relevance of environmental effects as defined for policy purposes. Who generates this bundle of"environmental goods"? On what basis is the selection of effects rationalised? Who defines the effects? Such an approach would appear to imply certainpreconceptions about the nature of the environment which are not validated by reference to the experiences and information levels of those exposed to the effects. Only in the case of imperceptible environmental effects, or impacts, (for example, carbon monoxide) would there appear to be a case for the categorical statement of effects explicit in this approach.

5.2.4. The Social Psychological Approach

This approach to the definition of environmental quality represents an attempt to generate a definition on the basis of the subjective response of the individual to the environment within which he operates. In other words, the approach is based on an attempt to define environmental quality in terms of environmental attributes to which individuals respond. This is, of course, a disaggregated approach to the problem. However, it is not without its problems. Indeed, there are formidable theoretical and conceptual problems associated with the aggregation of individual responses to the environment and this is clearly a prerequisite for the definition of group and community values regarding the environment. This approach, nonetheless, although perhaps the most appealing must ultimately come to terms with the problem of identifying group and community value systems if it is to prove a credible basis for defining policy criteria and evaluating the environmental implications of policy options.

Four approaches to the problem of defining environmental quality have been described. None of these approaches are straightforward and certainly some embody rather gross assumptions concerning the nature of the environment. Of the four, the social psychological approach would appear to offer the only direct method of isolating components of environmental quality. However, to accept this approach is not to minimise the problems inherent in the definition of individual, group and community value systems.

5.3. Disciplinary Perspectives on Subjective Responses to the Environment

An interest in subjective, personalised responses to the environment is by means confined to those involved in the study of traffic impacts. Environmental perception has been a significant growth area in certain social science disciplines over the past ten years or so. Much of the literature in various disciplines has been concerned with basic theoretical and conceptual issues, although there has been a steady increase in the number of empirical studies of human responses to various environmental settings and phenomena.

Much of this literature has derived from the discipline of geography, although more recently there has been a growing interest in the study of environmental perception and attitudinal responses to the environment in the field of planning. Similarly, the disciplines of sociology and psychology have exhibited an interested in subjective responses to the environment. It is, however, worth noting that in the discipline of economics very little emphasis has been placed on the underlying psychological basis of individual behaviour with respect to the environment.

It is perhaps not unnatural that the issue of valuing environmental impacts should dominate the discussion of economic perspectives on responses to the environment. Howver, it is self evident that the definition of environmental impacts and the derivation of valuations of these impacts are closely related issues. In a sense, the problem may be viewed in terms of an analytical chain (Johnson and Joyce, 1975) incorporating the definition of impacts, perceptual and cognitive processes, the formation of preferences, the generation of values and the derivation of these values.

Clearly, the economist has regarded his point of entry into this chain as the valuation of environmental impacts. However, it is also apparent that the link between the formation of preference functions for environmental quality components and peoples' behaviour is not clearly understood. Thus, in the context of defining the environment rather than placing a value on components of it, economists can provide very little help.

The study of subjective responses to the environment in geography has become synonymous with the term "behavioural geography". This area of geographical research has drawn heavily on social psychological concepts and techniques. The factors which led to the emergence of this field of study, and subsequent developments within it have been extensively reviewed in the literature ((Doherty, 1969)(Goodey, 1970)(Koroscil, 1971)(Downs and Stea, 1974)).

Geographers have been primarily concerned with eliciting subjective responses to the environment which reflect information levels, attitudinal expression and potential behaviour traits persisting after the stimuli representing perceptual inputs are no longer present ((Schiff, 1970)(Downs and Horsfall, 1971)).

The conceptualisation and measurement of what geographers have termed "spatial" or "environmental" perception implies the existence of a knowledge structure, or mental representation (Harrison and Sarre, 1971), which is based on more than the inputs derived from the monitoring of the environment by the sensory organs. Thus, research in behavioural geography has focused on the conceptualisation and measurement of spatial and environmental images rather than perception per se.

A useful framework for classifying research themes in behavioural geography is provided by Upshaw's conceptualisation of attitude as a three dimensional construct, incorporating affective, cognitive and behavioural components (Upshaw, 1968).

The affective and cognitive dimensions of attitude were mentioned in a previous section. The former represents value systems and positive or negative feelings towards and attitude object, and the latter, experience and information levels.

The affective dimension of attitude has found expression in studies of space preference ((Doherty, 1968)(Gould, 1969) (Downs, 1970a)(Silzer, 1972a)(Lundeen, 1972)).

The cognitive dimension has been explored through numerous image structure analyses (for example, (Downs, 1970b)(Eyles, 1968)).

The behavioural dimension, relating to decision making processes and expressed behaviour, reflects the extent to which the first two dimensions constitute a basis for action. Examples of this dimension, as expressed in research terms, remain somewhat limited although Morley and Thornes (1973) employ a Markov decision model incorporating behavioural constraints to analyse flows through a network system.

Much of the research undertaken in behavioural geography has not unnaturally reflected academic rather than applied empirical interests. As such, it is akin to the study of environmental value systems.

However, at the interface between geography and planning, and, indeed, within the field of planning itself, there is evidence of a growing interest in subjective responses to the environment in applied problem solving situations ((Craik, 1968)(Goodey, 1970)(Church, 1973)(Cane, forthcoming).

Environmental sociology, or as it is more commonly known, the situational analysis of human behaviour provides another disciplinary perspective on subjective responses to the environment. This research area focuses on individuals and attempts to account for their actions in particular types of decision making contexts, or situations, and their definitions of these situations.

It is a basic assumption of environmental sociology that social behaviour is relative to the situation, that is:

> ..... to the characteristics of the objective environment, as well as the characteristics of the subjective environment. (Silzer, 1972b)

Stebbins (1967) defines the objective environment as:

> ......the settings in which men find themselves in everyday life.....

and the subjective situation as:

> ......the psychological image of the settings in which men find themselves.

This subjective situation is recognised as a mental construct based on selective perception, which is itself influenced by the actor's goals. The actual definition of the situation is regarded as a process by which the individual gives a meaning to these settings in which he may find himself (Stebbins, 1969).

The explicit mention of selective perception as the basis of the subjective situation raises a basic theoretical question concerning the processes by which subjective responses to the environment are generated. Certain situational analysts (for example,(Znanieki, 1965)) have argued that if the study of the definition of the situation is interpreted as the study of selective perceptual processes then it is not susceptible to empirical analysis.

This problem may, however, be overcome at the operational level by examining respondent statements concerning specified situations. The definition of the situation may, therefore, be derived by ascertaining the actor's information set pertaining to a specific setting ((De Fleur and Westie, 1958)(Gorden, 1952)). An alternative approach involves inferring situational definitions from observed behaviour in both private and public spaces, and from statements regarding behaviour in these settings ((Goffman, 1959; 1963)(Suttles, 1968)).

Situational analysis incorporates the explicit assumption that behaviour is in part a product of the characteristics of the objective environment. Much discussion in the field has centred on the significance of the influence of the objective environment on the individual's subjective view, or image, of that environment and his behaviour within that environment. The objective environment is generally viewed in terms of four basic components; the physical-spatial, temporal, social and behavioural. It is these components which combine to produce what MacIver (1942) termed:

> ......the situation as it might appear to some disinterested eye.

Situational analysis focuses primarily on the temporal and social components of interaction contexts, in contrast to the geographer's concern with the spatial dimensions of images and behaviour. Thus, the concern is with the definition of subjective situations, one from another, and the identification of relevant actors in any specified situation.

The final perspective on subjective responses to the environment which should be mentioned is that which derives from work carried out in the field of environmental psychology.

This field developed during the 1950's and 1960's in response to the growing need for a better understanding of the relationship between the physical environment and human behaviour.

As Proshansky, Ittelson and Rivlin (1970) have shown in their text of collected readings in the field, environmental psychology is an extremely wide ranging subject area and one which currently lacks a precise subject definition.

As the authors point out, it is not yet possible to propose a definition of environmental psychology based on theoretical constructs. Instead, they adopt an operational definition based on what environmental psychologists do.

It is clear, however, that there exist fundamental linkages between environmental psychology and the disciplinary perspectives provided by geography and sociology.

Spatial and social considerations figure prominently in many area of environmental psychological research, as do integrative design considerations. Examples of this spatial dimension are provided by Stea (1965) and Beck (1967). Sociological considerations are prominent in the work of Strauss (1961) and Fried and Gleicher (1961). Socio-spatial factors have been extensively explored by Lee (1963; 1968), and the same researcher is currently (Lee, 1974) examining the psychology of severance in relation to the community impact of urban roads. A sociological perspective on community severance effects is provided by Williams (1973).

The work of Craik should be mentioned in particular. Craik has made numerous contributions to the field, which have served to indicate the linkages between spatial-geographical interests, planning and environmental psychology((Craik, 1968; 1972a; 1972b)).

There is clearly a strong emphasis on design issues in environmental psychology, and in particular, with institutional design problems; offices, prisons, hospitals and hospital wards (Proshansky, Ittelson and Rivlin, 1970). This interest in the relationship between architectural design and psychology has become more sharply defined in recent years and a discreet field of architectural psychology has emerged

(Canter, 1969; 1970; 1972).

5.4. Subjective Responses to Traffic Environments

Our limited knowledge regarding subjective responses to traffic environments represents a fundamental issue in environmental evaluation. Despite the increasing emphasis placed on environmental considerations in transportation planning and traffic management little is known about how individuals structure traffic environments in cognitive terms (what they are aware of), and how they respond (attitudinally and behaviourally) to this type of environment.

We know very little, therefore, about the nature of the environmental value systems of individuals, groups and the community in general and, in consequence, cannot make substantive statements regarding the value attached to specific environmental attributes. Furthermore, we are not yet in a position to make valid interpersonal comparisons regarding environmental changes which may result from the trade offs incurred, for example, in environmental traffic management schemes. Our knowledge concerning the influence of different behavioural contexts on subjective responses and value systems, as well as the relationships between the two, is likewise sparse.

The implications of these shortcomings in our knowledge are considerable and find expression in various aspects of environmental evaluation methodology.

In order to establish the cognitive dimensions of traffic environments we must at present rely on a limited number of social surveys. These surveys have gone some way towards revealing a number of key areas of public concern regarding specific impacts associated with road traffic. Allowing for the limited and fragmentary nature of these data, they do nonetheless suggest the existence of certain relevant impacts which should be accounted for in the impact matrix.

Although the rationale for impact selection has not always been apparent in some of the existing research in environmental evaluation, it would appear that those impacts which have received the greatest attention do coincide with those isolated in the social surveys. Impact selection for evaluation purposes has also been constrained by two other important considerations. First, a concern with traffic impacts per se rather than environmental issues associated with highway construction. Second, the technical aspects of impact measurement and prediction, reflecting essentially the practicality and effectiveness of technical procedures. As will be indicated in the following chapter, it is not yet feasible to measure or predict certain impacts in relation to the traffic parameters of policy options. This naturally precludes an objective physical statement of impact intensity in such cases.

Having established some of the constraints on the selection of traffic impacts in environmental evaluation, what then is the nature of the evidence regarding subjective responses to traffic environments?

Crompton (1971) has reported a study of the environmental capacities of central area streets in Edinburgh. The objectives of the study were to describe existing traffic and environmental conditions and then to determine how much traffic could be accepted in each street in the future.

In determining environmental capacities Crompton sought to examine subjective responses to existing traffic-environment conditions. A total of some 739 respondents were interviewed on 26 streets. The streets, selected on the basis of their traffic characteristics, had off-peak traffic flows ranging from 48 - 1800 vehicles per hour.

The responses elicited in the survey indicated a particular concern with issues of traffic noise, danger from traffic and difficulty in crossing the road. It is interesting to note that the most pronounced response took the form of a negative feeling towards overall traffic levels. Many respondents (52%) thought that their street conditions reflected the presence of too much traffic.

The Report of the Urban Motorways Committee Project Team (HMSO, 1973) includes response data relating to residential area respondents located adjacent to a road improvement scheme. The UMPT data are cross-referenced with distance from the road and therefore allow for variations in impact intensity over distance. Traffic noise, fumes, dirt and pedestrian severance impacts figured prominently in the response profiles. It should be emphasised that certain of the impacts reported as being annoying are perhaps specific to new road construction or road improvement schemes rather than traffic per se. Such impacts as "loss of privacy", visual intrusion or "spoilt views" fall into this category.

It has been argued (Joyce, Williams and Johnson, 1975a) that if our concern is to be the development of evaluation methods for assessing the environmental implications of policies for the secondary and local road networks then impacts of this type, which are primarily associated with new road structures, are not of the same significance as direct traffic impacts.

Eyles and Myatt (1970) undertook a survey of responses to traffic impacts as part of their study of traffic-environment issues in the Wandsworth area of London (LTS Zone 277). They summarise their findings concerning individual values with respect to traffic environments in the following way:

> The evidence appears to range from a relatively minor concern about visual environment (though this is far from conclusive), through material degrees of increased irritation from traffic noise above a certain threshold, to a marked concern about the problems of crossing busy roads.

Although much of the work concerning subjective responses to traffic environments has focused on residential areas there is a limited amount of information concerning pedestrian responses to traffic impacts.

Crompton's Edinburgh study should again be mentioned. An attempt was made to examine the responses of shoppers on the sample of streets considered. Crompton suggests that they fall mid-way between residents and workers in terms of their environmental awareness. In terms of vulnerability, Crompton argues that his statistical analysis of activity group responses (that is, residents, shoppers and workers) indicates that shoppers are the least vulnerable group on the basis on his specified vulnerability indicators. The derivation of these indicators is somewhat obscure however, and there is conflicting evidence which suggests that shopper-pedestrians may well be highly vulnerable to traffic impacts ((Hedges, 1974)(Cullen, 1975 - personal communication).

There exists a useful "before and after" study relating to the Catford Traffic Management Scheme (Pearce and Stannard, 1973). The relevant report includes a social survey of residents' and shoppers' responses to changes in the level of environmental impacts resulting from the scheme.

Pedestrian responses to the effects of the scheme reflected a basic concern with issues of road crossing movements, and the ease or difficulty involved therein. Pedestrians were clearly aware of increased noise levels on certain links, and this particular impact appeared to annoy the highest proportion of respondents. There was also a marked awareness of changes in the levels of traffic generated fumes and increased pedestrian journey times resulting from severance effects.

Pedestrian surveys incorporating response analyses have also been carried out in the context of the TRRL work on urban freight distribution mentioned in the previous chapter (Christie, et al, 1973a; 1973b).

In the Putney study, some 704 pedestrians were interviewed. In response to a general open-ended question concerning the High-Street, some 95% of the replies included unfavourable comments on the environment of the street. Difficulty and danger associated with crossing the High-Street was a prominent source of concern, noise levels being somewhat less significant. Some 30% of the respondents indicated that they were bothered a lot by traffic in the High-Street and 24% a little. However, from the theoretical and methodological viewpoint a source of some considerable concern is the fact that, as the authors note:

> ......many of the respondents who had earlier replied that they were not at all bothered by traffic then went on to give high bother scores to individual disbenefits.

The authors conclude, however, that noise and delay in crossing the road are the most significant impacts from the pedestrian viewpoint in this particular location.

Similar results were derived from the pedestrian surveys undertaken in Newbury and Camberley, although it should be noted that overall dissatisfaction with traffic was lower than in Putney in both these other other locations. Comparative data are presented in Table 5.1..

An on-going research project in the pedestrianized shopping area in central Liverpool (Rees, et al, 1975) has also found that pedestrian responses are geared primarily to pedestrian-vehicle conflict and traffic noise issues.

Table 5.1. Classified Responses to Traffic by Pedestrians in Three High-Street Shopping Centres

Response*	Newbury	Camberley	Putney
A lot	13.9%	8.0%	29.4%
A little	24.7%	30.2%	24.1%
Not at all	61.4%	61.1%	46.2%
Don't know/ Did not answer	---	0.7%	0.3%

*In response to the question - "Does traffic bother you?"

Source: Christie, et al (1974).

5.5. Subjective Responses to Traffic Environments: Key Issues

It is clear from the review of existing evidence regarding subjective responses to traffic environments that certain impacts figure prominently in individual responses to such environments, in both a cognitive and affective sense.

The relevant impacts are:

(a) traffic noise,

(b) traffic fumes/ atmospheric pollution impacts,

(c) various dimensions of pedestrian-vehicle conflict.

A range of socially relevant impacts upon which the display matrix may be based has now been established.

Accepting that subjective responses should form the foundation of definitions of the environment for evaluation purposes, it is self evident that they are also of critical importance in determing the relative significance of environmental attributes.

This issue of the relative significance of impacts is inextricably linked to the concept of preferences. Economists have explored environmental preference functions by means of "willingness to pay","hypothetical compensation" and"house price differential" formulations ((Hedges, 1972)(Hammond, 1972) Flowerdew and Hammond, 1973)). These economic approaches are not, however, without their problems, both theoretical and practical. Existing evidence from such studies as yet gives few clear indications of the vital relationship between preference functions and observed economic behaviour.

In this context of environmental valuation, as well as in the definition of the environment, reference should be made to the TRRL environment assessment simulator programme (Dawson,1974). A simulated living room is used and visual images and associated sound profiles are presented to respondents with the aim of:

> .....obtaining subjective and possibly monetary assessments of environmental changes.

The research on the monetary valuation of the environment has been paralleled by explorations into the attitudinal values of individuals in relation to the environment. In some cases the distinction between the two has broken down, most notably in those studies where attempts have been made to relate "hard" monetary valuations to "soft" attitudinal data (Joyce and Johnson, 1975). The term "soft data" is applied to data of ordinal or lower status, which, essentially, gives no indication of the relative or absolute separation of values on a scale (Cane, 1975).

Little is known about the relative significance of traffic impacts in terms of subjective responses. Although it has become apparent that individuals are able to compare different environments and state their preferences for particular environments from among a range of alternatives, it is also clear that people find it somewhat difficult to state the extent to which they prefer one environment from another.

Even if we accept the need to rationalise the components of the environment with which we are concerned, and seek to elicit responses from individuals, we are still faced with the formidable problem associated with the difficulties individuals experience in stating their preferences in absolute rather than relative terms.

Research on this aspect of subjective responses is currently in progress (Hodgins, 1974) and is examining the potential of various psychological testing techniques as a means of deriving absolute preference functions.

The advantages to be gained from preferences registered in absolute rather than relative terms are considerable. It would be feasible to measure the annoyance resulting from various impacts on a common scale. Annoyance measures could subsequently be aggregated to produce overall measures of environmental disbenefit against which policy options could be evaluated.

In the absence of absolute measures of preference it is necessary to continue exploring the application of "soft" attitudinal data in environmental evaluation. This does, however, have considerable implications for the methodology of environmental evaluation.

It imposes three basic constraints on the nature of the comparisons which can validly be made in environmental evaluation (Joyce, Williams and Johnson, 1975b).

First, no absolute value can be attached to a given change in one environmental impact as opposed to another. In other words, it cannot be said that a reduction in noise levels is worth as much as a reduction in pedestrian delay, or as much as a reduction in the smoke level. This implies that it is only possible to compare one effect at a time when evaluating alternative options.

Second, no absolute comparison may be made between alternative environments, even with regard to the same effect. It may be said that, for example, an L_{10} of 75 dB(A) is more annoying than a lower level of 65 dB(A) but not by how much. The implication here is that it is not possible to generate overall environmental rankings of options. Differences between options must be evaluated on a pair-wise basis.

Finally, it is not yet clear whether changes in the level of specific impacts have the same value attached to them when these changes take place at different absolute levels. It may, however, be that equal changes in impact intensity are more noticeable at lower levels. By implication, this constraint indicates that the absolute level at which changes in impacts occur should form the basis of comparisons between options.

5.6. Implications for the Project Methodology

Three types of traffic impact are suggested as being significant in response terms; traffic noise, atmospheric pollution and pedestrian-vehicle conflict.

The measurement and prediction of traffic noise levels is a well established component of environmental evaluation.

The measurement and prediction of air pollution impacts has, on the other hand, presented far greater problems and it is only recently that predictive models for such impacts have become available. Even so, as yet it is only possible to predict the levels of two pollutants; carbon monoxide and smoke. Carbon monoxide presents particular problems in that it is imperceptible and will not, therefore, be represented in the articulation of responses to pollution impacts. Smoke emissions are, however, of a physical form which renders them readily perceptible in terms of both sight and smell.

Pedestrian-vehicle conflict issues are most readily expressed in terms of delay to pedestrians crossing roads. Statements of pedestrian risk and hazard, as well as accident rates, should ideally be presented in evaluation but are not readily susceptible to analysis due the fundamental problems of data availability and comparability.

The predictive models utilised in the research project relate to traffic noise, carbon monoxide, smoke and pedestrian delay. There is an explicit recognition, however, that such impacts represent only a partial definition of the environment, but are at least a starting point for evaluation. Furthermore, we do at least have some evidence to suggest that these impacts are meaningful in human terms. The models are described in the following chapter.

Finally, the constraints on evaluation methodology resulting from our lack of knowledge concerning preferences must be emphasised. These constraints are recognised in the proposed methodology. Only one effect is examined at a time. Pair-wise comparisons between options are made, rather than overall ranking. Changes in effects as between options are related to the absolute levels at which they occur.

CHAPTER SIX

PREDICTING THE ENVIRONMENTAL IMPACT OF TRAFFIC

6.1. Selection of the Impacts to be Predicted

The discussion in the previous chapter indicated that it was necessary to rely on a limited number of reported attitude surveys in order to identify meaningful effects to be included in the impact statement.

The surveys reviewed suggest that people are aware of, and respond negatively to, traffic noise, atmospheric pollution and pedestrian delay impacts. These impacts were subsequently selected to form the basis of the impact statement.

The next stage in the development of the methodology was concerned with establishing the means by which these impacts could be predicted. In order to state the environmental implications of policy options with different traffic flow parameters it is clearly necessary to be able to predict the levels of selected impacts in relation to these traffic parameters.

Initial identification of the research problem by the Study Group did not preclude the development of predictive techniques specific to the author's project. However, ongoing research projects within the Joint Unit for Research on the Urban Environment (JURUE) were already tackling the problem of developing empirically based predictive models of physical environmental variables for urban non-free flow traffic conditions. The models, relating to traffic noise, carbon monoxide (CO), smoke and pedestrian delay have recently been reported in the literature (Joyce, Williams and Johnson, 1975a).

Although these models appear to have a reasonably high level of resolution and are based on a wide range of observed trafficflow conditions, the original data on which the models are based derives from surveys conducted in two London Boroughs; Hammersmith and Kensington and Chelsea. Thus, while it appeared that the models might prove satisfactory predictive tools in the author's project there was no guarantee that they would perform effectively in locations other than those for which they had originally been developed. A validation test in the West Midlands was naturally required.

Data relating to traffic flow and relevant site characteristics required as input to the models were collected at sites on two secondary road network shopping links in Birmingham. Simultaneous measurements of the levels of the environmental effects were taken to provide observed data.

The results of this validation test (Technical Appendix II) suggested that the models might be used in the project with some considerable degree of confidence as to their predictive capabilities. In consequence, therefore, it was decided that the existing JURUE predictive models should be used and that they should be integrated into the proposed methodology.

It is recognised, however, that an impact statement based on these four particular traffic impacts presents only a partial picture of the possible environmental implications of policy options. This approach may, to some extent, be justified on the basis of the survey evidence considered in the previous chapter. Nonetheless, certain other impacts do exist. Techniques for predicting these impacts in objective physical units are not yet available although this does not preclude a subjective statement of their possible incidence in relation to policy options. The impacts which cannot be considered in an objective manner include the levels of certain air pollutants, vibration and pedestrian hazard.

Carbon monoxide and smoke are just two of a number of pollutants associated with vehicle exhaust emissions. Others include nitrogen oxides, photochemical oxidants, lead, organic and inorganic particulate materials, aldehydes and nitrogen compounds other than oxides ((OECD, 1973)(Sherwood and Bowers, 1973)).

In as much as individuals can and do respond to exhaust emissions they are primarily reacting subjectively to the presence of smoke (unburnt hydrocarbons), which is both visible and odourous. However, in recent years increasing emphasis has been placed on imperceptible pollutants, most notably CO and lead compounds derived from "anti-knock" additives in petrol. These are known to be of a neurotoxic nature and constitute a potential health hazard.

Carbon monoxide and smoke emissions are both susceptible to measurement with relatively unsophisticated equipment. This is not true of many of the other vehicle related pollutants. Furthermore, these other pollutants are generally present in only very small quantities rendering measurement over sample time periods potentially erratic.

Thus there would appear to be significant factors militating against the development of predictive models for these impacts. The selection of CO and smoke as the atmospheric pollution impacts is, however, useful in that these two measures respond to potential issues involving perceptible and imperceptible impacts and also the differential impacts associated with petrol and diesel engined vehicles as expressed in terms of these two pollutants.

Vibrations result from the response of vehicles to "irregularities in the surfaces of roads and bridges" (Burt, 1972). Vibrations originate in the road structure and are then transmitted possibly inducing adverse effects in people and buildings. Much of the vibration which people complain about is in fact infra-sound - a low frequency noise. The equipment required to measure this impact is again expensive and sophisticated. Predictive techniques are not available for these impacts and they have not been considered in existing examples of environmental evaluation (Lassiere, 1974). It is doubtful whether these impacts are in themselves harmful to either people or buildings (Burt, 1972).[1]

Pedestrian hazard is an effect which requires long term data collection exercises if valid statistical samples are to be compiled for model building. This requirement stems from the low incidence of pedestrian accidents and the consequent need to examine traffic flows, accident rates and pedestrian flows over an extended period (JURUE, 1974a). Such an exercise was not feasible in the research project and available data were not adequate to generate predictions of accident rates.

Four traffic impacts have been selected as the basis of the impact statement: traffic noise, carbon monoxide, smoke and pedestrian delay. It has been established that these impacts may be predicted using the JURUE models. These models have been validated in the locational context of the project. It is

---

[1] Some vibration -response curves are presented in the UMPT Report (HMSO, 1973, p.64)

recognised that the predictive models available permit only a partial statement of the environmental impacts of policy options. However, it is suggested that other impacts may be treated in a subjective manner if only to provide some indication of their incidence and changes in intensity under alternative policy options.

6.2. Characteristics of the Effects to be Predicted

6.2.1. Traffic Noise

Traffic noise is perhaps the most significant and contentious impact resulting from road traffic activity. The emphasis placed on the amelioration of noise impacts in the Land Compensation Act (1973) is a clear indication of both public and political sensitivity to traffic noise issues. Traffic noise is also the impact which has been subjected to the greatest amount of study.

Noise may be regarded as "unwanted sound". Sound itself being "the sensation due to the fluctuations in air pressure detected by the human ear" (TRRL, 1970).

Vehicle noise is made up of two basic components; engine exhaust noise and noise generated by tyre-road surface interaction (Galloway, et al, 1969). Under normal vehicle operating conditions there is unlikely to be a great difference between the noise generating capacities of the two, but under acceleration engine exhaust becomes prominent as the noise source.

Noise levels are conventionally measured in decibels (dB). Traffic noise measurements are weighted by the 'A' weighting, this having been shown to correlate well with subjective responses to individual vehicle noise expressed in terms of loudness (Mills and Robinson, 1963).

Human responses to traffic noise have been extensively reviewed in a number of reports ((HMSO, 1963)(TRRL,1970)(OECD, 1971)). Possible responses may be categorised as follows:

(a) expressions of annoyance,

(b) speech interference ,

(c) sleep disturbance,

(d) activity disruption and potential task performance degradation.

(e) sociological responses expressed in terms of a desire to move from a noise affected environment, or noise induced annoyance disrupting group tasks and interpersonal relations.

With regard to the physiological effects of traffic noise, there is at present no evidence to indicate that exposure to such noise may harm hearing. There may , however, be indirect physiological effects - stress syndromes - associated with exposure to traffic noise but little is currently known about this area.

The fact that traffic noise levels fluctuate through time has stimulated considerable discussion among researchers as to the most effective and meaningful form of traffic noise criterion, or index, with which to represent this variability.

The L_{10} index, which is the noise level exceeded for 10% of the time period under consideration, has been widely used and, furthermore, has recently been recognised by official regulations in its 18 hour form (DOE, 1972; 1973). L_{10} is known to correlate with community noise responses to some extent, although not as well as somewhat more complex indices; the Traffic Noise Index (Langdon and Scholes, 1968) and the Noise Pollution Level (Robinson, 1971). A further index, the equivalent noise level (L_{eq}) has also been proposed but does not appear to correlate well with responses to traffic noise (Griffiths, 1968).

Despite official recognition of the L_{10} index, little, if anything, is known about the nature of the relationship between this index and expressed annoyance in locations other than residential areas. Without validation of the index in external activity locations like shopping centres it is not possible to determine the significance, in human terms, of the noise impacts associated with such locations.

Individual noise exposure patterns in shopping centres exhibit considerable differences from those characteristic of most residential areas, not the least in that pedestrians in shopping centres are exposed to unmediated kerbside noise levels. Data collected by the author suggest that pedestrian noise exposure tends to be characterised by relatively short doses of high intensity but we do not know how this pattern of exposure correlates with response.

The JURUE model predicts noise levels in terms of the L_{10} index. In the absence of any evidence regarding the validity or otherwise of this index for shopping environments it has been necessary to assume that it does give some measure of noise levels which are meaningful in human terms in this type of activity location.

Research directed to the development of predictive models of traffic noise has, until recently, focused primarily on the problem of modeling noise from freely flowing traffic ((Delaney, 1972)(Hardy and Lewis, 1971)(Scholes and Sargent, 1971).

Urban areas, and particularly the secondary and local road networks are however more typically characterised by non-free flow traffic conditions. Prior to the development of the JURUE noise model the only other reported work on non-free flow noise conditions was that of Crompton and Gilbert (1970a; 1970b). Although the methodology of this work was regarded as relevant to the JURUE studies, doubts were raised as to the locational transferability of the models and their sensitivity (JURUE, 1974a).

6.2.2. Carbon Monoxide

Carbon monoxide (CO) is produced in considerable quantities by petrol driven vehicles and to a lesser extent by diesel engined vehicles. This is illustrated in Table 6.1.

Concentrations of CO in the air, measured in parts per million (ppm), may be determined even in streets with relatively low traffic flows, and as such may be regarded as a useful surrogate for the various forms of gaseous exhaust emission (JURUE, 1974a). Carbon monoxide has also been shown to correlate to some extent with lead and aldehyde pollutants (Everitt, 1975).

Motor vehicles have been shown to represent the most significant source of CO emissions at a national level in two reported surveys. These surveys relate to the United States and Sweden. The relevant data are presented in Tables 6.2. and 6.3..

The health effects of CO have been extensively studied (WHO, 1969). It is well known that CO has poisonous effects at high concentrations and must, therefore, be regarded as a serious potential health hazard. The gas is absorbed

Table 6.1. Representative Composition of Exhaust Gases (Concentration in ppm)

tion

E

Die

e

Source: Burt (1972) Roads and the Environment. TRRL Report LR 441, p.10

Table 6.2. Estimated Nationwide Emissions of Air Pollutants United States (1969)

Source: OECD (1973), p. II-5.

Table 6.3. Estimated Nationwide Emissions of Air Pollutants: Sweden (1970)

Source: OECD (1973), p. II-5.

through the lungs and has an adverse effect on the capability to transport oxygen to vital tissues. Concentrations as low as 10 ppm may produce significant physiological responses in non-smokers. Longer term exposure to higher concentrations has been shown to induce adverse psychomotor and visual acuity effects, as well as heightened physiological stress in the case of individuals with heart conditions ((OECD,1973)(O'Flaherty, 1973)).

Attempts to establish relationships between CO levels and traffic flow parameters have been limited. Docherty and Bayley (1970) have reported on the quantification of CO levels in the urban environment and have attempted to relate these levels to characteristics of traffic flow. CO emissions are, however, known to relate to vehicle speeds and are likely to be particularly intense under idling conditions (OECD, 1973).

Carbon monoxide is an imperceptible pollutant, being both invisible and odourless. This has led to the suggestion that there would be "no point in predicting its concentration" (Lassiere, 1974). However, the fact that CO represents a potential health hazard and that it raises important questions of equity in exposure may be used as counter arguments to this suggestion. Furthermore, CO is a useful variable in that it may perhaps be regarded as an indicator of the presence of other toxic elements.

6.2.3. Smoke

Smoke is composed of very fine particles of carbon derived from unburnt fuel. The major road traffic source of smoke is the diesel engined vehicle. Smoke is conventionally measured in microgrammes per cublic metre; a measure of the weight of particles per unit volume of air. Public responses to vehicle generated atmospheric pollution have centred on this particular component of exhaust emissions.

Smoke itself does not appear to be harmful to health but the carbon particles of which smoke is composed may act as nucleii in the formation of haze and in the absorption of certain types of gas (sulphur dioxide and nitrogen oxides), which may induce lung damage ((Burt, 1972)(OECD, 1973)).

6.2.4. Pedestrian Delay

Pedestrian delay is one dimension of pedestrian-vehicle conflict; pedestrian hazard and trip inhibition representing the other basic dimensions of this general impact.

Pedestrian delay predictions have typically derived from theoretical models of gap acceptance, assuming random traffic arrival patterns (Joyce and Williams, 1973). Such formulations may be traced back to the work of Adams (1937). The JURUE model is, however, empirically based.

Delay may be expressed in various ways. Crompton (1971) has suggested a measure expressed in terms of the percentage of pedestrians delayed. The model used in the proposed methodology predicts mean delay, that is, the delay (in seconds) most likely to be incurred when attempting to cross the road at any point in time. Two assumptions are embodied in the model. First, that an attempt is made to cross the road in one direct movement. Second, that no pedestrian crossing facilities are available. Mean delay as a measure can also account for the pattern of gaps in traffic arrival, a feature not characteristic of an alternative JURUE delay formulation expressed in terms of percentage delay (JURUE, 1974a).

6.3. The Models

The models used for predicting the levels of the selected impacts in relation to alternative policy options are those developed by JURUE over the period 1972-1974. These models have been presented in a recent paper by Joyce, Williams and Johnson (1975a). The following descriptions of the

Table 6.4. Data Range on which the JURUE Environmental Models are Based

Source: Joyce, Williams and Johnson (1975a).

models are derived from this particular paper.

The models are based on empirical data collected during surveys conducted at site locations in the London Borough of Hammersmith and the Royal Borough of Kensington and Chelsea. A twenty minute observation period was used. Simultaneous measurements of the four effects were made and data relating to traffic flow, speed, composition and pattern of arrival as well as climatic and street layout characteristics were collected. The data range on which the models were built is presented in Table 6.4.. Predictive equations of the effects were generated by means of standard linear multiple regression analysis of the data.

6.3.1. The Noise Model

The model predicts the noise level in terms of the L_{10} index. Noise levels are estimated on an hourly basis and these can subsequently be aggregated to yield 18 or 24 hour L_{10} s. The model takes the following form:

$$L_{10} = 11.8 \log_{10} (Qw) - 3.8 \log_{10} (d) + 40.5$$

$R = 0.94$ Residual Error = 1.6 dB(A)

where:

L_{10} = noise level at kerbside exceeded for 10% of time period, dB(A)

Q_w = weighted flow = (C+ 2.L+ 15H+ 7.B+ 2.M)

C = total flow of cars, both directions in vehicles per hour

L = total flow of light commercial vehicles, both directions in vehicles per hour

H = total flow of heavy commercial vehicles, both directions in vehicles per hour (vehicles over 30 cwt)

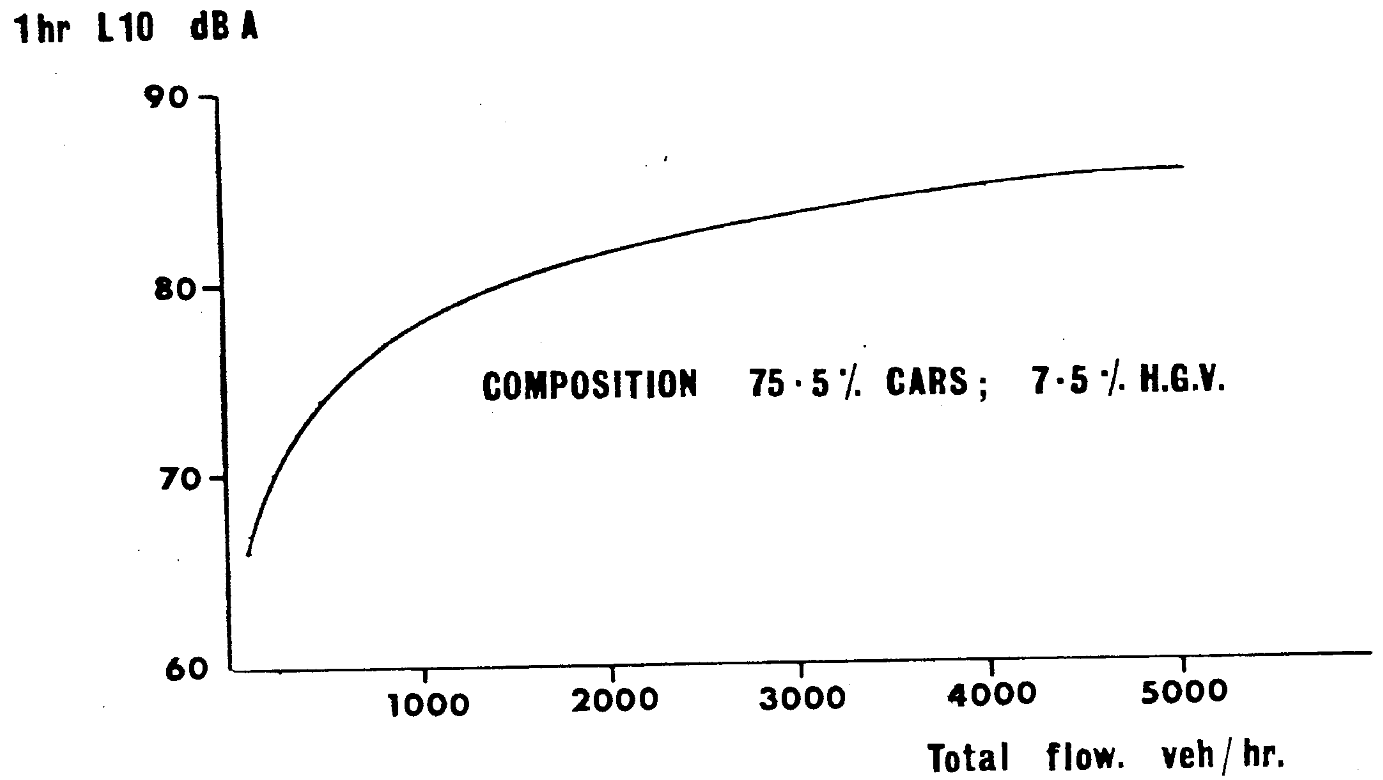
B = total flow of buses, both directions in vehicles per hour

M = total flow of motorcycles, both directions in vehicles per hour

d = distance from the kerbside to the centre of traffic flow, in metres (a point midway between traffic flow streams)

The model may be explained as follows: traffic generates noise which is then attenuated over distance before reaching the kerbside. The predominant variables in the model are flow and proportion of heavy goods vehicles. The influence of these variables is illustrated in Figure 6.1. and Table 6.5.. A doubling of flow will always result in an L_{10} increase of 3.5 dB(A) reflecting the situation that a given percentage change in the flow will result in the same absolute increase in L_{10} .

With regard to traffic compsition, equal changes in the percentage of heavy commercial vehicles will produce equal changes in the L_{10} irrespective of the level of flow. These characteristics indicate that at low flows, changes in composition and flow are likely to be critical in terms of the L_{10}.



Variation in noise level with traffic flow.

Fig 6·1

Table 6.5. Variation in Noise Level (1 hour L_{10} dB(A)) with Traffic Flow

Source: Joyce, Williams and Johnson, (1975a).

6.3.2. The Carbon Monoxide Model

The carbon monoxide model predicts the average concentration of the gas in parts per million over the hourly period under consideration. The form of the model is:

$$CO = 0.006C_n - 9 \log_{10} V_n - 0.3 W + 17$$

$R = 0.74$ Residual Error = 3 ppm

Where:

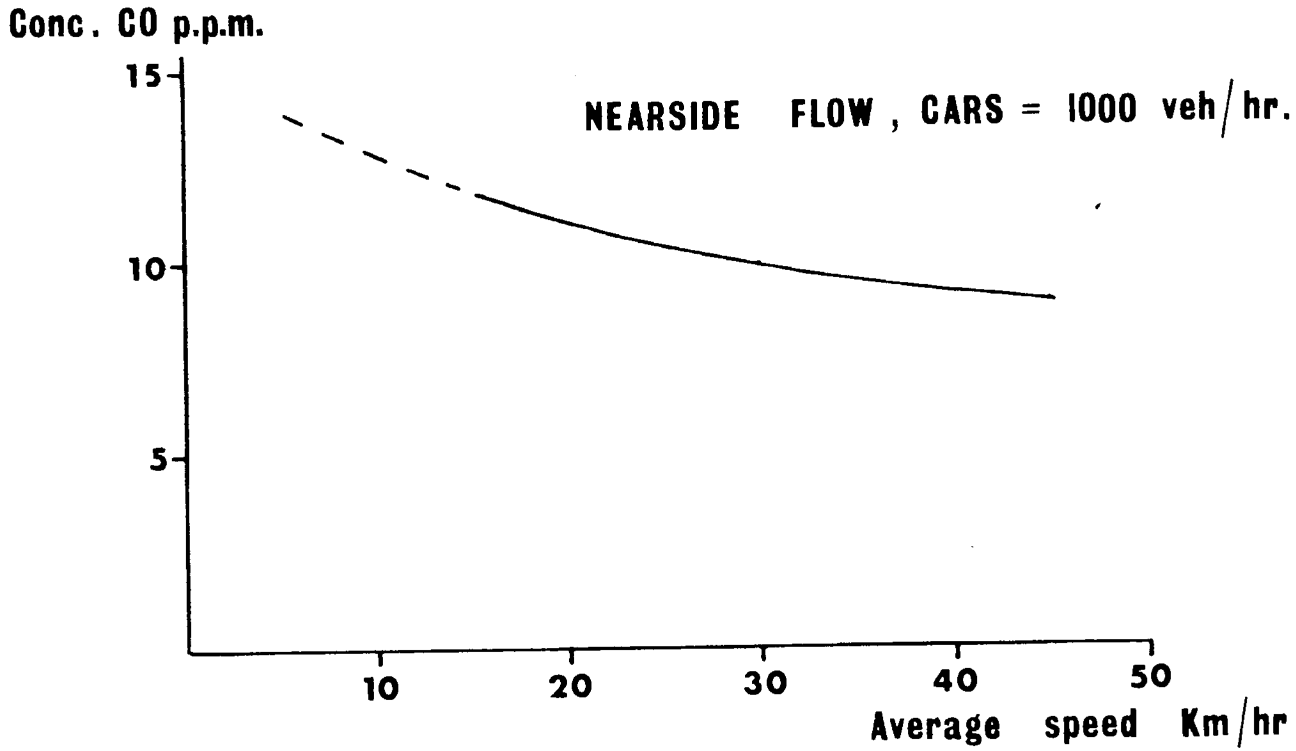
CO = average concentration of CO in air in ppm

C_n = flow of cars on the nearside of carriageway vph (direction of flow not lanes)

V_n = average speed of vehicles on the nearside of carriage way in kilometres per hour

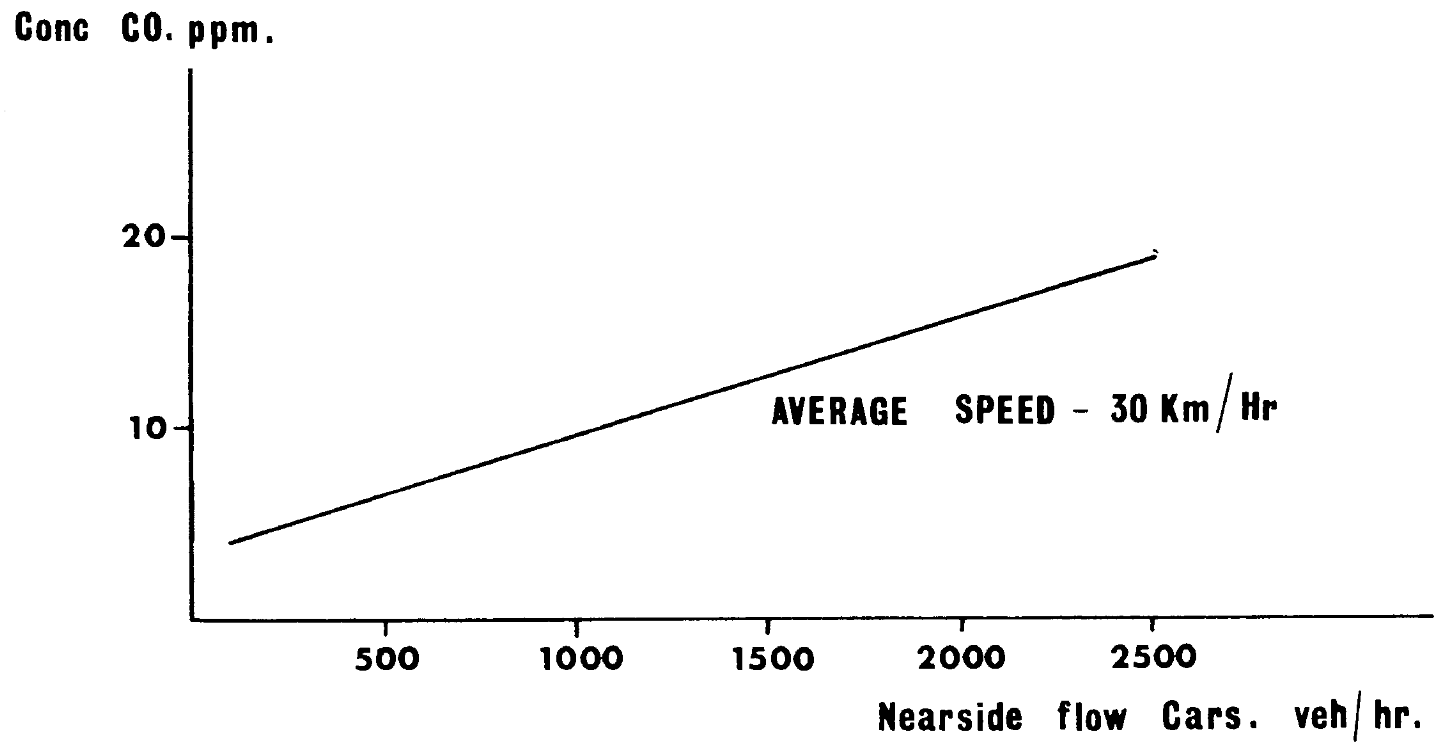
W = average wind speed during period in kilometres/hour

This model reflects the importance of both the presence of petrol driven vehicles and the influence of speed. Figure 6.2. indicates the relationship between speed and carbon monoxide and it is clear that the generation of CO declines markedly at vehicle speeds in excess of 20 - 25 Km.ph. Figure 6.3. indicates the variation in CO concentration with traffic flow. These two figures suggest that higher concentrations of CO will tend to be associated with either congested conditions involving low traffic speeds and idling engines or high traffic flows. The wind factor in the equation must of necessity be set at zero for predictive purposes, thereby indicating the worst conditions likely to obtain. The inclusion of this factor was required in the



Variation in carbon monoxide concentration with speed.

Fig 6·2



Variation in carbon monoxide concentration with traffic flow. **Fig 6·3**

empirical analysis but it does serve to indicate the sensitivity of air pollution effects to wind conditions.

6.3.3. The Smoke Model

The smoke model predicts the average concentration of smoke in microgrammes per cubic metre for the considered period.

The form of the model is as follows:

$$S = 0.1\,(H_n + B_n + L_n) + 0.03C_n - 2.5\,W + 38$$

$R = 0.82$ Residual Error = 18.8 microgm/m^3

where:

S = average smoke concentration microgm/m^3 for period

H_n = flow of heavy commercial vehicles on nearside of carriageway (over 30 cwt) in vehicles/hour

B_n = flow of buses on nearside of carriageway in vehicles per hour

L_n = flow of light commercial vehicles on nearside of carriageway in vehicles/hour

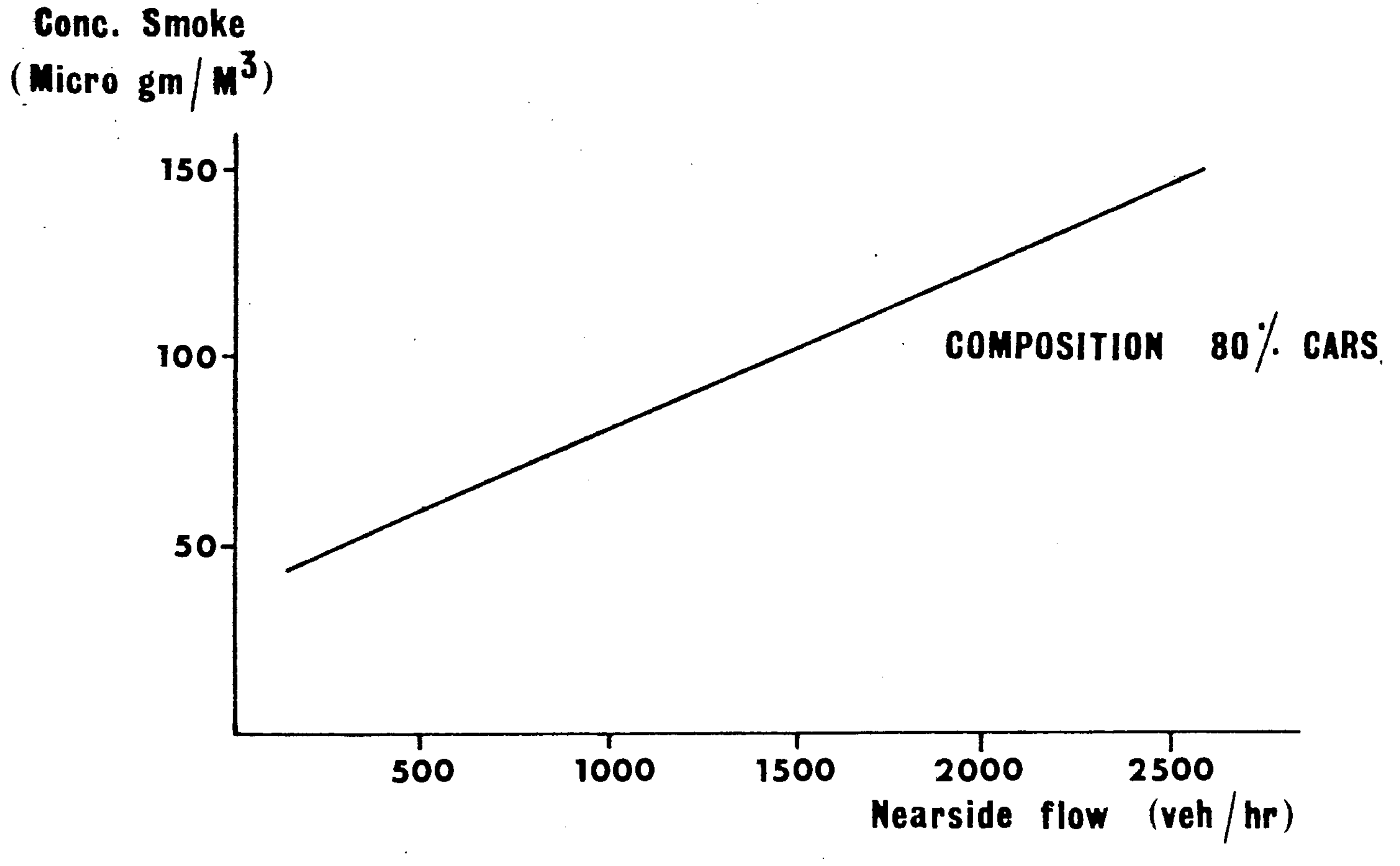
C_n = flow of cars on nearside of carriageway in vehicles / hour

W = average windspeed in km/h during period

The use of the term 'nearside' in the specification of the flow variables relates to the direction of traffic flow and not just simply to traffic lanes, as in the CO model. The significance of diesel engined vehicles is reflected in the equation and also, by implication, in Table 6.6. and Figure 6.4..

Table 6.6. Variation in Average Concentration of Smoke (microgm/m^3) with Traffic Flow

Source: Joyce, Williams and Johnson (1975a).



Variation in smoke concentration with traffic flow. **Fig 6.4**

6.3.4 The Pedestrian Delay Model

The model is based on the concept of mean delay described in section 6.2.4.. The model takes the following form:

$$D = 6.7 \times 10^{-6} (Q)^2 + 0.3$$

$R = 0.88$ Residual Error = 2.8

where:

D = delay most likely to be incurred in seconds

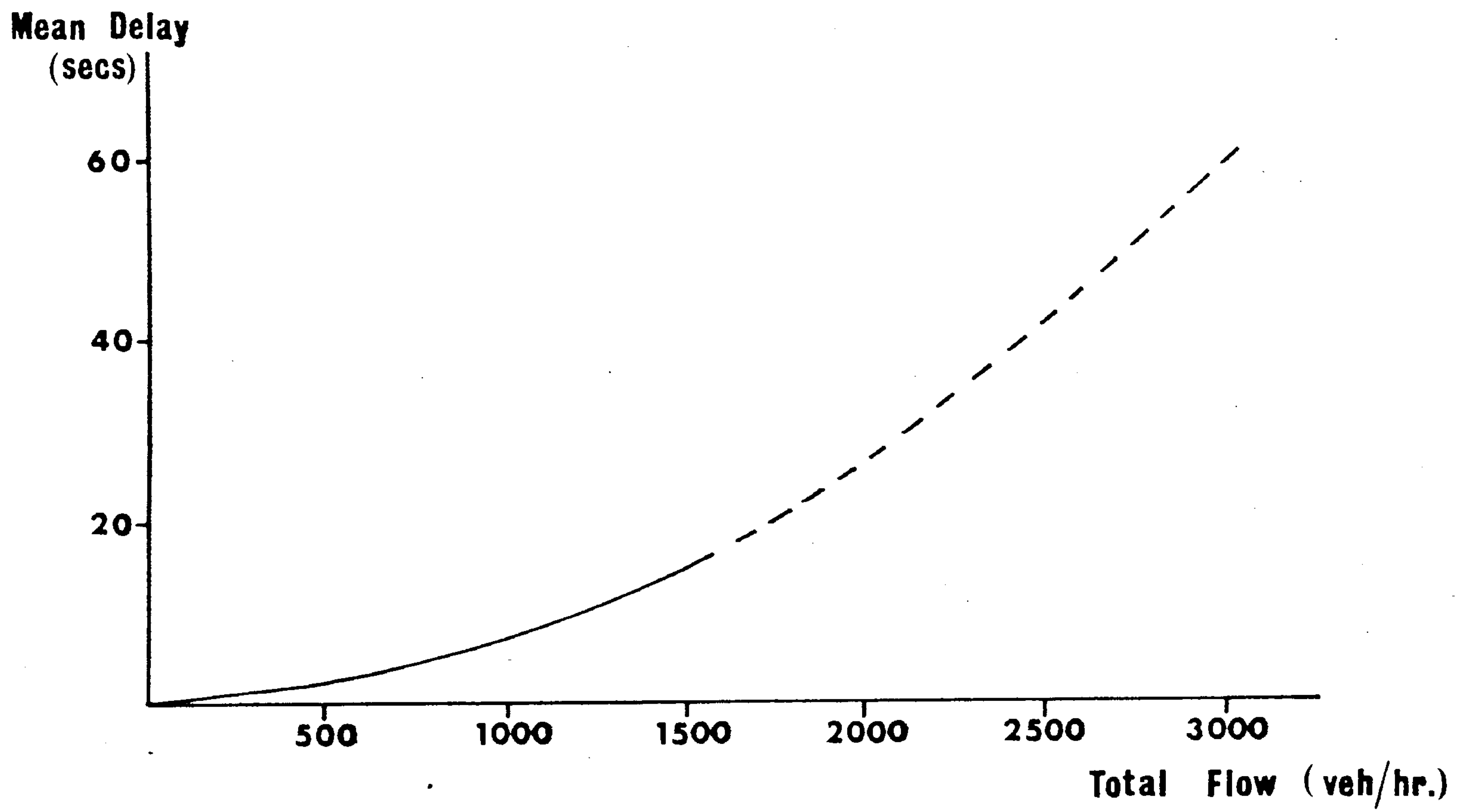
Q = total vehicle flow in both directions in vph

The actual delay experienced when attempting to cross a road is without doubt related to age and physical condition of the pedestrian and the individual's perception of risk factors. The empirical data on which the model is based was found to exhibit marked irregularities on roads with traffic flows in excess of 1600 vph, suggesting that the observer's perception of periods of delay was being influenced by personal factors.

The model as defined is therefore based on data derived from site locations on links with a flow of 1600 vph or less. Delay tends to rise geometrically with flow (Figure 6.5, Table 6.7) and small changes in the total number of vehicles at high flow levels will, in contrast to the noise level impact, produce

Table 6.7. Variations in Mean Delay (sec) with Traffic Flow

Source: Joyce, Williams and Johnson (1975).



Variation in pedestrian delay with traffic flow.

Fig 6·5

considerable changes in the level of pedestrian delay.

6.4. Summary

The present chapter and the one preceding it have been devoted to a systematic description of the way in which a critical component of the project was handled.

The importance of defining components of environmental quality was stressed in Chapter 5. A theoretical approach to the definition of environmental quality based on subjective responses to the environment was postulated as the approach most likely to indicate relevant environmental attributes which policy should both take account of and respond to.

The limited evidence relating to subjective responses to traffic environments was examined. This suggests the existence of certain key components of such environments which should be considered in environmental evaluation; traffic noise, atmospheric pollution and pedestrian delay. These effects, or impacts, associated with traffic were selected for inclusion in the impact statement methodology.

The present chapter has considered the problems associated with predicting these impacts in objective physical units. A series of fairly robust models, validated in the locational context of the research project have been described and discussed. It is recognised explicitly that only a partial definition of traffic impacts is feasible.

Thus far, we have established the nature of the impacts to be considered and the means by which they may be predicted in relation to policy options. We have, therefore, resolved one set of problems central to the development of the methodology.

We now turn our attention to a rather different problem area but one which is nonetheless central to the project, namely the issue of pedestrian exposure to traffic impacts in shopping centres.

CHAPTER SEVEN

PEDESTRIAN EXPOSURE TO TRAFFIC IMPACTS

7.1. Pedestrian Exposure and the Impact Display Matrix

The impact display matrix, which constitutes the basis for evaluation of alternative options in the proposed methodology, indicates the degree of traffic impact on shopping links in terms of the following criteria:

(a) the levels of the selected traffic impacts,

(b) the number of pedestrians exposed, and,

(c) measures of the time duration of exposure.

Given the traffic parameters of the policy options to be evaluated and the requisite site characteristics, the models described in the previous chapter are used to predict the levels of traffic noise, carbon monoxide, smoke and pedestrian delay impacts, thereby fulfilling the data requirements of (a) above.

The present chapter focuses on the project approach to the conceptual and measurement issues raised by (b) and (c) above. The chapter commences with a discussion of the relationships between pedestrians, shopping centres and traffic impacts. The conceptual basis of exposure measurement is then considered. The aggregate exposure measurement approach is examined and found to be characterised by certain conceptual and methodological shortcomings. A disaggregated method of exposure accounting based on the concept of potential stress situations is proposed in order to overcome the present difficulties associated with relating exposure to annoyance levels. The measurement procedures required to operationalise this alternative framework are described in the final section of this chapter.

7.2. Pedestrians, Traffic Impacts and Shopping Centres

The importance of pedestrian activity in shopping centres was emphasised in earlier chapters. Various studies of pedestrian movements have indicated that shopping streets are characterised by high concentrations of pedestrians (see for example, (Burley and Mitcham, 1967)(Thompson and Hart, 1968)).

The exposure of large numbers of pedestrians to potentially intense traffic impacts is a fundamental factor in the environmental sensitivity of shopping links in the highway network. The tendency of district centres to straddle important secondary roads, and in particular radial routes, may result in considerable environmental disbenefits to the pedestrian due to the high traffic flows characteristic of such links.

The linear spatial configuration of the traditional High-Street district centre may serve to exacerbate the exposure problem for pedestrians. Increased pedestrian trip lengths, resulting in increased exposure time, may be required to link together the establishments which the pedestrian shopper wishes to visit.

There is some evidence to suggest that the time taken to complete a standardised shopping trip in a High-Street centre is longer than that required in a pedestrian precinct shopping area (Jacobs, 1968). Mean overall trip times were found to be some 15% longer in the High-Street sample, and between-shop times approximately 25% longer.

The spatial configuration of the precinct appears to be more efficient and such shopping facilities clearly have the advantage of being free from traffic activity with consequent environmental benefits to pedestrians. It is interesting to note that pedestrian delay accounted for an average 4% of the additional trip time required in the High-Street centres.

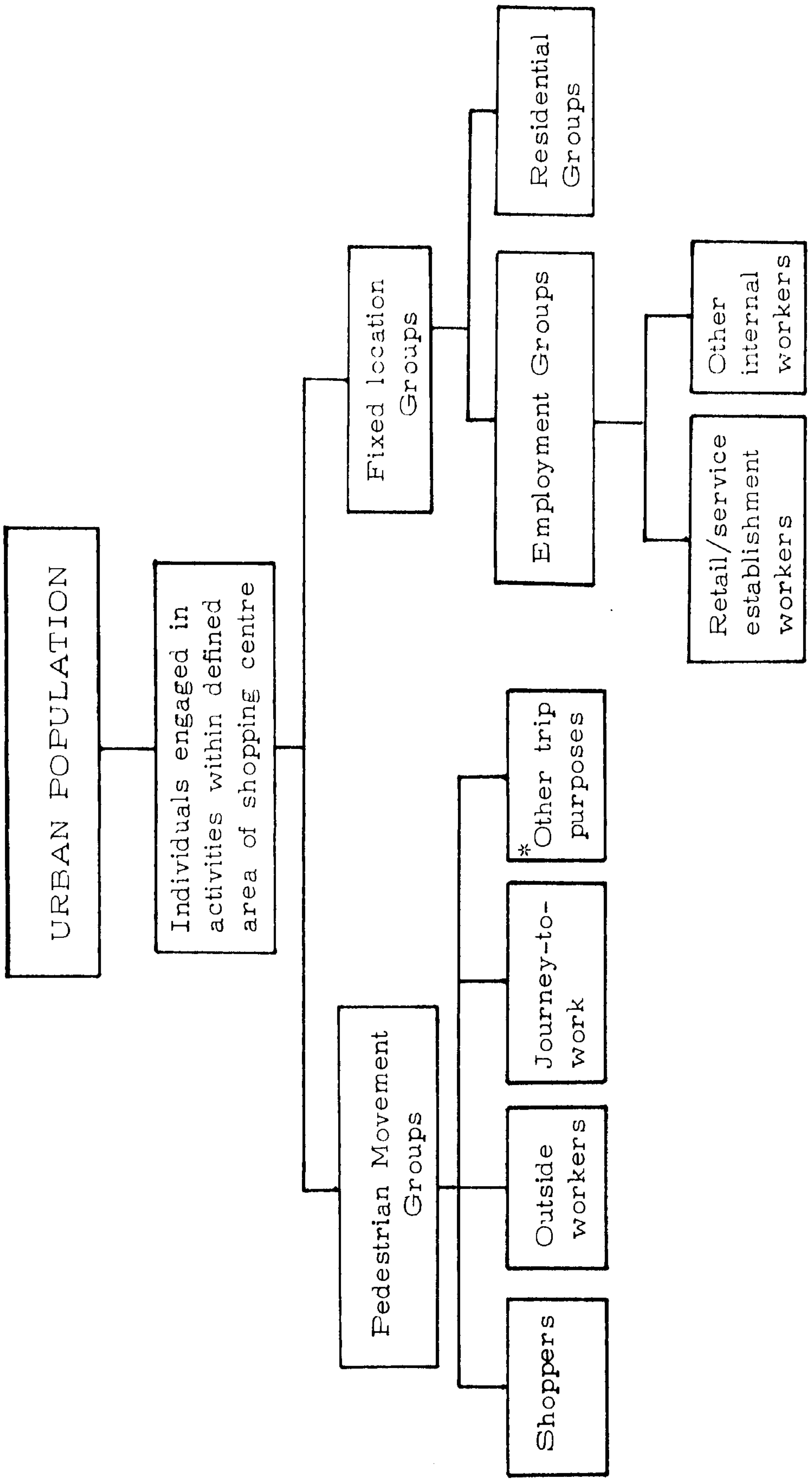
Thus far, discussion has centred primarily on the pedestrian engaged in shopping activities. During the period of the day when shopping centres are functioning as activity locations[1] this particular activity group is assumed to be numerically dominant. For reasons to be discussed below, it may be argued that this group is also the most significant in exposure terms.

To focus on the shopper group is not to deny the existence of a variety of other activity groups who may be exposed to traffic impacts in shopping centre locations.

Initially, a basic distinction may be made between those groups engaged in activities dependent on some degree of pedestrian movement, and those whose activities are essentially confined to buildings on frontages along the shopping link. A schematic breakdown of potentially exposed activity groups employing this basic distinction is presented in Figure 7.1..

The research project was very much concerned with shopping centres as functioning activity locations. Data collected by the author indicate that, depending on the significance of the centre itself, between 6000 and 10000 people

[1] The "shopping day" has been defined as the period 10.00-16.00 hours (Rees, et al 1975) in a study of shopper responses to pedestrianized streets in Liverpool. The author adopted the the same definition for survey purposes in the research project described herein.



* social/recreational, educational and business trips

Figure 7.1. Activity Groups Exposed to Traffic Impacts in Shopping Centres

visited the district centres studied on a normal weekday.[2]

The inevitability of pedestrian activity in the context of shopping trips means that the pedestrian shopper on the High-Street will be exposed to:

(a) traffic noise,

(b) carbon monoxide,

(c) smoke, and,

(d) pedestrian delay impacts.

Exposure to traffic impacts not considered objectively in the display matrix (other exhaust emissions, vibrations and pedestrian hazard and risk) may also be experienced.

The intensity of exposure will, in the case of traffic noise and atmospheric pollution impacts, correspond to the kerbside environment, or a close approximation to it. Kerbside exposure will, however, most probably be interspersed with periods of attenuated or mediated exposure during those sequences when activities are conducted in retail or service establishments. The implications of this transition from potentially high intensity exposure to mediated exposure and back again may well be considerable in response

---

[2]These data are derived from a survey conducted in July 1974. Weather conditions were, for the most part, good. It has been shown, however, that weather conditions can have a profound effect on the level of pedestrian activity in shopping centres. Lovemark's research in Gothenberg has shown that pedestrian activity can drop by 50% in rain or low temperature conditions (Lovemark, 1972).

terms. However, the nature of the relationships involved has yet to be determined.

The time duration of exposure would appear to depend on two basic factors. First, the individual's shopping trip characteristics and the relative locations of the shops to be visited. Second, the walking speed of the individual. Women with children and old people tend to be well represented in shopping centre user populations (Green, 1967), a feature borne out by the author's own survey.

Constraints on walking speed - physical condition, children, heavy shopping loads - may be significant in the context of this component of exposure.

It should be emphasised that our basic concern in the case of pedestrian exposure is the intensity of the impacts to which individuals may be exposed. Pedestrian shoppers are a high intensity exposure group. This clearly implies that they may be high losers in environmental terms but, by the same token, will be high gainers with respect to the implications of environmental policies for shopping links.

From the review of existing evidence concerning responses to traffic environments carried out in Chapter 5 it is obvious that pedestrians are aware of certain types of traffic impact, and, indeed, find them objectionable.

The TRRL research on Putney, Newbury and Camberley provides some indication of pedestrian reactions to traffic impacts in shopping streets (Christie, et al, 1973b). An attempt was made to generate mean "bother" scores on the basis of individuals scoring impacts on a scale 0-5. These scores must be seen, however, as reflecting reactions at the time of the survey and are in a sense therefore measures of the extent to which individuals were "bothered".

Interpretation of the results of the surveys must of necessity be cautious bearing in mind the assumptions embodied in the use of such scaling procedures. We do not know if individuals operate on the basis of the same, or even similar, zero point levels for rating impacts. We do not know if the inter-point spaces have the same meaning for each individual.

In the case of Putney High-Street, noise was found to be the most bothersome impact, followed by pedestrian delay, the effects of fumes on breathing and danger in crossing the road. In Newbury and Camberley pedestrian delay was rated as the most bothersome impact.

The study of the Catford Traffic Management Scheme (Pearce and Stannard, 1973) found that shoppers were more frequently annoyed by increases in traffic noise, fumes and journey times than those respondents engaged in journey-to-work trips. Increased journey times were found to cause more annoyance on the part of younger respondents (under 20 years). An interesting finding was that males appeared to be more sensitive than females to traffic fumes but the situation was reversed in the case of traffic noise. This again is a point to be considered in evaluating impacts on shopping links where female shoppers may be expected to represent a high proportion of the user population.

As in the TRRL studies, annoyance was found to be greater in the regular user or visitor group and less in the case of infrequent visitors to the location. The Catford research indicates that traffic noise caused annoyance to more people than did the increase in traffic fumes or extended journey times.

It may be suggested, therefore, that there is evidence which indicates that people may indeed be annoyed by traffic impacts in shopping centres. Hedges (1974) has suggested that annoyance levels may be greater in shopping environments than in residential settings, but this supposition cannot as yet be validated.

The number of persons involved in shopping activities, coupled with the impact intensity parameters of pedestrian exposure, suggest that the degree of traffic impact on shopping links should be expressed primarily in terms of the exposure parameters of this particular activity group. The project approach to exposure measurement detailed in a later section is based on this premise.

Of the other activity groups isolated in Figure 7.1., some present problems of definition, and in any case may be assumed to be small in number (outside workers, business, social/recreational and educational) during the period of the "shopping day". The journey-to-work group, although perhaps numerically large will typically be present in shopping locations outside the "shopping day" period as operationally defined, and are, therefore, excluded from the analysis.

Shop and office workers may exhibit certain similarities with residents, in exposure parameter terms. Traffic noise, for example, would be attenuated by the building facades. The duration of exposure is, however, likely to vary considerably between these two groups and overall exposure statements will, in consequence, be difficult to generate.

Furthermore, the selection of a noise index for these various activity groups raises certain problems. Although the 18 hour L_{10} may be used for residential noise exposure, having been validated in that context, it is clearly not valid for shop or office workers, nor for pedestrians. As yet, little is known about the relationships between noise exposure parameters and annoyance for non-residential activity groups.

For the purposes of the proposed methodology, the hourly L_{10} is used for shopping links, and estimates of pedestrian exposure are displayed against this noise level index.

In the worked examples provided in Chapter 9 some attempt has been made to include estimates of the number of households exposed on shopping links, where relevant, and the number of shop and office workers affected. The hourly L_{10} is also used in these cases.

Similarly, it is also used for residential streets to which traffic may be diverted as a result of environmental policies for the shopping link concerned. However, in those situations where diversion is necessary <u>and</u> road improvements are required then the 18 hour L_{10} should be used in the relevant display matrix. Such a case is provided by the Dunley example in JURUE (1975), where a local lorry routing proposal entails such improvements and sound insulation may be provided under Land Compensation Act powers.

7.3. The Concept of Pedestrian Exposure

The presentation of estimates of pedestrian exposure has become an essential component of the impact statement approach to environmental evaluation ((Lassiere, 1973) (Pearce and Stannard, 1973)(Coventry Transportation Study, 1973)).

Such estimates can provide a fundamental link between the physical impact statements themselves and human responses to those impacts. However, the conceptual basis of exposure measurement remains somewhat unclear. It requires more detailed consideration, as do the criteria upon which exposure measurement is based and the measurement and data presentation techniques employed.

The following discussion focuses on various problems associated with the conceptualisation and measurement of pedestrian exposure to traffic impacts. As a preliminary to this discussion it would be useful to clarify what is meant by the term "exposure".

Exposure may be defined as the subjection of the individual to sensory stimuli. As such it may be regarded as a prerequisite for physical perception (Warr and Knapper, 1968). The term "sensory stimuli" is used here in its broadest sense to include both those stimuli which may be reflected in the individual's cognitive structure of the environment and those which induce a physiological response (for example, carbon monoxide) but which will not find expression in this cognitive structure. For any individual we may suggest that exposure comprises of two basic dimensions; stimulus intensity and time duration.[3]

The dichotomy which exists in the use of the exposure concept in different contextual settings should be mentioned. This manifests itself in the use of exposure in the experimental psychological setting, or clinical situation, and its use in far less formal, unregulated settings such as those reflecting the interaction between the individual and road traffic. This is not to say that exposure to traffic impacts on a selective basis is not feasible. Indeed, the TRRL environment assessment simulator is based on this principle (Dawson, 1974).

However, to return to the dichotomy, it may be argued that it embodies, firstly, a difference in the extent to which the intensity of sensory stimuli can be regulated and controlled, and secondly, the time duration and frequency parameters of the individual's exposure to specific sensory stimuli.

---

[3] It has been suggested (Lindvall and Radford, 1973) that the quality or composition of the agent should be distinguished (for example, the spectral shape of complex noise).

More significantly, it may also be seen as reflecting a fundamental distinction between the analysis of response sensations in the physical perception sense, and, by implication, a concern with those longer term repetitive sensory experiences which figure prominently in the development of cognitive structures.

It is argued that in the case of exposure to traffic impacts we are primarily concerned with these longer term cognitive structures, which represent a basic link between the concept of exposure and subjective responses to the environment.

The rationale for the concept of exposure may be found in this relationship between exposure and subjective responses. It may be argued that the significance of exposure rests on the hypothesised relationship between the time duration and stimulus intensity parameters of exposure and variations in the individuals level of expressed annoyance with traffic impacts.

Annoyance may be defined (Lindvall and Radford, 1973) as:

> ,..... a feeling of displeasure associated with any agent or condition believed to affect adversely an individual or group.

As the authors note, the term "annoyance" from a medical viewpoint implies an effect which involves a negative state for the individual in terms of comfort and well-being. This effect need not, however, be demonstrably pathogenic.

This relationship between what may be termed "units of exposure" and levels of expressed annoyance is, therefore, of fundamental importance. What we would assume is that it is possible to account for variations in annoyance by examining variations in the exposure profiles of individuals and groups.

Clearly, the measurement of annoyance itself is of great significance as we need to know which elements of the transportation system require manipulation in order that disamenity issues may be resolved.

In the case of imperceptible, pernicious traffic impacts - the carbon monoxide issue,for example - a relationship between exposure and expressed annoyance cannot be established. However, the nature of the equity problems which arise may only be isolated on an objective basis with exposure data.

Attempts to operationalise this conceptual framework concerning the relationship between exposure and annoyance are severely constrained by the problems of deriving meaningful values of disamenity, or annoyance, either attitudinal or monetary. Thus, while it is possible to measure exposure parameters in objective units on an interval scale the same does not at present hold for levels of expressed annoyance. Currently we must work within the constraints of ordinal response data.

We are, then, in something of a quandary. Ideally, we would seek to relate units of exposure to annoyance but in the case of attitude measurement are constrained by scaling problems.

This perhaps an opportune moment to examine the aggregate approach to pedestrian exposure measurement for it also raises a number of fundamental issues related to the relationships between exposure and response.

Examples of this approach may be found in both the Catford Traffic Management Study (Pearce and Stannard, 1973) and the Coventry Transportation Study (CTS, 1973). The techniques involved were developed to a somewhat higher degree in the CTS environmental evaluation exercise and the following comments will, therefore, be directed to the "Coventry approach".

As part of the CTS environmental evaluation exercise an attempt was made to calculate pedestrian exposure to road traffic noise and pedestrian delay. Pedestrian surveys were conducted in 105 shopping locations in Coventry containing five or more shops. The central area was not included as it was felt that pedestrian activity was less predictable in that location. Exposure in the 105 centres was viewed as a reasonable proxy for exposure over the network as a whole.

The details of the procedures employed have been extensively described in CTS reports (CTS, 1973), and it is not proposed to discuss them in great detail here.[4] Rather, the basic purpose of this discussion is to indicate some of the issues which arise in the use of the aggregate method.

The Coventry output takes the form of a statement of aggregate person-hours of exposure to specified noise level bands (for example, 70-74 dB(A), 74-78dB(A)). Pedestrian delay is also presented in aggregate terms as person-hours of incurred delay.

A basic assumption of this approach is that there is a linear relationship between exposure and annoyance. It is assumed, explicitly, that one person spending thirty minutes

---

[4]The predictive models for pedestrian numbers and crossing movements reported in CTS were generated from the survey data. A similar approach was not adopted in the research project as the sample of centres under study was too small for statistical analysis and the locational transferability of such models must be questioned in view of their dependence on shopping centre catchment areas.

exposed to traffic noise in a particular street is equivalent to six people each spending five minutes exposed to the same level of noise in the same street.

However, it is very unlikely that the relationship between exposure and annoyance is linear. Furthermore, evidence from community noise response surveys suggests that there are a number of response groups ranging across a spectrum from ultra-sensitive individuals to the so-called "imperturbables" (Walters and Lawson, 1973). Personality factors may be extremely significant in determining responses to traffic impacts, a factor which implies that there may well be a considerable number of response groups across the spectrum.

The aggregate approach is, therefore, geared to certain fundamental assumptions concerning the relationship between exposure and annoyance. Furthermore, the "mechanics" of this approach inevitably place greater emphasis on the stimulus intensity parameters of exposure than time duration considerations. Clearly, individuals on the same shopping frontage may be exposed to basically similar noise levels but their duration of exposure may differ significantly. If we accept the proposition that the time duration of exposure is indeed important in response terms then it may be argued that the aggregate approach obscures this vital component of exposure. This situation is somewhat analogous to that which pertains to network noise evaluation. Significant variations may be lost in the process of aggregation.

Although the aggregate approach allows for comparisons between options, it may be argued that it really does not provide the decision maker with very much information about the implications of policy options at a socially relevant level.

In the case of household exposure there is at least some response data, and now of course, legislative standards for certain situations, which inform the decision maker of acceptable and unacceptable traffic noise levels. No such data or standards exist in the case of pedestrian exposure. One suspects, therefore, that aggregate household exposure statements may have a good deal more meaning for the decision maker than pedestrian exposure statements.

The aggregate approach to pedestrian exposure accounting is, therefore, characterised by certain shortcomings of both a conceptual and methodological nature. The approach must, of necessity, incorporate some rather gross assumptions concerning the relationship between exposure and annoyance. The significance of pedestrians as a high intensity exposure group requires that meaningful measures of exposure be prepared for decision making purposes. It is argued that the existing aggregate approach does not fulfill these requirements, and that a more meaningful approach may be found in a disaggregated view of exposure, in which it is also possible to start examining distributional issues.

The approach to be described below is based on the concept of stress and stress situations. The conceptual framework proposed sidesteps the issue of what people find annoying with respect to traffic environments and suggests instead that pedestrian exposure to such impacts may be potentially stressful. The extent to which the exposure situation becomes annoying will, it is argued, depend on the personality of the individual, the intensity of the impact and the duration of exposure. It is argued, by implication, that there may well be a threshold level of exposure after which stressful situations become distressing or annoying.

The important distinguishing feature between this conceptualisation of exposure and the aggregate approach is that it is not necessary to make implicit assumptions about the relationship between exposure and annoyance. Ideally, of course, we would still like to establish such a relationship and clearly, attitude provides us with a measuring mechanism by which to establish this relationship. However, certain difficulties previously referred to must be overcome before such an approach is feasible.

The interaction between the individual and traffic environments is, therefore, viewed as a source of potential stress situations, which may or may not generate annoyance or distress on the part of the individual (see (Cullen, 1974; 1975)).

Stress may be defined (Lee, 1966) as :

> .....the force producing, or tending to produce, deformation in a body.

This is quite different from strain, which may be defined as:

> .....the deformation resulting from stress.

As Lee indicates there are a variety of relationships between attitude and stress, and also various modes of individual response to stress effects.

Lee argues that attitude is unlikely to have anything but a minor or short term effect in situations where conditions exceed physical tolerance limits. However, where stress approaches, but does not exceed this level , attitude may have a significant effect on tolerance and performance by influencing the stress-strain relationship through:

> .....modification of stress, (of) exposure to stress, (of) response to stress or (of) tolerance to the consequences of stress.

Modes of response or modification to stress situations may take various forms. These may be viewed as a type of response hierarchy ranging from quite dramatic overt responses to those of a much more gradual and subtle nature.

Response may take the form of avoidance. The easiest way to escape possible strain is to simply avoid the stressor. The individual may, on the other hand, adopt an aggressive response to the stressor. Response may take the form of acceptance or psychological adaptation, representing an attempt to adjust to the existence of the stressor and the associated strain. Physiological adaptation may take place, strain in the body resulting from a specified stress being ameliorated by the development of compensatory forces. Finally, response may be articulated through constructive behaviour, in which an attempt is made to reduce the incidence of the stressor. As Lee (1966) notes, however, this presupposes that:

> ......the operator knows what he is doing, and that he is not creating a new set of environmental stresses while removing the old.

Lee's comments on attitude-stress relationships and stress-response reactions provide some useful insights into the manner in which the concept of stress may be linked with exposure analysis.

In the context of individual exposure-response relationships our concern is essentially with response s of the first four types mentioned above, although at present we lack sufficient data with which to characterise the nature of the relationships and responses involved in the case of traffic impacts. From the planning viewpoint we are deeply concerned with elements of constructive behaviour which might permit some control over stress inducing agents. Certainly, if we adopt this stress framework for exposure analysis then we are essentially assessing environmental policies for shopp ng links on the basis of their performance in reducing the incidence of potentially stress situations for the pedestrian.

The use of the stress concept in this way has the basic advantage that exposure need not initially be related toc distress or annoyance felt by the individual.

Cullen (1974) argues that stressors, or stress inducing agents, may produce two sets of conditions. First, they may produce "difficult or unpleasant" conditions for the individual. Second, at the threshold level, which will obviously vary according to the behavioural sequence involved, individual personality factors and the parameters of the relevant exposure variables, these conditions may themselves generate feelings of annoyance or distress.

While Cullen has attempted to quantify the time duration of both these stress situation elements, it would seem possible to apply the stress concept in a more limited manner to the pedestrian exposure problem.

Thus, pedestrian exposure may be conceived of as a potentially stressful situation. Relating exposure to response in this way allows for the incorporation of any information concerning distress or annoyance levels which might become available. Such an approach would, however, require more detail about the individual's pattern of exposure if potential stress incidence is to be examined in distribution terms.

The existing conceptualisation of exposure and the measurement techniques associated with it have been criticised for failing to articulate the basic assumptions underlying the application of the concept of exposure in environmental evaluation. It has been argued that the aggregate approach gives no indication of the significance of the time duratipn of exposure at the level of the individual, nor the distribution of exposure rates among the pedestrians under study. Despite the assumption of a relationship between exposure and expressed annoyance there exists no body of data with which to assess the nature of this relationship, or to clarify the relative significance of the time and stimulus intensity parameters of exposure in the generation of subjective responses to traffic environments.

The stress formulation of exposure clearly requires a more detailed data input than has previously been the case. However, it would appear to be far more meaningful to adopt a disaggregated approach to exposure accounting and thereby consider both the time and stimulus intensity parameters in a realistic way. Furthermore, distribution issues may only be examined through such an approach.

The disaggregated approach would also appear to have a number of distinct advantages from the decision maker's viewpoint. Firstly, the measurement procedures to be described below give a clear indication of the total number of pedestrians using a shopping centre during the "shopping day". This in itself provides some useful detail on the potential scale of the impact problem. Secondly, it would seem reasonable to suggest that the decision maker can comprehend more readily exposure measurements presented at the level of the individual. Thirdly, as it is feasible to give some indication of the likely duration of exposure for individuals on shopping links it is possible for decision makers to undergo direct environmental experience which reflects, with some accuracy, that experienced by the pedestrian. Such experienced on the part of decision makers is regarded as an important component of the evaluation procedure proposed in this thesis. Finally, the survey procedures may also be used simultaneously to collect data which may well prove valuable in the context of local plan formulation. Thus, although the data requirements of this approach may appear somewhat demanding, it is possible to derive other useful planning data from the survey procedures.

The project approach to exposure measurement does, therefore, differ markedly from existing methods of analysis. The objective of the measurement procedures developed in the project is to make it possible to generate measures of pedestrian exposure at the level of the individual.

Various classificatory systems may be used to explore the distributional implications of exposure. In the worked examples presented in Chapter 9 particular emphasis is placed on variations in the exposure rates of different mode user groups - those travelling to the centres by foot, bus and car.

Measurements are presented in terms of minutes of exposure. On the basis of the conceptual framework adopted, these periods are assumed to be potentially stressful situations.

At the present time, it is only possible to give some general indication as to the relative stress associated with different traffic-environment conditions. However, it is felt that the approach has a number of basic advantages over the aggregate method, not the least of which are its flexibility and the more realistic presentation of exposure statements.

7.4. Measuring Pedestrian Exposure: The Project Approach

The measurement procedures developed in the project are designed to derive data relating to the following components of exposure statements:

(a) the total number of pedestrians exposed,

(b) the time duration of exposure for a random sample of pedestrian shoppers.

The survey procedures involve the simultaneous counting and interviewing of pedestrians at defined exit points from the shopping centre.

7.4.1. Pedestrian Count Procedures

Having established the shopping centres to be studied (those which appear as the worked examples in Chapter 9) an operational definition of the spatial limits of each centre was formulated. In all cases the extremities of the centre were readily definable, but in cases where centres do not exhibit such characteristics it may be necessary to adopt a criterion based, for example, on the proportion of shops to other land use types. The limits of the centre may be fixed where shops represent less than 1 in 3 of the buildings on the fronatge, for example.

The procedures then requires that a cordon be drawn around the defined area of the centre encompassing potential exit pointsfrom the shopping axis. These exits will generally take the form of both ends of the High-Street and all side-roads, as well as any bus stops within the shopping area so-defined. In one of the worked examples, there is a case of a recently constructed pedestrian precinct area with parking facilities above the shopping concourse. In this example, it was decided to include the car park as a potential exit point in view of its significance in relation to the use of this element in the shopping provision of this particular centre.

Clearly, the incidence of on-street parking raises a number of issues. Monitoring this particular aspect of shopping centre activity does not appear to be a feasible proposition unless a large number of survey staff are available. Parking controls may, in fact, serve to eliminate a good deal of on-street parking and divert drivers to side-streets, or off-street car parks, where they may be picked up in the cordon count procedures. However, inevitably there will be some on-street parking and related pedestrian activity which will not be represented in the survey data. Such activity may, in fact, be insignificant in exposure measurement terms, particularly if a minimum time constraint on exposure accounting is adopted - for example, those exposed for less than three minutes might be excluded from the exposure statement. However, it is felt that the number of individuals involved is likely to be small in relation to the overall number of centre users.

A conscious attempt was made to limit the number of exit points to approximately six. In certain cases this involved grouping adjacent exit points into one, for both counting and interviewing purposes. It should emphasised that manpower resources for the survey work conducted by the author were extremely limited and that this in itself was a severe constraint on survey procedures. The survey team did, in fact, comprise of two individuals, one of whom assumed responsibility for the pedestrian counts and one who undertook the interviewing.

Thus, where possible, exit points or aggregations of exit points were limited to six. This made it possible to adopt a temporal sampling frame of ten minutes at each exit point, the minimum which was regarded as satisfactory if the potentially erratic nature of pedestrian movement from the centres was not to disrupt the survey. This comment applies both to the count and to the interview survey, which is naturally dependent on a throughput of pedestrians.

The adoption of the ten minute sample time period made it possible to count at each exit at least four times during the period of the "shopping day" as operationally defined: 10.00 - 16.00 hours. The normal shopping day in the weekly context was also further defined as being Tuesday, Thursday and Friday. Monday was not regarded as a normal shopping day in view of its proximity to the high activity Saturday shopping situation. Wednesday was excluded on the grounds that it was half day shopping. Saturday was not considered in view of the fact that it was initially intended that the output of this component of the project would be related to WMTS output, which itself was confined to weekday traffic conditions.

The counting procedure entailed recording all pedestrians leaving the High-Street shopping axis at the defined exit points. Data were recorded on a count sheet for subsequent processing.

In the case of bus stops all those getting on to buses and those waiting for buses during the sample period were recorded. In the one case of a car park exit point all occupants of vehicles leaving were recorded.

The processing of this survey output was relatively simple. The total number of individuals leaving through each exit point over the sample time periods during which counting took place were summed. These figures were then factored by the ratio of the total shopping day to the time period sampled. Thus, where exit points were sampled for a total period of 40 minutes during the shopping day, then the total number of pedestrians, or vehicle occupants in the case of the car park exit point, recorded as leaving through the specified exit point would be grossed up by a factor of 9, this being a self averaging process.

In the case of bus stops it soon became apparent that the cycle of sampling periods could, under certain conditions, produce a situation in which counting commenced just after a bus pick up or counting terminated just prior to a pick up. Obviously, this can present certain problems when attempting to gross up figures, and reflects one of the weakness of a short sample time period.

The problem appeared to be acute in only one case however, and it was assumed that if individuals waiting, but not picked up, during the counting period were regarded as having exited the centre then this would balance out those periods when buses had recently cleared the waiting queue. Total numbers leaving centres at bus stop exit points were derived by the same factoring method described previously.

The overall total number of individuals leaving the centre during the "shopping day" is derived by simply adding up the factored figures for each exit point. Thus, we are in a position to display the total number of individuals potentially exposed to traffic impacts, accepting, of course, that some individuals may not be recorded at the cordon points due to operator error or the volume of movements exceeding a manageable level for the observer. In addition, it is recognised that individuals parking on the High-Street and then engaging in pedestrian activity will not be recorded by the procedures described here.

7.4.2. Pedestrian Interview Survey

The primary purpose of this survey was to obtain the data required to calculate individual exposure profiles for pedestrian shoppers. Interviewing was conducted simultaneously with the pedestrian count at each exit point over the same ten minute sample time period.

Prior to undertaking the survey an inventory of all retail and service establishments on the High-Street frontages was made. The locations of all establishments were noted and subsequently entered on a map of the High-Street. This information is essential for the processing of the responses to questions concerning the characteristics of the shopping trip undertaken by the respondent. It also proved invaluable in interpreting responses which were lacking in clarity with regard to the establishments visited. The master map was also marked with all potential entry and exit points on the High-Street, this again being vital information required to establish the points of origin and termination of shopping trips.

The questionnaire which was used in the survey work is presented overpage. It was designed to yield as much information as possible from the minimum number of questions. It was felt that a maximum of 2 minutes interviewing time was the effective limit for a successful on-street survey of this type, where an attempt was being made to obtain as many interviews as possible. Again the limited manpower resources available, effectively constrained the scale of interviewing survey which was practicable.

Interviews were made on a random basis at each

QUESTIONNAIRE

(1) "Could you please tell me the shops which you have visited in the shopping centre ? Could you please try to give me the order in which you visited them and whereabouts they are?"

(2) "By what means of transport did you travel to the shopping centre?"

(3) If by car "Where did you park your car?"
If by bus "At which bus stop did you get off the bus?"
If walking "Whereabouts did you enter the High-Street?"

(4) "How many times a week do you shop here?"

(5) "Is this your main shopping trip of the week?"
If NO "On which day of the week do you do your main Shopping trip?"

(6) "Can you you tell me the main reason why you shop here?"

(7) "Is there anything in particular that you do not like about this shopping centre?"

(8) Male/ Female Under 30/ 30-50/ 50+

exit point. As soon as one interview was completed an attempt would be made to start another, the objective being to obtain the maximum number of interviews in each ten minute period. It generally proved possible to administer the questionnaire in approximately 1½ - 2 minutes. The response rate was good, with only a limited number of refusals.

Up to six interviews were conducted at certain exit points during the ten minute period. The simultaneous counting and interviewing of pedestrians does allow for the calculation of a sampling fraction applicable to each exit point over each ten minute period.

As the survey was directed to those pedestrians engaged in shopping activities it was necessary to filter out from the interviewing process all those engaged in other activities. This was achieved prior to interviewing when the interviewer would ask the potential respondent if, indeed, he or she had been shopping in the centre.

Clearly, no distinction was made between different activity groups in the pedestrian count. Ideally, an additional component of the survey would have been a comprehensive cordon count coupled with a trip purpose question posed to each pedestrian. However, this was not feasible at the time of the pedestrian survey work.

Nonetheless, in the centres studied only a very small number of individuals had to be filtered out of the interview survey and this fact, coupled with the pre-eminence of shopping activity in these centres , suggests that we are dealing primarily with a shopper activity group. Furthermore, the selection of the"shopping day" period excludes many individuals who might be engaged in other types of activity.

The most important aspect of the survey processing procedures is that which involves the derivation of pedestrian trip lengths. This variable is a fundamental component in the calculation of individual exposure profiles.

The data with which to calculate pedestrian trip length was derived essentially from questions 1 and 3 in the questionnaire. Question 3 was used to establish the individual's point of entry into the area defined by the cordon. As interviewing was carried out at exit points located on the cordon it was also possible to establish the terminal point of the individual's trip.

Question 1 was designed to isolate those intermediate locations visited during the trip. Eliciting the required information did prove to be something of a problem in certain cases, particularly, isolating all the locations visited in their correct order. Many respondents found this question difficult to answer and considerable prompting was often required together with an examination of the contents of the shopping bag.

Having established entry point, exit point and intermediate locations visited during the shopping trip, the problem then became one of manipulating the data in order that trip lengths could be calculated.

The method adopted involves the preparation of maps of each centre with entry / exit points defined and each retail/service establishment marked as a point location on the axis of the High-Street.

Each questionnaire was then processed by measuring with a scale the distance between entry point, intermediate point locations and exit point. The distance measured represented the pavement distance (plus road widths where applicable) required to reach all points, and not the shortest straight line distance.

The calculation of trip lengths also involved estimating the number of road crossing movements undertaken in the trip. This does present problems in many cases as we do not know if the individiuals concerned are actually attempting to minimise the number of crossing movements. The assumption was made, however, that pedestrians did attempt to minimise such movements and trip lengths, including crossing distances, and crossing movements were minimised subject to the locations to be linked together. Crossing movements were defined as either High-Street/ major road or minor side-road.

The phrasing of question 1 is in some senses unsatisfactory. Clearly, it expresses an interest in the establishments visited in the centre. The author is of the view that respondents interpreted this question as meaning the shops they had physically entered. It is , therefore, possible that locations outside the individual's stated trip sequence may have been visited for the purpose of window shopping for example, but were not reported. It is, therefore, suggested that the trip lengths calculated should be regarded as the minimum distance walked within the defined area of the shopping centre.

Thus, the output of the survey provides initially a measure of pedestrian trip length and the number of crossing movements involved in each trip. The problem now becomes one of converting units of distance into units of time in order that statements concerning the likely duration of stress situations can be made.

Clearly, we need a measure of pedestrian walking speed by which this conversion may be effected. However, the selection of a pedestrian speed measure raises a number of issues.

There exists a considerable volume of literature on this particular aspect of pedestrian movement studies, and Copley and Maher (1973) have provided an extensive review of the subject. Pedestrian planning and design issues have been explored in some depth by Fruin (1971). Pedestrian movement on shopping streets has been studied by Older (1968).

Research evidence suggests that, under free-flow conditions, pedestrian walking speeds may vary considerably. Fruin quotes studies in the United States which suggest that grade and load carrying have little effect on free-flow speeds. However, walking sppeds do decline with age and, more significantly, with pedestrian traffic density. Under situations of increasing density the variability in speed between individual pedestrians is reduced.

Pedestrian walking speeds in district shopping centres are likely to exhibit considerable variability, both between individuals and during different sections of the same trip where congestion on narrow pavements may severely restrict movement. We may naturally expect considerable variations in walking speed between different age groups.

It would seem that the most practical method of overcoming the problem is to assume a mean walking speed and apply this to each trip. A much more complex approach would entail the calculation of mean walking speeds for each sectionof frontage in each centre, and to adjust trip time characteristics on the basis of these figures, frontage by frontage. Such speeds could be derived either by direct behavioural observation, or by the use of formulae which relate speed to the concentration of pedestrians (for example, (Older, 1968)). This latter approach was, however, rejected on the grounds that it was too complex and would detract from the feasibility of the proposed methodology in the applied decision making context.

It was decided, therefore, to adopt a mean walking speed measure in the calculation of exposure. The walking speed to be used had to be selected in a rather arbitrary manner. The figure used was 44.2 metres per minute (145 feet per minute), which corresponds to the low point on the range of observed free-flow walking speeds (Fruin, 1971). This relatively low speed may at least go some way towards accounting for pedestrian congestion effects and, possibly, window shopping. In the case studies undertaken, older persons were well represented in the sample and in that respect this figure be more realistic than a higher one.

From the interview survey it is, therefore, possible to generate measures of individual exposure and mean exposure values for the sample as a whole or for different sub-groups classified, for example, by mode use, age sex and so on.

The other questions on the interview schedule provide useful information with which to expand on the likely pattern of shopper exposure.

Question 2 allows for comparisons between different mode user groups. Question 4 is designed to give some indication of shopping trip frequency and thereby to provide data concerning the incidence of stress situations for the shopper. Question 5 provides information concerning shopping trip distribution through the week and the significance of the trip which the respondent was questioned about. Further detail on this aspect may be provided by cross-referencing responses to the question with the answer to question one which indicates the number of shops visited. Clearly, if interviews are mainly conducted with respondents on very minor or spontaneous trips then doubts would arise about the validity of the exposure staements generated.

Questions 6 and 7 were of an opened nature and were simply designed to derive spontaneous reactions to each centre. As in the case of the TRRL studies in Putney, Newbury and Camberley (Christie, et al, 1973a; 1973b) very few respondents isolated traffic impacts initially as a source of concern to them.

Question 8 provided some information on respondent characteristics, although of course it may be argued that a more extensive series of questions could have been posed in this section. Household income and place of residence would have added another perspective to the analysis, but in what was basically a pilot exercise testing the survey method, their use was felt to be of only limited value.

The survey procedures described above were developed for the purpose of establishing, firstly, the total number of individuals engaged in pedestrian activity during the period of the "shopping day", and secondly, measures of pedestrian exposure to traffic impacts at the level of the individual. Obviously, there are shortcomings in the method, but it is argued that the approach adopted in the research project provides a viable alternative to the aggregate method of exposure analysis.

CHAPTER EIGHT

CHOOSING BETWEEN ENVIRONMENTAL ALTERNATIVES

8.1. Introduction

The basic inputs to the impact display matrix have now been specified and the relevant technical/operational details discussed. In the present chapter attention will be focused on the evaluation process itself and alternative methodological approaches to evaluation. This provides the necessary basis for the presentation of the proposed methodology and some worked examples in the following chapter.

It was stated in Chapter 3 that the impact statement approach is one of a number of methodological options for environmental evaluation. It was also suggested, however, that various theoretical and practical issues precluded the use of these alternative approaches in the research project. Evaluation methodologies will be examined in a following section and the discussion will seek to indicate why certain approaches were not regarded as feasible options in the context of the research project.

There are a number of fundamental issues related to environmental evaluation which, as noted, have considerable implications for methodology. Certain of these issues have already been raised in earlier chapters. At the expense of some reiteration, the present discussion would be better served if these issues were drawn together. Accordingly, a chapter section is set aside for this purpose.

Prior to moving on to consider these issues and methodological approaches to evaluation, it would be appropriate the consider the evaluation process; the function of evaluation, its linkages with decision making and the decision types confronting both central and local government for which evaluation procedures are required.

8.2. Evaluation, Decision Making and Decision Types

Evaluation has been defined (Kettle and Lichfield, 1975)[1] as:

> ......the formal analysis of the comparative advantages and disadvantages of plans or proposals in terms of stated criteria.

[1] The paper from which this definition derives previews a forthcoming text by Lichfield, Kettle and Whitbread - Evaluation in the Planning Process (London: Pergamon).

This view of evaluation is analogous to that in which it is regarded as plan testing.[2] Such an interpretation is explicit in Lichfield's (1970) review of evaluation methodologies, in which he suggests that evaluation is:

> .....one form of testing plans or parts of plans with a view to selection as among alternatives.

A definition with a somewhat different emphasis (DOE, 1971) regards evaluation as a process by which choices between alternatives are made by:

> .....bringing the objectives, or values, of decision makers to bear on the courses of action under consideration.

In the broader context, the function of evaluation is to inform the various participants, or actors, in the planning process of the advantages and disadvantages of undertaking alternative courses of action (Whitbread, 1973). In so doing, the intention is basically to indicate and assess the extent to which desirable goals, stated as objective functions, are achieved by alternative solutions (JURUE, 1975).

Evaluation has been viewed (Lichfield, 1970) both as an aid to decision makers in the process of selecting an

---

[2] Perspectives on evaluation are reviewed by Perraton (1972).

alternative which is "best" for the community, and as an aid to planners themselves in what is, essentially, the iterative process ((DOE, 1971)(Mcloughlin, 1969)) of generating and assessing options prior to selecting a short list to put forward to decision makers.

With the emergence of formalised public participation exercises over the past few years evaluation clearly has a role to play in the wider community context. It has also been viewed, therefore, as a means of informing individuals in the community about policy implications (Kettle, 1973).[3]

Evaluation and decision making are clearly closely interrelated but they are by no means synonymous, either sequentially or functionally. Evaluation obviously incorporates two basic components. Firstly, it comprises of an analytical process involving data preparation and presentation intended to reveal the extent to which alternatives achieve the stated objectives This process is essentially the responsibility of the professional planner. Secondly, it comprises of a plan or project appraisal

---

[3]For an interpretation of the relationship between evaluation and participation see O'Riordan (1975). Also of relevance to this area of discussion is the limited literature concerning the relationships between "specialization" and environmental appraisal. Sewell and Little (1973) discuss the relationships between appraisal and specialization in the context of environmental impact statements. Sewell (1971) explores the environmental attitudes of specific specialist groups.

process which constitutes a basis for decision making. The appraisal process may involve both planners and decision makers, the former group particularly during the earlier stages of the planning process where a wide range of possible alternatives are progressively reduced to a short list of preferred options. However, at the stage when short listed options are appraised and a choice exercised, the evaluation process moves quite explicitly into the political arena.

This is not to say, however, that the analytical exercise will necessarily determine the outcome of the choice situation in the political context. It seeks, rather, to provide a data base for decision making. By the same token, the analytical component of evaluation is by no means free from decisions as the previous chapters of this thesis have hopefully revealed.

The research project's concern with evaluation clearly reflects an interest in the provision of information for decision makers. As such, the proposed methodology seeks to indicate who is affected by alternative courses of action, the nature of the effects involved and, in a limited sense reflecting the constraints imposed by the use of ordinal comparisons, the extent to which individuals and groups are affected. The methodology thus seeks to respond to the basic data requirements of evaluation (Whitbread, 1973).[4]

Decision types for which evaluation methods are required have been classified by Williams (1975a). A basic distinction may be made between uni-objective project or policy decision types, and decisions related to multiple objectives. Decision types involving a single objective may be categorised thus:

(a) the selection of one project from among a set of mutually exclusive projects,

(b) the selection of a series of projects in order to exhaust the allocated budget (for environmental improvement, let us assume),

(c) a variation on (b) above, namely, the selection of projects eligible for approval or support from the given budgetary allocation.

Decision type (a) generally confronts those operating in the local government context and may be simply expressed as the need to select one scheme from a set of alternatives. Local lorry routing proposals with the objective of improving

---

[4]Gendell (quoted in Weiner and Deak (1972)) has provided a useful definition of terms regarding evaluation. Values are defined as a system of preferences which govern society's actions. Goals are regarded as ends strived for and objectives as goal components. Evaluation criteria are standards to use for assessing the extent to which plans attain goals and objectives. Policies are defined as definitive courses of action towards plan implementation.

environmental quality on shopping links fall into this category of decision, examples of which may be found in JURUE (1975) and in the manual presented in the following chapter. Evaluation of such alternatives may, Williams (1975a) suggests, adequately be made at the ordinal level, an implication of the fixed budgetary allocation generally provided for such schemes. The data demands of evaluation for such decisions will, therefore, be somewhat less rigorous and the limited scale and complexity of the procedures required may well permit quite detailed examination of alternatives by all participants in the planning process.

Decision type (b) is of a somewhat higher order and the environmental performance and cost comparisons required appear better suited to interval measurement. This type of decision is again more typical of the local government context where, for example, General Improvement Area policy may present decisions of this type. Ordinal measures of effectiveness may, under certain conditions, suffice, but maximisation of performance in relation to budgetary constraints requires interval measurement as between alternatives.

Type (c) decisions are a variant of (b) and are more characteristic of the central government context where decisions must be made regarding the suitability of projects from the approval or grant aid viewpoint. Criteria may be required to provide a basis for scheme eligibility, the most useful indicator being the relationships between costs and benefits. This again is dependent on interval measurement of the environmental performance of schemes.

Decision types (a) to (c) are characterised by increasing complexity and more rigorous data requirements on the environmental performance of schemes. Similarly, the cost implications of schemes must receive more detailed consideration as decision types get more complex. Clearly, a basic concern here is the maximisation of environmental benefits given the specified budget constraints. However, the fact that certain of the resource costs of environmental improvement may not be set against the budgetary allocations deriving from central or local government sources also requires that the financial implications of environmental policies be carefully considered.[5]

The three decision types described above are concerned essentially with a single objective. In contrast, the fourth decision type (d) is concerned with choices between alternatives

---

[5] Local lorry routing proposals produced in accordance with Dykes Act provisions may well impose costs on vehicle operators which will ultimately be be borne by the community, costs which are, however, outside the normal budgetary framework.

with multiple objectives. This type of decision may be summarised thus:

(d) establish the budget allocations for policy areas with different but technically related objectives.

Decisions of this type are clearly of a higher order than those previously described. Such decisions arise in both levels of government and are characteristic of environmental quality issues which exhibit a variety of technical linkages with various components of the urban system. In the transportation-environment field an example is provided by decisions involving resource allocation between accessibility objectives and public transport provision linked with environmental objectives.

Such problems require both environmental quality measures and a measure by which environment may be compared with accessibility objectives.

In the transportation field there exists a good example of a variant on this type of decision problem provided by the Land Compensation Act. In this case environment is defined as a constraint on accessibility thereby maintaining one objective by imposing it as a constraint on another. Such constraints as are provided by this legislation are relatively flexible compared to those in which strict environmental standards are established,[6] but do, however, raise the formidable problem of resolving how compensation payments to those affected should be arrived at.

Four primary decision types are, therefore, recognised. These range from selecting one project from a mutually exclusive set within an essentially fixed budget framework to allocating resources between environmental objectives and other technically related objectives. Significant related issues raised are the determination of budgetary constraints (decision types (a) to (c)) and the determination of standards and compensation in type (d) decisions, where environment may be established as a constraint on technically related sector activities.

Decisions types become more complex with progression through this classification and demands on evaluation methodology become more rigorous. Most notably, higher order decision types are better served by

[6] Flowerdew (1975) raises various issues related to the use of environmental standards. He argues that from the economic viewpoint there are "some grave objections" to their use. The use of standards, he argues, would imply that the requisite levels be met regardless of costs incurred. The economist would argue that where high standards can be met at low cost this is acceptable, but high standards at a high cost might make it desirable to lower the standards. Low standards would still leave many people suffering adverse impacts, while high standards would result in "astronomical" costs being incurred. Mid-point standards would produce a situation in which the economist would argue that " it would be better to improve the standards at some places and relax them at others if it were possible to achieve a reduction in overall costs without significantly allowing the overall environmental effects to

evaluation based on interval scale measurement and require more detailed consideration of resource cost implications and technical linkages with other objectives.

8.3. Issues in Environmental Evaluation

For the purposes of the present discussion a number of key issues in environmental evaluation have been drawn together and will be discussed in this section. These issues are considered prior to an examination of evaluation methodologies because the current limitations on the use of certain methods and approaches to evaluation are best understood when set in the context of the various theoretical and practical issues raised by the evaluation of environmental quality.

Some of these basic issues are represented by:

(a) the definition of the environment,

(b) the development of criteria - "operational definitions of objectives" (Williams, 1975a)

(c) the valuation of the environment,

(d) the prediction of the conditions associated with alternative courses of action - the outcome or consequences of alternatives.

The problems associated with the definition of the environment and various approaches to this component of evaluation were discussed in Chapter 5. Four approaches were described; the generalised, holistic approach, the use of environmental indicators, the bundle of "environmental goods" approach and, finally, the social psychological approach based on the analysis of individual responses to the environment.

It was suggested that the last named approach appeared to offer a means of deriving socially relevant environmental variables, meaningful in terms of human responses. However, it was recognised that the approach is not without its problems, the most significant of which are its inability to cope with imperceptible components of disamenity and the issues and problems raised by the need to aggregate individual responses, expressed in terms of the cognitive dimension of attitude, in order to identify meaningful group or community definitions of the environment.

Considerable emphasis was placed on the shortcomings in our knowledge concerning the cognitive structure of traffic environments. It was, however, recognised that progress could be made by utilising the findings of a number of existing social surveys, which had indicated that certain impacts were perceived and regarded as objectionable.

However, in the general context of environmental evaluation the definition of the environment must be regarded as a fundamental theoretical issue which will continue to attract the attention of researchers, and necessarily so, for some considerable time to come.

The development of criteria is itself related to the definition of the environment, and also to the valuation of components of environmental quality. The issues associated with valuation have already been briefly touched upon and will be returned to shortly. However, a significant general point concerning the interrelations between these types of issue may be stated. The limitations imposed by our lack of knowledge concerning the way in which the environment is defined and components valued, individually or one against another, mean that it is not yet feasible to establish an objective function for the environment.

Of necessity, therefore, environmental policies tend to respond to particular issues (for example, traffic noise) which represent sub-objectives within the overall goal of environmental improvement. The implications of this fragmentation of the environment find expression in evaluation through the need to compare and trade off these various objectives, a process not unlike that associated with the evaluation of proposals with multiple objectives.

Almost inevitably, then, distributional issues will arise in the context of environmental evaluation. This in itself reflects to a large degree the spatial nature of environment. In consequence, therefore, evaluation must contend with a variety of issues raised by comparisons between losers and gainers; compensation, consumer surplus and interpersonal comparisons (Williams, 1975a).

It was noted in the discussion of decision types that effectiveness measures based on maximisation criteria might be used in decision types (a) - (c), given fixed budget constraints. The measurement level requirements were, however, held to vary between decision types, with more complex evaluation problems requiring interval effectiveness measures. In multiple objective evaluation exercises a similar criterion might well be applied, but the basic problem of establishing relationships between resource costs and environmental values does, at present, preclude the development of the required criteria.

The valuation of the environment, or components thereof, presents formidable theoretical and practical problems. It is this problem area which at present constrains the development and application of several approaches to environmental evaluation.

The valuation of environmental quality is, of course, closely related to the definition of the environment. Thus, in attempting to derive either attitudinal or monetary valuations of the environment, we require some clear idea of what the relevant components of the environment are. On the asumption that the environment may be defined, for operational purposes, how may the problem of environmental valuation be approached?

Two basic categories of study are in evidence; attitudinal response and studies of market behaviour designed to establish revealed preferences. The distinction between these approaches has to some extent been "blurred" in the case of certain studies where researchers have sought to link "hard" monetary values with "soft" attitudinal data (Joyce and Johnson, 1975).[7]

The derivation of monetary valuations of environmental quality clearly has many attractions from the evaluation methodology viewpoint. As Lassiere (1973) notes:

> ......appropriate extensions would be made to the cost-benefit calculations which are already carried out in the economic evaluation.

---

[7] For a useful discussion of some of the relevant "parameters" which require determination in valuation studies, see Johnson and Joyce (1975). These parameters provide a basis for the definition of a typology of approaches.

However, as available research findings indicate, there remains considerable doubt as to our present capability to derive meaningful and unambiguous values for environmental stimuli.[8] Some might even argue that such a possibility is remote indeed.

The central point at issue is the correspondence between money values derived from attitudinal studies and those expressed in the behavioural context, that is to say, in a market. In order to have any meaning, the values derived by "willingness-to-pay" or "hypothetical compensation" exercises should be replicated in the behavioural context (Joyce and Johnson, 1975). If such a relationship can be

---

[8] For a detailed discussion of approaches to valuation see Hedges (1972). Hedges isolates a number of basic reasons for the difficulties which arise in valuation analyses. These include the hypothetical nature of the situation, the lack of "orderly and uni-dimensional" value systems among individuals, the fact that environmental concepts are poorly developed, the sensitivity of attributed values to the context involved, difficulties associated with the translation of values into monetary terms reflecting a lack of acceptance of this process on the part of some individuals, and a lack of uniformity in the concept of money.

Additional problems include the rejection of the concept of compensation by many individuals, the implications of ability to pay for willingness to pay criteria, and the difficulties involved in specifying environmental benefits in a form which may be appreciated by the individual. See also, Hammond (1972) for a discussion of valuation issues associated with attempts to incorporate environmental impacts within a cost-benefit analysis framework.

established then all to the good but if not, then, clearly we are in a difficult position with this approach and one may question whether it is worthwhile continuing to follow it.

The use of monetray values also raises problems related to the interpersonal comparisons which arise in compensation situations involving assumptions about the marginal utility of money.

Attitudinal valuation of the environment also has a number of attractions. These are related to the possibility of deriving a measure, on a common scale, which would permit aggregation of disbenefits. In this case, the intention might be to measure annoyance with particular components of the environment - perceptible traffic impacts, for example. However, the issue of attitude scale properties must inevitably be faced. May responses be regarded as being of an interval nature, or are they simply ordinal? In the absence of clear evidence to the contrary, it would at present seem advisable to operate on the basis that responses are ordinal, with respect to both the levels of individual impacts and comparisons between impacts. This assumption is explicit in the proposed methodology presented herein.

Technical issues pertaining to both analysis and prediction are obviously of importance in the application of any methodology. In the case of prediction, we are clearly concerned with the ability to differentiate between the performance of alternative courses of action in terms of specified impacts. In consequence, therefore, predictive tools should be sensitive and accurate enough to provide the requisite data.

The implications of predictive capabilities for the evaluation process are considerable. Limited capability in prediction and analysis must necessarily impose constraints on the nature of the evaluation that may be undertaken, and, similarly, has implications for the degree of emphasis placed on the derivation of values for the evaluation process.

An additional point concerning predictive tools relates to their universality or transferability. There are obvious advantages to be gained in having techniques which may validly be used in various locational settings. One notable feature of much of the predictive modelling carried out in the context of traffic-environment studies has been the locational specificity of the models developed. The JURUE models employed in the proposed methodology do give some indication of being accurate and valid in locations other than those from which the required empirical data were derived.

Technical analysis of the environment is the only way in which the imperceptible impacts may be isolated, defined and incorporated in the evaluation process. The recognition of the distribution issues involved and their implications for policy making are, therefore, heavily dependent on the technical ability to measure and predict such impacts.

Various issues in environmental evaluation have been briefly discussed in the paragraphs above. The purpose has been to isolate some fundamental problem areas with a view to establishing some of the constraints on the selection of an evaluation methodology which the author faced. Some of the issues raised relate to specific categories of methodology, this being particularly so in the case of those approaches which are based on the derivation of environmental values. Other issues, most notably, those relating to analysis and prediction are relevant in the context of all approaches to evaluation.

8.4. Methodological Approaches to Evaluation

The purpose of this chapter section is to examine a number of alternative approaches to evaluation with a view to indicating why they were not regarded as feasible options for the author's project.

We may commence this discussion by viewing available methodological options for evaluation in terms of a spectrum ranging from the notional ideal of single sum cardinal project evaluation, to what may be regarded as generalised, intuitive "design-display" approaches. Between these two ends of the spectrum may be recognised a number of approaches varying in their degree of sophistication, the assumptions which they embody and the demands on data which they create.

A useful classification of evaluation methodologies is provided by Williams (1975c) and this affords a framework within which to discuss alternative approaches.

Four basic types of approach are defined, these being as follows:

(a) single sum,

(b) weighted matrix,

(c) constraint,and,

(d) "design" methods.

The following discussion of methods classified according to these categories will seek to illustrate the relevant constraints , which, it is argued, precluded their use in the research project. It is not, therefore, intended to undertake a detailed discourse on each method, but, rather, to examine its feasibility in terms of the project's requirements and the relevant constraints.

We may start by considering what many would indeed regard as the "ideal" approach, namely evaluation methods based on the derivation of a single sum measure of project performance.

Clearly, cost-benefit analysis would come under this rubric if the requisite assumptions could be met and non-priced goods dealt with in a satisfactory fashion. Cost-benefit analysis is perhaps the best known approach to project evaluation (Ferraton, 1973), and as Harrison (1974) notes:

> ... it is in the transport sector that the techniques of cost-benefit analysis have been most highly developed in theory and most widely put into practice.

Cost-benefit analysis of highway investment has, however, focused primarily on the issue of user benefits (Whitbread, 1970), and it is only recently that attempts have been made to incorporate the broader community and environmental implications of such investment within this particular approach to project evaluation. Such an extension of cost-benefit analysis, attractive though it may be, is not without its problems or its critics however (see, (Needham, 1971).

Cost-benefit analysis derives from welfare economics and the theory of the firm (McLoughlin, 1969), and seeks to establish which option from among those under consideration is the most economically efficient, in other words, that which maximises the cost-benefit ratio subject to specified constraints (Prest and Turvey, 1965).[9]

The method is based on the criterion of a potential Pareto improvement (Vass, 1972) and takes into account the total benefits, minus the total costs, irrespective of distributional effects (Perraton, 1973).

A number of fundamental questions must be resolved when using this method of evaluation. These are:

(a) the nature of the costs and benefits to be included,

(b) how they are to be valued,

(c) the discounting rate to be used, and,

(d) the nature of the relevant constraints.

In the context of environmental evaluation the first two questions obviously present some of the most severe theoretical and practical problems for those who would use this methodological approach.

Clearly, the problem of defining the environment

---

[9] The literature concerning cost-benefit analysis is voluminous. Useful readings include those of Layard (ed)(1972), Mishan (1971), Bohm (1973) and Harrison (1974).
The now classic studies in the applied transportation field include those of Beesley and Foster (1965) and Coburn, et al, (1960).

is itself of paramount importance and the problems involved have already been considered at some length. The monetary valuation of environmental attributes does, however, impose quite fundamental constraints on the application of cost-benefit analysis in the environmental field.

The Roskill Commission cost-benefit study may be quoted as an example illustrating the great, and some might say insurmountable, difficulties associated with carrying out even a partial environmental analysis within this methodological framework. The Roskill approach has been widely criticised for the methods used to derive noise nuisance values ((Mishan, 1970)(Self, 1970)(Peters, 1974)). Mishan's critique of the noise valuation exercise reveals the sensitivity of the findings to changes in quite basic assumptions, while Self criticises the use of notional values, preferring those derived from and tested in the market.[10] He also argues that certain things cannot be priced.

The inclusion of environmental factors within a cost-benefit analysis framework was also attempted in the work carried out by the Urban Motorways Project Team. The procedures employed aredescribed in considerable detail

---

[10] In contrast, Perraton (1973) argues for the use of "notional" figures, suggesting that these may be more valid as an indication of "the social costs and benefits of a plan".

in their Report to the Urban Motorways Committee (HMSO, 1973). A summary statement of the approach, together with two others (Environmental Evaluation Index and cost-effectiveness) developed by UMPT may be found in the UMC Report "New Roads in Towns" (HMSO, 1972).

The cost-benefit analysis framework developed by UMPT consultants is reported extensively in the relevant literature and it is not proposed to discuss it here. However, it is clear from comments made in both the Project Team Report and the UMC document that a number of basic questions must be resolved if such an approach is to represent a meaningful extension of cost-benefit analysis.

Clearly, the validity of the derived environmental values is questionable as the discussion above has indicated and this must obviously have considerable implications for the degree of confidence we may have in the output of such exercises. Furthermore, the assumptions which must be made concerning the marginal utility of money in compensation situations also raises formidable problems related to interpersonal comparisons (Hammond, 1972).

Existing attempts to place monetary values on the environment have been confined in the main to residential settings. There are clearly advantages in attempting to link environmental values with the personalised, readily definable context of the home with which the individual has various affinities - economic, social and so on.

In the context of the research project it was difficult to see how a logical and coherent conceptual framework could be developed for deriving monetary valuations of components of shopping environments. Data collected by the author in the generalised open-ended response questions included in the pedestrian questionnaire survey suggest that the decision to shop at a specified locations reflects two primary dimensions - economic and accessibility.

One might argue that a "willingness-to-pay" criterion based on travel cost differentials between shopping centres with different levels of environmental quality might be used to explore individual preferences related to shopping environments. However, in large urban systems establishing the requisite experimental situation would be by no means easy, and we return inevitably to issues concerning the ability to pay, information levels concerning alternative shopping opportunities and numerous other problems.

Similarly, one might suggest that the "house price differential" could possibly give some insights into the value placed on shopping environments. However, the basic problem with this approach is disentangling one particular component from the bundle of goods which combine to make up a home and its locational attributes. One suspects, furthermore, that in the case of shopping provision it may well be the presence or absence thereof, rather than the environmental quality of the local centre, which is of significance.

The questionable validity of monetary values of environmental quality, problems of interpersonal comparisons and the difficulties associated with operationalising the cost-benefit analysis approach in the context of shopping environments combined to rule out this particular methodological option in the research project.

The weighted matrix approach has been widely used in evaluation exercises, examples of this approach including the Goals Achievement Matrix (Hill, 1968) and the UMPT Environmental Evaluation Index (HMSO, 1972; 1973)[11]

In the latter, impacts are weighted according to their significance in response terms. These weights are then multiplied by the number of people affected and are added

[11] See also Weiner and Deak (1972) for discussion of the development of a weighted matrix approach to highway investment appraisal.

to yield a single index number. Thus, for each option under evaluation an index number may be derived, which can then be compared with scheme costs. The weighting of impacts is clearly the critical element of the method, and, as the UMC Report acknowledges, there are as yet "very few research results to draw upon".

The Goals Achievement Matrix places particular emphasis on the weighting of objectives. A numerical weighting is, in fact, applied to each objective to express its relative importance for each element of the community. As McLoughlin (1969) notes:

> .....these weights are used to multiply the appropriate costs and benefits of actions striving for the attainment of objectives.

The use of weighted matrices in environmental evaluation raises a great many issues. Again, valuation of impacts constitutes a basic component of this approach and again the basic problems associated with such valuation must be faced. The aggregation of individual valuations expressed in annoyance terms, interpersonal comparisons between those who benefit and those who lose, linking non-monetary values with resource costs and the elimination of double counting are among the many issues which must be resolved in such an approach.

In the case of the Goals Achievement Matrix (GAM) the requirement of objective specification presents problems in the environmental evaluation context. Objectives must necessarily rely on the valuation of different impacts by individuals. It has been suggested that there exists considerable doubt as to our ability to specify an objective function for the environment. Williams (1975c) suggests that GAM may have a role to play in environmental evaluation where the problem is to compare and trade off various sub-objectives which arise as a result of the need to disaggregate the environment and related objectives (for example, noise reduction). The issues involved bear some similarity to those associated with the evaluation of projects with multiple objectives. Weiner and Deak (1972) have suggested, however, that GAM methods do not consider the interaction and interdependence between objectives and must, therefore, confined to single sector analysis and evaluation.

The issue of specifying objectives also provides a convenient link with another method of evaluation, which, it might be argued, occupys a somewhat less well defined position on the continuum of evaluation methodologies, namely, the Planning Balance Sheet (Lichfield, 1956; 1970). The PBS approach seeks to extend cost-benefit analysis by attempting to consider all the gains and losses associated with alternative courses of action. The incidence of gains and losses for "producers" and "consumers" are established and valued as far as possible. The actual measurement of gains and losses is not necessary, although it is clearly desirable. As McLoughlin (1969) notes, the essence of the method is:

> .....precise description enabling the planner to balance the monetary costs and benefits with the intangibles. At the same time a clear picture is presented of who pays and on whom benefits are bestowed.

Hill (1968) has criticised this approach, arguing that costs and benefits must be related to "a well defined objective". Furthermore, he argues that if the community place little value on a particular objective then any costs and benefits derived for that objective are "irrelevant for the community in question".

While the PBS obviously has to contend with the valuation issues described above, it does nonetheless exhibit certain superficial similarities with less sophisticated impact statement approaches to evaluation.

In the absence of established and validated procedures and derived environmental values the difficulties inherent in operationalising the above approaches are clearly considerable.

Thus, the development of extended cost-benefit type approaches (PBS) or approaches based on the weighting of impacts, or objectives, must necessarily be regarded as non-feasible methodological options in the context of the research project.

"Constraint" methods provide yet another group of approaches to evaluation. Probably the best known approach coming under this rubric is that of standard setting. In this case, projects are evaluated in terms of their ability to conform to, or provide, the stipulated standards.

Standard setting, is as Flowerdew (1975) comments:

> .....an obvious and tempting way to pursue the problem of controlling the environmental effects of urban roads.

The economic objections to standard setting presented by Flowerdew have previously been noted. There are, however, other issues which arise in connection with the process of standard setting. Clearly, responses to the environment and to specific traffic impacts, for example, will vary considerably between individuals. The enforcement of standards will not, as Flowerdew notes, necessarily produce an "acceptable" environment for sensitive individuals and may require "unnecessarily high expenditure" to satisfy those with a high tolerance level.

Flowerdew accepts the value of standards in the context of specifying "minimum levels of health or environmental protection" and also sees considerable value in their use as guidelines. However, he argues that there exists a danger that advisory standards may come to be viewed as an entitlement, in which case, if this were accepted, they would become analogous to mandatory standards.

Cost-effectiveness, minimum-cost and performance maximisation methods may be regarded as variations of this basic approach.

Cost-effectiveness analysis seeks to establish the ratio between the costs incurred and the effectiveness of alternative options. Only costs are expressed in monetary terms, benefits being expressed in terms of the measures of effectiveness of proposals in meeting the specified objectives (DOE, 1971). Such an approach was developed in the context of the UMPT work (HMSO, 1972; 1973).

This approach must inevitably raise questions concerning the levels of environmental quality (essentially standards) which are acceptable within the context of particular schemes. Thus, we return to the issue of environmental valuation and its attendant problems. Other problems are apparent in the framing of effectiveness measures. Flowerdew (1975) argues that, to be valid, the doubling of the derived effectiveness measure should correspond to:

> ......the doubling of the value to society of the improvement suggested....a proposal which is twice as effective as an alternative proposal for the same road, must be as valuable to society as two proposals of the alternative kind adopted at different locations.

He then proceeds to argue that if this condition does not hold then it is meaningless to compare cost-effectiveness ratios, and one can only say that, given the same cost a proposal with higher effectiveness is preferable to one yielding a lower level of effectiveness.[12]

The cost-minimisation technique is concerned only with the costs associated with alternative courses of action. The assumption is made that benefits between alternatives are equal. The cost implications of alternatives can only be identified "in terms of the resources utilised without any indication of the rate of return" (DOE, 1971). While it is possible to explore the distributional incidence of costs, the same is not true for benefits. Furthermore, unless the

[12] The use of input-output techniques in relation to implicit or explicit standard setting for components of environmental quality may be viewed perhaps as a variant on the general cost-effectiveness approach. For a discussion of input-output approaches see Hirsch, Sonenblum and St. Denis (1972).

objective is cost minimisation itself, then the technique does not relate to the specification of objectives.

Performance maximisation, on the other hand, seeks to identify the benefits of policy alternatives with the assumption that costs are equal between the alternatives considered. Indicators of performance may be related directly to objectives and distributional implications may be explored by disaggregating performance measures. However, this technique cannot identify resource implications, "either in toto or in distributional terms" (DOE, 1971).

Related to performance maximisation, in some senses, is an approach based on the definition of "direct" constraints. This approach is reflected in the Land Compensation Act, where in dealing with multiple objective situations transportation considerations expressed in accessibility terms are maximised subject to enviro nmental considerations. This approach has fundamental linkages with standard setting and may possibly be regarded as more of a formalised constraint on the evaluation and decision making processes rather than a methodological option in evaluation.

The dependence of the above techniques on the specification of acceptable or desirable levels of impact, expressed through the mechanism of a standard, makes them difficult to operationalise in the context of environmental of environmental evaluation. The assumptions which should be met in cost-effectiveness are difficult to validate given our very limited knowledge concerning environmental values. Cost-minimisation can say little about the distribution of benefits, and in any case is dependent on a full assessment of the cost implications of options: a formidable task in the environmental context. Performance maximisation is again dependent on the specification of costs if the assumption of equal costs between alternatives is to be validated. These approaches were not, therefore, viewed as feasible assumptions in the research project.

The final set of approaches to evaluation are those which may be termed "design" methods (Williams, 1975c). Such methods include the"design display"approach and also the use of unweighted matrices of the environmental impact display type (for example, (Lassiere, 1973)).The latter type of approach is, of course, the basis of the methodology developed in the research project.

The "design display" approach may be regarded as the "traditional architect/planner method" (Williams, 1975c). The method depends essentially on an intuitive evaluation of project performance with no valuation of components of the objectives. The weakness of the approach is its failure to specify objectives in any detail and value relevant elements.

The identification of costs and benefits is , in consequence, far from easy. However, there are clearly design constraints, expressed primarily through the technical feasibility of the scheme or project; it must work.

The reliance of the method on professional intuitive judgements is perhaps its fundamental weakness. There exists no opportunity to evaluate the professional judgement expressed. The basis of scheme selection may, to quote Flowerdew (1975), be expressed thus:

> ....."do we think that this is a better scheme to the alternative" - or " do we accept X's opinion that it is a better scheme?"

The unweighted matrix approach of the type adopted in the research project represents a development of the "design" approach. The matrix format is employed to display the implications of alternatives in terms of a specified set of impacts.

These impacts may be expressed in descriptive terms or, as in the case of the project approach, an attempt is made to specify levels of impacts in terms of objective physical units. Where valid data exist, it might also be possible to value certain impacts - numbers annoyed by specified impact levels.

The elements of the display matrix are derived from the objectives themselves, and from the available response data indicating the relevance and importance of impacts. The unweighted matrix approach does not seek to make comparisons concerning the relative significance of the impacts considered, nor the significance of changes in the levels of impacts, either individually or one against another.

By implication, therefore, an objective must be framed for each individual impact, or, as is perhaps more commonly the case, it is left to the decision maker to place his own value judgements on the data so presented.

8.5. Concluding Statement

Various methodological approaches to evaluation have been examined. The discussion has centred on the relevant constraints and/or operational difficulties which precluded the use of many of these approaches in the research project.

Although we do not as yet have a cardinal form of project evaluation, and although it is not feasible to weight environmental impacts or objectives, we can prepare unweighted impact display matrices which do serve an important role in indicating, if only on a partial basis, the environmental implications of alternative courses of action. Such an approach is the basis of the method developed in the research project and which is described in the following chapter.

CHAPTER NINE

CHOOSING BETWEEN ENVIRONMENTAL ALTERNATIVES FOR SHOPPING LINKS: A PROPOSED METHODOLOGY

9.1. Introduction

The purpose of the methodology to be described below is to provide a basis for the process of choosing between environmental alternatives associated with transport proposals at the specific spatial scale of the district shopping centre.

The methodology seeks to provide a logical and coherent framework for evaluation based on the environmental impact statement approach.

Relevant constraints on evaluation are specified. The principles of the method and its applicability are then considered. The nature of the inputs to the methodology and requisite operational details are described. Methods of data presentation and approaches to the problem of choosing between environmental alternatives using the proposed methodology are then discussed. A number of worked examples illustrating the use of the methodology are presented.

9.2. Constraints on Environmental Evaluation: A Summary of the Position

The methodology is based on the fundamental proposition that it is not yet feasible to derive valid and meaningful values for environmental quality, either by the use of monetary or attitudinal approaches.

It is also recognised explicitly that the environment as a construct remains poorly defined. In short, we do not know what the environment comprises of for the individual and must, therefore, undertake environmental evaluation with only a partial definition of that construct.

The inability to specify components of environmental quality in a rigorous fashion, coupled with the difficulties inherent in environmental valuation, renders it impossible to formulate an objective function for the environment in applied policy making terms. Of necessity, policy must respond to "key" issues which become apparent only through disaggregation of the environmental totality.

Environmental evaluation is severely constrained by the limited ability of individuals to articulate their cognitive and affective responses to environmental quality. The limited perceptions of individuals expressed through the cognitive component of attitude present problems when one attempts to derive definitions of environmental quality. That is to say, when we seek to establish those components of the environment of which individuals are aware.

More significantly, perhaps, the difficulties which individuals appear to experience in articulating their affective (positive or negative feelings) responses to the environment operate as very effective constraints on the feasibility of many methodological approaches to evaluation, and, by implication, on the comparisons between options which may validly be made.

Whereas it would seem reasonable to suggest that individuals can state their preferences as between alternative environments, it is by no means clear that they can state by how much they prefer one environment as against another.

In the absence of validated interval scale response data relating to alternative environments it would appear sensible to operate on the assumption that response measures are of an ordinal nature.

If this proposition is accepted then we must acknowledge that it imposes a number of limitations on the nature of comparisons which can be made with respect to environmental alternatives.

Among these limitations, or constraints, are the following.

In the first case, it cannot be said, in absolute terms, that a particular change in one environmental impact is of greater or lesser value than a specified change in another impact. Thus, for example, we cannot therefore say whether a change in pedestrian delay from 45 seconds to 30 seconds is worth as much as a noise reduction from an L_{10} of 75 dB(A) to 65 dB(A). This constraint requires that only one impact at a time be considered in evaluation.

The second constraint reflects the fact that alternative environments cannot be compared in absolute terms, even when examining the same impact. This implies that although we may say an L_{10} of 75 dB(A) is more annoying than one of 65 dB(A), it cannot be said that it is twice or three times as annoying. Thus, we cannot undertake an overall ranking of alternatives but must instead make comparisons on a pair-wise basis.

Thirdly, we cannot say whether the value ascribed to a change in the intensity of a particular impact is of the same magnitude when such a change takes place at different absolute levels. We may suggest, however, that equal changes in impact intensity are likely to be more noticeable at lower absolute levels. Thus, in the case of noise, for example, an increase in the L_{10} from 60 dB(A) to 70 dB(A) is probably more annoying than a similar 10 dB(A) increase from 75 dB(A) to 85 dB(A). This implies, therefore, that between option changes in impact intensity should be related to the absolute levels at which the relevant changes are occurring.

These three constraints on evaluation, which, it is argued, are valid irrespective of the scale of the proposals under consideration (for example, alternative network proposals or local environmental traffic management schemes), are made explicit in the proposed methodology.

9.3. The Principles of the Method

The method is based on the compilation of a physical impact statement incorporating the levels of intensity of specified traffic impacts in relation to options, to which are added measures of the total number of pedestrians exposed and the duration of exposure. Thus, the principles of the method may be simply stated in terms of an attempt to display impact intensity, numbers exposed and time exposed.

The formulation of exposure adopted in the methodology is based on the proposition that exposure to traffic impacts is potentially stressful and may indeed be annoying. However, we lack the response data necessary to establish the nature of the relationships between the impact intensity and time duration parameters of exposure and levels of expressed annoyance. It is suggested, therefore, that periods of exposure to specified impact intensity be interpreted as potential stress situations.

In view of the aforementioned constraint on comparisons between options, we are only in a position to make tentative suggestions as to the relative stress associated with alternative environments and must relate stress to the absolute levels of the impacts concerned. Unfortunately, we are not yet in a position to specify the likely significance of variations in exposure time in stress terms. Again, we may only make some very tentative assumptions about this component of exposure.

Environmental impacts resulting from road traffic activity are displayed in terms of objective physical units of measurement. Exposure statements for pedestrians are presented in terms of the numbers exposed and the time duration, in minutes, of exposure. The latter must be assumed to be constant from option to option as we have no means, at present, of predicting variations in the level and characteristics of pedestrian activity in shopping centres.

This statement applies to both activity responses to changes in shopping facility provision and location at the individual shopping centre scale and changes in activity levels resulting from environmental modifications, be they adverse or beneficial.

9.4. Applicability of the Methodology

The methodology was developed for the purpose of assessing the environmental impact of traffic in district shopping centres. The emphasis placed on the measurement of pedestrian exposure characteristics renders certain facets of the methodology specifically applicable to this particular type of activity location. It is argued that the environmental sensitivity of shopping links in the highway network may be attributed to the interaction between high levels of pedestrian and vehicle activity, and the disamenity implications for pedestrians thereof.

The basic limitation on the application of the methodology derive from the characteristics of the predictive models which are recommended for use as a means of establishing the environmental conditions associated with alternatives. These are derived from empirical data relating to urban non-free flow traffic conditions. This obviously means that the application of the methodology must be confined to shopping locations characterised by such traffic conditions.

Furthermore, although the models have been validated in the locational context within which the author was operating (the West Midlands) and appear to be fairly robust,it may be that certain environmental and/or traffic flow conditions at a particular location produces spurious predictions. It is suggested, therefore, that, where possible, the models are validated by means of a test of observed environmental conditions against the output of the predictive models.

Clearly, the models should only be used in those locations with site and traffic flow conditions falling within the range of observed conditions on which the models are based.

The methodology is, therefore, recommended for use only in the urban non-free flow situation and where conditions fall within the range of the empirical data with which the models were built.

9.5. Inputs to the Methodology

The methodology requires two basic forms of input;

predictions of the levels of specified traffic impacts in relation to policy alternatives, and, measurements of the number of pedestrians exposed on shopping links and their pattern of exposure in terms of time duration.

The relevant technical and operational details will be summarised below.

9.5.1. The Traffic Impacts Considered

The limited research evidence available suggests that individuals are aware of, and respond negatively to, the following types of traffic impact:

(a) traffic noise,

(b) atmospheric pollution, and,

(c) pedestrian vehicle conflict issues.

Traffic noise as an impact may be readily defined and measured. Considerable research has been undertaken into both the means by which traffic noise may be predicted and also individual responses to it. Noise is, in fact, the most deeply researched traffic impact.

Atmospheric pollution impacts present far greater problems in that many of the pollutants associated with vehicular activity are imperceptible to the individual and also present severe problems of measurement and prediction.

Individuals are, however, aware of smoke emissions, or unburnt hydrocarbons, as these are of a form which render them perceptible in terms of both sight and smell. Smoke may be measured with relatively unsophisticated equipment and is susceptible to prediction. Smoke is, if fact, one of the impacts considered in the methodology.

The other air pollution variable considered is carbon monoxide. Although imperceptible, CO raises a number of significant issues including the health hazards associated with traffic activity, it being poisonous at high concentrations, and, by implication, equity issues which are likely to arise as a result of exposure to the environmental conditions produced by policy alternatives.

Smoke and CO also add an interesting dimension to the impact statement in that the former is primarily associated with diesel engined vehicles and the latter with petrol engines. It should also be noted that CO levels have been shown to correlate to some extent with lead and aldehyde emissions.

Pedestrian-vehicle conflict is a multi-dimensional impact incorporating pedestrian hazard, risk, trip inhibition and pedestrian delay in crossing the road.

Pedestrian hazard, risk and trip inhibition are generally not susceptible to prediction unless long term data collection exercises are undertaken in order to compile valid statistical samples. Such exercises are required because of the low incidence of pedestrian accidents and the consequent need to analyse traffic flows, accident rates and pedestrian flows over an extended period.

Pedestrian delay is, however, susceptible to prediction and therefore provides us with a means of displaying at least one component of pedestrian-vehicle conflict issues.

Four environmental impacts of traffic activity are therefore considered in the methodology. Existing social response data indicate that these effects , with the exception of carbon monoxide, are perceived by individuals and may well produce distressing or annoying conditions. The effects are:

(a) traffic noise,

(b) smoke,

(c) carbon monoxide, and,

(d) pedestrian delay.

9.5.2. Predicting the Impacts in Relation to Policy Options

Predictive models are available for the four impacts listed above. These are empirically based models developed by The Joint Unit for Research on the Urban Environment (JURUE) of the University of Aston in Birmingham. The models were developed over the period 1972-74 and are based on empirical data derived from observation sites in the London Borough of Hammersmith and the Royal Borough of Kensington and Chelsea.

Required data inputs to the models may, for the most part, be derived from classified vehicle counts. Two observers are generally required, each assigned to a side of the road. The count classification required for each direction of flow is as follows:

(i) cars

(ii) light commercial vehicles, under 30 cwt

(iii) heavy commercial vehicles, above 30 cwt

(iv) buses

(v) motorcycles

A sample time counting period of 20 minutes has been validated in a number of exercises using these models and is therefore proposed in the methodology presented herein.

Additional data requirements of the models are as follows.

The noise model requires that the distance from the kerbside to the centre of the traffic flow be ascertained.

This need not be simply the distance from the kerbside to the centre of the carriageway. Parked vehicles may serve to deflect the traffic stream. Thus, the distance required is that from the kerbside to a point midway between traffic flow streams.

Both the smoke and CO models require data relating to the nearside flow, which refers to the direction of flow and not simply to traffic lanes. That is to say, the counts required relate to that traffic flow closest to the observer in multiple flow situations.

The CO model also requires a vehicle speed input. Ideally, this should be obtained from site measurements using a speed measuring device. However, if such equipment is not available then the only way to proceed is to make sensible estimates of vehicle speeds (the average over the time period) on the links under consideration.

It should also be noted that the wind speed elements of the predictive equations for smoke and CO must be set at zero. It is clearly impossible to predict wind speeds for inclusion in the model and in fact the use of the term in the equations is dictated only by the requirements of the empirical analysis from which the models derive. Setting wind speed at zero will, therefore, indicate the worst conditions obtaining under varying traffic flow parameters.

The data range on which the models were built is presented in Table 9.1.. The predictive models take the following form:

Traffic Noise Model

$$L_{10} = 11.8 \log_{10} (Qw) - 3.8 \log_{10} (d) + 40.5$$

$R = 0.94$ Residual Error = 1.6 dB(A)

where:

L_{10} = noise level at kerbside exceeded for 10% of the time period considered

Qw = weighted flow = (C + 2.L + 15.H + 7.B + 2.M)

C = total flow of cars, both directions, vph

L = total flow of light commercial vehicles (under 30 cwt), both directions, vph

H = total flow of heavy commercial vehicles (over 30 cwt), both directions, vph

B = total flow of buses, both directions, vph

M = total flow of motorcycles, both directions, vph

d = distance from the kerbside to a point mid-way between the traffic flow streams, in metres.

Aston University

The Smoke Model

$$S = 0.1\,(H_n + B_n + L_n) + 0.03C_n - 2.5\,W + 38$$

$R = 0.82$ Residual Error = 18.8 microgm/m^3

Where:

S = average smoke concentration microgm/m^3 over period considered

H_n = flow of heavy commercial vehicles (over 30 cwt) on nearside of carriageway, vph

B_n = flow of buses on nearside of carriageway, vph

L_n = flow of light commercial vehicles (under 30 cwt) on nearside of carriageway, vph

C_n = flow of cars on nearside of carriageway, vph

W = average windspeed in Km/hr during period (set at zero)

The Carbon Monoxide Model

$$CO = 0.006C_n - 9\log_{10} V_n - 0.3\,W + 17$$

$R = 0.74$ Residual Error = 3 ppm

Where:

CO = average concentration of CO in air in ppm over period considered

C_n = flow of cars on the nearside of the carriageway, vph

V_n = average speed of vehicles on the nearside of the carriage way, Km/ph

W = average wind speed during period, Km/ph (set at zero)

The Pedestrian Delay Model

$$D = 6.7 \times 10^{-6} (Q)^2 + 0.3$$

R = 0.88 Residual Error = 2.8 secs

Where:

D = delay most likely to be incurred in seconds

Q = total vehicle flow, both directions, vph

The models presented above provide us with a means of predicting the environmental implications of policy options of terms of four physical environmental variables. The data derived from the use of these models constitute the first basic input to the impact statement. The second input is provided by estimates of the number of pedestrians exposed and measures of the time duration of exposure. The procedures pertaining to the derivation of the necesary data are described in the following sub-section.

9.5.3. Measuring Components of Pedestrian Exposure

Whereas it is possible to predict at least some of the physical environmental implications of alternatives this is not true of pedestrian exposure parameters. In consequence, therefore, it is necessary to measure, in some detail, various components of pedestrian exposure in the field. Furthermore, the measures so derived must be assumed to be constant under the varying assumptions embodied in each policy option. Thus, it is not possible to say that an improvement or deterioration in environmental conditions on a specific shopping link will result in an increase or decrease in the numbers exposed or in the time duration of exposure for individual pedestrians. Exposure must, therefore, be regarded as a constant although we may suspect that certain types of policy option may have some effect on the variables involved.

The approach to exposure measurement proposed in the methodology is based on the disaggregation of exposure into two basic components; the number of pedestrians exposed and measures of the time duration of exposure. This contrasts markedly with the existing approach to exposure measurement in which aggregate measures of person-hours of exposure are generated. This approach, although allowing for comparisons between options does not do so, it is argued, at a meaningful level. It is further argued that decision makers may find it extremely difficult to place any meaning on measures presented in this way.

It is , therefore, proposed that exposure be measured at the level of the individual and that the measures so derived be used in the evaluation process as a means of affording decision makers a realistic time parameter for exposure which they may wish to employ in direct environmental experience sequences. That is to say, decision makers will be in a position to visit shopping centres under consideration in the evaluation process and actually experience environmental conditions over the same or similar time duration as regular users of the centre.

The recommended procedures involve a simultaneous pedestrian count and interview survey. The data so derived permit the calculation of the total number of pedestrians exposed and various measures of exposure duration. It is proposed that the derived measures of exposure duration be viewed in terms of potentially stressful situations for the pedestrian. We cannot at present say how annoying different environmental conditions are for the pedestrian nor can we indicate a relationship between the duration of exposure and annoyance. We are, therefore, limited to making tentative statements regarding the relative stress associated with different exposure rate

9.6. Choosing Between Environmental Alternatives Using the Methodology

The proposed methodology is based on the preparation of an unweighted environmental impact statement.

Impacts are not weighted, either individually or one against another, because, it is argued, we lack sufficient data concerning the absolute values attached by individuals and the community to components of environmental quality. Furthermore, it is argued that any kind of weighting system, arbitrary as it must be given current constraints, may well serve to confuse the situation rather than make environmental evaluation any more effective or efficient.

Data are, therefore, presented in an unweighted form and it is explicitly accepted in the methodology that it is the prerogative of decision makers to construct their own weighting system if they so desire.

The objectives of the methodology may, therefore, be summarised thus. Unweighted information relating to a number of specified traffic impacts, the numbers of individuals exposed and measures of the time duration of exposure is presented in the form of an impact statement. A display matrix form of presentation is employed indicating the environmental implications of policy options for the shopping link under consideration. This display matrix represents, essentially, an attempt to indicate the degree of traffic impact in relation to the policy parameters.

The methodology seeks to present information which is both relevant and meaningful in human terms and which is intelligible to the decision maker.

It is, of course, self evident that the display matrix presentation for a particular policy option is by itself meaningless. The basis of evaluation is clearly the process of comparing the alternative environments resulting from specified policy options and examining the trade offs which are involved. Thus, the actual process of choosing between alternatives must necessarily commence when at least two options (of which one may be the "do-nothing") are subject to evaluation and the requisite impact statements prepared.

It is at this point in time that the decision maker must contend with the trade offs which arise between accessibility considerations and environmental quality and also the technical linkages between the two. He will of course have to examine the cost implications of policy alternatives and set these against the environmental benefits to be obtained from policy options with such objectives in mind.

The technical linkages between various traffic impacts may clearly present the decision maker with complex trade off problems. Basically, this reflects the situation that a specified change in traffic flow will vary in its significance, both with respect to the particular impact under consideration and the level of flow at which the change takes place.

Thus, for example, policy options which result in the addition or subtraction of only a limited number of vehicles from a road with high traffic flows will have little effect on noise levels but a considerable effect on pedestrian delay. In the case of small changes at low traffic flows the converse is true. In such situations, the decision maker must be informed of policy implications through the evaluation methodology and must consciously trade off various components of environmental quality.

The evaluation of policy options for shopping links clearly raises additional problems for the decision maker. Environmental traffic management policies for such links may well result in the diversion of traffic to adjacent residential areas. As the worked examples will show, this necessarily involves trading off environmental quality in one type of sensitive location for that in another. Furthermore, the decision maker is obliged to make significant comparisons concerning the exposure of residents, and pedestrians on the shopping link. One particular advantage of the proposed methodology is that the derivation of measures of individual pedestrian exposure allows the decision maker to experience for himself environmental conditions on a given shopping link under the "do-nothing" assumption for a time period which reflects that for which the user of the centre may well be exposed.

Furthermore, an extension of this facet of the recommended methodology offers the opportunity for decision makers to undergo direct environmental experience in a range of alternative shopping environments. Such an approach, to be described below, would appear to represent a useful extension of the evaluation process and would again serve to broaden the information base on which the decision maker operates.

To recap then: it must be emphasised that evaluation is concerned with choosing between alternatives and that any evaluation methodology must be directed to this end. Ordinal evaluation, by definition, involves consideration of at least two alternatives, even if one is purely the "do-nothing" situation.

In the context of the evaluation of traffic environments the decision maker may well be presented by comparisons and trade offs of considerable complexity reflecting in themselves the complex interrelationships and technical linkages between the parameters of policy options and components of environmental quality.

Clearly, the constraints imposed by ordinal evaluation mean that evaluation must be tackled on the basis of pair-wise comparisons, and it is this process of comparison which gives the evaluation methodology its meaning and significance.

It is also important to remember that the decision maker is not provided with a weighting system and must, therefore, apply his own weights, either implicitly or explicitly, if he so desires.

Perhaps the most fundamental problem facing the decision maker who may be presented with a series of impact statements regarding alternative policies for shopping links, is actually gaining some appreciation of the significance of the environmental changes involved.

The general lack of data concerning the way in which pedestrians respond to traffic environments makes it extremely difficult to give the decision maker any meaningful information on likely patterns of response to alternative shopping/traffic environments. It should be noted in this context that we are as yet unsure as to the validity of the L_{10} noise index in locations other than residential areas.

In terms of the social implications of alternatives it is hoped that the more detailed pedestrian exposure data yielded by the author's suggested approach will give a clearer indication of the human scale of the problem in shopping centres. It is clearly useful to know how many pedestrians are likely to be exposed to traffic impacts, and, by implication, how many are liable to suffer disamenity effects or how many will benefit from policy alternatives. The availability of mean exposure measures does, as previously noted, make it feasible to arrange direct environmental experience for decision makers which replicates to some extent that of pedestrians in shopping centres. Such experience is regarded as a key component of the methodology.

However, to return to the basic problem of indicating the significance of environmental change in shopping centres, one presentation technique which might prove useful is that which may be termed the "league table". The essence of this technique, which is employed in the worked examples, is to relate environmental change in a particular district centre resulting from policy options to existing conditions both in that centre itself and in a number of comparable centres. Thus, a ranking of centres based on existing impact intensity levels is compiled from"best"to "worst", this being done for each individual impact. It is self evident that overall environmental rankings cannot be produced, so impacts must be considered individually. Having constructed the "league table" for existing conditions it is then possible to display the shifts in rank order which take place in the case of specified centres under alternative policies. If, for example, a centre previously at the bottom of the "league table" on the basis of noise levels and smoke concentrations is subject to local lorry routing proposals which remove heavy goods vehicles from the High-Street then the resulting environmental change might be expected to improve the ranking of that particular centre on those two particular "league tables". Thus, the centre which had previously been among the "worst" five, for example, might be elevated to a ranking which placed it in the "best" five, in terms of those two criteria.

Clearly, such a display technique can give the decision maker a very useful indication of the significance of environmental change. However, its effectiveness would certainly be improved if it were coupled with the direct environmental experience proposed above. In that case, elected representatives might be taken to a number of shopping centres with different environmental characteristics, in impact terms, and thereby gain some impression of the exposure implications of changes in impact levels.

It would, of course, be particularly useful if centres with basically similar environments (and traffic flow conditions)to those predicted for specified centres under different policy parameters could be isolated. In such cases, the environmental experience exercise for decision makers might consist of replicated exposure (at the existing "do-nothing" impact level) in the centre for which proposals had been formulated followed by a similar pattern of exposure in the centre with the environment which most closely approximated predicted impact levels associated with a specific policy option for the first centre. Under such conditions, and through their own personal experience, decision makers might be better able to appreciate the environmental implications of alternative policies.

Such an approach, and indeed the "league table" concept itself, is somewhat constrained by the availability of comparable locations. The author was somewhat fortunate in that the locational context within which he was operating during the development of the methodology proved to be a fairly rich source of comparable district shopping centre locations. This made the compilation of a "league table" a realistic proposition. In fact, the example provided in the following section includes some twenty centres.

One might argue, of course, that an "environmental replication" exercise of the type suggested could be carried out using non-shopping links for comparative purposes. Although such an approach might well give some indication of environmental change it can be argued that such links would lack the necessary "ingredients" of a shopping link, not only purely in functional terms, but more significantly in terms of the interaction between traffic and pedestrians which is characteristic of shopping locations. Certainly, decision makers may only become aware of certain issues specific to individual centres if they themselves experience similar conditions.

Two additional points regarding the use of the "league table" display method should be made. First, it must be recognised that the ranking system produced for any given impact for a specified set of centres is dependent on the predictive accuracy of the model employed and the "typicality" of the traffic count data on which predictions are based. With regard to the latter, local experience will usually serve to indicate if recorded count data are atypical. Regarding the accuracy of the models, it should be emphasised that some measure of residual error remains in the case of all four recommended models. Thus, particular caution should be exercised when interpreting those situations in which the absolute level of change in an impact is within the residual error of the model concerned. Clearly, this means that limited changes in rank order for centres as between options in a"league table" when relatively small absolute variations between "best" and "worst" are involved should be treated with some caution as to their significance. The "league table " concept is obviously more effective in situations where larger absolute value changes are involved, both between ranked centres, impact by impact, and for the same centre in relation to different policy options.

The second point which should be made is that both the initial ranking of a specified centre for a particular impact and its subsequent ranking under different policy options are of importance when examining the "league table". Again, it is worth emphasising that rank changes should be related to the absolute levels at which change is taking place, for obvious reasons.

It is, therefore, suggested that the process of choosing between environmental alternatives for shopping links using the proposed methodology should consist of the following components:

(a) appraisal of the impact display matrix prepared for a specified shopping link, which indicates:

   (i) the intensity of traffic impact in terms of traffic noise, carbon monoxide, smoke and pedestrian delay,

   (ii) the total number of pedestrians exposed during the period of the "shopping day", and,

   (iii) measures of the time duration of exposure.

(b) appraisal of the impact "league table", which illustrates how policy options influence the rank ordering of specified centres, impact by impact.

(c) direct environmental experience exercises on the part of decision makers, which are designed to give them personal experience of the degree of traffic impact on the shopping link(s) under consideration. Where opportunities exist, this exercise may be extended by providing decision makers with a chance to compare and contrast alternative shopping/traffic environments of known impact intensity characteristics.

A small number of worked examples, illustrating the type of output produced by the methodology and decision situations which may arise in relation to shopping links will now be presented.

9.7. Using the Proposed Methodology: Some Worked Examples

At a very early stage in the author's research project the members of the West Midlands Transportation Study Group drew up a list of some twenty centres within the Study Area, which they believed were subject to adverse environmental impacts from road traffic activity.

Three of these district centres - Harborne, Kings Heath and Northfield - were subsequently selected for more detailed consideration and provide the locational contexts of the worked examples. Their locations are shown in Map 9.1.1..

All three centres are scheduled for bypassing in the context of the 1981 WMTS recommended highway network. Although there is now very considerable doubt as to the likelihood of investment in such highway construction schemes, at least before the intended "horizon year", it did nonetheless appear that evaluation of a number of policy options relating to the bypassing option might be a useful exercise. In consequence, therefore, three options reflecting, essentially, various levels of pedestrianization of the shopping links feasible with bypassing

Aston University

were formulated for test purposes. These are:

(a) complete pedestrianization - no vehicle access,

(b) bus only access ,

(c) bus and delivery vehicle access only

It is assumed that such policy options could be achieved by exercising discretionary powers under the relevant provisions of the Town and Country Planning Act (1971).

Such policies would clearly be expected to produce environmental benefits throughout the day. However, the operational definition of the "shopping day" (10.00-16.00 hours) and the availability of shopper exposure data, suggests that evaluation should be primarily confined to displaying and appraising the environmental implications of options in relation to the off-peak period. Thus, in the worked examples impact display matrices for this period are presented. Clearly, this also provides a logical basis on which to compare the environmental benefits of policy options against the existing off-peak "do-nothing" situation.

An additional point concerning bypassing should be made.

It is recognised explicitly that any bypass construction schemes will have environmental implications for those areas through which they pass. However, no attempt has been made to evaluate the losses or gains involved other than on the shopping link involved. This partly reflects on the fact that detailed design data for schemes were not available to the author, and also the assumption that such schemes would, of necessity, incorporate remedial measures under Land Compensation Act obligations.

Thus, three options based on pedestrianization of the existing High-Street link were examined and relevant data and comments are presented below.

Whereas pedestrianization schemes are likely to have quite dramatic effects on traffic flow and environmental conditions as they involve, by definition, considerable or total restraint on vehicle access, it was thought that a somewhat more "marginal" policy option should be considered in order to provide an additional perspective in the worked examples.

The option considered does, in fact, mirror a concern which is very evident in the contemporary perception of traffic-environment problems, namely, the issue of heavy goods vehicle movement. Thus, the particular option examined seeks to explore the possibilities of local environmental lorry management in the context of improving environmental quality on shopping links. This approach may be seen as an attempt to exploit the opportunities afforded by the provisions of the Heavy Commercial Vehicles (Controls and Regulation) Act (1973), more commonly termed the "Dykes Act".

The options involve the diversion of heavy goods vehicles (that is to say, those vehicles exceeding 3 tons unladen weight) away from the High-Street shopping link onto links in the adjacent local network.

In the case of many shopping links, such a policy approach will almost inevitably result in heavy goods vehicles being redistributed onto residential links. The centres used in the worked examples reflect this situation. In evaluation terms this clearly means that the decision maker will have to make trade offs between environmental quality factors in two types of sensitive location. The author's methodology has been developed specifically for shopping links, although of course many of the caveats and principles involed are applicable to evaluation at various scales and in various locations. However, certain issues and approaches to evaluation, as well as presentation techniques, are more applicable to residential areas than to shopping centres. Thus, while the author has made an attempt to display some of the costs and benefits incurred in residential areas to which heavy goods vehicles may be diverted, it should be emphasised that the evaluation undertaken is by no means comprehensive and should not be regarded as a guide to the process of impact statement evaluation for policy options in residential environments.

Similarly, the author's explicit concern with the shopping link per se and the environmental implications of policy options for that particular link means that only some of the basic trade off issues between residential and shopping environments are raised. The technical feasibility of lorry routing proposals is not examined in detail and, thus, there is a rider which should be made explicit. The options considered are, in any case, purely illustrative and do not represent either informal or formal policy proposals for specific links. There may well be cases in which some degree of junction realignment may be necessary in order to ease the problem of HGV turning movements. Similarly, traffic signal location or phasing may have to be changed. These may, of course, add significantly to the cost implications of lorry routing proposals, particularly so if some land-take is involved and Land Compensation Act obligations have to be met in cases where road improvements are undertaken. The author is cognizant of these issues but argues that they do not bear directly on the intended purpose of the worked examples. Some attempt has been made, however, to estimate the cost implications of the lorry routing proposals examined, these being expressed in terms of additional costs to hauliers through increased mileage and those to the local authority through the provision of signs.

The worked examples relate, therefore, to three district shopping centres in the Birmingham area. Some four policy options are considered, three of which are based on opportunities to exploit the provision of a bypass round the centres concerned. The fourth options considers the opportunities which might be afforded by local lorry management to improve environmental conditions on the shopping link. Options are used purely for illustrative purposes and it is recognised that certain evaluation and technical issues are considered in only very limited terms. The output from the exercises undertaken will be presented on the following pages.

9.7.1. Harborne District Shopping Centre

Harborne is primarily a residential suburb of Birmingham and is located approximately 3 miles to the south-west of the city centre. Harborne is a fairly heterogenous residential area, both socially and in terms of property types.

The High-Street shopping centre comprises of approximately 110 shops and is of a linear form. The centre is at present in a state of change, with considerable segments of the older shopping frontages being redeveloped. Some redevelopment has, in fact already taken place and this includes the provision of three sizeable supermarkets.

The shopping link is itself narrow and also has rather narrow pavements. From the pedestrians viewpoint, this creates congestion and brings the individual on the pavement into very close contact with passing traffic.

In traffic terms, the link is frequently congested, particularly during the peak period when it functions as a major route into the city centre from large residential developments to the west. During the off-peak period conditions may also be congested due to delivery vehicles, on-street parking of shoppers' cars and through movement of buses Harborne suffers particularly from buses due to its close

9·7·1

9·7·2

HARBORNE

proximity to a bus garage and the significance of the bus routes on which it is located.

The area adjacent to the shopping centre is residential in nature comprising of a mix of older terraced properties, semi-detached and detached houses. Thus, in the context of local lorry routing proposals trade off situations between environmental quality on the High-Street and in residential areas will necessarily arise. Similarly, the construction of a bypass would inevitably impinge on at least part of this residential area.

Two photographs of Harborne High-Street are presented on the previous page (Photographs 9.7.1. and 9.7.2.). Local network and land-use details are provided in Maps 9.7.1.1. and 9.7.1.2..

9.7.1.1. Policy Options

Four options for the High-Street are considered, as described in the earlier discussion. These are:

(a) complete pedestrianization with no vehicle access

(b) pedestrianization with bus only access

(c) pedestrianization with bus and delivery vehicle access only

(d) a local lorry routing proposal

Pedestrianization would be associated with bypassing of the High-Street, the most recent estimate of costs being in the

the order of £5m . Relevant assumptions concerning bypassing options for all three centres have already been stated and will not be reiterated. The options will be briefly discussed and the relevant impact data presented. A more extensive discussion of lorry route proposals will, however, be required, this being true in the case of all three centres. Having specified the options and their implications discussion will then centre on issues of comparison between the options.

9.7.1.1(a) Complete Pedestrianization

This option would require the closure of the existing High-Street shopping link to all vehicles, possibly on a twenty four hour basis, but at the minimum for the period of the "shopping day". It should be emphasised that the primary shopping axis in Harborne extends along High-Street (i) as defined on the local network map. This is the area of most intensive pedestrian activity and where environmental policies would clearly have the most to offer.

The relevant impact display matrix is presented in Table 9.7.1.2.. The display matrix for the current off-peak situation is presented in Table 9.7.1.1.. As emphasised at an earlier point in the discussion of the methodology, pedestrian exposure parameters are held to be constant between options. Exposure measurement procedures employed by the author to derive the reported data are described in an appendix to this chapter.

9.7.1.1.(b) Pedestrianization with Bus Only Access

Clearly, bus access to shopping streets is an issue to which transport operators, decision makers and the general public are very sensitive.

This option retains public transport vehicles on the High-Street shopping link, defined operationally as High-Street (i) (as in the previous option), thereby causing no inconvenience to operators,and bus users who may wish to shop in Harborne. Clearly, this may only be achieved at some environmental cost on the High-Street as against the previous option, but does nonetheless produce considerable benefits as against the "do-nothing" existing situation.

The level of bus operations has been adjusted downwards slightly from existing recorded levels in the view of the incidence of non-service bus movements which currently occur as a result of the nearby bus garage.

The impact display matrix for this option is presented in Table 9.7.1.3..

9.7.1.1. (c) Pedestrianization with Bus and Delivery Vehicle Access Only

This option is one that has actually found increasing expression in many town and city centre pedestrianization schemes.

Again, it is clear that bus access is being retained with some associated environmental costs but in this case further costs (in terms of the no access option) must be incurred with the addition of commercial vehicles. However, as in the case of the previous two options considerable improvements over the "do-nothing" situation are obtained.

In order to predict the environmental implications of this option it was necessary to make what is hopefully a sensible estimate of likely commercial vehicle usage of the shopping link under such conditions. Ideally, of course, observations of delivery vehicle activity rates should be input to this option. The same comments as before apply to the bus activity level factor.

The impact display matrix for this option is presented in Table 9.7.1.4..

9.7.1.1 (d) A Local Lorry Routing Proposal [1]

This option seeks to improve, or rather, explores the possibilities of improving, environmental conditions on the High-Street link in Harborne by removing through heavy goods vehicle traffic (vehicles over 3 tons unladen weight).

It should be noted that the predictions of environmental impact associated with such policy options must be generated from a somewhat more detailed set of traffic count data. Thus, it is clearly necessary to isolate heavy goods vehicles (HGV), as a component of traffic flow. This may appear to present problems in terms of the predictive equations which define such vehicles as being those over 30 cwt.. Such problems may be overcome, however, by introducing an additional category of medium commercial vehicles (30 cwt to 3 tons) but treating them as for "heavy commercials" when using the predictive equations.

To return to the local lorry routing proposal for Harborne: this clearly presents a case where the decision maker must face up to some quite complex trade off issues

---

[1] The following discussion is an abridged version of that which appears in JURUE (1975) Lorry Route Proposals: Some Local Planning Examples. The author was a member of the Project Team engaged on that study. The cost of vehicle operation used in the worked examples (15p per mile) is the same as that used in the JURUE study as are signing costs.

arising from the need to compare environmental benefits accruing to a shopping link against losses in an adjacent residential area.

The existing pattern of heavy goods vehicle movements in Harborne is displayed in Map 9.7.1.3.. The proposal is presented in Map 9.7.1.4..

Basically, the proposal involves diverting HGV's from the residential roads which they currently use during the peak period (Greenfield Road and Barlows Road) to the High-Street. This would clearly produce some environmental benefits on the two residential roads at minimal expense to pedestrian shoppers on the High-Street, it being argued that the centre is not tru ly functional during the peak period.

During the off-peak period the converse would apply, with heavy goods vehicles being diverted from the shopping link to the residential roads.

It should be emphasised that the flow of HGV's on Greenfield Road and Barlows Road can only be accommodated on the High-Street during the peak period because they run counter to the tidal flow of city-bound commuter vehicles, and road capacity is available.

The off-peak situation is rather more complex however. Greenfield Road is too narrow to permit two heavy vehicles to pass one another easily. Thus, the proposal embodies the feature that only westbound heavy commercial vehicles are diverted along that road during the off-peak. Eastbound vehicles would be diverted along Harborne Park Road, which is part of the city's outer ring road, and St Mary's Road. The environmental disbenefits in residential areas during the off-peak would, therefore, be"shared out" rather than imposed on a single link.

The proposal would, therefore, result in some short term environmental benefits on certain residential links during the peak, longer term environmental benefits on the High-Street during the off-peak and longer term losses on some other residential links, again during the off-peak.

The shopping link impact display matrix for this option is presented in Table 9.7.1.5.. An attempt to display the noise implications of this option for those links experiencing changes in HGV flow levels is made in Table 9.7.1.6.

An additional point of interest which may be made regarding this and similar lorry routing options concerns the behavioural response of lorry drivers to route signing. Clearly, one-way goods vehicle routing systems may lead to some degree of confusion on the part of drivers; in other words, they may think that access is banned from both directions if they are confronted with a limited access sign at one end of a link. However, where lorry movements are local in the main one would expect the driver learning-process to be fairly rapid. This is, nonetheless, a point to be borne in mind where relatively complicated routing systems are proposed, such as the one summarised above.

9.7.1.2. Evaluation: Some Basic Points

If we commence discussion with a reference to the existing or "do-nothing" display matrix it is clear that we have in that matrix a basis for comparison between the various options outlined above. Although pedestrian exposure parameters are assumed to remain the same from option to option we can see nonetheless that some 6400 pedestrians may be exposed to traffic impacts over the period of the shopping day. The summary exposure statement for Harborne (Table 9.7.1.7.) indicates, as does the display matrix, that the mean period of exposure for shoppers is 7.8 minutes, with a minimum of 0.7 minutes and a maximum of 20.4 minutes. These are estimates of the duration of kerbside exposure and not, it is emphasised, the duration of the shopping trip.

Consideration of variations between different mode-user groups indicates that individuals walking to the centre have a higher mean exposure rate than bus or car users. This pattern does, in fact, repeat itself from centre to centre and reflects in part the accessibility afforded at the "micro-level" by the bus and car within specific locations like shopping centres.

Examination of the respondent profile data (Table 9.7.1.8.) relating to the author's survey indicates a high proportion of women in the sample, some 85.8% in fact. Of these, 43.5% were estimated to be above 50 years of age. Therefore, in Harborne we have a predominantly female user population, many of whom are middle-aged or pensioners. This factor may in itself have important implications for the stress experienced under various environmental conditions.

However, to return to the options themselves. Consideration of the impact display matrices relating to the three pedestrianization options clearly reveals that significant environmental gains may be derived on the shopping link as against the "do-nothing" situation.

Complete pedestrianization might, on the basis of existing evidence, be expected to reduce noise levels to an L_{10} figure in the order of 65 dB(A). This would represent at least a halving of the loudness of noise and would clearly be perceptible to pedestrians, and would indeed be significant. Air pollution levels would also drop dramatically to whatever their ambient level might be. In the case of Harborne, as with the other two centres under consideration, these would probably be very low. Pedestrian delay would, of course, cease to be an impact.

The other two forms of pedestrianization also produce significant environmental benefits as the relevant impact display matrices reveal. Impact levels are again reduced markedly. We would expect some level of CO in both cases as diesel engines do produce very small quantities of this pollutant. However, this is not reflected in the model and we would expect the level to be slightly above the ambient.

In the case of pedestrianization options the decision maker must clearly compare these significant environmental benefits with other implications of pedestrianization. Total prohibition on vehicle access to shopping streets, although the most beneficial in environmental terms may have considerable consequences for the functional activities therein as well as shopper access. In choosing between alternative forms of pedestrianization he must, therefore, be aware of the trade offs involved. Thus, he may choose to trade off a certain environmental impact against the functional advantages for the centre of retaining bus and delivery vehicle access.

In the case of Harborne, as in the other three centres, the retention of bus and limited goods vehicle access would imply trading off noise, primarily, for that relatively limited degree of accessibility. The noise level difference between the first option and the third would be perceptible. The other impacts would, however, change in intensity only very marginally.

Clearly, in exposure terms pedestrianization will produce what we would expect to be a considerably less stressful environment for the pedestrians using the centre. One suspects, however, that permitted vehicles, which it should be remembered will tend to be larger on average than those using the link under existing conditions, may well be intrusive, both visually and in stress terms. It would not seem too trivial to suggest that if the pedestrian is to feel at ease in what is a very significant form of pedestrian environment then any vehicular presence is liable to be disruptive, perhaps even more so if it is on an infrequent and unpredictable basis.

The local lorry routing proposal for Harborne provides an interesting comparison with the pedestrianization options. Clearly, the decision maker must now involve himself with comparisons between two types of activity environment and the implications of exposure for different activity groups. The short term, high intensity exposure of more than 6400 shoppers must be set against the amenity losses incurred by approximately 190 households.

He will also have to consider the relationship between environmental benefits to the shopping link and the costs of the proposal. In the Harborne case these costs amount to approximately £1680 for the necessary signing and something in the order of £20 per day to the hauliers whose vehicles are subject to the diversions.

The concept of the "league table" was introduced and discussed in the previous section of this chapter. We may make use of this concept in the present worked examples in order to illustrate the point concerning the significance of change.

Tables 9.7.1.9. to 9.7.1.12. illustrate the concept in use. The 20 centres included in the tables are those defined as district centres in the City of Birmingham Structure Plan Report on Shopping (1973). The original list of district centres so-defined did extend to some 26 but a number have been excluded due primarily to changes in their spatial structure which render them somewhat atypical of the High-Street centre.

The "league tables" are ranked from "best" (lowest) to "worst" (highest) on the basis of predicted impact levels. A "league table"is constructed for each impact.

The table opposite each indicates the absolute predicted levels on which the "league tables" are constructed. These reference tables for absolute levels are obviously applicable to each worked example.

It should, however, be emphasised that a shift in rank order, for example, from 10 th to 2 nd does not necessarily mean that the centre concerned has taken the original absolute value involved under a particular option. The actual absolute level associated with each policy option is to be found on the relevant impact display matrix.

Harborne is, for example, ranked 9th in the noise "league table" on the basis of existing conditions. Under all three pedestrianization options it climbs to occupy the top ("best") position. The change is somewhat less significant in rank order terms for smoke and delay and no change at all takes place in the case of CO.

The local lorry routing proposal clearly has a more variable effect on rankings for noise, smoke and delay. In the case of noise and smoke impacts Harborne moves into the "best" five centres on those two criteria, while in the case of delay it moves from 5th to 2nd place.

Harborne is obviously a centre which does not rank particularly low on any of the four impacts, and in the case of

CO ranks 1st. Thus, the significance of change expressed in terms of the "league table" concept is obviously not as great as for a centre starting from a much lower position on any of the impact level rankings, given, of course, the same absolute value range involved in the initial construction of the table.

It is clear, however, that any of the pedestrianization options will produce significant environmental changes on the shopping link in Harborne, both in absolute terms and on the basis of the "league table". Even the "worst" pedestrianization option permitting access to both buses and delivery vehicles would reduce noise levels by some 7.6 dB(A), which would be readily perceived by pedestrians.

The lorry routing proposal is naturally more complex in its evaluation requirements. The resulting noise reduction on the High-Street shopping link would perhaps just be noticeable, while smoke and pedestrian delay changes would be imperceptible. CO levels similarly might change but as they are low even under existing conditions they are not of great significance.

It may well be argued in such cases as Harborne that, where local lorry routing proposals are concerned, the status quo is the best "solution", in other words, a "do-nothing" situation. The basic point in the Harborne example and this is emphasised in the JURUE study referenced earlier, is that one would find it difficult to decide whether the environmental benefits accruing to the shopping link would outweigh those environmental losses suffered by the residential links to which heavy goods vehicles are diverted.

Aston University

Content has been removed for copyright reasons

Aston University

Aston University

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
680 total per hour	77.3	4.0	54.5	3.4	6400	7.8 mins
					comments:	comments:
					300-400 shop/ office workers	

TABLE 9.7.1.1. HARBORNE EXISTING OFF-PEAK SITUATION

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
0	ambient 65 dB(A) approx.	----- ambient	-------	0	6400	7.8 mins
					comments:	comments:
					also 300-400 shop/office workers	

TABLE 9.7.1.2. COMPLETE PEDESTRIANIZATION OPTION : OFF-PEAK

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
45 buses per hour	67.5	-----	40.3	0.3	6400	7.8 mins
					comments:	comments:
					also 300-400 shop/office workers	

TABLE 9.7.1.3. FEDESTRIANIZATION WITH BUS ONLY ACCESS: OFF-PEAK

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
65 total per hour 45 buses per hour 10 light goods per hour 10 heavy goods	69.7	----	41.3	0.3	6400	7.8 mins
					comments:	comments:
					also 300-400 shop/ office workers	

TABLE 9.7.1.4. PEDESTRIANIZATION WITH BUS AND DELIVERY VEHICLE ACCESS ONLY: OFF-PEAK

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
610 total flow 0 heavy goods	73.7	4.0	51.0	2.8	6400	7.8 mins
					comments:	comments:
					also 300-400 shop/ office workers	

TABLE 9.7.1.5 LOCAL LORRY ROUTING PROPOSAL: OFF-PEAK

	GREEN FIELD RD			METCHLEY LA.			HARBORNE PARK RD		
PEAK	flow vph	HGV vph	1 hr L10	flow vph	HGV vph	1 hr L10	flow vph	HGV vph	1hr L10
EXISTING	571	40	75.3	916	12	74.8	927	66	78.3
PROPOSED	531 am 533 pm	0 2	71.9 72.1	952	48	76.7	927	66	78.3
OFF PEAK									
EXISTING	468	20	73.6	546	22	74.2	876	112	79.4
PROPOSED	496	45	75.3	616	92	77.5	951	157	80.4

TABLE 9.7.1.6. RESIDENTIAL LINK NOISE IMPLICATIONS OF LORRY ROUTING PROPOSAL

	ST MARY'S RD			BARLOWS RD			SOMERSET RD		
PEAK	flow vph	HGV vph	1 hr L10	flow vph	HGV vph	1 hr L10	flow vph	HGV vph	1hr L10
EXISTING	541	6	71.5	551	38	75.0	662	9	73.3
PROPOSED	541	6	71.5	513 am 515 pm	0 2	71.5 71.7	710 am 655 pm	47 2	75.8 72.6
OFF PEAK									
EXISTING	472	3	71.4	359	18	72.0	320	9	71.1
PROPOSED	517	48	75.0	359	18	72.0	320	9	71.1

TABLE 9.7.1.6. (cont)

TABLE 9.7.1.7. HARBORNE

PEDESTRIAN EXPOSURE SUMMARY STATEMENT

total pedestrians (shopping day)	6400		
mean pedestrian shopping trip length	347 metres		
duration of kerbside exposure (all respondents)	max	min	mean
	20.4 mins	0.9 mins	7.8 mins
mode user groups: kerbside exposure	max	min	mean
car users	15.7 mins	0.9 mins	7.1 mins
bus users	18.2 mins	1.5 mins	6.9 mins
walk trips	20.4 mins	2.3 mins	9.5 mins
mean of estimated minimum number of road crossing movements per trip (all respondents)	major roads	minor roads	
	0.96	1.9	

TABLE 9.7.1.8. HARBORNE

RESPONDENT PROFILE

SEX		AGE		TOTALS
	under 30	30 - 50	50+	
females	23 (9.8%)	76 (32.5%)	102 (43.5%)	201 (85.8%)
males	3 (1.3%)	11 (4.7%)	19 (8.1%)	33 (14.1%)
TOTALS	26 (11.1%)	87 (37.2%)	121 (51.7)	234 (100%)

Source: Author's survey July 1974

PREDICTED DELAY IMPACT LEVELS FOR DISTRICT CENTRES IN THE "LEAGUE TABLE"

CENTRE	OFF-PEAK DELAY (SECS)
Ladypool Rd	1.8
N. Yardley	2.9
Erdington	3.1
Villa Rd	3.3
Harborne	3.4
Hawthorn Rd	3.5
Alum Rock	4.9
Moseley	4.9
Salt ley	5.0
Acocks Green	5.4
Kings Norton	5.9
Stirchley	6.5
Springfield	7.7
Kings Heath	7.9
Soho Rd	8.2
Hall Green	8.4
Selly Oak	9.9
Northfield	11.2
Sparkhill	11.6
Small Heath	11.9

PEDESTRIAN DELAY LEVEL "LEAGUE TABLE" AND IMPLICATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Ladypool Rd	1	←	←	←	
N. Yardley	2				←
Erdington	3				
Villa Rd	4				
Harborne	5	┘	┘	┘	┘
Hawthorn Rd	6				
Alum Rock	7				
Moseley	8				
Saltley	9				
Acocks Green	10				
Kings Norton	11				
Stirchley	12				
Springfield	13				
Kings Heath	14				
Soho Rd	15				
Hall Green	16				
Selly Oak	17				
Northfield	18				
Sparkhill	19				
Small Heath	20				

TABLE 9.7.1.9. HARBORNE

Options:

1 Complete pedestrianization
2 Pedestrianization with bus only access
3 Pedestrianization with bus and delivery vehicle access only
4 Local lorry routing proposal

PREDICTED NOISE IMPACT LEVELS FOR DISTRICT CENTRES IN THE "LEAGUE TABLE"

CENTRE	OFF PEAK L_{10} dB(A)
Ladypool Rd	72.8
Erdington	73.1
N. Yardley	74.7
Villa Rd	74.7
Hawthorn Rd	75.2
Moseley	75.8
Acocks Green	76.6
Kings Norton	77.2
Harborne	77.3
Stirchley	77.5
Alum Rock	77.9
Soho Rd	78.4
Saltley	78.5
Hall Green	79.1
Kings Heath	79.2
Springfield	79.2
Selly Oak	79.8
Sparkhill	80.3
Northfield	80.4
Small Heath	80.6

NOISE LEVEL "LEAGUE TABLE" AND IMPLICATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Ladypool Rd	1	← ┐	← ┐	← ┐	
Erdington	2	│	│	│	
N. Yardley	3	│	│	│	← ┐
Villa Rd	4	│	│	│	│
Hawthorn Rd	5	│	│	│	│
Moseley	6	│	│	│	│
Acocks Green	7	│	│	│	│
Kings Norton	8	│	│	│	│
Harborne	9	┘	┘	┘	┘
Stirchley	10				
Alum Rock	11				
Soho Rd	12				
Saltley	13				
Hall Green	14				
Kings Heath	15				
Springfield	16				
Selly Oak	17				
Sparkhill	18				
Northfield	19				
Small Heath	20				

TABLE 9.7.1.10 HARBORNE

Options: as in TABLE 9.7.1.9

PREDICTED SMOKE IMPACT LEVELS FOR DISTRICT CENTRES IN THE "LEAGUE TABLE"

CENTRE	OFF-PEAK SMOKE CONC. (MICROGM/M 3)
Ladypool Rd	47.0
Erdington	49.5
N. Yardley	51.4
Villa Rd	51.6
Hawthorn Rd	52.9
Moseley	53.8
Harborne	54.5
Acocks Green	56.7
Alum Rock	57.0
Kings Norton	58.1
Saltley	59.1
Stirchley	59.2
Hall Green	61.8
Soho Rd	62.1
Springfield	62.9
Kings Heath	63.1
Selly Oak	67.2
Sparkhill	69.4
Northfield	70.5
Small Heath	71.4

SMOKE LEVEL "LEAGUE TABLE" AND IMPLICATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Ladypool Rd	1	←	←	←	
Erdington	2	│	│	│	
N. Yardley	3	│	│	│	←
Villa Rd	4	│	│	│	│
Hawthorn Rd	5	│	│	│	│
Moseley	6	│	│	│	│
Harborne	7	┘	┘	┘	┘
Acocks Green	8				
Alum Rock	9				
Kings Norton	10				
Saltley	11				
Stirchley	12				
Hall Green	13				
Soho Rd	14				
Springfield	15				
Kings Heath	16				
Selly Oak	17				
Sparkhill	18				
Northfield	19				
Small Heath	20				

TABLE 9.7.1.11 HARBORNE

Options: as in TABLE 9.7.1.9

PREDICTED CO IMPACT LEVELS FOR DISTRICT CENTRES IN THE "LEAGUE TABLE"

CENTRE	OFF-PEAK CO CONC. (PPM)
Harborne	4.0
Hawthorn Rd	4.2
N. Yardley	4.6
Alum Rock	4.8
Saltley	4.9
Moseley	5.0
Erdington	5.1
Kings Norton	5.1
Springfield	5.1
Acocks Green	5.2
Villa Rd	5.2
Hall Green	5.3
Kings Heath	5.3
Northfield	5.7
Soho Rd	5.7
Ladypool Rd	5.8
Selly Oak	5.8
Stirchley	6.1
Small Heath	6.6
Sparkhill	7.3

CARBON MONOXIDE LEVEL "LEAGUE TABLE" AND IMPLICATATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Harborne	1	←			→
Hawthorn Rd	2				
N. Yardley	3				
Alum Rock	4				
Saltley	5				
Moseley	6				
Erdington	7				
Kings Norton	8				
Springfield	9				
Acocks Green	10				
Villa Rd	11				
Hall Green	12				
Kings Heath	13				
Northfield	14				
Soho Rd	15				
Ladypool Rd	16				
Selly Oak	17				
Stirchley	18				
Small Heath	19				
Sparkhill	20				

TABLE 9.7.1.12 HARBORNE

Options: as in TABLE 9.7.1.9

9.7.2. King's Heath District Shopping Centre

King's Heath is, like Harborne, a residential suburb of Birmingham. It is located approximately 5 miles to the south of the city centre. King's Heath is a mixed residential area, although the particular area adjacent to the High-Street shopping link is for the most part characterised by older terraced properties.

The shopping centre extends along the High-Street from a point just to the south of Valentine Road down to the junction of Mossfield Road and Alcester Road South. There are approximately 145 shops in the centre, including a number of major generators, like, for example, a large Sainsbury's supermarket. At the southern end of the centre some localised redevelopment has taken place but for the most part the shopping frontages comprise of older shop units.

The shopping link is somewhat wider than at Harborne and the pavements are of a greater width. Thus, the particular problems of pedestrian congestion and proximity to traffic are less severe than is the case in Harborne.

King's Heath is located on a radial route of some considerable importance in the strategic highway network providing as it does access to the city centre for residents of peripheral suburban areas as well as local residents.

The peak period in King's Heath is usually marked by considerable traffic congestion and it has long been suggested that the centre should be bypassed. This congestion has, in fact, stimulated a considerable volume of through movement in adjacent residential areas and there are a number of "rat-run" situations.

Although the off-peak period traffic situation is not a severe problem the link carries quite high volumes of traffic throughout the day. The situation is, however, somewhat complicated by the presence of the outer ring road (Addison Road - Vicarage Road) and there is a dog-leg junction through which ring road traffic must pass.

As in the case of Harborne, both bypassing and lorry routing proposals would entail some impingement on adjacent residential areas.

Photographs of King's Heath High-Street are presented on the following page (Photographs 9.7.3 and 9.7.4.). Local network and land-use details are provided in Maps 9.7.2.1 and 9.7.2.2..

9.7.2.1. Policy Options

Four policy options are again examined, three relating various pedestrianization options and one with local lorry routing.

9·7·3

9·7·4

KINGS HEATH

The discussion of policy options in the Harborne example raised a number of general issues pertinent to all three examples and it is not proposed to restate these in the case of King's Heath or the final example, Northfield. Discussion of options will, therefore be somewhat briefer than in the preceding example.

9.7.2.1 (a) Complete Pedestrianization

This would again entail the closure of the High Street to all vehicular traffic for the minimum of the off-peak shopping day. For the present purposes of illustrating the application of the methodology the High-Street shopping link has been operationally defined as the shopping frontages south of Valentine Road to the High-Street - Vicarage Road junction.

The impact display matrix for the existing off-peak situation is presented in Table 9.7.2.1. and that for the complete pedestrianization option in Table 9.7.2.2..

9.7.2.1. (b) Pedestrianization with Bus Only Access

Similar comments are applicable to this example as were made in the case of Harborne. However, no adjustments were made to bus flows during the off-peak as a similar problem like the one experienced in Harborne does not appear to exist. Bus flows are, therefore, generated on the basis of existing off-peak levels and are projected forward to the pedestrianization situation. The impact display matrix is presented in Table 9.7.2.3..

9.7.2.1. (c) Pedestrianization with Bus and Delivery Vehicle Access Only

The option is again similar in concept to that examined in the Harborne context. Some upward adjustment was, however, made to the estimated activity levels of goods vehicles making deliveries to the centre in view of King's Heath greater size as a shopping centre (in terms of the number of establishments).

The impact display matrix for the shopping link is presented in Table 9.7.2.4..

9.7.2.1. A Local Lorry Routing Proposal

In order to illustrate the environmental implications of removing heavy goods vehicles from the High-Street, as operationally defined, the author has devised a relatively simple, and admittedly partial, local lorry routing proposal.

Many of the comments previously made in the Harborne example are again applicable here, particularly those directed to the problems inherent in comparing and trading off environmental quality in different types of sensitive locations. As before, the problem ultimately becomes one of attempting to assess the environmental benefits achieved on the shopping link against the losses incurred on residential roads.

The proposal takes the following form. During the off-peak period all heavy goods vehicles (over 3 tons unladen weight) wishing to travel along the north-south axis of the High-Street would be obliged to travel along the following links: Valentine Road, Springfield Road and Addison Road. This proposal is presented in map form in Map 9.7.2.4., the existing goods vehicle movement situation being display on the preceding map (9.7.2.3.).

A peak period element in the proposal was not considered feasible in view of the intensive use of Springfield Road and Valentine Road for through movement, primarily by private vehicles. A more extensive proposal involving rerouting down to Wheelers Lane was also not considered because it appeared to achieve little other than to extend the possible impact of heavy goods vehicles and increase hauliers incurred costs. Similarly, no action is proposed in the case of heavy goods vehicles travelling east-west along the ring road and passing through the dog-leg junction. It should be noted that Howard Road West already fulfills the role of a surrogate bypass for these east-west movement and it is clearly indicated by signs on Vicarage Road that it may be used for the purpose of avoiding King's Heath.

Thus, the proposal would require that heavy goods vehicles entering the High-Street at its northern end be diverted along Valentine Road and Springfield Road and then into Addison Road. They would then be in a position to re-enter the High-Street at its southern extremity. There is, of course, a point to be made about the possibility of heavy goods vehicles wishing to continue south from Springfield Road into Barn Lane, and from there into Wheelers Lane. This clearly might be a promising alternative to drivers particularly as the roads involved have ample carriageway width. However, attempts to effectively sign the junctions involved present certain difficulties in view of the various directional movements involved.

It has, therefore, been assumed for the purposes of the test option that heavy goods vehicles could be directed onto Addison Road by restricting entry into Barn Lane from both directions. This might also serve to deter northbound lorries from using the Wheelers Lane - Barn Lane route to get onto the Springfield - Valentine Road proposed route.

From the preceding discussion it is clear that northbound lorries would be expected to turn right into Addison Road before reaching the main axis of the shopping centre.

The proposal is obviously simple in form and leaves various technical and operational details unanswered. However, it is purely designed as a means of rationalising the examination of the environmental implications of heavy goods vehicle restraint on the main High-Street shopping link area.

The shopping link impact display matrix for this option is presented in Table 9.7.2.5. and the noise implications for the links to which lorries are diverted in Table 9.7.2.6..

9.7.2.2. Evaluation: Some Basic Points

We may commence again by considering the existing situation, or "do-nothing" display matrix. We clearly have a situation in which individuals engaged in pedestrian activity on the shopping frontages may experience potential stress situations.

Pedestrians are exposed to traffic impacts for an average period of 11.1 minutes, a significantly higher figure than that applicable to Harborne. One might argue that King's Heath is perhaps a more potentially stressful shopping/traffic environment in view of both the mean exposure parameters involved and the greater intensity of traffic impact. These comments, of course, are directed to the existing situation during the off-peak.

The summary exposure statement also displays the maximum and minimum exposure values estimated for respondents and as may be seen, there is a very considerable variation between the two. This Table (9.7. 2.7) also indicates that pedestrian trips in King's Heath require a higher mean road crossing movement rate when compared with Harborne. This of course has implications for pedestrian hazard and risk as well as delay impacts.

On the point of pedestrian delay it should be noted that most district shopping centres of the scale of the three under consideration here are provided with pedestrian crossing facilities, which, one might suggest detract from the meaningfulness of using delay as an impact. However, pedestrians may experience delay even at crossing facilities and large numbers of crossing movements in shopping centres do appear to take place away from such facilities.

The mode-user exposure differentials present an interesting picture with only relatively small variations between bus and car users but again with those walking to the centre experiencing the longest duration of exposure within the centre itself. One suspects that in certain cases the length of the shopping link and the relative locations of key trip generators may serve to reduce such differentials.

The respondent profile table (9.7.2.8) again indicates the predominance of women shoppers (87.5%) and particularly those in the older age group (47.7% of the total sample).

Similar comments apply in the case of King's Heath and the implications of pedestrianization options as those made in the Harborne example. The absolute changes in the levels of impacts under these options are, however, greater and may,therefore, be regarded as more significant in those terms. Any such gains derived from a particular pedestrianization option might in part be set against the costs of bypassing, which are estimated to be in the order of £8 - £10 millions.

The lorry routing proposal presents a picture in which it is clear that environmental gains on the High-Street are relatively insignificant and are unlikely to be perceptible to pedestrians. Noise levels would, however, increase on the residentiallinks to which lorries are diverted and would be noticeable in the case of Addison Road and, possibly, Springfield Road. Costs to hauliers of the proposal would be approximately £30-35 per day and the cost of signing approximately £1000.

To illustrate the significance of the environmental changes associated with these options we may again refer to the "league tables" of impact intensities in the 20 district shopping centres.

To begin with, it should be noted that King's Heath occupies a lower position on each table than did Harborne. Thus, in the case of the bypassing options the significance of the changes as expressed in the"league tables" (Tables 9.7.2.9 to 9.7.2.12) appears somewhat greater, as indeed it is in both rank order change terms and absolute change terms.

The lorry routing proposal is somewhat deceptive in terms of its implications on the "league table" for noise. Although the absolute change is relatively small and not likely to be noticeable it does nonetheless result in King's Heath moving some 8 places up the order. Clearly, this emphasises the need to remain conscious of the range of absolute values on which the "league table" is based.

To summarise, it is clear again that pedestrianization policies will produce significant environmental benefits on the shopping link. These will be significant both in absolute terms and in terms of the relative position of the centre in the "league table", as well as the shifts in position that will result in the latter.

The lorry routing proposal obviously yields very little in environmental terms for the High-Street and in such cases one would imagine that decision makers would have few qualms about trading off a 2.2 dB(A) noise reduction for 10100 pedestrians per day (who probably would not notice the change) for a retention of the status quo. Thus, approximately 450 households on the residential streets affected by the proposal would be relieved of any any increase in noise levels.

Aston University

Content has been removed for copyright reasons

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
1068 total flow	79.2	5.3	63.1	7.9	10100	11.1 mins
					comments:	comments:
					500-600 shop and office workers	

TABLE 9.7.2.1. KINGS'HEATH: EXISTING OFF-PEAK SITUATION

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
0	ambient 65 dB(A) approx	----- ambient	-------	0	10100	11.1 mins
					comments:	comments:
					500-600 shop and office workers	

TABLE 9.7.2.2 COMPLETE PEDESTRIANIZATION OPTION: OFF-PEAK

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
50 buses per hour	67.9	---	40.5	0.3	10100	11.1 mins
					comments:	comments:
					500-600 shop and office workers	

TABLE 9.7.2.3. PEDESTRIANIZATION WITH BUS ONLY ACCESS: OFF-PEAK

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
85 total per hour	70.8	-----	42.3	0.4	10100	11.1 mins
50 buses 20 light goods 15 heavy goods					comments: 500-600 shop and office workers	comments:

TABLE 9.7.2.4. PEDESTRIANIZATION WITH BUS AND DELIVERY VEHICLE ACCESS: OFF-PEAK

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
1013 total flow 0 heavy goods	77.0	5.3	60.3	7.2	10100	11.1 mins
					comments:	comments:
					500-600 shop and office workers	

TABLE 9.7.2.5. LOCAL LORRY ROUTING PROPOSAL: OFF-PEAK

	VALENTINE RD			SPRINGFIELD RD			ADDISON RD		
PEAK	flow vph	HGV vph	1 hr L10	flow vph	HGV vph	1 hr L10	flow vph	HGV vph	1hr L10
EXISTING	—	—	—	—	—	—	—	—	—
PROPOSED	—	—	—	—	—	—	—	—	—
OFF PEAK									
EXISTING	356	10	72.5	468	16	73.2	608	20	74.8
PROPOSED	411	65	75.0	523	71	76.4	665	75	77.3

TABLE 9.7.2.6. RESIDENTIAL LINK NOISE IMPLICATIONS OF LORRY ROUTING PROPOSAL

TABLE 9.7.2.7. KING'S HEATH

PEDESTRIAN EXPOSURE SUMMARY STATEMENT

total pedestrians (shopping day)	10100		
mean pedestrian shopping trip length	491 metres		
duration of kerbside exposure (all respondents)	max	min	mean
	32.2 mins	0.9 min	11.1 mins
mode user groups: kerbside exposure	max	min	mean
car users	23.2 min	0.9min	9.6 mins
bus users	21.7 min	3.7mins	10.0 mins
walk trips	32.2 mins	4.2mins	12.9 mins
mean of estimated minimum number of road crossing movements per trip (all respondents)	major roads	minor roads	
	1.7	2.8	

TABLE 9.7.2.8. KINGS HEATH

RESPONDENT PROFILE

SEX		AGE		TOTALS
	under 30	30 - 50	50+	
females	29 (14.4%)	75 (37.3%)	72 (35.8)	176 (87.5%)
males	3 (1.5%)	7 (3.5%)	15 (7.4%)	25 (12.4%)
TOTALS	32 (15.9%)	82 (40.8)	87 (43.2)	201 (100%)

Source: author's survey July 1974

PEDESTRIAN DELAY LEVEL "LEAGUE TABLE" AND IMPLICATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Ladypool Rd	1				
N. Yardley	2				
Erdington	3				
Villa Rd	4				
Harborne	5				
Hawthorn Rd	6				
Alum Rock	7				
Moseley	8				
Saltley	9				
Acocks Green	10				
Kings Norton	11				
Stirchley	12				
Springfield	13				
Kings Heath	14				
Soho Rd	15				
Hall Green	16				
Selly Oak	17				
Northfield	18				
Sparkhill	19				
Small Heath	20				

TABLE 9.7.2.9. KING'S HEATH

Options:

1 Complete pedestrianization
2 Pedestrianization with bus only access
3 Pedestrianization with bus and delivery vehicle access
4 Local lorry routing proposal

NOISE LEVEL "LEAGUE TABLE" AND IMPLICATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Ladypool Rd	1				
Erdington	2				
N. Yardley	3				
Villa Rd	4				
Hawthorn Rd	5				
Moseley	6				
Acocks Green	7				
Kings Norton	8				
Harborne	9				
Stirchley	10				
Alum Rock	11				
Soho Rd	12				
Saltley	13				
Hall Green	14				
Kings Heath	15				
Springfield	16				
Selly Oak	17				
Sparkhill	18				
Northfield	19				
Small Heath	20				

TABLE 9.7.2.10. KING'S HEATH

Options: as in TABLE 9.7.2.9.

SMOKE LEVEL "LEAGUE TABLE" AND IMPLICATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Ladypool Rd	1	←	←	←	
Erdington	2				
N. Yardley	3				
Villa Rd	4				
Hawthorn Rd	5				
Moseley	6				
Harborne	7				
Acocks Green	8				
Alum Rock	9				
Kings Norton	10				
Saltley	11				
Stirchley	12				
Hall Green	13				←
Soho Rd	14				
Springfield	15				
Kings Heath	16				
Selly Oak	17				
Sparkhill	18				
Northfield	19				
Small Heath	20				

TABLE 9.7.2.11. KING'S HEATH

Options: as in TABLE 9.7.2.9.

CARBON MONOXIDE LEVEL "LEAGUE TABLE" AND IMPLICAT
ATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Harborne	1	←	←	←	
Hawthorn Rd	2				
N. Yardley	3				
Alum Rock	4				
Saltley	5				
Moseley	6				
Erdington	7				
Kings Norton	8				
Springfield	9				
Acocks Green	10				
Villa Rd	11				
Hall Green	12				
Kings Heath	13				←
Northfield	14				
Soho Rd	15				
Ladypool Rd	16				
Selly Oak	17				
Stirchley	18				
Small Heath	19				
Sparkhill	20				

TABLE 9.7.2.12. KING'S HEATH

Options: as in TABLE 9.7.2.9.

9.7.3. Northfield District Shopping Centre

Northfield, the third and final example, is also a residential suburb of Birmingham and is located some 7.5 miles from the city centre in the south-west sector of the city. Housing for the most part dates from the 1930's.

The main shopping area extends from the junction of Church Road along the High-Street to the junction with Frankley Beeches Road. The centre comprises of some 150 shops, and includes a modern precinct centre with car parking facilities.

Like King's Heath, Northfield is located on a major radial route (A.38) into the city centre and is heavily trafficked during the peak period.

Northfield is located some 2 miles north-east of the British Leyland plant at Longbridge and this produces some special problems for the centre. In particular, it is extensively used by heavy commercial vehicles carrying supplies to Longbridge.

The traffic problems of the centre are further exacerbated by the sparsity of alternative strategic routes in the immediate area. The large residential estates to the west of the centre provide few opportunities for traffic to filter through and do themselves generate large numbers of of private vehicles which enter the A.38 in the Northfield area.

The major off-peak problem at Northfield would, however, appear to be the high level of goods vehicle activity on the link, which suggests that a lorry routing proposal might achieve some measure of environmental improvement if a suitable alternative is available.

Northfield, like the two other examples, is scheduled for bypassing in the 1981 WMTS strategic network at a currently estimated cost of approximately £7m.

Photographs of the centre (9.7.5. and 9.7.6) are presented on the following page. Local network and land-use details are provided in Maps 9.7.3.1. and 9.7.3.2..

9.7.3.1. Policy Options

The same four policy options are considered as in the previous two examples. Specification and description will again be brief.

9.7.3.1.(a) Complete Pedestrianization

The same assumptions and principles again apply. The relevant impact display matrix is presented in Table 9.7.3.2., following that for the "do-nothing situation" (9.7.3.1).

2

9·7·5

9·7·6

NORTHFIELD

9.7.3.1.(b) Pedestrianization with Bus Only Access

The same assumptions and principles also apply here as in the previous examples. Existing off-peak bus flows are projected into the pedestrianization situation. The impact display matrix is presented in Table 9.7.3.3..

9.7.3.1.(c) Pedestrianization with Bus and Delivery Vehicle Access Only

The level of goods vehicle activity has been set at the same scale as that used in the King's Heath example, reflecting,essentially, the similarities in size between the two centres. In other respects the same assumptions and principles apply. The impact display matrix in presented in Table 9.7.3.4..

9.7.3.1. (d) Local Lorry Routing Proposal

Examination of the local network map reveals that Greatstone Road, to the east of the centre might provide an alternative route for heavy commercial vehicles.

The author has, therefore, generated a very simple proposal which requires that during the off-peak period all heavy commercial vehicles (over 3 tons unladen weight) are diverted onto Greatstone Road from the High Street.

A peak period solution does not appear feasible in view of the fact that Greatstone Road already functions as a surrogate bypass and is heavily trafficked during this period. As before, it may be argued that environmental benefits on shopping links during the peak period will not have the same significance for pedestrians exposed to traffic impacts because the shopping centre has yet to become fully operational. Alternative solutions using other routes appear to be non-existent in view of the characteristics of the local network.

This simple proposal would, therefore, seek to divert north-east bound heavy goods vehicles from the Bristol Road,at the extreme south-western end of the High-Street , into Greatstone Road, onto Church Road and then back to the Bristol Road. For south-west bound vehicles the converse would apply.

Again it should be emphasised that the option has not been formulated in detail and is used only as an illustrative example.

The relevant impact display matrix for the shopping link is presented in Table 9.7.3.5.. Existing goods vehicle movements are displayed in Map 9.7.3.3. and the proposal in Map 9.7.3.4.. Noise implications of the proposal are presented in Table 9.7.3.6..

9.7.3.2. Evaluation: Some Basic Points

The existing level of impact intensity in Northfield is considerable as evidenced by the "do-nothing" impact display matrix. Furthermore, a large number of pedestrians are potentially exposed during the "shopping day" (10400). However, one might argue that the lower incidence of kerbside exposure (mean value 6.5 minutes) counteracts to some extent the high impact intensity levels (Table 9.7.3.7).

One interesting feature of exposure rates at Northfield is the considerable variation between the mean exposure values for the three mode user groups. Shoppers who walk to the centre clearly experience considerable periods of exposure. This may be partly explained by a number of individuals in the sample who entered the High-Street at the extreme south-western end and walked to the shopping precinct at the other end, and then back again. The very low value recorded for car user exposure reflects the relationship between parking provision above the precinct and the presence of a primary attractor within the precinct itself. A considerable number of car users did not actually experience any kerbside exposure whatsoever.

In stress, or potential stress situation terms we would, therefore, expect a greater incidence of such situations in the case of those who walk to the shopping centre. It should also be noted that such individuals may already have been exposed to traffic related stress situations on their walk trip to the centre.

As in the previous two examples, a majority of the survey respondents were women (86%), but older women only comprised some 37.5% of the sample interviewed in this centre (Table 9.7.3.8).

The "league tables" indicating the significance of change clearly reveal that the pedestrianization options again produce pronounced shifts in rank order. What should be noted in the case of Northfield is its very low ("bad") initial ranking on noise, smoke and delay impacts. In the case of noise, for example, the centre ranks 19th under existing off-peak conditions, but shifts up to ranking 1 under all the pedestrianization options. Clearly, the absolute values involved are large and the likely stress incidence for pedestrians would be markedly reduced. The importance of the initial ranking position should again be emphasised in such comparisons.

The lorry route option , which would cost approximately £30 per day to hauliers and perhaps £500 in signs, also produces changes in rank ordering, particularly in the case of traffic noise. However, it is again necessary to refer to the the absolute changes in impact intensity involved. The reduction in the noise level is, in fact, only in the order of 3.2 dB(A) which might be just about noticed by the pedestrian.

Against this reduction in noise levels on the High-Street would have to be set those increases which would affect the 90 households on Greatstone Road and the 35 on Church Road. The change in noise levels on the former link would probably be noticeable. Changes in other impacts would probably not be so however.

The decision maker is again presented with a situation in which he obliged to weigh up environmental gains on one sensitive link against losses on another. In view of the relatively limited gains to be achieved on the High-Street one might argue that the status quo has a certain appeal.

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
1277 total flow	80.4	5.7	70.5	11.2	10400	6.5 mins
					comments:	comments:
					600-700 shop and office workers	

TABLE 9.7.3.1. NORTHFIELD: EXISTING OFF-PEAK SITUATION

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
0	ambient 65 dB(A) approx	----- ambient	--------	0	10400	6.5 mins
					comments:	comments:
					600-700 shop and office workers	

TABLE 9.7.3.2. COMPLETE PEDESTRIANIZATION OPTION: OFF-PEAK

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
56	68.4	----	40.8	0.3	10400	6.5 mins
					comments:	comments:
					600-700 shop and office workers	

TABLE 9.7.3.3. PEDESTRIANIZATION WITH BUS ACCESS ONLY: OFF-PEAK

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
91 total flow	71.1	-----	42.5	0.4	10400	6.5
56 buses 20 light goods 15 heavy goods					comments: 600-700 shop and office workers	comments:

TABLE 9.7.3.4. PEDESTRIANIZATION WITH BUS AND DELIVERY VEHICLE ACCESS: OFF-PEAK

SHOPPING LINK IMPACT DISPLAY MATRIX

FLOW	IMPACTS				EXPOSURE	
	noise dB(A)	CO ppm	smoke mgm/m^3	delay secs	total pedestrians (shopping day)	mean time duration of exposure (mins)
1153 total flow per hour 0 heavy goods	77.2	5.5	64.3	9.2	10400	6.5
					comments:	comments:
					600-700 shop and office workers	

TABLE 9.7.3.5. LOCAL LORRY ROUTING PROPOSAL: OFF-PEAK

	GREATSTONE RD			CHURCH RD					
PEAK	flow vph	HGV vph	1 hr L10	flow vph	HGV vph	1 hr L10	flow vph	HGV vph	1hr L10
EXISTING	—	—	—	—	—	—	—	—	—
PROPOSED	—	—	—	—	—	—	—	—	—
OFF PEAK									
EXISTING	412	46	74.8	733	34	75.8	—	—	—
PROPOSED	536	170	79.4	842	143	79.6	—	—	—

TABLE 9.7.3.6. RESIDENTIAL LINK NOISE IMPLICATIONS OF LORRY ROUTING PROPOSAL

TABLE 9.7.3.7. NORTHFIELD

PEDESTRIAN EXPOSURE SUMMARY STATEMENT

total pedestrians (shopping day)	10400		
mean pedestrian shopping trip length	286 metres		
duration of kerbside exposure (all respondents)	max	min	mean
	21.7	0	6.5
mode user groups: kerbside exposure	max	min	mean
car users	7.7	0	2.4
bus users	15.2	1.9	6.1
walk trips	21.7	2.4	12.7
mean of estimated minimum number of road crossing movements per trip (all respondents)	major roads	minor roads	
	1.3	0.6	

TABLE 9.7.3.8 NORTHFIELD

RESPONDENT PROFILE

SEX		AGE		TOTALS
	under 30	30 - 50	50+	
females	26 (9.6%)	106 (38.9%)	102 (37.5%)	234 (86.0%)
males	6 (2.2%)	14 (5.1%)	18 (6.6%)	38 (13.9%)
TOTALS	32 (11.8%)	120 (44.1%)	120 (44.1%)	272 (100%)

Source: author's survey July 1974

PEDESTRIAN DELAY LEVEL "LEAGUE TABLE" AND IMPLICATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Ladypool Rd	1	←	←	←	
N. Yardley	2				
Erdington	3				
Villa Rd	4				
Harborne	5				
Hawthorn Rd	6				
Alum Rock	7				
Moseley	8				
Saltley	9				
Acocks Green	10				
Kings Norton	11				
Stirchley	12				
Springfield	13				
Kings Heath	14				
Soho Rd	15				
Hall Green	16				←
Selly Oak	17				
Northfield	18				
Sparkhill	19				
Small Heath	20				

TABLE 9.7.3.9 NORTHFIELD

Options:

1. Complete pedestrianization
2. Pedestrianization with bus access only
3. Pedestrianization with bus and delivery vehicle access
4. Local lorry routing proposal

NOISE LEVEL "LEAGUE TABLE" AND IMPLICATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Ladypool Rd	1				
Erdington	2				
N. Yardley	3				
Villa Rd	4				
Hawthorn Rd	5				
Moseley	6				
Acocks Green	7				
Kings Norton	8				
Harborne	9				
Stirchley	10				
Alum Rock	11				
Soho Rd	12				
Saltley	13				
Hall Green	14				
Kings Heath	15				
Springfield	16				
Selly Oak	17				
Sparkhill	18				
Northfield	19				
Small Heath	20				

TABLE 9.7.3.10. NORTHFIELD

Options: as in TABLE 9.7.3.9.

SMOKE LEVEL "LEAGUE TABLE" AND IMPLICATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Ladypool Rd	1	←	←	←	
Erdington	2				
N. Yardley	3				
Villa Rd	4				
Hawthorn Rd	5				
Moseley	6				
Harborne	7				
Acocks Green	8				
Alum Rock	9				
Kings Norton	10				
Saltley	11				
Stirchley	12				
Hall Green	13				
Soho Rd	14				
Springfield	15				
Kings Heath	16				←
Selly Oak	17				
Sparkhill	18				
Northfield	19	↑	↑	↑	↑
Small Heath	20				

TABLE 9.7.3.11. NORTHFIELD

Options: as in TABLE 9.7.3.9.

CARBON MONOXIDE LEVEL "LEAGUE TABLE" AND IMPLICATATIONS OF POLICY OPTIONS: EXISTING OFF-PEAK

CENTRE	RANK	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Harborne	1	←	←	←	
Hawthorn Rd	2				
N. Yardley	3				
Alum Rock	4				
Saltley	5				
Moseley	6				
Erdington	7				
Kings Norton	8				
Springfield	9				
Acocks Green	10				
Villa Rd	11				
Hall Green	12				
Kings Heath	13				
Northfield	14				←
Soho Rd	15				
Ladypool Rd	16				
Selly Oak	17				
Stirchley	18				
Small Heath	19				
Sparkhill	20				

TABLE 9.7.3.12. NORTHFIELD

Options as in TABLE 9.7.3.9.

9.8. Choosing Between Environmental Alternatives for Shopping Links: Some Concluding Remarks

Three examples illustrating the application of the proposed methodology have been presented and briefly discussed. A number of test policies reflecting possible approaches to the problem of improving environmental quality on shopping links have been examined and the relevant output from the methodology procedures displayed.

Clearly, the procedures recommended in the methodology can go someway towards indicating the environmental implications of policy options for shopping links. However, it is explicitly recognised that the evaluation framework adopted is partial and that many questions and issues must be left unresolved. This is particularly so in the case of assessing the human response implications of policy alternatives. Certain tentative statements were made from time to time in the examples as to the likely stress incidence associated with environmental alternatives. However, such statements must at present remain at the level of supposition in view of the lack of validated data relating to pedestrian responses to traffic environments. Similarly, we are not in a position to make definitive statements concerning the relationships between the time duration and impact intensity parameters of exposure. Is there a greater potential for stress incidence in those situations where pedestrians are exposed for a relatively short period of time to high impact intensities than in those where the duration of exposure is longer on average but impact intensity is lower? This we cannot say at present.

Nonetheless, the decision maker may be called upon to choose between options for centres with such variations in exposure parameters. Thus, the concept of direct environmental experience may have a particularly significant role to play in helping decision makers to at least partially resolve such issues.

The environmental trade offs which may be required between shopping and residential environments under certain types of policy option again presents the decision maker with complex evaluation problems. How can he weigh up gains on the shopping link to large numbers of pedestrians exposed for short periods against possibly longer terms losses for the residents of links to which traffic may be diverted. This issue is, perhaps, one which is fundamental to the evaluation of alternatives for shopping links because such trade offs may arise in many situations. Clearly, we are in a quandary because we are not in the position to make the requisite interpersonal comparisons between gainers and losers. The problem is that much more complex because it is necessary to make such comparisons between different activity groups.

An additional dimension of this problem finds expression in the fact that gainers (essentially pedestrians) may also be losers in their role as residents of roads to which traffic is diverted in order to achieve environmental objectives on the shopping link (as, for example, in local lorry routing proposals).

Of the policy options examined in the worked examples, it is clear that the benefits to be derived from pedestrianization schemes may well be very considerable. Using the "league table" concept it is also possible to express the significance of the changes involved in terms of comparable locations. Although the options considered in the examples may, perhaps, be regarded as rather limited in terms of the alternative environments which they produce, the "league table" display technique does provide a means of examining, impact by impact, the environmental implications of the options in relation to a range of other known environments.

It should be stressed that the most effective use of the "league table" will probably be made when it is used in conjunction with the direct environmental experience approach proposed for decision makers.

The lorry routing proposal options examined in the examples clearly reveal the need for decision makers to be conscious of the environmental trade offs which may be required between shopping and residential environments. The fact that the particular options considered did not in actual fact appear to produce any really significant environmental benefits for the shopping links clearly should not be interpreted as meaning that this will always be the case. In some situations it may well prove possible to divert heavy goods vehicles from shopping links and achieve significant gains on that link with minimal losses in terms of residential environmental amenity. On this point, reference may be made to the Dunley example presented in the JURUE (1975) report on local lorry routing.

It is hoped that the discussion and presentation of examples in this chapter has given an indication of the way in which the proposed methodology may be used to choose between environmental alternatives for shopping links. The methodology is by no means comprehensive in terms of the environmental implications considered and the constraints on evaluation specified in an earlier section clearly limit the comparisons which may be made between options. It is hoped, however, that the methodology represents a useful addition to the existing techniques and procedures available for environmental evaluation of transport policy options. In particular, it is felt that the suggested approach to the measurement of pedestrian exposure at the individual level will add greater meaning to a component of environmental evaluation which is of basic importance but which has received only very limited attention.

APPENDIX 1

PEDESTRIAN EXPOSURE MEASUREMENT METHODS

Measuring the Number of Pedestrians Exposed

1. Given a particular shopping centre for which environmental evalution is to be undertaken, it is necessary first to identify all potential exit points from the shopping axis. Such exits will include both ends of the "typical" High-Street district centre link, all side roads and bus stops. Car parks providing access to and from the High-Street shopping facilities should be included. On-street parking must, however, be ignored for the purposes of counting unless adequate survey staff are available.
2. Having established all potential exit points survey staff should be assigned to each exit point. In most cases one individual should be sufficient for counting purposes.
3. Depending on the number of exit points and available staff a sample time period for counting should be established. A minimum of 10 minutes at each exit point is recommended. Counting will, in any case, be confined to the period of the "shopping day", defined as 10.00 - 16.00 hours, and attention must be paid to the number of sample counts

feasible over that period, given the number of exits defined. At least four sample counts should be conducted at each exit over the day and some aggregation of exit points may, therefore, be necessary if the number of staff is limited.

4. The counting procedure simply entails recording each person (adult) leaving the centre through a specified exit point during a sample time period. The recording of adults only does of course raise issues of operational definition. The definition of the shopping day does serve to exclude children attending school if survey work is undertaken during term-time. If survey work is undertaken during school holidays the number of children should be enumerated separately as they may not be regarded as potential regular users during the "shopping day". It is further suggested that survey work not be undertaken during those periods of the year when weather conditions are particularly adverse. Low temperatures and rain have been shown to have a significant impact on levels of pedestrian activity on shopping streets.

5. In order to derive the total number of pedestrians leaving the centre during the "shopping day" the figures for the individual exit points should each be grossed up by the ratio of the sampled time period to the total "shopping day".

Thus, if four ten minute sample counts are conducted at each exit point then the total for the four counts should be grossed up by a factor of 9.
In the case of bus stops, it is suggested that both the number boarding buses and the number waiting during the sample count should be recorded as leaving, it being assumed that the numbers waiting problem will average out over a number of sample counts.
In order to derive the overall number of people leaving the centre during the "shopping day" the grossed up figures for each exit point are summed.
The figure arrived at represents the total number of individuals assumed to have been exposed, or potentially exposed, to traffic impacts and thereby to have experienced potential stress situations.

Measuring the Duration of Exposure

1. A very short interview schedule is administered to a random sample of individuals leaving the shopping centre at the defined exit points. Interviewing is carried out simultaneously with the pedestrian count by a second operative. Clearly, there are considerable advantages to be gained from having several interviewers available

at each exit point. Only shopper pedestrians are interviewed.

2. Prior to undertaking the interview survey it is useful, though not at this stage essential, to undertake an inventory of all shopping facilities and their locations within the defined area of the shopping centre. This may prove useful in the interpretation of responses to particular questions on the proposed questionnaire. However, such an inventory and its transcription onto a map of the centre at a suitable scale is necessary for subsequent analysis of the questionnaires.

3. The basic purpose of the interview survey is to obtain data relating to the trip characteristics of individuals who have at some point been engaged in pedestrian activity within the defined area of the shopping centre. The most important data to be collected relate to point of entry into the High-Street, or defined shopping area, and the intermediate locations (shops) visited between entry and exit points. Thus, one question must necessarily be directed to establishing where the individual entered the High-Street (which side-road or bus stop, for example) and one to finding out which shops were subsequently visited. An example of a complete questionnaire designed for a pedestrian survey of this type is presented on the following page. Non-shoppers are filtered out by a preliminary question relating to trip purpose.

QUESTIONNAIRE

(1) "Could you please tell me the shops which you have visited in the shopping centre ? Could you please try to give me the order in which you visited them and whereabouts they are?"

(2) "By what means of transport did you travel to the shopping centre?"

(3) <u>If by car</u> "Where did you park your car?"
<u>If by bus</u> "At which bus stop did you get off the bus?"
<u>If walking</u> "Whereabouts did you enter the High-Street?"

(4) "How many times a week do you shop here?"

(5) "Is this your main shopping trip of the week?"
<u>If NO</u> "On which day of the week do you do your main Shopping trip?"

(6) "Can you you tell me the main reason why you shop here?"

(7) "Is there anything in particular that you do not like about this shopping centre?"

(8) Male/ Female Under 30/ 30-50/ 50+

As interviewing is conducted at exit points from the centre it is, therefore, possible to establish a trip profile for each individual interviewed.

4. Additional questions may be posed to the respondent, as for example in the questionnaire presented. Useful questions include those relating to frequency of shopping trips, the significance of shopping trips and mode of travel to the centre. Respondent profile data should also be included as this may also prove useful in analyses of the distribution of exposure and its implications for different user groups.

5. It should be emphasised that the interviewing approach described here might easily be adapted to collect a considerable volume of useful data suitable for local plan making purposes, thereby providing both exposure analysis data and information of a more general planning nature.

6. The analysis of the shopping trip characteristics data takes the following form.

   The master map of the centre which includes all shopping and service establishments marked as point locations (that is, a point located mid-way along the frontage of each shop) is used to calculate the walking trip length for each respondent's reported shopping trip. Having established the individual's point of entry into the High-Street, the distances covered along the pavement (not the straight line distances linking each point) which are required to fulfill the reported trip are measured using a scale and then recorded, in metres. It is perhaps easiest to assume that individual's will attempt to minimise the pavement distance walked, this being necessary when respondents cannot recall the sequence in which they visited establishments on the shopping frontages. Incurred road crossing distances should also be included in the calculation of overall trip lengths.

7. It is also useful to record the number of crossing movements involved in each trip, if possible, as this can give some indication of the likelihood of individuals experiencing pedestrian delay and risk factors. It is suggested that crossing movements be classified according to whether they are across major or minor roads.

8. Having derived the individual pedestrian trips lengths from each questionnaire it is now necessary to convert these into units of time representing the duration of exposure. It is suggested that trip lengths be divided by a figure of 44.2 . This figure corresponds to the minimum observed free-flow walking speed of pedestrians and may

go some way towards accounting for pedestrian congestion on shopping street pavements and "window shopping". The figure of 44.2 is, in fact, a conversion to metres from the observed walking speed in feet per minute.

9. Thus, the division of each recorded pedestrian trip length (metres) by the figure of 44.2 will yield a figure in minutes and a decimal place which represents the duration of the individual's exposure on the reported shopping trip. Subsequent processing of this data may take a variety of forms. Initially, however, it is suggested that the mean duration of exposure be calculated as this gives a useful indication of the general scale of the exposure problem. Maximum and minimum estimated figures will also be useful. Analysis may be further extended, as in the examples to be presented, by considering exposure differentials between different user groups classified by mode of travel to the centre. Similarly, other classifications for exposure analysis may be employed depending on the format of the questionnaire used. The method is, therefore, very flexible and may provide a variety of data on the exposure issue.

10. Analysis of other questions in the interview survey will probably best be effected by the preparation of tables, or,

if desired, cross tabulation of data. Much will depend however on the nature of the questions posed in addition to those specifically required to derive trip length measurements.

11. It should again be emphasised that the time measures derived through the use of the procedures described above are assumed to represent periods during which the individual may be exposed to potentially stressful situations in the context of the district shopping centre traffic environment.

With regardto the duration of exposure, we may suspect that longer periods of exposure to a specified impact level are likely to be more stressful than shorter periods of exposure to the same impact levels. However, in isolating time duration of exposure we have added a third dimension to the traffic-response problem and we cannot, as yet, specify the nature of the relationships between impact intensity, exposure duration and response.

CHAPTER TEN

CONCLUSIONS

10.1. Introduction

This thesis has described the background to, and development of, a systematic impact statement methodology designed to aid in the process of choosing between environmental alternatives for shopping links in the highway network.

The thesis has been primarily concerned with environmental evaluation methodology and, in particular, the use of the impact statement approach. In this concluding chapter, therefore, comments will in the main be directed to evaluation issues and the proposed evaluation methodology developed in the research project.

10.2. Environmental Evaluation: Basic Issues

Two fundamental issues in environmental evaluation have been prominent throughout the discussion in the main body of this thesis. The first of these concerns the problem of defining the environment for evaluation purposes, and the second, the valuation of environmental quality.

It is evident that the environment as a construct remains poorly defined. Thus, we do not know what the environment comprises of for the individual, or, indeed, for groups or the community in general. We cannot specify components of environmental quality in a rigorous fashion. Of necessity, we are obliged to operate with only a partial definition of the environment as a construct.

Clearly, one may philosophize as to the nature of the environment but such a pursuit is something of a luxury at a time when concern with environmental quality issues demands that a pragmatic approach be adopted.

Although the definition of the environment presents some formidable problems, the author is of the opinion that some progress may be made by examining available data relating to subjective responses to the environment.

As the discussion in an earlier chapter indicated, there is evidence to suggest that individuals are aware of certain types of traffic impact and, indeed, that they may find them distressing or annoying. Such evidence, it is argued, does at least provide a starting point for establishing a range of socially relevant impacts which should be considered in the evaluation process. Such an approach clearly provided the basis for the author's own admittedly partial definition of traffic environments.

Inevitably, we must recognise that environmental evaluation is severely constrained by the difficulties which individuals experience in articulating their cognitive and affective responses to the environment. Thus, it is difficult to establish what the individual is actually aware of in environmental terms, and his preferences for different environments or components of those environments.

With regard to affective responses to the environment, in the absence of validated interval scale data it would seem sensible to operate on the basis that response measures are of an ordinal nature. Acceptance of this proposition does, of course, necessitate acceptance of the constraints imposed on evaluation by use of ordinal comparisons. The nature of these constraints has been discussed at some length in earlier chapters.

Thus, we cannot cannot at present derive valid and meaningful values through the measurement of attitudinal responses to the environment.

Similarly, monetary valuation of environmental quality has yet to yield values, the validity of which have been established by observed replication in a market context.

The author concludes, therefore, that it is not yet feasible to derive valid and meaningful values for environmental quality either by the use of attitudinal or monetary approaches. He is, furthermore, sceptical as to the likelihood of such values being derived in the short term or the longer term.

10.3. The Project Methodology

Having concluded that the valuation of environmental quality is not a feasible proposition it is clear that we are severely constrained as to the nature of the methodological options which may be used in environmental evaluation.

The notional ideal of single sum cardinal project evaluation is clearly a "non-starter". Similarly, we must rule out those methodologies which involve either the weighting of objectives or the weighting of specific impacts. Thus, it would appear that we must seek to explore the possibilities afforded by methodologies which are a good deal less sophisticated than those to which we would aspire.

Nonetheless, such an approach, pragmatic as it is, reflects the increasing demand for techniques and methods designed to indicate the environmental implications of policy options in the transport field.

Although it may be necessary to adopt a pragmatic approach to the development of evaluation methods this does not remove the need for a systematic and objective framework within which this process of development should be conducted.

The author's methodology is clearly a pragmatic response to the specified research problem. However, it is hoped that it also represents a systematic and objective attempt to develop an evaluation methodology applicable to a specific type of activity location, namely, the district shopping centre.

The impact statement approach adopted by the author was regarded as the only feasible methodological option available, given the constraints currently imposed on the choice of methodological options in evaluation.

The various stages in the development of the methodology, which have been described in earlier chapters, represented an attempt to proceed in a logical and systematic fashion towards the objective of viable evaluation methodology.

Thus, inputs to the methodology were isolated and defined. The choice of traffic impacts to be considered was made on the basis of existing evidence concerning subjective responses to traffic environments. Some further definition of impacts was required in view of the technical limitations on the measurement and/or prediction of certain types of impact.

The final set of impacts selected comprised of traffic noise, smoke, carbon monoxide and pedestrian delay. Predictive models for these impacts under urban non-free flow traffic conditions were presented.

The inclusion of the atmospheric pollution impacts does, it is argued, represent a valuable extension of the impact range considered, this having previously been confined in the main to traffic noise and delay impacts.

The issue of pedestrian exposure, representing, essentially, the human factor in the traffic-environment problems of shopping locations was considered in some detail. The author was by no means convinced of the effectiveness or validity of existing approaches to exposure measurement and chose to develop an alternative approach based on disaggregated measurement and presentation techniques. It is argued that this approach incorporating the concept of stress situations for pedestrians represents a meaningful and useful development with respect to this particular component of environmental evaluation.

Problems do, however, remain in the interpretation of exposure estimates. Clearly, until more is known about the interelationships between impact intensity parameters and exposure duration observations on the significance of changes in either of the dimensions of exposure will have to be speculative. However, the author maintains that his proposed approach to exposure measurement does represent an original contribution to the field and does have considerable potential as a means of displaying the human implications of policy options. Furthermore, the presentation of data relating to the total number of pedestrians exposed also represents a useful extension of exposure accounting methods.

The use of the methodology as a means of choosing between environmental alternatives for shopping links illustrated in the previous chapter. Relevant output was presented in the form of the proposed shopping link impact display matrix for a small number of test of options.

It is argued that the methodology can provide a meaningful and useful basis for choosing between such options. The unweighted form of the display matrix clearly places the onus on the decision maker to arrive at his own weighting system for specific impacts. A vital part of the methodology is, however, the recommendation that decision makers undergo direct environmental experience in a range of alternative shopping environments in order to appreciate variations in impact intensity and the significance of environmental change which may be predicted for policy options under evaluation.

The concept of the "league table" was introduced as a means of displaying the significance of change in environmental impacts. Each impact must be considered individually and the table itself should be constructed from absolute impact level predictions for a number of similar links; similarity in this case meaning district shopping centres.

The "league table" concept would appear to be useful but caution should be exercised in its interpretation. Clearly, the decision maker presented with such a table must be adequately informed of the range of absolute values involved in the initial rankings. If the absolute range of impact intensities is very small then there may be cases where options for centres appear to produce very significant changes in rank order but in reality produce only marginal change in environmental conditions. Similarly, the implications of the residual error in the predictive models should be taken note of when examining the"league tables". Finally, the rank order from which a centre shifts is as important in terms of the significance of change as the rank order which it might subsequently occupy as a result of policy option evaluation.

Clearly, the proposed methodology is limited in its applicability to urban shopping links characterised by non-free flow traffic conditions. This reflects the nature of the data inputs to the predictive model building process. However, it is most unlikely that urban shopping links are characterised by anything other than non-free flow conditions and so the author is confident as to the potential applicability of the methodology on a broad scale. A more significant constraint on the application of the methodology may be imposed by the predictive capabilities of the models in locations other than those for which they were developed. The author validated the models in the locational context within which he was operating and suggests that similar procedures should, where possible, be adopted.

The author is of the opinion that the methodology provides a useful and effective basis for evaluating the environmental implications of policy options for shopping links. It is by no means a perfect methodology and, of course, must leave the decision maker to contend with the complex trade off issues which may arise in evaluation, as well as the basic pair-wise comparisons between options which must be made. The methodology seeks,essentially to provide a data base for evaluation and in that respect the author does feel that it achieves its purpose. The impact statement approach is,of course, flexible, allowing for the inclusion of additional impacts, for example, and response data should that become available. Above all, the approach is compatible with the current constraints on evaluation, which should be explicitly recognised in any attempts to develop evaluation methodologies in the environmental field.

10.4. Future Research

Future research requirements in the field of environmental evaluation are clearly extensive. Issues of environmental definition will continue to act as a research focus and rightly so. Much more response data is required if we are to be able to define the environment with greater rigour.

As suggested above, the author is doubtful as to our ability to derive valid and meaningful values for environmental quality. However, a priority must be the investigation of monetary valuations and the extent to which they are replicated, if at all, in the market, or behavioural,context. If derived values are not seen to be replicated then it is very questionnable whether the approach is a useful one.

In terms of the author's key areas of concern in the methodology, there is clearly a need for the continual development and improvement of predictive modelling procedures, which are essential to any evaluation methodology. It is interesting to note that the Department of the Environment has recently released details of a recommended noise model for urban non-free flow conditions. Robust models are required in order to overcome the locational specificity of certain models developed in recent years. In that respect, the JURUE models do represent a significant step forward as they have been used in various locational contexts.

In terms of pedestrian exposure, there is clearly a need to explore the response implications of exposure parameters. It has become apparent to the author that no matter how sophisticated and detailed exposure measurement procedures may become, the derived measures have only very limited meaning until we are able to establish how significant the duration of exposure is and what the relationships between duration, intensity and response are. There are obviously formidable problems to be faced in this research area but the author hopes that his disaggregated approach to exposure measurement will help to provoke discussion of the underlying issues.

Finally, there exists a growing need for research into the feasibility and effectiveness of data display techniques in evaluation methodology. The "league table" concept illustrates how a very simple display format may be used to indicate the significance of environmental change for decision makers. Display techniques must obviously present data in a form which is readily understood. Thus, they should seek to be simple and yet effective. Above all, they should avoid given false impressions, which might confuse decision makers. Underlying assumptions should be stated and proper guidance on the interpretation of display formats provided. The increasing use of unweighted matrix forms of evaluation suggests that the demand for such techniques may well intensify in the years to come.

10.5 Final Remarks

This thesis has covered a great many research areas, a point which illustrates the breadth of perspective which is required in the field of the environmental evaluation of transport proposals and policies. Many areas have been only briefly touched upon whereas a few have been examined in somewhat greater detail.

The complexity of environmental issues necessitates the adoption of a broader based interdisciplinary perspective, if such issues are to be explored in an effective and meaningful fashion. This is certainly the case in transportation planning and it is the author's hope that this thesis will give some indication of both the potentialities and problems inherent in such an approach.

TECHNICAL APPENDIX I

The Use of a Linear Programming Trip Restraint System and Behavioural Costing Procedures to Derive Trade Off Costs Between Accessibility and Environment

1. Introduction

It was stated in Chapter 3 that an attempt was made to develop a costing procedure which might be used to derive the costs incurred as a result of trading off accessibility for environment. Such a procedure was, in fact, partially developed, although its application in the methodology test examples described in Chapter 9 was not a feasible proposition due to a variety of problems.

However, despite the problems and constraints which precluded the use of these procedures in the author's work, it was felt that it would be useful to give a brief description of the approach that was explored in order to indicate not only the problems to be overcome but also its potentialities.

2. Background to the Method

The method described below has been developed to aid in the evaluation of policies which require the implementation of private trip restraint on a highway network.

Two hypothetical policy options have been subjected to analysis. The first requires that specified links in the 1981 WMTS network are maintained at existing capacity and are not, therefore, upgraded to 1981 capacity specifications. The second is based on the implementation of private trip restraint in order to explore the potential for improving environmental quality on certain links in the network.

In the context of the exercise, the implementation of the two options was viewed as a two stage process. Initially, link capacities for a number of sensitive shopping links in the 1981 WMTS network were maintained at then 1974 capacities. The costing procedures were then used to determine the behavioural costs incurred by failing to increase these link capacities to their specified 1981 network levels.

The sensitivity of these links is viewed not only in terms of capacity limitations with respect to 1981 predicted trip demand but also in terms of potential environmental disbenefits, primarily to pedestrians, on the links concerned.

The second option represents an attempt to articulate some rather limited environmental objectives for the links in question. On the assumption of restraint to existing (1974) capacity in 1981 supplementary restraint is applied to explore environmental objectives. Having applied this additional restraint, the costing procedures are again employed to derive some indication of the costs incurred as a result of this environmentally based restraint policy.

The costing procedures involve the use of a linear programming model. This LP model is designed to restrain private trips in accordance with stipulated capacity constraints on specified links in the network, subject to the objective function of maximising total trips on the network.

Modifications to the capacity constraints applied to links under analysis will produce changes in the level of private trip restraint required on the specified links, as well as in the overall level of trip restraint on the network. These modifications to link capacities are framed in terms of the requirements of the hypothetical policy options.

The LP model produces an output which takes the form of the number of private trips restrained by destination zone for a stipulated link capacity. Origin - destination matrices are then examined to derive O - D data for each restrained trip on the link(s) analysed in the LP run.

The next stage in the procedure requires that the trip cost differential between private and public modes be calculated for all relevant (restrained) zone to zone movements. It is therefore a basic assumption of the method that restrained private trips shift to public transport.

The derived trip cost differential is central to the generation of the trade off costs. The aggregate costs so derived provide what is essentially a surrogate costing mechanism. When set against the changes in the environmental impacts of traffic resulting from trip restraint policies such costs provide an indirect link between environment and accessibility.

3. The Linear Programming Model

The LP model used in this method is known as TRESS (Trip Restraint System). The TRESS model is designed essentially to determine the level of private trip restraint which is required to achieve optimum overall highway network capacity subject to specified constraints. The model is intended for use in situations where assigned trips exceed link or junction capacity. Furthermore, it is assumed that, where necessary, private trip restraint may be achieved by restraining private vehicle parking.

The TRESS model maximises private trips on the network subject to junction or link capacities. The latter are normally derived from speed flow curves by the specification of a minimum speed.

Flows on overloaded links are brought within the stipulated capacity of that link. Specified minimum zonal attractions may be established for each destination zone, thereby allowing limits to be set on the degree of restraint suitable to conditions at the local level.

The model itself takes the following form:[1]

Maximise $$\sum_{j=1}^{n} \alpha_j * A_j$$

Subject to $$\sum_{j=1}^{n} K_{rj} * A_j = C_r \qquad r=1....m$$

Where K_{rj} fraction of private trips attracted to area j and using link r

C_r capacity available on link r for private trips

---

[1] A more detailed description of TRESS may be found in the TRESS User Manual (SIA, 1971).

TRESS, in common with other LP formulations seeks to solve a set of simultaneous equations subject to the maximisation of a specified objective function. In the case of TRESS this objective function is represented by total private trips on the network. TRESS operates on the number of private trips and does not consider trip length and trip cost factors.

TRESS is an iterative process. Commencing at a zero point TRESS progresses through a feasible region and ultimately will define an optimum solution subject to satisfying specified constraints. The most important constraint is clearly the specified link capacity. Other constraints may, however, be imposed. As stated previously it is possible to stipulate zonal attraction levels. Thus, minimum specified attractions to zone j may be an additional constraint on the solution.

In the TRESS solution some of the Aj values, which represent private attractions allowed to zone j after restraint, will be at Bj (demand level), some at Dj (specified minimum) and some between these values. In the author's TRESS analyses minimum attraction limits were specified in only a limited number of cases, and then only to ensure that local trips were carried on the key links.

TRESS evaluates each K_{rj} , that is, the fraction of private trips attracted to zone j which use link r. Capacity is allocated initially to the lowest K_{rj} elements as these require the least capacity to meet the requirement of allowing as many trips as possible to as many destination zones as possible. As the K_{rj} increases, and as capacity constraints are reached, restraint on trips may be required.

The higher K_{rj} related trips will therefore be restrained as they require the greatest resources and consume capacity quickly. Low K_{rj} related trips will be satisfied, as will any trips required due to the specification of minimum zonal attraction limits, and residual capacity will be allocated to the high K_{rj} related trips. There is, therefore, an element of fractional dependence in the solution but there is not a fixed point which determines when restraint becomes operative.

An additional element of the TRESS formulation which should be mentioned is the weighting factor applied to trips. This weighting factor is represented by α j in the objective function. Through manipulation of this function it is possible to introduce various other criteria into the restraint exercise. In the author's work this function was set at 1.0 for all trips, which were therefore treated as being

In TRESS, trip ends are limited in a systematic fashion such that capacity limits are not violated and that total trips are maximised. In the output of the LP "key" links at capacity are indicated. Each link at capacity is assigned a shadow price indicating the overall extra trips allowable for a unit increase in link capacity. The highest shadow price indicates the most valuable link for improvement of the overall solution.

To conclude this section, it should be emphasised that the manner in which the TRESS LP model was used by the author in this exploratory exercise differs considerably from its usual form of application. The way in which TRESS was used in the WMTS Stage 2 analysis is described in Technical Paper 7 of the Stage 2 Final Report (Volume 3).

4. The Specification of Link Capacities

For the purposes of the costing analysis which the author attempted four WMTS highway network links were selected for consideration. The links are all adjacent to district shopping centres and three of them were used as case studies in the previous chapter (Harborne, King's Heath, Northfield). The fourth centre was Brierley Hill in the western part of the Conurbation approximately three miles south of Dudley.

At the present time all these links, with the exception of Brierley Hill, are operating at or near their capacity during the peak period.

Under WMTS proposals, Harborne, King's Heath and Northfield are all scheduled for bypassing in the 1981 network proposals with increases in capacity to accommodate projected trip demand.

The extent to which actual and projected trip demand in 1981 will coincide is at present a matter for conjecture for obvious reasons. In the context of the exercise the full implications of the current economic situation, public expenditure cuts, inflation and so on could not be reflected in the examination of the hypothetical policy options. The study itself was exploratory and illustrative and for this reason the data used took the form of the original unmodified WMTS output.

The testing of the two policy options described earlier required the specification of new link capacities for the 1981 situation. For the first option link capacities were specified on the basis of a no-change situation. The existing 1974 capac ities were therefore projected forward to the 1981 situation but trip demand was held at 1981 levels. The immediate result of such a policy formulation is to create a situation in which there is likely to be a gross excess of demand for trips over available capacity.

In the specification of link capacities it is necessary to determine the number of trips involved in each constituent element of the traffic flow. Total flows on each link considered in the 1981 network may be broken down into four basic elements ; through and local privates and through and local goods vehicle trips. The analysis of restraint policies described here is based on restraint on private through trips only.

The existing capacity having been established by discussion with members of WMTSG, capacity was then allocated for 1981 goods vehicle trips. As the TRESS model is unable to differentiate between through and local private trips it was then necessary to allocate capacity for local private trips and adjust local attraction zone limits to ensure that such trips were not restrained in the LP.

The second policy option seeks to explore the feasibility of achieving environmental improvements on specified links by a further restraint on private through trips. Thus, 50% of remaining private trips on the links were restrained again with the proviso that local private trips be allowed capacity. The figure of 50% was selected in an arbitrary manner but restraint of this order was required if, it was then thought, environmental improvements were to be discernible. More will be said about the potential for environmental improvement using such an approach in a subsequent section of this Appendix.

Restraining private trips through the application of the TRESS model has both link and network implications. As this model restrains by destination zone with the assumption of a related parking policy, the degree of parking restraint required to achieve specified link capacities tends to produce a situation in which there are limits on private trips on links for which a reduced capacity has not been stipulated.

Where a number of links are considered in detail in the TRESS analysis it is possible to determine exactly how many trips are being restrained in order that the capacity of these particular links is not exceeded. At the network level it is only possible to establish the total number of trips which must be restrained to achieve capacity constraints on specific links, and these trips cannot be related to individual links. A basic drawback of the method is that it may well produce a situation in which many more trips are restrained than is necessary to meet the capacity limits on a sample of links.

It should, however, be emphasised that TRESS is being used here purely as a device to restrain private through trips using a particular link in some systematic way.

5. The Cost Calculations

The TRESS output yields both zone and link data relating to restrained trips on the links under analysis. The zone data includes the number of trips desired to each destination zone, the number of trips allowed, the number restrained and the % trips allowed. By examining this data it is possible to isolate those destination zones subject to restraint and the level of that restraint.

The link data includes the actual load on the link after restraint, the specified capacity, the volume of spare capacity, the % capacity used and the shadow price applicable to the specified links. A summary statement of restraint is also provided showing the total network trips desired, trips allowed, trips restrained and % trips allowed.

The starting point for the calculation of costs is the zone data from the TRESS output. The level of restraint applied to each destination zone is noted and all restrained destination zones are entered in the columns of an O-D matrix. The rows of this matrix comprise the origin zones of all trips attracted to the restrained destination zone which are assigned to the link under analysis.

The next stage involves the examination of the private and public cost matrices for zone to zone movements. Assuming a modal shift from private to public modes for restrained trips, the difference in trip cost provides the means by which the overall policy costs of restraint may be derived. The cost difference is then multiplied by the number of restrained trips moving between the zones concerned. When the costs incurred in each cell of the matrix are summed the total cost of restrained trips may be derived.

The calculation of an annual link cost for restrained trips involved the use of the following costing formula:

$$\text{COST} = \frac{\dfrac{\pounds\,(\text{CU} \times 2.12 \times 2)}{240} \times 255}{0.55} \quad @\ 1964 \text{ values}$$

Where:

CU — cost units expressing trip cost differential between private and public modes

x 2.12	conversion factor to bring CU to old pence
x 2	doubling to account for return trip
÷ 240	to bring to £s
x 255	number of days on which typical peak hour conditions occur
÷ 0.55	conversion factor to restore costs to 2 hour peak period modelling assumptions

When this costing formula is applied to restrained trips previously assigned to a specific link an annual cost is derived. By making use of the summary restraint information output from TRESS it is also possible to place some kind of cost on the network restraint incurred. The procedure used is extremely crude and at best gives only a rough indication of the order of magnitude of these costs, which cannot be related to individual links in the network. The generation of these network costs requires the calculation of a mean trip cost differential. The extent to which such a measure reflects actual trip cost differentials for relevant zone to zone movements is clearly unknown.

This, then, is the method which the author attempted to develop to an operational level. For reasons which will be explained below the method could not be effectively and validly integrated within the methodology test exercises described in the penultimate chapter.

It had been intended to set the costs derived by this method against the various environmental impacts included in the impact display matrix. Thus, it would hopefully have proved possible to tentatively define trade off costs between accessibility and environment and add an important dimension to the proposed evaluation methodology.

This unfortunately was not possible. However, some of the output from the cost calculations which were undertaken is presented in the following pages. It should be emphasised that all the costs derived are at 1964 values. Had it proved possible to integrate the costing procedures within the methodology an attempt would have been made to update these costs using contemporary data concerning the value of travel time. However, as the data presented herein is essentially illustrative the original, unmodified WMTS values have been retained.

LINK	SPECIFIED CAPACITY FOR PRIVATE TRIPS	ACTUAL TRESS LOAD	TRIPS RESTRAINED AGAINST 1981 PEAK	% TRIPS RESTRAINED	TOTAL ANNUAL COST ON LINK
HARBORNE					
6199-6154	1108	625	2110	77.1	£225,000
6154-6199	600	501	0	0	0
KING'S HEATH					
6240-6241	662	662	2576	79.6	£374,500
6241-6240	400	245	0	0	0
NORTHFIELD					
7200-7194	1811	1248	857	40.7	£[illegible],500
7194-7200	1200	1027	0	0	0
BRIERLEY HILL					
8059-7050	670	663	0	0	0
7050-8059	300	298	0	0	0

TOTAL ANNUAL COST	£[illegible],000	ON [illegible]
NETWORK COSTS	£2,450,000 [illegible]	
OVERALL COSTS	£3,1[illegible],000 [illegible]	

(1) RESTRAINT LEVELS AND COSTS ON LINKS WITH LINKS AT EXISTING CAPACITY

	FOR PRIVATE TRIPS	LOAD	AGAINST 1981 PEAK		
HARBORNE					
6199-6154	1108	1108	1627	59.5	£ 154,500
6154-6199	600	501	0	0	0
KING'S HEATH					
6240-6241	3238	2256	982	30.3	£ 136,500
6241-6240	400	245	0	0	0
NORTHFIELD					
7200-7194	2105	1593	512	24.3	£ 51,500
7194-7200	1200	1027	0	0	0
BRIERLEY HILL					
8059-7050	670	663	0	0	0
7050-8059	300	298	0	0	0

TOTAL ANNUAL COST	£ 342,500 ON LINKS
NETWORK COSTS	£1,050,000
OVERALL COSTS	£1,392,500

(2) RESTRAINT LEVELS AND COSTS WITH HARBORNE AT EXISTING CAPACITY AND REMAINING LINKS AT 1981 CAPACITY

	FOR PRIVATE TRIPS	LOAD	AGAINST 1981 PEAK		COST ON LINKS
HARBORNE					
6199-6154	2735	2735	0	0	0
6154-6199	600	461	39	7.7	£1350
KING'S HEATH					
6240-6241	3238	3238	0	0	0
6241-6240	400	238	7	2.9	£650
NORTHFIELD					
7200-7194	1811	1811	294	13.9	£4800
7194-7200	1200	1027	0	0	0
BRIERLEY HILL					
8059-7050	670	663	0	0	0
7050-8059	300	298	0	0	0

TOTAL ANNUAL COST	£6800 ON LINKS
NETWORK COSTS	£210,600
OVERALL COSTS	£217,400

(3) RESTRAINT LEVELS AND COSTS WITH NORTHFIELD AT EXISTING CAPACITY AND REMAINING LINKS AT 1981 CAPACITY

LINK	SPECIFIED CAPACITY FOR PRIVATE TRIPS	ACTUAL TRESS LOAD	TRIPS RESTRAINED AGAINST 1981 PEAK	% TRIPS RESTRAINED	TOTAL ANNUAL COST ON LINK
HARBORNE					
6199-6154	2735	2735	NO RESTRAINT	0	NO COSTS
6154-6199	600	501	NO RESTRAINT	0	NO COSTS
KING'S HEATH					
6240-6241	3238	3238	NO RESTRAINT	0	NO COSTS
6241-6240	400	235	NO RESTRAINT	0	NO COSTS
NORTHFIELD					
7200-7194	2105	2105	NO RESTRAINT	0	NO COSTS
7194-7200	1200	1027	NO RESTRAINT	0	NO COSTS
BRIERLEY HILL					
8059-7050	670	663	NO RESTRAINT	0	NO COSTS
7050-8059	300	298	NO RESTRAINT	0	NO COSTS

(4) BRIERLY HILL AT EXISTING MINIMUM CAPACITY WITH REMAINING LINKS AT 1981 CAPACITY

TOTAL ANNUAL COST	NO COSTS	ON LINKS
NETWORK COSTS	NO COSTS	
OVERALL COSTS	NO COSTS	

LINK	SPECIFIED CAPACITY FOR PRIVATE TRIPS	ACTUAL TRESS LOAD	TRIPS RESTRAINED AGAINST 1981 PEAK	% TRIPS RESTRAINED	TOTAL ANNUAL COST ON LINK
HARBORNE					
6199-6154	554	554	2181	79.7	£ 224,500
6154-6199	554	501	0	0	0
KING'S HEATH					
6240-6241	3238	1127	2111	65.2	£ 317,500
6241-6240	400	245	0	0	0
NORTHFIELD					
7200-7194	2105	1301	804	38.2	£ 88,000
7194-7200	1200	1027	0	0	0
BRIERLEY HILL					
8059-7050	670	663	0	0	0
7050-8059	300	298	0	0	0

(5) HARBORNE WITH SUPPLEMENTARY RESTRAINT TO 50% OF EXISTING CAPACITY WITH REMAINING LINKS AT 1981 CAPACITY

TOTAL ANNUAL COST	£ 630,000 ON LINKS
NETWORK COSTS	£2,315,000
OVERALL COSTS	£2,945,000

LINK	SPECIFIED CAPACITY FOR PRIVATE TRIPS	ACTUAL TRESS LOAD	TRIPS RESTRAINED AGAINST 1981 PEAK	% TRIPS RESTRAINED	TOTAL ANNUAL COST ON LINK
HARBORNE					
6199-6154	2735	360	2375	86.8	£ 246,000
6154-6199	600	501	0	0	0
KING'S HEATH					
6240-6241	331	331	2907	89.7	£ 424,000
6241-6240	400	245	0	0	0
NORTHFIELD					
7200-7194	2105	1166	939	44.6	£ 107,000
7194-7200	1200	1027	0	0	0
BRIERLEY HILL					
8059-7050	670	663	0	0	0
7050-8059	300	298	0	0	0

TOTAL ANNUAL COST	£ 770,000 ON LINKS
NETWORK COSTS	£3,440,000
OVERALL COSTS	£4,210,000

(6) KING'S HEATH WITH SUPPLEMENTARY RESTRAINT TO 50% OF EXISTING CAPACITY WITH REMAINING LINKS AT 1981 CAPACITY

LINK	SPECIFIED CAPACITY FOR PRIVATE TRIPS	ACTUAL TRESS LOAD	TRIPS RESTRAINED AGAINST 1981 PEAK	% TRIPS RESTRAINED	TOTAL ANNUAL COST ON LINK
HARBORNE					
6199-6154	2735	953	1782	65.2	£ 179,000
6154-6199	600	150	351	70.1	£ 49,000
KING'S HEATH					
6240-6241	3238	1173	2065	63.8	£ 291,500
6241-6240	400	169	76	31.0	£ 9,900
NORTHFIELD					
7200-7194	835	835	1270	60.3	£ 147,000
7194-7200	835	835	192	18.7	£ 27,000
BRIERLEY HILL					
8059-7050	670	663	0	0	0
7050-8059	300	298	0	0	0

TOTAL ANNUAL COST	£ 703,400 ON LINKS
NETWORK COSTS	£2,560,000
OVERALL COSTS	£3,263,400

(7) NORTHFIELD WITH SUPPLEMENTARY RESTRAINT TO 50% (46%) OF EXISTING CAPACITY WITH REMAINING LINKS AT 1981 CAPACITY

LINK	SPECIFIED CAPACITY FOR PRIVATE TRIPS	ACTUAL TRESS LOAD	TRIPS RESTRAINED AGAINST 1981 PEAK	% TRIPS RESTRAINED	TOTAL ANNUAL COST ON LINK
HARBORNE					
6199-6154	2735	2735	0	0	0
6154-6199	600	498	3	0.6	£ 470
KING'S HEATH					
6240-6241	3238	3230	8	0.2	£ 800
6241-6240	400	245	0	0	0
NORTHFIELD					
7200-7194	2105	2095	10	0.5	£ 1,400
7194-7200	1200	1027	0	0	0
BRIERLEY HILL					
8059-7050	335	335	328	49.5	£ 57,500
7050-8059	300	298	0	0	0

(8) BRIERLEY HILL WITH SUPPLEMENTARY RESTRAINT TO 50% OF EXISTING CAPACITY WITH REMAINING LINKS AT 1981 CAPACITY

TOTAL ANNUAL COST	£ 60,170 ON LINKS
NETWORK COSTS	£ 871,500
OVERALL COSTS	£ 931,670

6. Problems Associated with the Use of TRESS in the Author's Project

It had been intended that the costs derived by the procedures described above would be set against the environmental changes resulting from the traffic restraint associated with the options under analysis. This would have provided a means of placing some kind of monetary value on the trade off between accessibility and environment.

The basic problem which confronted the author was that the origin-destination matrices employed in the TRESS analysis, and, of course, the assignments themselves, related only to am peak conditions. This clearly meant that any costs derived through the use of the procedures developed would be relevant only to that period. Clearly, one could have approached the problem by attempting to factor the peak hour derived values and thereby establish some measure of the longer term (that is to say, daytime) costs involved in restraint. However, there appeared to be no systematic or valid method available for carrying out such a factoring exercise. Furthermore, the stability of the trip origin-destination relationships which must necessarily be assumed in such an approach could not be established.

Clearly, the author was concerned, essentially, with shopping centres and their related highway links as functioning activity locations. As shopping activity primarily occurs during the off-peak traffic period this conversion process would have been essential if the benefits to centre users and the trade off costs involved were to be related in a meaningful way.

The nature of the data base of the WMTS Stage 2 analysis was, therefore, a fundamental constraint on the use of this approach.

In some very limited environmental analyses which the author carried out it did become clear that, in fact, the environmental benefits to be achieved by even quite severe private trip restraint were not as marked as perhaps one might expect. The assumption of the method that restrained trips shift to the public mode inevitably means that one must seek to take account of the necessary increase in bus service provision. Thus, cars are removed from the links under analysis but more buses are added, thereby reducing the anticipated environmental benefits. It would seem that from the analyses carried out by the author that it is by no menas unreasonable to argue that private trip restraint as a policy is most relevant in those situations where the limited technical ability of the network requires some reduction in private vehicle trip making.

TECHNICAL APPENDIX II

Results of a Validation Test of the JURUE Environmental Models: Harborne and King's Heath District Shopping Centre Links, Birmingham

Traffic Noise

Harborne

Observation Period		Observed L_{10}	Predicted L_{10}	Variation *
(i)	Peak (am)	80.0 dB(A)	78.9 dB(A)	1.1 dB(A)
(ii)	Off-peak (am)	77.6 dB(A)	78.1 dB(A)	0.5 dB(A)
(iii)	Off-peak (pm)	76.8 dB(A)	78.0 dB(A)	1.2 dB(A)

King's Heath

Observation Period		Observed L_{10}	Predicted L_{10}	Variation *
(i)	Peak (am)	80.0 dB(A)	81.0 dB(A)	1.0 dB(A)
(ii)	Off-peak (am)	77.8 dB(A)	79.2 dB(A)	1.4 dB(A)
(iii)	Off-peak (pm)	78.0 dB(A)	78.7 dB(A)	0.7 dB(A)

Carbon Monoxide Model

Harborne

Observation Period		Observed Conc.	Predicted Conc.	Variation
(i)	Peak (am)	9.7 ppm	7.7 ppm	2.0 ppm
(ii)	Off-peak (am)	7.5 ppm	4.8 ppm	2.7 ppm
(iii)	Off-peak (pm)	7.7 ppm	5.6 ppm	2.1 ppm

King's Heath

Observation Period		Observed Conc.	Predicted Conc.	Variation
(i)	Peak	10.3 ppm	9.2 ppm	1.1 ppm
(ii)	Off-peak (am)	7.6 ppm	5.3 ppm	2.3 ppm
(iii)	Off-peak (pm)	7.3 ppm	5.6 ppm	1.7 ppm

Smoke Model

Harborne

Observation Period		Observed Conc.	Predicted Conc.	Variation
(i)	Peak (am)	72.5 mgm/m^3	63.7 mgm/m^3	8.8 mgm/m^3
(ii)	Off-peak (am)	69.7 mgm/m^3	60.1 mgm/m^3	9.6 mgm/m^3
(iii)	Off-peak (pm)	68.4 mgm/m^3	57.7 mgm/m^3	10.7 mgm/m^3

King's Heath

Observation Period		Observed Conc.	Predicted Conc.	Variation
(i)	Peak (am)	86.4 mgm/m^3	72.3 mgm/m^3	14.1 mgm/m^3
(ii)	Off-peak (am)	78.2 mgm/m^3	63.1 mgm/m^3	15.1 mgm/m^3
(iii)	Off-peak (pm)	75.7 mgm/m^3	62.3 mgm/m^3	13.4 mgm/m^3

Pedestrian Delay

Harborne

Observation Period		Observed Delay	Predicted Delay	Variation
(i)	Peak (am)	10.5 secs	8.5 secs	2.0 secs
(ii)	Off-peak (am)	8.7 secs	7.2 secs	1.5 secs
(iii)	Off-peak (pm)	8.1 secs	5.9 secs	2.2 secs

Kings Heath

Observation Period		Observed Delay	Predicted Delay	Variation
(i)	Peak (am)	14.9 secs	12.6 secs	2.3 secs
(ii)	Off-peak (am)	6.1 secs	7.9 secs	1.8 secs
(iii)	Off-peak (pm)	7.1 secs	9.0 secs	1.9 secs

Remarks:

All variations between observed and predicted impact levels are within the residual error of the model concerned. Residual error values are as follows:

noise - 1.6 dB(A)

CO - 3 ppm

smoke - 18.8 microgms/m^3

delay - 2.8 seconds

BIBLIOGRAPHY

Adams, W.F. (1937) "Road Traffic Considered as a Random Series." J. Inst. Civ. Eng., 4, 121-130.

Antoniou, J. (1971) Environmental Management. London McGraw-Hill.

Beck, R. (1967) Spatial Meaning and the Properties of the Environment. in D. Lowenthal (ed) Environmental Perception and Behaviour. Research Paper 109 Dept. of Geography Chicago University.

Binks, R. (1974) Pedestrian Precincts. Monograph 15 I.M.E.

Bohm, P. (1973) Social Efficiency: A Concide Guide to Welfare Economics. MacMillan.

Boulding, K. (1956) The Image. University of Michigan: Ann Arbor.

Buchanan, C. and D. Crompton (1968) "Objectives of Traffic Management." Traff. Engng. Control, 10, 1, 24-27.

Burley, K. and A. Mitcham (1967) Pedestrian Movement in Leeds Central Area. Dip. T P Thesis Leeds School of Town Planning.

Burt, M. (1972) Roads and the Environment. TRRL Report LR 441.

Cane, S. (1975) The Problems and Uses of Soft Data in Evaluation and Decision Making. JURUE Research Seminar on Environmental Quality March 1975.

--------- (forthcoming) Environmental Quality in Residential Areas. Ph.D. Thesis, University of Aston.

Canter, D. (1969) "Attitudes and Perception in Architecture." Arch. Assoc. Q., 1, 24-31.

---------- (1970) (ed) Architectural Psychology: Conference Proceedings. Univ. of Strathclyde: R.I.B.A.

---------- (1972) "Architecture and Psychology." Built Environment, 1, 188-190.

Cassidy, M. (1975) Environmental Impact Assessment. JURUE Research Seminar on Environmental Quality, March 1975.

Christie, A.W., et al (1973a) Urban Freight Distribution: A Study of Operations in High Street, Putney. TRRL Report LR 556.

-------------------- (1973b) Urban Freight Distribution: Studies of Operations at Newbury and Camberley. TRRL Report LR 603.

Church, M. (1973) The Analysis of Resident Satisfaction as an Indication of Environmental Quality. M. Phil. Dissertation, University of Aston.

City of Birmingham (1973a) Structure Plan. Report of Survey: Shopping.

------------------ (1973b) Structure Plan. Transportation.

Coburn, T.M., et al, (1960) The London-Birmingham Motorway. Traffic and Economics. RRTP No.46, HMSO.

Collins, M.S. (1972) Environmental Management and Traffic Restraint. PTRC Conference.

Copley, G. and M.J. Maher (1973) Pedestrians Movements: A Review. Institute of Transport Studies, Leeds University, WP. 6.

Council on Environmental Quality (1973) Preparation of Environmental Impact Statements. Federal Register, Vol. 38, No. 147.

Coventry Transportation Study (1973) The Technical Report Parts 1 & 2.

Craik, K. (1968) "The Comprehension of the Everyday Physical Environment." J.A.I.P., 34, 29-37.

--------- (1972a) "An Ecological Perspective on Environmental Decision Making." Human Ecology, 1, 69-80.

--------- (1972b) "Psychological Factors in Landscape Appraisal." Environment and Behaviour, 4,3, 255-266.

Crompton, D.H. (1971) Edinburgh: Environmental Capacities Of Central Area Streets. Imperial College, London.

---------------- and D. Gilbert (1970a) "The Traffic and Environment Analyser." Traff. Engng. Control, 12, 4, July.

-------------------------------- (1970b) "Traffic and Environment." Traff. Engng. Control, 12, 6, October.

-------------------------------- (1971) "Estimating the Impact of Traffic on the Environment." Surveyor, December 10, 1971, 51-52.

Cullen, I. (1974) The Redistribution Effects of Time and Space. JURUE Internal Seminar.

--------- (1975) Patterns of Behaviour and Responses to the Urban Environment. JURUE Research Seminar on Environmental Quality, March 1975.

Dalby, E. (1973) Pedestrians and Shopping Centre Layout: A Review of the Current Situation. TRRL Report LR 577.

Dawson, R. (1974) Environmental Simulator: Progress Report. TRRL Report LR 659.

De Fleur, M. and F.R. Westie (1958) "Verbal Attitudes and Overt Acts: An Experiment on the Salience of Attitudes." Amer. Soc. Rev. 23, 667-673.

Delaney, H. (1972) The Prediction of Traffic Noise Levels. NPL Acoustics Report AC 56.

DOE (1971) Evaluation in Structure Plan Making (Report of the Forecasting and Evaluation Working Group) Second Draft.

---- (1972) New Housing and Road Traffic Noise. Design Bulletin No. 26.

---- (1973) Technical Memorandum H 8/73 DOE.

---- (1975) Standard Forecasts of Vehicles and Traffic. Technical Memorandum H 3/75.

Docherty, A. and E. Bayley (1970) "Carbon Monoxide Pollution of Urban Air." Traff. Engng. Control, 11, 12, 594-597.

Doherty, J. (1968) Residential Preferences for Urban Environments in the United States. L.S.E. Dept. of Geography, Graduate Discussion Paper 29.

----------- (1969) Developments in Behavioural Geography. L.S.E. Department of Geography, Graduate Discussion Paper 35.

Downs, R. (1970a) Geographic Space Preference- Past Approaches and Future Prospects, in, Board,C., et al, (eds) Progress in Geography, Vol. 2, 65-108.

---------- (1970b) " The Cognitive Structure of an Urban Shopping Centre." Environment and Behaviour,2, 13-39.

---------- and R. Horsfall (1971) Methodological Approaches to Urban Cognition. Paper presented to the 67th meeting of the Association of American Geographers, Boston, Mass. April 1971.

---------- and D. Stea (1974) Image and Environment. Arnold: London.

Everett, M. (1975) "Roadside Air Pollution Hazards in Recreational Land Use Planning." JAIP, 40, 2, 83-89.

Eyles, J. (1968) Inhabitants'Images of Highgate Village : An Example of a Perception Measurement Technique. L.S.E. Dept. of Geography, Graduate Discussion Paper 15.

Eyles, D. and P. Myatt (1970) Road Traffic and Urban Environment in Inner London (A Study of LTS Zone 277) Research Memorandum 250 G.L.C..

Flowerdew, A. (1975) Environmental Effects of Urban Motorways: Comparison of Evaluation Techniques. JURUE Research Seminar on Environmental Quality, March 1975.

-------------- and A. Hammond (1973) "City Roads and the Environment." Reg. Stud., 7, 123-136.

Foster, C.D. and M.E. Beesley (1963) "Estimating the Social Benefit of Constructing an Underground Railway in London." J. Roy. Stat. Soc. Series A, Vol. 126, 1, 46-92.

Fried, M. and P. Gleicher (1961) "Some Sources of Residential Satisfaction in an Urban Slum." JAIP, 27, 4, 305-315.

Freight Transport Association (1974) Planning for Lorries.

Fruin, J. (1971) Pedestrian Planning and Design. New York: Metropolitan Association of Urban Designers and Environmental Planners Inc..

Galloway, W.J., et al, (1969) Highway Noise - Measurement, Simulation and Mixed Reactions. U.S. Highway Research Board.

Goffman, I. (1959) The Presentation of Self in Everyday Life. New York: Doubleday.

----------- (1963) Behaviour in Public Places. New York: Free Press.

Goodey, B. (1970) Perception of the Environment: An Introduction to the Literature. Centre for Urban and Regional Studies, Univ. of Birmingham, Research Memorandum 5.

Gorden, R.L. (1952) "Interaction between Attitudes and the Definition of the Situation in the expression of Opinion." Amer. Soc. Rev., 17, 50-58.

Gould, P. (1969) "Problems of Space Preferences: Measures and Relationships." Geog. Analysis, 1, 1, 27-33.

Gray, J. (1965) Pedestrianised Shopping Streets in Europe. Pedestrians Assoc. for Road Safety, Edinburgh Branch.

Greater London Council (1971) Proposals for Secondary Roads- illustrative examples. GLDP Enquiry-Background Paper 443.

------------------------ (1973) Pedestrianised Streets: Report of a Study Tour in Europe and North America.

Green, P.M. (1967) "Planning for the Customer." OAP, August, 1967.

Greenberg, M. and R. Horden (1974) "Environmental Impact Statements: Some Annoying Questions." JAIP, May 1974, 164-174.

Griffiths, I. (1968) "A Note on the Traffic Noise Index and the Equivalent Sound Level." J. Sound Vibr., 8, 2, 198-200.

Gwilliam, K.M. (1970) "The Indirects Effects of Highway Investment." Reg. Stud., 4, 2, 167-176.

-------------- (1973) Economics, Transport Planning and the Environment. in Rose, J. (ed) Wheels of Progress. London: Gordon and Breach.

Hammond, A. (1972) The Evaluation of Amenity. PTRC Conference Summer 1972.

Hankin, B.D. and R.A. Wright (1958) "Passenger Flow in Subways." Op. Res. Q., 9, 2, 81-88.

Hardy, A. and P. Lewis (1971) A Study of the Noise Generated by Urban Motorways and Its Influence on the Development of Adjacent Land. Final Report, Dept. of Architecture, Univ. of Newcastle.

Harris, J. (1961) "The Design of Shopping Centres." JTPI, 47, 245-251.

Harrison, J. and P. Sarre (1971) "Personal Construct Theory and the Measurement of Environmental Images." Environment and Behaviour, 3, 4, 351-373.

Harrison, A.J. (1974) Economics of Transport Appraisal. London: Croom Helm.

Hatfield, W. (1972) Designing for Deliveries: Design Standards for Service and Off Street Loading Areas. Freight Transport Assoc., Research Report No. 4.

Hedges, B. (1972) Attaching Money Values to Environmental Disturbance: A Review Paper. SCPR.

----------- (1974) JURUE Internal Seminar.

Hill, M. (1968) "A Goals Achievement Matrix for Evaluating Alternative Plans." JAIP, 34, 19-29.

Hirsch, W., S. Sonenblum and J. St. Dennis (1972) Estimating the Quality of Urban Life with Input-Output. in Brody, A. and A. Carter (eds), Input-Output Techniques. North-Holland.

Hodgins, H. (1974) Evaluating Preferences. JURUE Unpublished Paper.

HMSO (1963) The Buchanan Report - Traffic in Towns.

------ (1964) The Smeed Report.

------ (1967) Better Use of Town Roads.

------ (1968) Traffic and Transport Plans (MOT).

------ (1970) Transport Planning: The Men for the Job. A Report by Lady Sharp.

------ (1972) New Roads in Towns. The Report of the Urban Motorways Committee.

------ (1973) The Report of the Urban Motorways Project Team.

------ (1974) Lorries and the World We Live In.

------ (1975) Review of the Development Control System, The Dobry Report.

Jacobs, G. (1968) A Comparison of Shopping Times in 'High-Street' and 'Precinct' Types of Shopping Area. RRL Report LR 150.

Jennings, A., et al, (1972) Delivering the Goods. Freight Transport Assoc. Research Report No. 2.

Johnson, D. and F.E.Joyce (1975) The Derivation of "Environmental Values" - A Critique and Research Strategy. JURUE Research Seminar on Environmental Quality, March 1975.

Joyce, F.E. and H. Williams (1973) On Assessing the Environmental Impact of Road Traffic. in Rose, J. (ed) Wheels of Progress. London: Gordon and Breach, 29-36.

----------- and D. Johnson (1975) The Derivation of "Environmental Values" (ii)- A Note Relating to Attitudinal Values. JURUE Research Seminar on Environmental Quality, March 1975.

-----------,H. Williams and D. Johnson (1975a) "The Environmental Effects of Urban Road Traffic 1: Predictive Models." Traff. Engng. Control, 16, 3, March 1975.

------------------------------------- (1975b) "The Environmental Effects of Urban Road Traffic 2: Evaluating Alternative Transport Proposals." Traff. Engng. Control, 16, 4, April 1975.

JURUE (1974a) The Environmental Effects of Urban Road Traffic: Predictive Model Development. Report Submitted to the London Borough of Hammersmith, February 1974.

------- (1974b) West London Study: The Environmental Consequences in Hammersmith. August 1974.

------- (1975) Lorry Route Proposals: Some Local Planning Examples. A Report Prepared for the Department of the Environment, January 1975.

Kettle, P. (1973) A Comparison of the Planning Balance Sheet and Goals Achievement Matrix Methods of Evaluation. PMRU WP.7, University College, London

--------- and N.Lichfield (1975) Evaluation in the Planning Process. Forma, July 1975.

Kirwan, R.M. (1969) Economics and Methodology in Urban Transport Planning. in Orr, S. and J.B. Cullingworth (eds) Regional and Urban Studies. London: Allen and Unwin.

Koroscil, P. (1971) "The Behavioural Environmental Approach." Area, 3, 2, 96-99.

Kuhnemann, J. and R. Witherspoon (1974) Thirty-two German Cities. in, OECD Streets for People. Paris: OECD, 57-70.

Lassiere, A. (1973) Environmental Evaluation of Transport Plans at the Strategy Level. PTRC Summer Conference.

------------ (1974) The Environmental Evaluation of Transport Plans and Proposals at the Strategic Level. DOE (Unpublished)

Langdon, F.J. (1969) Social Nuisance Caused by Traffic Noise. BRS EN 7/69.

-------------- and W.E. Scholes (1968) "The Traffic Noise Index: A Method of Assessing Noise Nuisance." Arch. J., 147, 16, 813-820.

Layard, R. (ed) (1972) Cost Benefit Analysis. Penguin Books.

Lee, D.H. (1966) "The Role of Attitude in Response to Environmental Stress." J. Soc. Issues, 22, 4, October 1966.

Lee, T.R. (1963) "The Optimum Provision and Siting of Social Clubs." Durham Research Review, 4, 53-61.

---------- (1968) "Urban Neighbourhood as a Socio-Spatial Schema." Human Relations, 21, 241-267.

---------- (1974) JURUE Internal Seminar.

Lichfield, N. (1956) The Economics of Planned Development. London.

------------ (1970) " Evaluation Methodologies of Urban and Regional Plans: A Review." Reg. Stud., 4, 2, 151-165.

Liekerman, A. and A. Wilcock (1970) "Suburban Shopping Precincts: An Assessment." JTPI, 56, 4.

Lindvall, T. and E.P. Radford (1973) Measurement of Annoyance due to Exposure to Environmental Factors. The Fourth Karolinska Institute Symposium on Environmental Health.

Lovemark, O. (1972) "New Approaches to Pedestrian Problems." J. Trans. Econ. Pol., January 1972.

Lundeen, R. (1972) The Semantic Differential Technique and Personal Construct Theory in Image Measurement. Discussion Paper 5, Dept. of Geography, York University, Toronto.

MacIver, R. (1942) Social Causation. New York: Farrar and Rinehart.

McLoughlin, J.B. (1969) Urban and Regional Planning: A Systems Approach. London: Faber.

Metra (1970) Study of the Generation of Goods Vehicle Movement in Selected Town Centres.

Mills, E. (1974) Recent Developments in Retailing and Urban Planning. PRAG Technical Papers TP 3.

Mills, C. H., and D.W. Robinson (1963) The Subjective Rating of Vehicle Noise. Noise - Final Report of the Committee on the Problem of Noise, Cmnd 2056 HMSO, 173-185.

Mishan, E.J. (1970) "What is Wrong with Roskill?" J. Trans. Econ. Pol., 4, 3, 221-234.

------------ (1971) Cost Benefit Analysis. London: Unwin.

Morley, C.D. and J. Thornes (1973) "A Markov Decision Model for Network Flows." Geog. Analysis, 4, 2, 121-137.

Multiple Shops Federation (1964) Shopping Centres in North West Europe. London.

------------------------ (1968) Standards for Service Areas in Shopping Centres. London.

Needham, D.B. (1971) "The Cost Benefit Fallacy." OAP, 34, 1, 47-50.

OAP (1967) Theme Feature on Shopping. OAP, 30, 8 August, 1967.

OECD (1971) Urban Traffic Noise. Paris: OECD.

------ (1973) Environmental Implications of Options in Urban Mobility. Environment Directorate, Paris:OECD.

------ (1974) Streets for People. Paris: OECD.

O'Flaherty, C.A. (1973) People, Transport Systems and the Urban Scene - An Overview Parts 1 & 2. in, Rose, J. Wheels of Progress London: Gordon and Breach, 37-74.

Older, S.J. (1968) "Movement of Pedestrians on footways in Shopping Streets." Traff. Engng. Control, 10, 4, 160-163.

O'Riordan, T. (1975) Some Comments on the Importance of Public Participation in the Evaluation of Environmental Quality. JURUE Research Seminar on Environmental Quality, March 1975.

Orski, K. (1974) Practical Experience. in, Streets for People. Paris: OECD, 41-48.

Pearce, K. and C. Stannard (1973) The Catford Traffic Management Study. Vols. 1 & 2 G.L.C. 1973.

Perraton, J. (1972) Evaluation as Part of the Planning Process. LUBFS WP 33.

------------ (1973) Plan Evaluation: A Review of Research. LUBFS WP 67.

Peters, G.H. (1974) Cost Benefit Analysis and the Third London Airport. in, Lessons of Maplin. IEA Occasional Paper 40.

Peterson, G.L. et al, (1974) "Assessment of Environmental Impacts: Multidisciplinary Judgements of Large Scale Projects." Ekistics, 218, January 1974, 23-30.

Pickering, D. (1975) The Quantification of Environmental Impact for Strategic Evaluation. JURUE Research Seminar on Environmental Quality, March 1975.

Planning (1975) Assessing Environmental Impact Analysis. Planning 117, May 30, 1975.

Plowden, W. (1971) The Motor Car and Politics in Britain. Penguin Edition.

Prest, A.R. and R. Turvey (1965) "Cost Benefit Analysis: A Survey." Econ. J., 75, 683-735.

Proshansky, H., W. Ittelson and L. Rivlin (1970) Environmental Psychology: Man and His Physical Setting. New York: Holt, Rinehart and Winston.

Radcliffe, J.W. (1973) Traffic Engineering as an Aid to the Protection and Improvement of the Environment. Monograph 18 I.M.E..

Rees, F., et al, (1975) An Investigation of Shifts in the Attitudes of Pedestrians Using a Shopping Street After the Implementation of a Major Traffic Scheme. JURUE Research Seminar on Environmental Quality, March 1975.

Richards, B. (1974) Approaches and Techniques. in, Streets for People. Paris: OECD, 7-28.

Ritter, P. (1964) Planning for Man and Motor. Pergamon Press.

Schiff, M. (1970) Some Theoretical Aspects of Attitude and Perception. Natural Hazard Research Working Report 15, University of Toronto.

Scholes, W.E. and J.W. Sargent (1971) Designing Against Noise from Road Traffic. BRE Current Paper 20/71.

Self, P. (1970) "Nonsense on Stilts: Cost Benefit Analysis and the Roskill Commission. Pol. Q. 1970.

Seneca, J.J. and M.K. Taussig (1974) Environmental Economics. New York: Prentice Hall.

Sewell, W.R. (1971) "Environmental Perception and Attitudes of Engineers and Public Health Officials." Environment and Behaviour, 3, 23-56.

----------- and B. Little (1973) "Specialists, Laymen and the Process of Environmental Appraisal." Reg. Stud., 7, 2, 161-171.

Sharp, C. (1973) Living with the Lorry. Freight Transport Assoc./ Road Haulage Assoc. London.

Sherwood, P.T. and P.H. Bowers (1973) Air Pollution from Road Traffic: A Review of the Present Position. TRRL Report LR 352.

SIA (1971) TRESS (Trip Restraint System) User Manual.

Silzer, V. (1972a) The Situational Analysis of Human Behaviour: A Critical Review. Dept. of Geography York University, Toronto (Unpublished).

---------- (1972b) Personal Construct Elicitation in Space Preference Research. Discussion Paper 1 Dept. of Geography York University, Toronto.

Starkie, D.N. (1973) Transportation Planning and Public Policy. Progress in Planning, 1, 4, 313-389.

Stea, D. (1965) "Territoriality, the Interior Aspect: Space, Territory and Human Movements." Landscape, 15, 1, 13-16.

Stebbins, R.A. (1967) "A Theory of the Definition of the Situation." Can. Rev. Anthrop. & Soc., 4, 148-164.

--------------- (1969) "Studying the Definition of the Situation: Theory and Field Research Strategies." Can. Rev. Anthrop. & Soc, 6, 193-211.

Suttles, G. (1968) The Social Order of the Slum: Ethnicity and Territory in the Inner City. Chicago: University of Chicago Press.

Strauss, A. (1961) Images of American Life. Glencoe: The Free Press.

Stringer, P. (1973) Some Remarks on Peoples' Evaluation of Environments. in, Wilson, A.G. (ed) Patterns and Processes in Urban and Regional Systems. Pion.

Thompson, B. and P. Hart (1968) "Pedestrian Movement: Results of a Small Town Survey." JTPI, 54, 4, 338-342.

Thorpe, D. (1970) The Goods Traffic Generated by Supermarkets. PTRC Summer Conference.

TRRL (1970) A Review of Road Traffic Noise. The Working Group on Research into Road Traffic Noise. RRL Report LR 357.

------ (1972) Bus Priority. Proceedings of a Symposium held at the Transport and Road Research Laboratory TRRL Report LR 570.

Upshaw, H.S. (1968) Attitude Measurement. in, Blalock, H.M. and A. Blalock (eds) Methodology in Social Research. New York.

Vass, P. (1972) Environmental Evaluation. PTRC Summer Conference.

Vickerman, R. (1972) "The Demand for Non-work Travel." J. Trans. Econ. Pol.,2, 176-210.

Walters, D. and B. Lawson (1973) The Effects of a New Motorway on an Established Residential Area. JURUE Internal Seminar.

Warr, P. and C. Knapper (1968) The Perception of People and Events. New York: Wiley.

Weiner, P. and E. Deak (1972) Environmental Factors in Transportation Planning. Heath Lexington: Mass.

West Midlands Transportation Study (1968) Stage 1 Report Volumes 1 & 2 (Freeman, Fox, Wilbur Smith and Associates).

-- (1971) Developing Policy for Transportation.

-- (1972) A Transportation Plan for 1981.

-- (1974) Stage 2 Report Volumes 1, 2 & 3.

Whitbread, M. (1970) Towards an Economic Assessment of the Environmental Costs of Urban Motorways. PTRC Spring Conference.

White, G.F. (1972) "Environmental Impact Statements." Prof. Geogr., 24, 4, 302-309.

Williams, H. (1975a) Environmental Evaluation: Some Key Issues. JURUE Research Seminar on Environmental Quality, March 1975.

----------- (1975b) Policy Options in Transport and the Environment. JURUE Research Seminar on Environmental Quality, March 1975.

----------- (1975c) A Classification of Evaluation Methodologies. JURUE Research Seminar on Environmental Quality, March 1975.

Williams, W.M. (1973) The Impact of New Roads on the Community. PTRC Summer Conference.

Wilson, A., et al, (1969) New Directions in Strategic Transportation Planning. Centre for Environmental Studies WP 36.

Wood, A. (1974) Norwich, England. in, Streets for People. Paris: OECD.

World Health Organization (1969) Urban Air Pollution With Particular Reference to Motor vehicles. WHO Report 410.

Znanieki, F. (1965) Social Relations and Social Roles. San Francisco: Chandler.

ADDENDA

City of Birmingham (1968) Shopping Development: Birmingham. City Planning Dept. January 1968

Harrison, J. and P. Sarre (1971) "Personal Construct Theory in the Measurement of Environmental Images." Environment & Behaviour, 3, 4, 351-373.

OECD (1975) "Better Towns With Less Traffic". Proceedings of an OECD Conference, April 1975, Paris.