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ASSESSMENT OF DISRUPTIVE EFFECTS ASSOCIATED WITH URBAN TRANSPORTATION TUNNEL CONSTRUCTION

Abt Associates Inc.
55 Wheeler Street
Cambridge MA 02138

JUNE 1976
FINAL REPORT

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION ADMINISTRATION
Office of Research and Development
Washington DC 20590

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16. Abstract

Social, economic, and environmental impacts resulting from tunnels' being constructed for mass transportation purposes in urban areas are identified. A matrix is constructed identifying the locus of costs to affected groups by four kinds of causal agents: traffic interference, property takings, environmental disturbances, and utility disruptions. A separate matrix must be constructed for social, economic, and environmental costs. The cells of the matrix must be further expanded in order to pinpoint actual costs: variables must be identified for each affected group and each causal agent and measures for the variables determined. One row of the economic matrix and one row of the social matrix are expanded by way of example: economic costs to retail businesses and social costs to residents. The measurement and aggregation of impacts are then discussed. Four possible ways of lessening impacts are mentioned: good planning and institutional procedures, proper community relations, the use of advanced construction techniques, and the utilization of monetary compensation.

Two small case studies are included: the construction of the Waterfront station by WMATA in Washington, D.C. and the extension of the Picadilly Line in London to Heathrow Airport. Directions of possible future research are indicated.

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PREFACE

This study was prepared by Abt Associates Inc. for the Rail Technology Division, Office of Research and Development of the Urban Mass Transportation Administration, U.S. Department of Transportation, under contract with the Transportation Systems Center in Cambridge, Massachusetts.

The report is the work of many persons: Howard Birnbaum had special responsibility for the economic parts of the work; Malcolm Fitzpatrick addressed the environmental problems, and Judy Goldberg took on the social aspects. Billy Salter was instrumental in developing the matrix described in Chapter 4, while Peter Scholnick was particularly helpful in the data collection. The report was written by Peter Wolff. Stephen J. Fitzsimmons gave invaluable help in reviewing the design and the writing of this report, but any remaining errors are the responsibility of the author.

Two subcontractors, Parsons, Brinckerhoff, Quade & Douglas and London Transport Executive, contributed a great deal. We thank Robert Burlin of Parsons and D.G. Jobling of London Transport for their professional and timely help. Copies of the reports prepared by the subcontractors are available at the Transportation Systems Center.

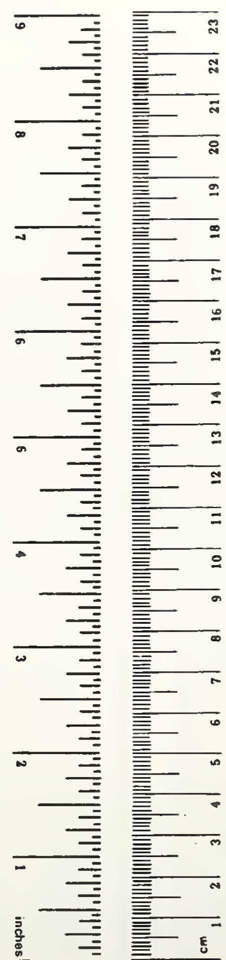
We also want to thank the many persons who responded to our questions about tunnel disruptions. We must single out the Washington Metropolitan Area Transit Authority as being particularly helpful and candid in the information they made available. We are grateful to Attorney Charles S. Fax for his help in locating some of the documentation of residents' concerns about the construction of the Waterfront Station in Washington, D.C.

Many persons at the U.S. Department of Transportation extended themselves to help us. We wish to thank Gilbert Butler of the Rail Technology Division of the Office of Research and Development of UMTA and Paul Abbott of the Environmental Design and Control Division of FHWA for their assistance. Special thanks must go to the technical monitors for this contract at the Transportation Systems Center, Glen Larson and Gerald Saulnier. Their help in supervising, criticizing and checking this work is deeply appreciated.

METRIC CONVERSION FACTORS

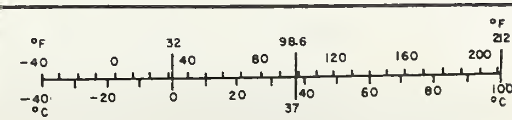
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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CONTENTS, continued

CONTENTS, continued

ILLUSTRATIONS

1. INTRODUCTION AND OUTLINE OF REPORT

1.1 PURPOSE OF THE REPORT

This report is concerned with the assessment of the disruptive effects associated with urban transportation tunnel construction. Specifically, it addresses three separate but connected objectives: first, the identification and classification of social, economic, and environmental impacts; second, the measurement of impacts; third, initial steps in the development of a methodology for assessing the impacts that may be expected in a transportation tunnel project.

The title of the report makes clear that it focuses on three precise aspects of a tunnel project.

a. The tunnels considered are those being built in urban areas for transportation purposes, including rapid transit and highway. Tunnels are built for many other purposes, for example, for sewers, utilities and water. While there may be many similarities between tunnels constructed for different purposes, only rapid transit tunnels were considered here.

b. The effects being considered are those alone which are due to the construction phase of the tunnel. There are many effects arising from completed and operative subway and highway tunnels which deserve attention, for example, the noise and vibration generated in them. Here, however, only the construction effects are being studied.

c. All of the effects studied are disruptive effects. This arises from the fact that the effects are those due to the construction process. There are no positive or beneficial effects that arise from the construction of the tunnel as such.[1] However tempting

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[1] This statement is not completely accurate. There are a few benefits that may occasionally accrue from tunnel construction. Construction workers may spend money at lunch time and thus help some local merchants. The very disruption of the construction may provide an opportunity and occasion for redevelopment of an area. The former effect is probably insignificant in size, while there may be some argument as to whether redevelopment is really a benefit.

it may be to consider the beneficial effects of the completed project and to try to trade them off against the disruptions of the construction, that was not our purpose here.[2]

1.2 DESIGN OF THE STUDY

The initial research was done through a review of the relevant literature. The books and reports that were read are reviewed in some detail in Chapter 2. The literature dealing just with tunnel construction is not large, except for works of a purely engineering nature. Nevertheless, we were able to collect data--from works that deal with tunnel construction peripherally, such as environmental impact statements for tunnels--on impacts of the construction. In addition, we were able to gather some information on measures of the impacts and the methodologies for assessing the impacts from works on tunnels and other construction projects.

The next step was to devise a conceptual framework into which the identified impacts could be fitted. A matrix was devised which arrayed potentially disruptive factors on one margin, and potentially affected persons or groups on the other. By repeated applications of the matrix, it was seen to be possible to display disruptive effects of all kinds (social, economic, and environmental). By a detailed elaboration of the cells of the matrix, it becomes possible to discuss the variables that comprise each disruptive effect, the measurement of each variable, and possible ameliorative steps that might be taken.

The third step consisted of testing the applicability of the matrix of disruptive effects in a few real life tunnel construction projects. Some data on actual tunnel construction disruptive effects were therefore collected. This was not a large-scale data collection, nor was it meant to be exhaustive

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[2] It is very difficult, when collecting data from affected persons or groups, to have them restrict their perceptions to the effects of the construction only. Almost all such respondents immediately begin to trade off the disruptive effects of the construction against the anticipated benefits of the completed subway. If the respondent perceives himself as benefitting from the subway, he tends to be more tolerant of the construction disruption. If, on the other hand, he anticipates no future benefit to himself or his family, he is likely to be all the stronger in his perception of the disruptions he has to suffer.

even of one kind of effect. The data were collected through interviews with persons involved in constructing tunnels (persons working for transit authorities, engineers, and contractors), and with persons disrupted by the construction (local residents and merchants). Other data were collected from site inspections.

The data collection indicated that the conceptual framework--the matrix and its expansions--was indeed suitable for classifying the disruptive impacts, indicating on whom they fall, what the size of the impacts is, in what general area the disruptive effects bring about costs, and how those costs might be lessened. References to the data collected are scattered throughout the chapters in which the matrix is discussed. It appears, therefore, from the data that the conceptual framework is one which is applicable to reality and one which can be used in the future to study disruptive effects of tunnel construction in one or more large-scale, ongoing tunnel projects.

1.3 ORGANIZATION OF THE REPORT

This introductory chapter is followed by a lengthy chapter presenting the results of the literature search. This serves as the basis for much of what follows. In Chapter 3, certain background matters are discussed that must be kept in mind as one begins the assessment of disruptions. These are such things as the situation existing prior to the commencement of construction, the "no build" alternative, the distinction between primary and secondary effects, and some special considerations such as the role of time, in assessing impacts.

In Chapter 4, we present the matrix of construction impacts, which serves to display the loci of social and economic costs to different groups, as caused by different disruptive agents. Since the matrix is very large, with a total of 165 cells, we use the next two chapters (Chapter 5 and 6) to go into considerable detail for some of the cells. In Chapter 5, we expand the entire row of the matrix concerned with retail businesses: we explore the kind and size of disruptive effects which the various disruptive agents bring about for retail businesses in the <u>economic</u> area. In Chapter 6, we expand the entire row of the matrix concerned with residents: we explore the kind and size of disruptive effects which the various disruptive agents bring about for residents in the social area. In both Chapter 5 and Chapter 6, we discuss the variables that comprise the cost (whether it be economic or social) and the measurements that have to be taken to assess the size of the impacts.

Chapter 7 then deals with the problem of measuring impacts in general, with sections devoted to measurement of economic, social, and environmental impacts. In Chapter 8, we deal with how to aggregate impacts in order to arrive, if possible, at a total assessment of the disruptive effects.

Chapter 9 discusses some ways in which the disruptive effects of tunnel construction might be lessened. These are ways that became apparent in the course of both the literature search and the data collection. In Chapter 10, we present two small case studies. The first one deals with the impacts arising from the construction of the Waterfront Station by WMATA in Washington, D.C. The second one describes the extension of London's Picadilly Line from West Hounslow to Heathrow Airport. Both case studies are based on real-life observation of impacts and have added interest because the mitigating devices discussed in Chapter 9 were sometimes utilized and sometimes not.

Chapter 11, finally, discusses directions of possible future research. It indicates a two-fold need: one is for some theoretical studies in order to strengthen the methodological approach of the impact assessment; the other, for some fairly large-scale data collections in order to be able to forecast impacts of future tunnel projects.

2. LITERATURE REVIEW

The initial research for this report consisted of a review of relevant literature. Our purpose was to collect data on disruptive effects of tunnel construction that have been reported in a variety of works. Many of these works were reports on research previously undertaken for government agencies. However, there are not many books or reports that concentrate heavily on rapid transit tunnels and their construction; there are none that focus precisely on the disruptive effects arising during the construction phase of a rapid transit tunnel project.

The literature which we collected and examined, therefore, was that which touched on tunnel construction and its disruptions but did so in a more general context. Every environmental impact statement, for example, that is prepared in accordance with the National Environmental Policy Act is required to address both long-term and short-term effects of the project under consideration. Effects due to the construction of a facility are explicitly mentioned as among the primary impacts to be listed.[1] (In fact, however, the EISs which we examined treated the construction effects in very sketchy fashion only.)

Another very likely source for data on construction effects was the BART Impact Program, "a comprehensive, policy-oriented study and evaluation of the impacts of the San Francisco Bay Area's new rapid transit system (BART)." This valuable program, nevertheless, largely ignored construction effects. Its focus was the impact of the completed transit system; furthermore, it was not begun until 1970, when the largest part of the subway construction had already taken place.

In most of the literature, in other words, it became necessary to search for and find the few remarks about the effects of disruptions arising from the construction that were hidden within a different and much larger context. There was one notable exception to this: this was a series of newspaper articles (from the Atlanta Journal and Constitution) that dealt specifically with disruptions already caused in Washington, D.C. by WMATA's

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[1] Preparation of Environmental Impact Statements, Final Regulations, Section 6.304(c)(2). Federal Register, Vol. 40, No. 72, April 14, 1975, p. 16819.

construction and the similar anticipated effects in Atlanta from MARTA's soon-to-begin digging. This series provided a number of interesting examples of disruptive effects; it was, of course, a journalistic and not a full-fledged research effort.

The items from the literature which we examined were divided into seven categories, as follows:

1. Assessment of Social, Environmental and Economic (SEE) Impacts and Forecasting Methodologies
2. Environmental Impact Statements and Analyses
3. Studies on Tunneling Techniques
4. Noise and the Environment
5. Social Impact Assessment Methodologies and Survey Results
6. Articles from Newspapers and Periodicals on Reported Transit Tunneling Disruptions
7. Background Literature from Books and Technical Journal Articles.

2.1 SOCIAL, ENVIRONMENTAL AND ECONOMIC (SEE) IMPACT ASSESSMENT AND FORECASTING METHODOLOGIES

In this section, three major studies are treated that deal with the methodological issues of SEE impact assessment in urban transportation tunneling projects. They include reports on both highway and rapid transit tunneling, as well as a methodological study dealing with the "no build" alternative in the transportation planning process.

Planning Environmental International, Division of Alan M. Voorhees. Investigation and Recommendation of Guidelines for Reducing Environmental Impacts Related to Urban Rapid Transit Tunneling. Draft Interim Report, Office of Research & Development Urban Mass Transportation Administration, Washington, D.C. February, 1975.

Abstract

The report presents an inventory of the social, economic and environmental impacts associated with rapid transit tunneling as well as recommended measures which can be adopted to mitigate such adverse effects. The document identifies its audience as "transit authority planners and consultants, design and specification engineers, resident engineers, regulatory agencies, contractors, and insurance companies and safety consultants," in short, all those individuals and groups who are involved with the implementation of a rapid transit tunneling project. While the draft states its recognition of the trade-offs involved in reducing disruptive impacts versus rapidly completing the project, there is little discussion of these trade-off issues in quantitative terms.

Relevance

The authors of the report state that it should be thought of as "an encyclopedia for guidance on reducing environmental impacts during the rapid transit tunneling process." The study does identify the various adverse impacts associates with each phase of the major types of tunnel construction: cut-and-cover, soft ground tunneling, rock tunneling and open-water tunneling. It also aggregates disruptive impacts by type, such as noise, traffic disruption, ground stability, terrestrial biota, etc., and in turn correlates these with the various construction events from which they stem. While the effort to catalogue the various disruptive impacts has been exhaustive, the findings and recommendations are usually of a rather general nature.

One of the real achievements of the report is the identification of roles and responsibilities of the various actors involved in the tunneling process along with recommendations for making that process more sensitive to the issues of impact and more responsive to those individuals who are suffering the disruptive effects. The critical role of building needed regulation into the bid and contracting phase of the process is discussed; the need to have the contractor prepare an environmental control plan is mentioned, as is the need to incorporate into the process mechanisms for monitoring and inspection to insure that procedures, agreed to in the contract, are carried out.

The report also makes important recommendations concerning the need for increased community participation and liaison activity, particularly with respect to the dispensation of information to those who will be impacted. Of interest to our study is the analysis of the SEE impacts generated by both cut-and-cover and underground tunneling procedures. The dollar cost of implementing the various recommendations of the report are also, to some extent, provided.

David A. Crane and Partners/Boston, et al. The No Build Alternative. Social, Economic and Environmental Consequences of Not Constructing Transportation Facilities. National Cooperative Highway Research Program of the Transportation Research Board, Washington, D.C. December, 1975.

Abstract

The research project was commissioned with a three-fold purpose: to define what is commonly referred to as the "no build" alternative; to clarify its role in the transportation planning process; and to assess the adequacy of current methodologies used to predict its consequences. Throughout the report the "no build" alternative is referred to by the acronym NCTF which stands for Not Constructing a Transportation Facility. Included in the report was a literature search which included a thorough review of well over one hundred environmental impact statements. The study team also surveyed state transportation officials throughout the country relative to the state of the art for the definition and evaluation of the "no build" alternative. The authors undertook four comprehensive case studies which examined four major NCTF projects, in order to assess the impact of the decision as well as the role of the NCTF option in the decision-making process. The end product of the study effort was a set of guidelines to be used for the definition and assessment of the NCTF alternative in the future.

The report contends that the state of the art in using the NCTF alternative both for impact forecasting and analysis and as a component of the decision making process is highly deficient. The NCTF alternative is often not seriously considered but used by project planners as a method of project justification. Further in cases where the NCTF alternative is given serious consideration, methodologies for prediction of social, economic and environmental impacts are rarely developed or adequately utilized.

Relevance

The major emphasis of the report, and one which has direct transferability to a consideration of tunneling impacts, is the analysis of impact prediction methodologies which is included both in Chapter 1 of Part 1 and in Appendices A, B, and C of Part 2 of the report. The various methodologies currently utilized in impact forecasting were rated in the report in terms of adequacy. Also of importance was the analysis of the plan evaluation process, in terms of the problems presented by the superimposition of the personal values of the transportation planner in the process. Of particular interest to our study is Chapter 4, which identifies "gaps" in the state of the art of social and economic impact assessment methodology.

Alan M. Voorhees and Associates, Inc. A Study of Social, Economic and Environmental (SEE) Impacts and Land Use Planning Related to Urban Highway Tunnel Location. (Interim Report) Office of Research, Environmental Design and Control Division, Federal Highway Administration, Washington, D.C. April, 1975.

Abstract

The concern of this report is the development of analytical procedures for the identification and assessment of social, economic and environmental (SEE) impacts associated with urban highway tunnel construction. The focus of the study is the formulation of a framework in which highway planners and decision makers can weigh the costs and benefits associated with tunneling rather than surface construction of highway segments in the urban context. The focus of the report is impacts as received by "non-users" of the facility, typically in inner city neighborhood. Similarly, the type of facility analyzed is non-local in character, that is providing little or no service to the area through which it passes.

The unit of geography which the study employs for purposes of analysis is the neighborhood. Six different types of neighborhoods are presented according to various socio-economic characteristics for use in impact forecasting, for example, "working class single family" or "skid row." The study is heavily oriented toward sociological methodology, particularly in its presentation of an index of neighborhood cohesion, complete with an equation for calculating intra-neighborhood accessibility. Using a model developed for impact prediction, the report's authors were able to draw conclusions such as that ethnic, middle class single family and working class single family neighborhoods are among those most disrupted by the barrier effect of an urban expressway.

Relevance

The model developed in the report is appropriate for evaluating the extent of disruptive or adverse impacts of various design alternatives, such as cut-and-cover construction versus earth tunneling. The stated purpose of the model is to enable the planner/decision maker to best evaluate the trade-offs and arrive at the most desirable configuration. A major shortcoming of the model is that it fails to incorporate the critical characteristics of the specific area into the predictive process. For example, an ethnic middle class single family neighborhood which is characterized by instability and rapid turnover may be more adversely impacted by an expressway project than one which is stable. Thus the degree of stability, as expressed in the turnover rate in the period prior to construction, is an important piece of data which should be incorporated in the predictive process. Also important, and absent in the report, are the attitudes of residents toward the project: do they see themselves as potential users or nonusers or do they have fears that the facility will bring undesirable elements into the neighborhood?

The study is further limited in its failure to factor in the issue of time. While the project is concerned with post-construction rather than construction or pre-construction impacts, nonetheless it fails to acknowledge the fact that the nature of the post-construction impacts will be influenced by the extent and duration of the construction. Moreover, the post-construction impacts may be subject to variation over time. It is reasonable to assume that they may be different six months or two years after project completion depending upon a variety of factors.

Despite these limitations, the report is valuable in its consideration of transportation tunneling impacts, in terms of its approach to impact forecasting and assessment. The model which is presented has applicability to rail transit tunnel construction. Further, its concern with quantifying neighborhood cohesion and its typology of neighborhoods is of utility and has important transferability in the measurement of the social, economic and environmental impacts of urban transportation tunnel construction.

2.2 ENVIRONMENTAL IMPACT STATEMENTS AND ANALYSES

The largest single source of literature on the SEE impacts of rapid transit tunneling are the environmental impact statements and analyses prepared for various rapid transit projects which are currently either planned or ongoing.

Section 102(2)(c) of the National Environmental Policy Act (NEPA) of 1969 specifies that an Environmental Impact Statement be formulated concerning major federal action which can be expected to affect the quality of the human environment. Specifically, the Act requires that a detailed statement be filed which:

1. Identifies the environmental impact, both human and natural, of the proposed project.
2. Presents any adverse unavoidable impacts resulting from project implementation.
3. Presents alternatives to the proposed action, including the "no build" or no action alternative.
4. Discusses the relationship between local short-term use of the environment and its long-term maintenance and productivity.
5. Discusses the loss of any irretrievable resources should the project be implemented.

UMTA's Office of Program Planning issued a memorandum (Memorandum UMTA 5610.1), dated February 1, 1972, which established "internal procedures and policy for the Urban Mass Transportation Administration (UMTA) regarding the preparation of detailed Environmental Statements on proposals for major Federal action significantly affecting the environment."

The memorandum defines the areas of concern which need to be addressed in an environmental impact statement as follows:

"(1) General. Effects of UMTA actions which ordinarily should be considered as significantly affecting the environment include, but are not limited to:

-- actions involving significant taking of land, change in the use of land (particularly if it requires a change in zoning), or major construction.

-- material effect on the amount of land required to be devoted to transportation and related purposes in the future.

-- significant increase or decrease of traffic or congestion levels on streets and highways.

-- division or disruption of an established community; division of an existing use (e.g., cutting off residential areas from recreation areas or shopping areas), or disrupting orderly, planned development.

-- a substantial aesthetic or visual effect, especially on areas of unique interest or scenic beauty.

-- displacement of a substantial number of people or businesses.

-- a noticeable change in the ambient noise level for a substantial number of people.

-- direct or indirect contribution to substantial changes in the level, composition or distribution of air pollution.

-- destruction or derogation of important recreational areas not covered by section 4(f) of the DOT Act.

-- disturbance to the ecological balance of animal or natural resources.

-- involve a reasonable possibility of substantially altering or contaminating public resources, e.g., public water supply source, treatment facility or distribution system.

-- substantial physicial disruption during construction.

(2) <u>Actions always significantly affecting the environment</u>.

-- any action that is likely to be controversial on environmental grounds.

-- any action involving the acquisition or use of a public park, recreation area or wildlife refuge, or any land from a historic site.

-- any action falling under section 106 of the Historic Preservation Act."

In its concluding section, the Memorandum states that all applicants for UMTA capital assistance (such as transit authorities that wish UMTA assistance in building rapid transit tunnels) must submit certification to support the following findings:

"(1) Adequate opportunity was afforded for the presentation of views by all parties with a significant economic, social or environmental interest.

(2) Fair consideration has been given to the preservation and enhancement of the environment and to the interests of the community in which the project is located.

(3) A specific statement that there is no adverse environmental effect of the project or there is no feasible and prudent alternative to such effect and all reasonable steps have been taken to minimize such effect."

Additional legislation applicable to the preparation of an environmental impact statement for a rapid transit construction project includes

Section 4(f) of the Department of Transportation Act of 1966. This deals with projects which will impact publicly owned park or conservation lands, or properties of established architectural or historical significance. If such properties are to be impacted by a tunneling project, the impact statement must identify measures planned to minimize any potential harm. In addition, a specific statement must be included that there is no "feasible and prudent alternative" which would avoid impacting the 4(f) area entirely. Also to be complied with in the implementation of the project as expressed in the environmental impact statement, are Section 309 of the Clean Air Act, which accords the Environmental Protection Agency review authority over project related air pollutants, and Section 106 of the Historic Preservation Act which stipulates that the Advisory Council on Historic Preservation grant prior approval of projects which will impact properties listed on the National Register of Historic Places.

The various environmental impact statements which follow are not uniform in their consideration of the social, environmental and economic impacts of tunnel construction. Some of the documents deal with this issue in only a very brief and general fashion, while others handle the requirement more completely. As a general rule, the impacts most fully considered are environmental ones, with economic impacts treated less completely, and social impacts only mentioned briefly.

The EISs reviewed below come from five cities: Atlanta, Baltimore, Buffalo, Chicago, and Washington, D.C.

Metropolitan Atlanta Rapid Transit Authority, Draft MARTA Environmental Impact Statement, Volume 1. Atlanta, Georgia. October, 1972.

Abstract

This is the first volume in the three volume MARTA Environmental Impact series. This volume consists of the Draft Environmental Impact Statement (EIS) and was prepared in accordance with the relevant federal laws and guidelines. In addition to dealing with the various items identified in these regulations, the volume also includes, in a synopsis fashion, information on social, economic and environmental impacts of the proposed

project, both short-term and long-term, which are presented in a more detailed manner in Volumes II and III.

In accordance with the statutes, the document considers many of the larger impact issues of the completed project. These include unavoidable adverse impacts, irreversible and irretrievable commitments of resources associated with the project, as well as special consideration of impacts on historical and environmentally sensitive areas covered under Section 4(f). Project justification and an analysis of short-term versus long-term environmental effects of the project are included. Of special note are two chapters which deal with citizen participation and the environmental review process (Sections VII and X).

Relevance

While construction related project impacts are covered in the document, their treatment is often of a brief and nonspecific nature. The principal categories of construction impact discussed are: noise, utility disruption, vibration, air quality, water quality, and solid waste generation. Measurement techniques are suggested for the monitoring of excesses of construction related noise and the use of special equipment designed to muffle such excesses is stipulated. With respect to project related dust, the employment of emission control devices and dust suppression measures is insisted on as part of standard operating procedures.

The most extensively considered construction related impact is the generation of solid wastes as a by-product of both demolition and excavation. The report calculates the anticipated volume of excavation debris from the project, both in aggregate figures and by line segment. The nature of the waste materials is analyzed and guidelines for its proper disposal are included. A similar treatment is accorded to the problem of the disposal of excavation spoils. Existing state and local legislation governing the disposal of solid waste materials is cited and a model municipal ordinance designed to safeguard communities from improper dumping is also included. The report recommends that much of the waste material could be safely utilized as land fill at the Atlanta International Airport, pursuant to correspondence received from the airport's director.

Metropolitan Atlanta Rapid Transit Authority, Draft MARTA Environmental Impact Statement; Volume 2, Technical Appendices. Atlanta, Georgia. October, 1972.

Abstract

This section of the MARTA EIS concerns itself principally with a socio-economic impact assessment of the proposed rapid transit project. The study document places major emphasis on the impacts which the proposed project will have on land use, with a view toward determining the extent to which the project will influence future growth patterns, causing perhaps an intensification of activity around various nodes created by the construction. The consistency of this anticipated development with the long and short range planning goals of the metropolitan area is also discussed. Further, instances of possible joint community development and transit construction are explored in considerable detail with the intent of maximizing opportunities for enhancing existing land use by creating new community facilities and amenities.

Within the body of the report, each station area and line segment between stations is comprehensively discussed, first in terms of base line data, including a presentation of existing land use characteristics within a half-mile service area as well as a brief assessment of its social and economic characteristics. The nature of the anticipated changes which the transit line will have on the area in terms of development, as well as an identification of specific socio-economic impacts, both positive and negative, associated with these changes is presented. In separate sections the negative impacts associated with each of these line segments are analyzed in more detail, using a phase time frame of pre-construction, construction, and post-construction activities. Moreover, beside each negative impact identified according to time phase are recommended ameliorative measures designed to mitigate such impacts. In presenting negative socio-economic impacts in this fashion, the report scores some important achievements. By breaking out impacts along a time line and by identifying them in a micro, neighborhood-specific way, the recommendations become readily translatable into the construction plans of the project. Further the endeavor to marry community development goals with the construction of the project is highly

significant as an approach to mitigate, in some equitable fashion, those negative impacts which are unavoidable.

A sensitivity to the needs of those potentially impacted by the project's various alternatives is displayed in the relocation section. Here individual properties are listed in three categories: those to be possibly taken, those falling outside the taking line but significantly impacted by construction activity, and those which may be disrupted by such effects as noise, dust and change in neighborhood amenities. The report also discusses, in a data specific way, the ability of the metropolitan housing market to provide equivalent housing for those displaced. It further advises that a diagnostic survey be undertaken to determine the actual needs of the relocatee families and to pair them with the available supply.

On a line sgement specific basis, the report identifies the anticipated impact of the proposed alternatives on various community services including the following: primary and secondary educational facilities, colleges and universities, park and recreational facilities, police protection, utilities, health facilities, major public buildings, libraries, fire protection and social service agencies. In a rather comprehensive manner, the study inventories all of the above facilities by location within the proposed impact area, and identifies what impacts, if any, might be anticipated, be they of a positive or negative nature. In addition, the impacts are listed by phase of the project, pre-construction, construction and post-construction. The respective impact is also labeled as primary, secondary or tertiary.

The section on economic impacts is presented in a rather general macro scale. The chapter is primarily concerned with weighing the impacts which the finished project will have on the metropolitan economy, in terms of generating expansion in the number of jobs and amount of new construction. While the characteristics, in the aggregate, of the businesses to be dislocated are presented, tha authors never differentiate between businesses to be taken versus businesses to be adversely impacted. The problem of persons left unemployed by dislocation is dismissed with the comment that they will readily find re-employment in view of the anticipated expansion of the economy. The problems associated with small businesses being "priced out" of their location because of increases in rental rates is also surfaced as an "unavoidable" negative impact. Nowhere in the section are ameliorative measures suggested for the relief of small businesses adversely impacted by construction activity.

The volume closes with a lengthy chapter on visual impacts. The section takes the reader on a narrative tour of the proposed system. Its visual impact on the adjacent area is presented, along with recommendations designed to improve its visual appearance and mitigate against any adverse intrusion. What is missing, however, is any discussion of visual impacts associated with construction activity, along with appropriate techniques for the mitigation of adverse effects, associated with such activity.

Relevance

This environmental impact statement, though oriented most heavily toward post-construction impacts, is nonetheless useful, from a methodological point of view, in a consideration of construction-related impacts. Exhaustive data were generated on the areas and neighborhoods to be impacted. A matrix is then presented which identifies the nature and extent of impacts on major components of the affected neighborhoods. Both data and matrix would be useful for the assessment of construction as well as post-construction impacts.

Alan M. Voorhees & Associates, Inc. Baltimore Regional Environmental Impact Study, Technical Memorandum No. 7, Summary Analysis and Evaluation. Interstate Division for Baltimore City, Baltimore, Maryland. March, 1974.

Abstract

The report is concerned with evaluating the environmental impacts of various highway and transit alternatives for the Baltimore metropolitan area. The functional areas used for impact assessment were:

1. Socio-economic and Land Use Analysis
2. Travel Simulation and Traffic Analysis
3. Air Quality Analysis
4. Water and Solid Waste Analysis
5. Noise Analysis
6. Analysis of Environmentally Sensitive Areas.

In addition to evaluating the various system alternatives with respect to the above areas listed, the report included separate calculations for both short term alternatives (1980) and long term impacts (1995). Separate findings were recorded not only for the City and its suburbs, but also for various sub-areas called "regional planning districts" in the report and equivalent in the urbanized area to neighborhood units.

Relevance

The memorandum does not concern itself with the SEE impacts of a particular segment of transit line or highway in the construction phase *per se*; consequently construction related issues are never surfaced independently in the document. Nonetheless, the report has a degree of transferability from the point of view of the methodological approach taken. For example, the report provides a framework in which to quantify the projected impacts of the various modal alternatives on traffic congestion within the region. Mean strip speed and traveling time for various commutation patterns within the region were considered in terms of the impact which the different alternatives would be forecast to have. In addition, user costs were calculated for each of the different transportation alternatives. Items considered were as follows: daily vehicle miles of travel, daily vehicle hours of travel, daily time cost, daily operating cost, daily accident cost, daily total travel cost and annual travel cost. This methodology has direct application to an aggregation of the dollar cost of traffic disruption caused by a transit tunneling project.

Air Quality. With respect to air quality, the EIS recognizes that changes in pollution levels within the region will be produced by several factors, including source controls on vehicular and stationary sources, land use and development plans, and transportation policy, all of which will in turn be affected by the implementation of the State's air quality plan. Nonetheless, the EIS provided forecasts for anticipated pollution by type, though on an aggregate basis, and by year, 1980 and 1995. The types of pollutants considered, on a tons per year basis, were carbon monoxide, hydrocarbons, nitrogen oxides, particulates (all of which are emitted from motor vehicles), and other project related air pollutants including photochemicals and oxidants. The need to separate out various air pollutants by type is crucial, in view of the fact that some types of pollutants increase with motor vehicle congestion while others remain fixed. While the techniques used for forecasting pollution levels are regional in scope, they could be modified to apply to a smaller area, such as a tunnel impact corridor, by selected data gathering.

Economic Impacts. In discussing economic impacts, the report deals most in those impacts which are the result of the completed project rather than the construction phase. As a result, few of the indicators chosen have transferability to the construction phase of a project,
starts, population and employment shifts, etc. What does have applicability in terms of a regional assessment are items such as payrolls, retail purchasing power and retail sales. While such indicators have little real project related meaning on the metropolitan wide basis, they become significant when translated to the actual impact corridor. A comparison of the impact area economy with that of the metropolitan area could be meaningful in that it could surface the sectors which may be suffering decline, such as a downtown business/retail area, as compared to those areas which, when considered in the aggregate, may be experiencing project-related improvement, such as the entire SMSA.

Storm Water Management/Water Quality. The EIS found that the problems associated with storm water runoff and non-point source water pollution generated by runoff, the sedimentation of streams, would be greater with the highway than with the transit alternative. Transit, when considered as an alternative to highway construction, produces far less runoff related environmental problems. As regards the construction of transit tunnels, the cut-and-cover method produces far more sedimentation as a result of exposing soil to runoff, than tunneling wherein fewer areas are exposed.

American Bechtel, Inc. et al. Environmental Impact Analysis, Chicago Central Area Transit Project. Chicago Urban Transportation District, Chicago, Illinois.

Abstract

This rather massive document constitutes the formal Environmental Impact Analysis (EIA) for the proposed central area rapid transit project in Chicago, a project which includes both a subway and distributor. The

report includes background information on the City's transportation history as an introduction to the origins of the project. After a presentation of the physical characteristics of the system, the project impacts--social, economic and environmental--are identified both in terms of short-term or construction related impacts and long-term post-construction impacts. In accordance with UMTA guidelines, unavoidable adverse impacts are listed along with cases involving irreversible resource commitments. Short-term and long-term trade-off issues are considered both independently and within the context of alternatives and modifications to the proposed system. A chapter is also included on citizen participation and its role in the environmental review process.

Relevance

Those portions of the EIA most relevant to a consideration of the SEE impacts of transit tunneling are those which deal with short-term or construction related impacts. Some impacts are discussed in a more comprehensive and specific manner than others. For example, the authors devote considerable attention to the anticipated economic losses resultant from construction disruption. The problems associated with spoils disposal are presented in an equally specific fashion. Of special significance in the EIA is a forecast of the role which construction time periods play in the magnitude of adverse impacts, particularly with respect to economic losses. Presented in a more general manner are such impact categories as noise, vibration, air pollution, visual quality and quality of life.

While a temporary decline in retail sales within the impacted area is forecasted, on a metropolitan or regional scale such losses will be minimal. They will tend to be offset by increased economic activity generated by the actual project produced through the multiplier effect of increased construction-related employment and purchases. The EIA did, however, identify the commercial establishments which face probable losses because of certain characteristics. For example, establishments which serve the day-to-day needs of a neighborhood such as laundromats and corner variety stores, tend to be far less vulnerable than small retail shops within a commercial district which operate on a narrow margin and are dependent on casual or impulse sales. Eating and drinking establishments largely dependent on evening trade are also among the most likely to suffer, according to the report. Such vulnerable commercial establishments were identified in the report both by general location and type. It is of interest to note that in many cases the very type of business which suffers most during construction also benefits most after construction because of the advantages of access to a transit station.

The EIA notes that some businesses may either temporarily or permanently vacate an area to avoid the effects of the construction. The costs which these establishments are forced to bear are rarely calculated in an assessment of the costs of tunneling disruption despite the fact that they are very real and can, to a large extent, be quantified. The document states that in cases where the construction lasts less than six months no occupancy declines are likely, while in cases where the construction activity lasts for a year or longer, certain non-prestige office buildings can expect to experience declines in occupancy (p. 56). Thus, anticipated losses due to vacancy do not vary linearly with time. If the rate of vacancy were plotted on a graph, a critical time period would be identifiable after which significant numbers of vacancies result. The sensitivity of the graph to declines in occupancy is, of course, a function of several things which include price, quality and location of competitive space elsewhere as well as the locational requirements of the tenants. For example, in cities which are experiencing a boom in office building construction one might expect that such declines in non-prestige space would be more significant than in cities which have little office space available and little activity in the construction of new facilities. This factor was not dealt with in the report.

As a method of reducing the problem of access to businesses generated by the construction, the report offers several recommendations which have applicability to other cities: Parking spaces might be provided on the periphery of the central area and a shuttle bus provided to transport persons between the two points. Other options include transit authority assistance in organizing car pools as well as the possibility of a free or reduced fare shopping bus to service the impacted area.

With respect to the problem of spoils disposal, the report insists that any plan formulated must conform with existing regional land use plans. One suggestion offered was the use of spoils to provide fill for the development of new recreation areas adjacent to Lake Michigan. In the case of dumping spoils into the lake, special precautions should be taken to avoid pollution. The suggested measures include the use of double-walled impermeable breakwaters and an internal pervious diking system for the dewatering of spoil and treatment of the resulting leachates. The possibilities of potential littoral drift depletion resulting from the filling operation were also considered.

In summary, the report is highly useful in that it considers various issues associated with impact forecasting, for example, the non-linearity of time, which are rarely surfaced in such documents. The level of detail provided in the identification of both impacts and the ameliorative measures necessary for the lessening of their effects is also notable.

Environmental Services Department, Bechtel Associates Professional Corp. Applicant's Environmental Impact Analysis. Niagara Frontier Transportation Authority. June, 1974.

Abstract

The report presents, in a concise, comprehensive and logical fashion, a discussion of the social, economic and environmental impacts, both short term and long term, of a proposed 11 mile rail rapid transit line (including 8.4 miles of underground construction), in metropolitan Buffalo, New York. In addition to a discussion of the physical characteristics of the proposed system, the report provides detailed baseline information relative to the physical, biological and socio-economic characteristics of the study area.

The Niagara Frontier Transportation Authority (NFTA) study is notably complete in its consideration of short-term or construction related impacts across the full range of physical, biological and socio-economic indicators. Of particular importance is the study's thorough consideration of the construction impacts on surface water quality and hydrology, and its identification of potential soil disposal sites. Construction related noise and ground-borne vibration, along with mitigation techniques, are presented in a somewhat quantitative and site specific manner. Also worthy of special mention is the effort to employ quantitative measurement techniques to assess construction impacts on the quality of life through utilizing 14 quality of life categories as a base line, developed from A Study in Comparative Urban

Indicators: Conditions in 18 Large Metropolitan Areas, by Michael J. Flax. One of Flax's study areas was metropolitan Buffalo.

Relevance

Adverse construction related economic impacts are insufficiently considered such as those experienced by businesses which suffer losses due to impaired access. Unlike the Chicago Environmental Impact Statement, no effort was made to forecast business revenue losses either by geographic location and/or by type. Also rather sketchy was the discussion of the impacts of construction activity on community services. While community services were defined by functional category and in a site specific manner relative to the established one mile wide corridor, little consideration was given as to which community services would be impacted more than others, as a result of their locational and client characteristics.

The effort to quantify the impacts of the project on the quality of life through the use of Flax's index is of great methodological interest. This particular index, however, is of too macro a scale to be transferable to the assessment of construction related impacts on a neighborhood.

Wallace, McHarg, Roberts and Todd. Environmental Impact Study: Greenbelt Route E; Volume 2, Part 3, Section E006 to E008; Appendix. Washington Metropolitan Area Transit Authority. March, 1975.

Abstract

This study is part of the Washington, D.C. environmental impact series. Originally, no environmental impact statements were filed for the Washington Metro, because Congress had funded the project prior to the enactment of the Environmental Protection Act. Legal action, however, forced WMATA to prepare environmental impact statements.

Because the series was undertaken after the fact, many of the elements commonly associated with an EIS were not included, such as the consideration of the social and economic impacts of the construction activity. The report does draw attention to four sources of construction related environmental impacts:

a. Emissions from construction vehicles

b. Construction induced traffic congestion

c. On-site earth work and spoils removal

d. Fugitive particulate matter from demolition activity.

Emissions from Construction Vehicles. The report notes that while construction vehicle pollutants will make an insignificant effect on regional air quality, localized conditions may be significant, given a heavy concentration of construction vehicles accompanied by adjacent vehicles stalled in construction related traffic jams. Variables to be considered in forecasting such pollutants include vehicle model and year; the more recent the equipment, the more sophisticated the emission control devices. In view of the wide range of variables to be considered, the authors of the EIS do not forecast equipment related pollutant levels. Included, however, is a chart which presents hourly pollutants by type typically associated with various models of heavy equipment used in construction.

Construction Induced Traffic Congestion. The EIS report recognizes the fact that congestion induced by construction activity has the potential to increase pollution emissions in the immediate vicinity of construction sites. Although such an increase may have local significance, it is doubtful that it will effect regional levels in a significant way. The localized increases are due to the fact that automobiles emit more carbon monoxide at lower speeds than at higher speeds. For example, an automobile traveling at 15 mph emits 26% more carbon monoxide than while traveling at 20 mph. Similarly hydrocarbon emissions from automobiles increase by 18% when vehicle speed is reduced from 20 to 15 mph. It is also noted that exhaust emissions of nitrogen dioxide decrease with a decrease in speed while the levels of suspended particulates remain relatively constant with changes in speed. Therefore, the report concludes that construction-induced congestion will create no particular adverse impacts on local or regional concentrations of suspended particulates or nitrogen dioxide. The critical factor in forecasting congestion is the extent to which impacted streets will exceed their design capacity as a result of tunneling-related delays (V/C ratio). The report goes on to identify actual street segments which may become severely congested and consequently may be faced with a significant increase in air pollutants. In fact, one area is identified as anticipating a 423% increase in such concentrations, while another is forecast as having only a 36% increase (these increases are expected only during adverse meteorological conditions). A chart is included which related pollutant levels to traffic congestion.

The EIS notes, in a general way, that such high localized concentration levels can be reduced by the adoption of various traffic control measures. And, further, in view of the fact that such concentrations will only be experienced for a short time period, they should be accorded little weight in a consideration of various design and route alternatives.

On-site Earth Work and Spoils Removal. The report states that segments which involve ancillary parking facilities will have greatest potential for the generation of fugitive dust materials. Such activity, particularly when it involves formerly vegetated hillsides, has the added potential of inducing erosion and storm water runoff which may increase non-point source water pollutants in localized streams.

In addition, cut-and-cover techniques were described as producing higher levels of fugitive dust both from the fact that greater areas of excavation are exposed and greater volumes of spoil are generated by the process.

Demolition Related Pollutants. Often in the clearing of a right of way for transit tunneling activity, entire buildings or building foundations require demolition. A specialized problem may occur when buildings in which asbestos materials have been used are taken. The asbestos fibers can produce harmful effects on human respiratory tracts when they become airborne. In addition, similar problems have surfaced with respect to the demolition of steel structures which have been repeatedly painted with toxic lead-based paint. The federal government has outlined special regulations governing workers safety in working around such areas. These have been published in the Federal Register No. 66, Vol. 38, April 6, 1973.

Methods of Impact Mitigation. The EIS identifies four methods by which fugitive air pollutants (dust) can be controlled and reduced:

a. restriction of vehicle flow on unpaved surfaces,

b. watering twice a day during periods of highwinds and construction activity,

c. minimizing the period during which the cleared and regraded lands are exposed, and

d. minimizing the period when spoils are stored in the immediate vicinity of the construction site.

Relevance

Even though the report does not consider the full range of social, economic and environmental impacts associated with tunnel construction, it is very useful for its discussion of the impact on air quality of the four sources listed above. In particular, the effort to disaggregate and quantify different types of air pollutants is significant. The discussion of impacts derived from building demolition is important, as is the consideration of the problem of asbestos fibers and toxic lead-based paint, not discussed in other EISs.

2.3 STUDIES ON TUNNELING TECHNIQUES

Four reports are presented in this section. They serve both to familiarize the reader with the physicial steps involved in the tunneling process as well as the nature of the primary impacts associated with the various elements in the construction process. Two of the reports deal with state-of-the-art issues in the construction process while the other two are technical studies which assess the feasibility of various tunneling techniques for the construction of particular rapid transit projects. Considered in each are the parameters of cost, technical feasibility and impact.

Sverdrup & Parcel & Associates, Inc. Cut-and-Cover Tunneling Techniques. Office of Research, Federal Highway Administration, Washington, D.C. February, 1973.

Abstract

This report consists primarily of a state-of-the-art review of various cut-and-cover tunneling techniques as practiced both in the United States and abroad. The study was undertaken with the supposition that despite the advances in earth tunneling technology which have occured in recent years, cut-and-cover will continue to be used in future years in a variety of situations where other methods, principally earth tunneling, are infeasible. In the case of rapid transit tunneling, these include the excavation of line segments with shallow configurations, and station construction.

The underlining purpose of the study was in part to contribute toward the wider usages of new technology which typically is drawn from European examples throughout the report. The study looks at various methods of achieving ground-water control, ground-wall support, (including freezing and chemical injection methods) excavation, structural control, permanent structure construction and restoration. Various decking techniques, of both a temporary and permanent nature are fully explored. Further, each of the various alternatives is analyzed according to cost and attendant problems associated with each.

Relevance

A brief chapter in the report is devoted to methods for the abatement of primary and secondary construction impacts, including techniques for mitigating construction related noise, dust and vibration. Pertinent regulatory statutes relating to disruption associated with construction activities are identified, including laws governing payment of damages to businesses that suffer losses as a result of such disruptive activity, as well as various health, safety and environmental laws.

Data used in the preparation of the report were gathered from two principal sources, a review of existing literature and interviews with a number of individuals who have had practical experience in the construction process. According to the authors, the interviews were valuable in that they included information on construction techniques not yet written about in available literature as well as negative information concerning the drawbacks of the various construction techniques. The report is liberally illustrated with photographs of the different technques discussed. The photographs add much to an understanding of the methods presented.

The utility of the report to a study of the SES impacts of transit tunneling is twofold. First, integral to such a study is an understanding of the tunneling process. This report contributes in a significant way to the development of such an understanding. Secondly, many of the disruptive effects of the tunneling process can be mitigated through the use of improved technology, and this study provides important information, often drawn from foreign sources, concerning new techniques.

Metropolitan Atlanta Transit Authority, Evaluation of Alternative Construction Modes for MARTA's Central Line: Marietta Street to North Avenue. 1975.

Abstract

This report was prepared after the storm of controversy which arose in Atlanta over the decision to build the central segment of the new rapid transit system using cut-and-cover techniques. In an effort to justify the decision to recommend cut-and-cover rather than earth or rock tunneling techniques, the document analyzes the three alternatives according to a number of criteria. The various criteria could be grouped as follows: (a) transit system requirements, (b) environmental impacts, and (c) construction requirements and costs.

Items included under operational requirements were the functional aspects of the vehicle, its speed, heat generated, station interface requirements and needed support facilities. Also considered under system requirements was patronage--basically the logistics involved in moving passengers from street level to platforms. Considered under environmental impacts were three types of primary impacts: soil stability and the need to underpin various structures, utility dislocation, and spoils removal. Under the heading of construction requirements and costs, the bearing capacity and general suitability of the subsurface material relative to the various construction alternatives were analyzed, along with the grade variance requirements dictated by the design of the system as a whole. Finally the estimated costs associated with each of the construction alternatives were calculated for comparison purposes.

Relevance

The major recommendation of the study is that the Broad Street portion of the line in the downtown area should be constructed by cut-and-cover techniques in view of the tremendous cost differential, estimated at either $19 or $36 million less than the two tunneling alternatives. The authors were also of the view that while cut-and-cover does result in greater surface level disruption, tunneling in this instance carried with it the high probability of subsurface complications such as foundation settlement and utilities disruption. Overall station and system design and grade problems were a final justification for the cut-and-cover recommendation.

The study provides an excellent example of the issues that are involved in a decision whether to use cut-and-cover or tunneling techniques. The report could perhaps be criticized for its failure to incorporate all of the disruptive impacts, such as traffic disruption and loss of business, associated with cut-and-cover methods rather than tunneling. Nevertheless, some of the costs which it did consider, such as those of underpinning buildings which primarily are incurred with tunneling, are important in developing a better understanding of the trade-offs involved in such a decision.

Sverdup & Parcel & Associates, Inc. Preliminary Tunneling Studies Report for Red Line Extension Cambridge-Somerville. Massachusetts Bay Transit Authority, Boston, Massachusetts. April, 1972.

Abstract

This report, which was completed in April of 1974, provides a technical assessment of the feasibility of tunneling the extension of the Red Line rapid transit line beyond Harvard Square, Cambridge via three alternative routes to Alewife Brook Parkway in Cambridge. In considering the various alignment alternatives, one of which included a routing through Davis Square in Somerville, the authors evaluated the suitability of various tunneling and construction techniques as appropriate to each alternative. Cost estimates for each of the various construction alternatives were also provided for integration with the previously prepared socio-economic-environmental studies undertaken by the Boston Transportation Planning Review, specifically the Program Package Evaluation Report and Draft Environmental Impact Statement for the Northwest Region.

The major emphasis of the study is tunneling technology, with considerable attention paid to tunneling design issues, subsurface investigation both in terms of the suitability of subsurface soils and rock to the various types of construction contemplated and to the special problems generated by utility lines requiring relocation. Special attention was also paid to the problems of foundation settlement and the need to underpin adjacent buildings.

Relevance

While the entire study is valuable in a consideration of the SEE impacts associated with rapid transit tunneling from a case study point of view, of particular importance are three Appendices, which present state-of-the-art information on transit design criteria, subsurface construction and impact problems, and new developments in tunnel construction technology. The major emphasis of the investigation was on subsurface conditions as related to the suitability of cut-and-cover versus deep-bore tunneling techniques. Indeed, twenty-four test borings were taken in the study area to supplment the existing data base in order to provide more complete source material for the technical evaluation portion of the study.

Like the previous Atlanta report, this study is useful in developing an understanding, through consideration of an actual project, of the issues involved in the decision to use either cut-and-cover or boring techniques. Included is a valuable discussion of certain cost-saving technological advances in the boring process.

Bechtel Incorporated/San Francisco et. al. Systems Analysis of Rapid Transit Underground Construction; Volume I, Sections 1-5; Volume II, Sections 6-9. U.S. Department of Transportation, Office of the Secretary and Urban Mass Transportation Administration, Washington, D.C. September, 1974.

Abstract

The major emphasis of this two part study of the rapid transit tunneling process is the presentation in a sequenced fashion of the various stages involved in the actual construction of an underground system. The process is highly complex and its various steps are often difficult for the layman to understand. The study presents the process along a linear time line which correlates with illustrations of the actual construction activity. Each step is numbered on both the flow charts and illustrations to assist in comprehension.

The two volumes also look at the various techniques of tunneling, including not only cut-and-cover and earth tunneling but also various types of earth tunneling techniques, including manual and machine excavation. A goal of the study was the improvement of the cost and efficiency of the entire process. To this end, each technique is evaluated according to these criteria. Indeed, models are included for the purpose of identifying the sensitivities to cost and time of the major components of the construction process. Attention is also paid to the physical characteristics of the environment in which the project takes place. Factors such as ground conditions, utility density, traffic conditions and settlement problems of adjacent buildings are discussed within the context of alternative construction techniques and procedures.

The second volume deals primarily with the planning and institutional factors which effect project time tables and costs. Some of the institutional factors which are discussed include pre-construction planning, right-of-way acquisition, project scheduling, material and equipment supply, agency roles and responsibilities, and labor agreements and productivity. In addition to describing in a detailed manner, the institutional processes required for project implementation, the authors make important recommendations for the streamlining of that process. Many of the recommendations have important implication in the mitigation of disruptive construction impacts through both reducing construction time and improving the ability of the system to respond to periodic problems which may arise.

For case study purposes, the authors present five tunnel construction projects, three from the BART system and two from WMATA in Washington, D.C. The individual projects were analyzed with respect to their adherence to time schedules, cost projections and the sensitivity to physical and institutional parameters. Data from the five case studies were also utilized in the formulation of analytical models designed for the evaluation of various construction techniques with respect to costs and impacts.

Relevance

The documents are useful to the consideration of construction related impacts in the sense that an improvement of the efficiency of the tunneling process, in both physical and institutional spheres, will most often result in a net reduction of construction related disruptions. Nonetheless, direct disruptive impacts resulting from construction are only briefly touched upon. It is further important to be mindful of the fact that efforts to improve the cost and operational efficiency of the transit tunneling process are not always consistent with measures designed to reduce construction related disruption.

A major achievement of the two volumes is the consideration of probability with respect to scheduling and costs. For example, the real cost in cut-and-cover construction may often be higher than anticipated because of delays which result from inclement weather conditions, delays in materials deliveries, etc. Techniques suggested for factoring in such probabilities can be useful in forecasting disruption-related impacts.

The analysis of the institutional process is valuable. Improving this process will not only reduce project time and cost, but also very often reduce disruptive impacts, because of the critical nature of time as an impact element.

2.4 NOISE AND THE ENVIRONMENT

One of the most significant and thoroughly researched disruptive impacts associated with transit tunneling is noise. Several large cities have recently enacted noise abatement ordinances, which stipulate allowable levels of dBA's for construction activity. These levels often vary by zone, depending on the density and land use characteristics of the zone. In addition, the Occupational Health and Safety Act (OSHA) has established noise level limits for workers on construction sites.

Two studies dealing with construction related noise are presented in this section. They deal both with noise impact assessment and with methods of lowering excessive levels. The other study is a technical manual for implementing environmental control measures in the planning and construction of underground rapid transit systems.

Foster-Miller Associates, Inc. A Preliminary Assessment of the Environmental Impact of Mechanical Equipment Associated with Urban Transportation Construction. U.S. Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts.

Abstract

The purpose of this study was three-fold: (1) to assess the adverse environmental noise impact produced by equipment in the transit tunneling process and by various methods and processes currently employed; (2) to analyze techniques available to reduce excessive noise impact in order to conform with current standards (these options include modification of existing equipment, substitution of alternative equipment and the use of new types of equipment designed to meet current requirements); (3) to critique new regulations and legislation governing allowable noise levels associated with the urban transportation tunneling process.

Within the report, noise generation was classified according to several schemes. First, noise produced in the various phases of the construction processes was discussed, from initial site preparation to the restoration of pavement. Next, noise generation was discussed in terms of types of equipment employed. A number of measurement techniques including on-site measurement were utilized to arrive at figures. Noise generation produced by a construction site in aggregate at various distances from the sources was also considered. These data were then plotted on a curve and compared with the curve of community reactions to equivalent noise levels. The authors also compared noise generated by different construction techniques. Although only cut-and-cover was considered, five cut-and-cover methods were analyzed both in terms of noise generated by phase of the process and in the aggregate.

Relevance

A major strength of the study is its consideration of the human environment in which the construction activity takes place. For example, in its consideration of "equipment management techniques," the study is sensitive to the time of day and to location in their effect on acceptable noise level as viewed by the community. Similarly important is the utilization of the previously mentioned community noise acceptance curve as reflecting the orientation of the report.

The report identifies pile drivers as the major source of excessive noise produced in cut-and-cover operations. The authors evaluate alternative approaches to effecting reductions in this source, including the use of newer, quieter equipment or alternative techniques including substituting the slurry wall method. The various alternatives are evaluated with a measure of pragmatism as are the effectiveness of different noise abatement regulations. The report's finding is that while such legislation has been responsible for the development of newer, quieter equipment on a cost-competitive basis, such regulations will, however, be ineffective in cases where suitable quieter equipment is not available on the market or where its cost is prohibitive.

Bolt, Beranek and Newman, Inc. Regulation of Construction Activity Noise. U.S. Environmental Protection Agency, Washington, D.C. November, 1974.

Abstract

This report was prepared to assist the Environmental Protection Agency in the formulation of a strategy for the reduction of excessive noise associated with construction activity, pursuant to the provisions of the Noise Control Act of 1972. Nine different strategies for the achievement of noise reduction were analyzed by the authors of the report with respect to determining technical effort and cost required. The target of the effort was to achieve a reduction in noise levels in residential areas to an annual outdoor day-night equivalent sound level (L_{dn}) of no more than 55 dBA and to an annual L_{dn} of 65 dBA in commercial districts. The nine public policy strategies identified in the report, which include options such as the requirement of sound reducing barriers and the regulation of the internal combustion engine, were evaluated according to nine criteria which included costs to manufacturers and end users, ease of enforcement, timeliness, and burden placed on the nation's resources. Information concerning the characteristics, relative to noise production, of twenty-two types of heavy equipment used in construction activity was included as data.

Relevance

The information provided on the noise emission characteristics of heavy equipment used in tunneling operations is highly relevant in the consideration of construction related environmental impacts. So, too, is information contined in Section 3 of the report which looks at the noise levels generated by various types of equipment in different phases of the construction process. In Chapter 4 a mathematical formula is developed for forecasting the impact of construction noise on areas of different population density within a metropolitan context.

Transit Development Corporation, Inc. et al. Subway Environmental Design Handbook, Volume I, Principles and Applications. Office of Research and Development, Urban Mass Transportation Administration, Washington, D.C. 1975.

Abstract

The publication is intended as a manual for the implementation of environmental control measures in the construction of underground rapid transit systems. The environmental criteria discussed include temperature, air quality, humidity, air velocity and rapid pressure change as well as noise and vibration. The report includes different design criteria for the various environmental parameters in the different segments of the system (stations, tunnels, vehicles). In addition to establishing environmental guidelines, the report includes methodologies for the computation of the achievement of design standards.

The intended reader of the document is the decision maker who has little technical background in the engineering components of the design process, as well as the technical person who is involved in system planning and construction. Though the work is intended for both readers, approximately 75% of the material included is of a highly technical nature. For example, Part 1 of the report provides background information and current operational characteristics of existing subway systems in both the U.S.A. and abroad, while in later chapters, mathematical methods of calculating the equipment requirements for heating, cooling and ventilation are provided.

Relevance

While the work is important in the development of an understanding of the operational characteristics of an underground rapid transit system, it provides little in the way of data on construction related impacts. To the student of construction impact, information concerning the siting requirements and operational characteristics of ventilation shafts can, for example, be important in the development of an environmentally sensitive system design. A plan which both respects the esthetic standards of the community and at the same time serves the functional requirements of the system can emerge through the dispensation of such information to both planners and community groups alike.

2.5 SOCIAL IMPACT ASSESSMENT METHODOLOGIES AND SURVEY RESULTS

This section first reviews three works on social impact assessment methodologies. Then follows a summary of the findings of two social impact surveys dealing with tunnel construction for the San Francisco Bay Area Rapid Transit System (BART). Finally, some works dealing with the social impacts of relocation are reviewed.

2.5.1 Social Impact Assessment Methodologies

Braddock, Dunn and McDonald. A Methodology for Analyzing Social Impact Public Policy. Vienna, Virginia. May, 1975.

Abstract

While the usual social impact analysis is undertaken concurrently with environmental and economic impact assessment as well as the assessment of technical feasibility and legal constraints, the methodological approach presented in this paper assumes that these other types of analysis have been completed and that data from each of these functional areas can readily be used as inputs into the social impact analysis. For example, economic data identified include changes in sales, costs, operating income, employment, investments, and industry structures for those industries which might be either directly or indirectly affected by a public policy action. All of these factors may result in changes of prices and products available to the consumer. Thus the authors include in their methodolgoical process economic input/output models for the assessment of possible economic "ripple effects." The method developed also requires the identification of the roles and responsibilities of relevant governmental agencies.

The approach of the monograph's authors is that policy assessment should be carried out in a cyclical rather than linear fashion, with a first

a. Individual, Personal Effects (Life, Protection, and Safety, Health, Family and Individual Attitudes, and Environment);

b. Community, Institutional Effects (Demographic, Education, Government Operations and Services, Housing and Neighborhood, Law and Justice, Social Service, Religion, Culture, Recreation, Informal Organizations, and Institutional Viability);

c. Area, Social-Economic Effects (Employment and Income, Welfare and Financial Compensation, Communications, Transportation Economic Base, Planning and Construction);

d. National, Emergency Preparedness Effects (Water Supply, Food Production, Power Supply, Water Transportation, Scarce Fuels, Population Dispersion, Industrial Dispersion, Military, and International Treaties); and

e. Aggregate, Social Effects (Quality of Life, Relative Social Position, and Social Well-Being).

Completion of the SWB Account requires five steps:

a. Description of the history of water resources of the area, and of the functions, activities, impact area, and schedule of alternative water plans;

b. Description of the planning area to be affected in terms of its history, present-day social profile, and life-style;

c. Identification of the future social impacts attributable to each alternative plan for each of the components and their evaluation categories;

d. Comparison of the future beneficial and adverse social effects of the alternative plans; and,

e. Recommendations of the plan with optimal future social well-being effects on the plan area.

Ultimately, the optimal water development will be a function of the combined social, economic, regional, environmental, and regional effects.

Relevance

The Social Assessment Manual was developed in order to prepare the social well-being account for water development projects, in the context of the Bureau of Reclamation's multi-objective planning. The manual is also useful, however, for the assessment of social impacts arising from any large scale construction project, including rapid transit tunnels; for example, in order to prepare an environmental impact statement.

2.5.2 BARD Surveys

Gruen Associates, Inc., De Leuw Cather & Co. Preliminary Draft Environmental Project, BART Impact Program Pre-BART Data Analysis. March, 1975.

Abstract

The information contained in the report was obtained during the course of surveys conducted in June and July of 1972, subsequent to most of BART's construction but prior to its operation. 2531 respondents were surveyed on a random basis within one mile of the entire system, while 616 individuals were polled in 30 special sites usually within 1/8 mile of the line. Survey results expressed by impact element were as follows.

Residential Turnover. Although reports of moving in the study area were very substantial, virtually none were reported as being BART related (p. 3.).

Frequency of Anti-BART Actions. The greatest frequency of anti-BART actions took place within an eighth of a mile of station construction which included adjacent parking lot development. These actions run counter to an overall majority of pro-BART activity. On the whole the more property takings involved in parking lot construction, the greater the opposition. Respondents' view was that the parking lot represented a loss of a portion of the neighborhood, that it imposed a physical barrier to access and that it resulted in anticipated negative traffic and environmental effects.

Incidence of Reported Negative Impacts Associated with Tunneling. Respondents located near tunneling construction were as much as twice as likely (up to 60%) to report negative impacts. This contrasts with a very low incidence of such reported impacts in either at-grade or aerial segments. It is further of interest to note that the frequency of reported negative impacts was lowest at aerial configurations, with at-grade alignments falling between the other two.

Correlation between Perceived Impact and Distance from Construction. Virtually all reported construction impacts tended to subside with increased distance from BART. For most types of anticipated impact, there was a marked decrease in frequency about 1/4 mile from BART. Beyond that point the level

of concern became insignificant. For future surveys, the author concludes that a distance of 1/4 to 1/2 mile is probably adequate. It is important to note that respondents were far more concerned with the existence of a line near their home either at grade or elevated than they were with a subway. The incidence of negative responses toward the completed line among those living near subway portions did not vary either appreciably or consistently with distance.

Traffic Impact Incidence (Auto). The only impact element which showed no correlation with locational factors was traffic. This implies that the construction acted as a barrier to both local and regional auto trips with origins and destinations throughout the entire area of study, rather than affecting only those who lived or worked near the alignment.

Correlation of Anticipated Use with Attitudes toward System and Sensitivity to Construction Impacts. Persons expecting to use BART tended to be much more optimistic than others concerning the nature of both the construction impacts and the impacts to be generated when the system came on line. Indeed, this finding was one of the strongest and most consistent of the entire survey, tending to overshadow other factors in formulating opinions.

The group which expressed negative attitudes toward BART's impacts was disproportionately represented by non-users (anticipated). In general 25% of the respondents not expecting to use the system felt that BART was a bad idea, in contrast to less than 5% of those expecting to use it. In addition, probable non-users tended to be much more critical of the adverse impacts during the construction phase than expected users.

Correlation of Age and Status with Perceived Impacts. Respondents anticipating more urban development as a result of BART tended to be younger, renters rather than owners, and live closer to BART stations than others.

Expectations that BART would improve an area's physical amenities tended to come from those who were older and planned to use BART more than others.

Fears of BART related "neighborhood deterioration," i.e., more traffic, dust, litter and undesirable people moving in, tended to come from younger individuals who did not expect to use BART and who lived closer to railroads than did others in the same general proximity to stations. This general attitude of pessimism also was found among poorer, less educated persons who felt less able to effect changes in their community, and who also primarily were renters living in more crowded dwellings near freeways, railroads and BART stations.

Environmental Impacts. Concern over environmental impact issues because of residence very near the BART lines and stations was not a dominant factor, even in the attitudes of those not expecting to use the system. There was no meaningful evidence that correlates with a belief that BART would cause a significant reduction in either freeway traffic or automobile related air pollution. Concern over noise impact tended to be greatest among those most exposed to the impact as a result of locational factors, and who felt least able to influence it.

Relevance

This study is highly significant in that it constitutes one of the few sources of "hard" data concerning public perceptions of the impacts of construction. Many of the report's findings are highly significant, such as the role of potential ridership to the attitudes expressed toward the extent of disruption caused by the construction. The definition of the parameters of the impact corridor by perception of impact is also important, as are the disaggregate correlations of impact perception by age, length of residency and home ownership. Many of the findings have important implications to the development of strategies and guidelines for impact mitigation.

Nasatir, David. The Social Consequences of BART's Environmental Impact: Some Preliminary Considerations and Hypotheses. Metropolitan Transportation Commission. Berkeley, California.

Abstract

The thesis of this paper is that disadvantaged persons, the elderly, poor and minorities, suffer most from the disruptive effects of transit tunneling despite the fact that such groups often have difficulty in articulating their concerns through conventional channels. The author bases his hypothesis on data obtained from the results of a BART sponsored survey entitled Urban Residential Environmental Study. One of the major findings of the study was that persons whose family income is under $10,000 are more than twice as apt to report that their ability to get to places on foot was made more difficult by the construction than those with incomes over $10,000 (p. 3).

In the same study, for 17 out of 18 different kinds of inconvenience and disruption about which residents were questioned, long term residents, a high proportion of whom were elderly, often reported adverse effects. The one exception was access to work.

In so far as the impact of the construction on crime is concerned, while few respondents overall saw any correlation, long term residents tend to make the association more often than those whose length of resident was shorter.

This paper claims that since control over the environment has been a traditional symbol of privilege in Western society, uncontrollable intrusion, particularly if it is man-made, is personally debasing. However, to the extent to which the individual identifies with the origin of the intrusion, it may seem neutral or positive.

In general, perception of BART induced environmental changes will result, the author says, in attitudinal and behavioral adjustments that tend to compensate for any associated losses in self-perceived status.

Relevance

This study, like the previous one, documents the importance of attitude toward a project in influencing perception of impacts. This has important implications for the critical role of community relations and public participation in project design.

2.5.3 Social Impacts of Relocation

One of the social costs associated with most tunnel projects is the impact of relocation. Though tunnel construction, by its nature, usually involves far less relocation than construction of an at grade facility, still takings are often required at station locations and other sites where properties conflict with the system design. Current statutes and regulations do much to adequately compensate persons whose residence is taken. Businesses are less adequately protected, because they must often absorb the temporary costs of lost business resultant from the move.

The literature presented below is useful in developing a greater understanding of the relocation process and its costs. Extensive surveying was involved in two of the studies, which contributed to the development of a data base from which many of the conclusions concerning the long-term psychological effects of relocation can be drawn.

Fitzgerald, Ellen et al. Social Services and the Effects of Relocation: A Comparison of Intervention Strategies; Relocation with and without Intensive Social Services.

Abstract

Two of several unpublished reports based on research conducted by the Division of Psychiatry at University Hospital, Boston, and the Boston Redevelopment Authority on relocation in Boston's Southwest Corridor between 1967 and 1972.

The research, sponsored by the National Institute of Mental Health, focused on the extent to which relocation and associated family problems could be mitigated by the provision of intensive social services. The studies found that no matter how intensive the social services, the relocation program was of limited usefulness because it depended, in the final analysis, on the existing housing market.

The study is useful in illuminating various kinds of disruption experienced by relocatees, but should be examined in the light of the fact that the project for which they were displaced was a highly controversial highway, and the housing market into which the families had to relocate was an extremely tight one.

Wilson, James Q. "Grieving for a Lost Home," Urban Renewal: The Record and the Controversy. M.I.T. Press, Cambridge, Massachusetts. 1967.

Abstract

This study of the psychological effects of relocation on former residents of Boston's West End Urban Renewal area has become a classic in relocation literature. The subjects of the study were long-time residents of a closely-knit community. Although displacement for a transit project would not be likely to involve an entire neighborhood, as urban renewal often did, the impacts on households are often very similar.

Mogey, John et al. Social Effects of Eminent Domain. Massachusetts Department of Public Works and Boston Redevelopment Authority. July, 1971.

Abstract

This exhaustive study examined a wide range of residential, demographic and social characteristics of households displayed by public action in Boston's Southwest Corridor. Social system theory was used as a framework for analysis. The unit of study and analysis was the household, which was studied at two points in time: before and after relocation. Project data available in agency files was used, supplemented by direct interviews. In 1969, 550 "before" interviews were completed--the total number for which project records were available. Only 102 were available for an "after" interview, because of the moratorium on highway construction and further involuntary relocation declared by Governor Francis Sargent on February 2, 1970. These 102 households constituted the panel and data analysis focused on them.

Statistical techniques used were factor analysis and regression analysis.

The study found that relocation is followed by four independent types of change: change in social contentment, changes in anomie, change in housing condition, change in sociability.

It also found that no change took place in many household characteristics which had been expected to change in the relocation planning phase of the highway project. Some variables in which no significant change was found were: household size or composition, number of rooms lived in, distance from community facilities, household tenure, occupations or journey to work. Significant changes did occur, however, in the proportion of income spent on housing costs.

The report made a significant contribution in its identification of the most powerful explanatory variables. It found that relocation variables

which referred to aspects of the relocation service were the most powerful and that the strongest predictors of change came from certain combinations of predisposing and relocation variables. It indicates possible directions for further primary data research.

Relevance

All three studies in this section point out that there are certain social costs which individuals bear when they are relocated, and that certain types of individuals are more vulnerable to the social and psychological costs than others. The elderly and the poor are among those who have the greatest difficulty in adjusting to a move and often require the follow-up services of a social worker.

2.6 NEWSPAPER ARTICLES

Actual examples of the disruptive effects of transit tunneling are rarely found in the literature. Recently, however, some articles have appeared in newspapers and periodicals which offer such examples, though the treatment is, of course, journalistic in style.

"'MARTA'--Ready or Not," The Atlanta Journal, June 15-22, 1975.

This special series, which appeared in both the daily and Sunday editions of Atlanta's newspaper, provides a wealth of information, much of it of an anecdotal nature, on actual and anticipated social and conomic impacts associated with transit tunnel construciton. The actual examples are drawn from a series of interviews which the Atlanta Journal's reporters conducted in Washington, D.C. among individuals whose business or residence was located adjacent to the construction activity. Fears of anticipated disruptive impacts were articulated by members of Atlanta's downtown business community and its public officials who, in the wake of the Washington experience, forsaw similar difficulties occuring in Atlanta's pending project. Many of the construction related problems discussed elsewhere in the literature are cited in the context of specific examples. Problems such as the out-migration of businesses in anticipation of construction, and the loss of commerce due to the problem of poor access are mentioned. Examples of disrupted pedestrian, bus, auto and truck traffic are included, as are cases of excessive noise and dust in neighborhood areas which serve to make them less tenable. The reporters also discuss, in a general way, the impacts associated with various tunneling techniques, i.e., cut-and-cover, open-trench, and deep bore. The deficiencies of temporary sidewalks and wooden street decking are frequently surfaced, as are the problem of mud, dust and unesthetic construction equipment within the impacted retail district.

It is important to observe that the data contined in the newspaper series were of a journalistic rather than a scientific nature. Many of the comments, accordingly, are somewhat sensational and many reflect a degree of exageration which is not uncommon in such interviews. Notably absent were the remarks of persons within downtown Washington who felt little adverse impact from the construction, such as the Connecticut Avenue merchants near the Mayflower Hotel. Despite this journalistic biase, the series is useful in providing documentation of a subject area rearly covered in the media.

"Atlanta's Transit Plan Hits Snag," The New York Times, November 12, 1975.

Many of the financial, labor and impact problems which are currently facing the Metropolitan Atlanta Rapid Transit Authority (MARTA) in its effort to implement its rapid transit project are touched upon in this article. In particular, the fears of disrupting the downtown business community through impacts resulting from open trench or partically covered cut-and-cover tunneling techniques are highlighted. The specific issue of the type of tunneling method utilized downtown, was the subject of a special study undertaken by MARTA in response to community pressure. Indeed, as the article points out, the growth of new problems facing the Authority has succeeded in eroding much of its previous public support.

"Atlanta's Transit Trauma," Business Week, August 18, 1975.

The primary issue discussed in the article is the financial uncertainty surrounding the reimbursement levels which MARTA can anticipate in the construction of its rapid transit system. This uncertainty, as the article points out, has somewhat clouded the real estate development market in midtown Atlanta's Peachtree Center area. There is also concern among downtown retail establishments relative to the impacts of construction on their future planning schedules.

The issue of cut-and-cover versus open ditch construction of the downtown portion of the subway is also brought up, particularly with respect to the impact which the loss of front door access will have on the many businesses which have only a single entrance. Additional concern is evident, through interviews, over the duration of adverse construction impact, which is estimated at approximately two and one-half years.

2.7 BACKGROUND LITERATURE

TUNNEL CONSTRUCTION

Pequignot, Clifford A., ed., Tunnels and Tunneling. London, Hutchinson Press, 1963.

A basic textbook on tunnels. One chapter describes cut-and-cover process (with example of Toronto subway) and "tube" or bored tunnels. Fairly easy to understand and includes diagrams: examples of subways and their various sizes, carrying capacities, etc. are given.

"Tunnels," McGraw-Hill Encyclopedia of Science and Technology, Vol. 14, pp. 161-163. McGraw-Hill Publishers, New York, 1971.

Three pages giving overview of tunnel construction and relevant terms.

Marc, R. C., "The Underground Routing of Urban Highways," Roads and Road Construction, V. 49, Nos. 578-9, March 1971.

Advantages of underground highways and the problems--how deep, access, shape of tunnel and method of construction ventilation, lighting, terminals. Only interesting for general information.

SOCIOLOGY OF NEIGHBORHOODS

Lee, Terence, "Urban Neighborhoods as a Socio-Spatial Scheme," Human Relations, Vol. 21. 1968.

Sociological article discussing how to define a neighborhood. Interviews were conducted of residents of Cambridge, England, and residents drew maps of the area which they considered their neighborhood. Useful for definition of different types of neighborhoods.

Warren, Roland L., Studying Your Community, Free Press, New York, 1955, 1965.

Checklists for the community planner or organizer on how to define economic, political, social, etc., characteristics of a given community. Useful for general information.

MEASURING COMMUNITY VALUES AND ATTITUDES

Stein, Martin M., "Application of Attitude Surveys in Transportation Planning and Impact Studies: A Case Study of Southwest Washington, D.C." Traffic Quarterly, January 1975.

One example survey reveals relationship between attitudes toward freeway and distance from it, and attitudes and different physical designs of freeway. Discussion of telephone survey vs. personal interview. Good basic article on surveying citizen attitudes and applying results to transportation planning.

Weiner, Paul, and Edward J. Deak, "Non-user Effects in Highway Planning," sponsored by Committee on Social, Economic, and Environmental Factors of Transportation and presented at the 50th Annual Meeting, Highway Research Record, No. 354, 1971.

A methodology is given for measuring citizens' concerns and the trade-offs among concerns for highway projects. Thirty impact categories were used, drawn from public hearings, attitude surveys and academic work. A questionnaire was administered to regional planners and to community representatives, in which they ranked the importance of various impacts, categorized into aesthetic, economic, political, land use, health and safety, and social-psychological impacts. These impacts were then classified as stable, conditional, or volatile and important or unimportant. A somewhat detailed analysis of the results of this methodology used in one state (Connecticut) is given. The impact categories and ranking system are transferable to considerations such as tunneling.

Shaffer, Margaret T., "Attitudes, Community Values, and Highway Planning," paper sponsored by Committee on Community Values, Highway Research Record, 187, 1968.

Differentiates between citizen opinions and attitudes and suggests survey techniques to get at attitudes which are more stable and reliable than opinions.

Fielding, Gordon J., "Structuring Citizen Involvement in Freeway Planning," sponsored by the Committee on Social, Economic, and Environmental Factors or Transportation, Highway Research Record, #380, 1972.

Proposes methods for "value analysis." Appendix gives lists of possible impacts in social, economic, traffic and design.

Appleyard, Donals and Mark Lintell, "Environmental Quality of City Streets: The Residents' Viewpoint," sponsored by Committee on Social, Economic, and Environmental Factors of Transportation and presented at the 50th Annual Meeting, Highway Research Record, #356, 1971.

Three streets with varying traffic levels in San Francisco were observed and residents were interviewed. On an anecdotal basis certain generalizations are made about how certain groups react to noise, hot rodders, and heavy traffic. Residents were also asked about their sense of privacy and home territory, neighboring and visiting and identify and interest of their neighborhood. Results were fairly predictable: higher sense of community in neighborhoods with less traffic, frustration of residents at noise in heavily-trafficked neighborhoods. Diagrams of residents' movement patterns around the street may prove useful.

Socio-economic Study of a Proposed Rail-Like Rapid Transit System for the St. Louis Metropolitan Area. Volume I & II, East-West Gateway Coordinating Council, St. Louis, Missouri, February 1972.

Discusses user and non-user anticipated impacts and community reaction to proposed rapid transit system. Non-user effects discussed are land value changes, increase in employment for construction, environmental effects and augmentation of Civil Defense shelter capacity.

INNOVATIVE TUNNELING TECHNIQUES

"Traffic Goes Up as Tunnel Goes Down," Engineering News-Record, September 22, 1966, p. 43.

The article describes the technique during the construction of a cross-town highway tunnel in Paris, France, wherein the existing traffic was temporarily diverted onto a special elevated structure built above the walls which line the banks of the Seine River.

"Two Canadian Cities Go Separate Ways in Building Their Subways," Engineering News-Record, April 30, 1964, p. 26.

The two relatively new subway systems in Canada, Toronto's and Montreal's, were each constructed in a sharply different manner. One has made heavy use of cut-and-cover construction while the other relied more exclusively on boring. Some of the reasons for their divergence are explored in this article.

"Victoria Subway Sparks New Tunnel Making Methods," Engineering News-Record, April 30, 1964, p. 26.

Improved methods of bored tunneling as well as the use of the so called "umbrella" method for constructing a station via cut-and-cover were first used in the construction of London's Victoria line as presented in this journal article.

BART IMPACT SERIES

The BART impact series, which is still in its production phase, consists of a number of reports prepared over several years. These attempt to analyze many of the social, economic, and environmental impacts of the entire project. The focus is usually on the pre- and post-construction phases of the project.

The two reports of the BART series which deal with construction impacts have been previously reviewed in Section 2.5.2. Other elements of the series which were considered as part of the literature search, but which have little relevence to the subject matter of this study, are listed below for reference purposes.

Environment Project, Preliminary Findings: Barriers, March 1975. Gruen Assoc.

A Review of Some Anticipated and Observed Impacts of the Bay Area Rapid Transit Systems, Peat, Marwick, Mitchell and Co., May 1974.

Shepherd, Morris, Identification and Appraisal of Methodology for Assessing the Public Policy Impacts of BART, Metropolitan Transportation Commission, April 1974.

Strategic Plan, Metropolitan Transportation Commission, Berkeley, California

Operations Plan: Fiscal Year 1974, MTC, Berkeley, California. August 1973.

Program Design, MTC, Berkeley, California. November 1972.

Environment Project: Phase I Work Plan, Gruen Assoc., June 1974.

Environment Project, Preliminary Findings: Sound, Gruen Assoc., MTC, Berkeley, California. March 1975.

Backman, Susan, Data Summary, MTC, Berkeley, California. July 1974.

3. BACKGROUND FOR AN ASSESSMENT OF DISRUPTIVE EFFECTS ASSOCIATED WITH URBAN TRANSPORTATION TUNNEL CONSTRUCTION

In this chapter, we shall cover background considerations that have to be taken into account when identifying and measuring effects of urban transportation tunnel construction. In later chapters we will deal with the groups that are affected and with the causal agents that bring about disruptions (Chapter 4), with some actual economic effects (Chapter 5), with some actual social effects (Chapter 6), with measurement of effects (Chapter 7), and with the aggregation of effects (Chapter 8). The considerations in the present chapter precede all of these by setting the context within which the identification and measurement of effects take place.

The following topics will be discussed in this chapter:

3.1 The impact area

3.2 Alternative construction methods and the "No Build" alternative

3.3 Primary disruptive effects

3.4 Secondary disruptive effects

3.5 Some special considerations

- 3.5.1 Time
- 3.5.2 Uncertainty
- 3.5.3 Scheduling probabilities
- 3.5.4 Work schedules
- 3.5.5 Construction benefits.

3.1 THE IMPACT AREA: THE SITUATION PRIOR TO CONSTRUCTION

The first step in an impact assessment is a description of the special characteristics of the impact area. This assumes that the precise location of the tunnel has already been determined. Frequently, however, the assessment of <u>anticipated</u> impacts will itself be an important factor in the choice of the final route; in such a case the anticipated impacts for several different routes will have to be assessed.

Thus, the initial description may cover three or more different impact corridors. It is hard to overemphasize the importance of this initial description. This is the place at which all special peculiarities of an area will be noted--all those things which, according to the residents, make the area under consideration a "good" or "bad" neighborhood. This is also the place where it will be noted whether the impact area is economically depressed, whether it is primarily commercial or residential in character, what its demographic characteristics are, etc. In short, the description of the area will provide the baseline from which forecasting begins.

Part of the description will be an analysis of what the construction is going to do: that is, what the functions of the finished project are going to be, together with a description of the various structures that have to be built (stations, ventilation shafts, entrances and exits, etc.) in order to perform those functions.

An important consideration is the determination of what the impact area is for any given tunnel route. How far, and in what direction do the construction effects extend? According to a study undertaken by the Metropolitan Transportation Commission in Berkeley, California, the width of the corridor impacted by tunneling construction is usually less than 1/4 of a mile.[1] Residents were interviewed as to whether and how much they were bothered by noise, direct, etc. resulting from the construction; residents more than 1/4 mile away from the construction reported no appreciable effect.

The impact area may be extended somewhat at those places where intersections are blocked or are significantly reduced in size (and, therefore, useability). At places like this, traffic circulation in the side streets paralleling the construction corridor will be forced to carry more traffic than they did before construction began.

Some of the construction impacts however, may be experienced beyond the 1/4 mile impact corridor, to include the larger neighborhood, city or region. For example, if the barrier effect of the construction retards the transportation of people and goods undertaking trips with both their origin and destination points outside the impact corridor, then construction impacts will be experienced in this wider area. Individuals from outside the impact area may experience delays in mail delivery or traveling times to work. Such delays can be particularly significant if a major surface transit line is disrupted enroute through the impact area.[2]

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[1] The Social Consequences of BART's Environmental Impact: Some Preliminary Considerations and Hypotheses. Prepared by David Nasatir of the Metropolitan Transportation Commission, Berkeley, California, March 1975, p. 5.

[2] See Atlanta Journal, June 16, 1975. The article deals with the anticipated delays for commuters into the Central Business District when buses, especially express buses, will have to be rerouted because of MARTA construction.

In addition, ruptures in public utilities, such as telephone and electric service, may be experienced throughout a wide area as a result of a construction mishap during tunneling.

Thus, the precise definition of "impact area" becomes important. It may not be possible to give such a precise definition until after all the possible impacts have been examined, but at least a preliminary definition must be given early on, in order for the analysis to get started.

It is probable that a working definition of the impact area may define it as consisting of three parts: (1) the corridor of the construction itself, i.e., the area which is torn up for cut-and-cover tunneling, or the area beneath which boring is going on and which is periodically pierced by ventilation shafts, access shafts and by storage areas for equipment and perhaps temporary storage of spoils (if they are hauled away only at night, say); (2) the area extending to about 1/4 mile on each side of this corridor, and (3) the larger area affected primarily by the barrier effect.

3.2 ALTERNATIVE CONSTRUCTION METHODS AND THE "NO BUILD" ALTERNATIVE

For each of the routes to be considered, the different construction possibilities must be considered, i.e., will the tunnel be constructed by the cut-and-cover method, or by boring (either soft-earth or deep-rock). Different construction methods will result in different degrees of impacts. It may, of course, be the case that one or another of the possible routes is such that some of the construction alternatives are not feasible from an engineering point of view. In that case they need not be considered.

An important alternative to consider for each of the proposed construction routes is that of no construction at all. Although impacts arising from construction are presumably transient (at least most of them), tunnel construction is sufficiently complex so that it may last as much as five years. That is a significant amount of time during which there will be social, environmental and economic changes in the "impact area" (i.e., in what would be the impact area if the tunnel were constructed) even without any construction at all. In the course of five years, the demographic characteristics may change (e.g., it may become more commercial), fraternal organizations may come or go, store front churches may arise, etc.

In the same period of time, there will probably also be significant economic changes in the area: employment trends may be observable that will likely continue; property values may go up or down without the construction, and so forth.

There may also be environmental changes, even without any construction. For example, the area under consideration may be one through which more and more cars travel in order to get to the downtown section of the city. In that case, air pollution may increase. On the other hand, if--because of economic stagnation--automobile traffic is anticipated to remain the same as it is now, this would mean that air pollution levels will remain what they are now (as far as this cause is concerned). External causes may change these results: with the same amount of automobile traffic or even with more traffic, air pollution five years from now may be less because of more stringently enforced laws concerning automobile emissions.

It is not always easy to determine what present social economic and environmental trends are and to forecast what the area will be like with "no construction." The mere fact that a construction project has been planned, or talked about, may have set into motion certain social and economic trends that confuse the "no construction" alternative. I.e., the mere announcement of a subway going in may have caused land speculation, or may cause residential properties to be put up for sale, or retail businesses to sell out. Ideally, therefore, the "no construction" alternative should be considered from the point of time when there was not yet any inkling of the possibility of subway construction. The anticipated effects of the "no construction" alternative will provide a basis with which to compare the effects of one or several of the construction alternatives.[3]

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[3] A study dealing with the "no build" alternative has recently been completed. (The No-Build Alternative. Social, economic and environmental consequences of not constructing transportation facilities. December 1975. The study was done by David A. Crane & Partners/DACP, Inc.; Economics Research Associates, Inc.; Alan M. Voorhees & Associates, Inc.) It found that the no-build alternative has not received all the attention it should. As recently as 1972, "fully 33 percent of the EIS's reviewed did not mention the alternative of not going ahead with the project" (p. 24).

The no-build alternative has not been given the important role which we have advocated for it:

> While few agencies viewed the NCTF [Not Constructing a Transportation Facility] as a real alternative for decision-making, many (63 percent) used the no-build option as a baseline against which to evaluate other "build" options. More recent project studies and EIS's were likely to

3.3 PRIMARY DISRUPTIVE EFFECTS

Primary effects are those that are caused directly by the tunnel construction, without the intermediation of any other causality. The study began by examining five ways in which tunnel construction may cause disruption[4]:

a. It creates a barrier. Because of the construction, a barrier is or may be created along the right of way. The barrier may last more or less time, depending on the length of the construction. The actual length and severity of the barrier may also vary, depending on the type of construction employed. The barrier will probably last longer if the tunnel is constructed by cut-and-cover methods than if it is constructed by boring. For certain periods of time, the barrier may be total[5], while at other times the barrier may be only partial, particularly if the contractor is required to maintain a certain number of lanes for traffic and/or emergency vehicle access.[6]

b. It displaces businesses and residences in the right of way. Such property may have to be taken for purposes of construction. Less important because less disruptive is the requirement for easements across some properties.[7]

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include an NCTF option in response to increasing recognition of budgetary restrictions, intermodal funding competition and impact-related problems associated with highway construction. However, about 21 percent of the agencies stated that current usage amounted to "pro forma" compliance with environmental requirements or the development of "strawman" arguments to make projects look better. (ibid., p. 26)

[4] These were suggested in the Work Statement of Contract DOT-TSC-1018, pursuant to which this study was conducted.

[5] The intersection of Washington and Kneeland Streets in Boston was completely closed for six weeks during the construction of the southern extension of the Orange Line. (Notes from a visit to the South Cove Station, July 16, 1975.)

[6] Contractors, however, do not always live up to such requirements. In Washington, D.C. the Waterfront station on M Street, S.W. is being constructed by cut-and-cover methods. Merchants and residents in the nearby area were promised that two lanes of traffic would be kept going at all times. The contractor, however, maintained that this requirement would add unreasonable time and costs to the construction and only one lane of traffic in each direction is available. (Interview with Walter Mergelsberg, construction supervisor for the Waterfront station for WMATA, October 17, 1975.)

[7] Tunnel construction is able to avoid takings more easily than other construction projects, because the routes usually follow public rights-of-way. Some takings are unavoidable, however. (See Draft Report, London Transport Executive, pp. 1, 6.) In Washington, D.C., when WMATA puts station entrances into existing commercial buildings, it buys, or obtains easements for, three "cubes" of space in and under the building. (Conversation with Nicholas Roll, WMATA real estate division, October 17, 1975.) In London, where most of the construction is by boring, the subsoil is bought at £1 per running foot. (Conversation with Mr. Spencer King, London Transport Estates Division, October 29, 1975.)

c. It makes recreational areas unusable. This has a direct social impact on the health of the neighborhood residents. It is possible to extend this category by including in it the taking of any land or structures that perform a function of the impact area. That is, if a fraternal club's building has been taken, or if a school has to be taken, this would have immediate social and economic impacts, as much as, or more than, if a park is taken.[8] Where possible, of course, the tunnel route will be designed so that this kind of taking is held to a minimum. Parks and recreation areas, however, are a prime target for taking because they are already publicly owned and their social benefit is not so readily apparent (nor, therefore, the social costs of removing them).[9]

d. It stops and/or restricts traffic movement when following existing surface routes. If the tunnel route follows an existing street, traffic along that street will be restricted and occasionally completely stopped. Traffic at cross streets may also be restricted. All of this will result in traffic having to find new routes, in cars being slowed down (with consequent increases in air pollution) and in traffic volume increasing on streets that formerly were residential or carried only little traffic.[10]

e. It forces movement of residents from areas adjacent to construction site due to excessive noise or dust levels. Even though residences are not taken for the construction, they may be made untenable, not only because of noise and dust, but also from difficulty of access and perhaps from the general undesirability of the neighborhood during construction.[11]

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[8] At Jefferson Junior High School (8th and H St., S.W., Washington, D.C.) part of the school tennis courts had to be moved to another area of the school yard. WMATA paid for the move. At different times, students have been unable to use some of the playground areas because of materials storage, but at all times, some playing area was kept open for them. (Interview with Mrs. Robinson, secretary at the Jefferson Junior High School, December 18, 1975.)

[9] London Transport, Draft Report, pp. 2, 8. "It is inevitable in heavily populated, built-up city areas, that open spaces such as recreation areas are chosen for working sites." In Washington, D.C., the National Park Service and WMATA have been working together to coordinate construction so that the Mall area will be unaffected during the Bicentennial celebrations. (Interview with Jeff Knoedler, December 16, 1975.)

[10] Of all construction impacts, this is probably the most readily apparent one. The construction of the Waterfront Station in Washington, D.C. offers a good example of the way in which traffic is impeded. Only one lane of traffic in each direction was kept open, resulting in slowdown of traffic and traffic jams during rush hours. The intersection of 4th and M Street became severely restricted and required a flag man to help direct traffic. (Observations by Abt Associates staff from the middle of October to Christmas, 1975.)

[11] The manager of Town Center Plaza, an apartment complex facing M Street where the Waterfront Station is being constructed in Washington, indicated that the turnover of apartments facing M Street was much higher than that of other apartments. He ascribed this to the construction, particularly the blasting,

There is an unverified contention that crime goes up, because the many piles of construction materials, shacks and the like provide hiding places for would-be criminals. There is the opposite thought that crime goes down, because the presence of people (construction workers) in the evening makes the area safer. There is little doubt that aesthetically a construction site is not pleasing, even if fences are painted green.

These five suggested ways in which tunnel construction causes impacts overlap in some areas; at the same time, some environmental causal agents seem to be ignored. The following list of causal agents includes all of the ways suggested in the work statement, while avoiding some of the overlaps:

a. Traffic interference. This includes both the barrier effect and traffic interference. That is, traffic may have to be completely rerouted as a result of the barrier, or it may be slowed, temporarily detoured, and the capacity of a street may be diminished as a result of construction going on under it.

b. Takings. This includes takings of businesses, of residences, and also of recreational areas, parks, playgrounds and the like. There seems to be no reason to separate the taking of a park from the taking of a building, although these takings may differ in the number of persons affected and the severity of the impact.

c. Environmental effects. Such phenomena as increased noise, increased air pollution and others translate themselves into social and economic effects. Among the most prominent of these is that buildings (both residential and commercial) will be untenable or less desirable as places to work or live than they were before.

d. Utility disruptions. Like traffic interference, this is an unavoidable, even if undesirable, effect. These disruptions can be and are planned for, but still result in disruptive effects.

In Chapter 4 below, these four kinds of causal agents are used to construct a matrix which locates the costs of disruptions (caused by these four kinds of agents) to various affected groups.

3.4 SECONDARY DISRUPTIVE EFFECTS

Secondary effects are those impacts which are not caused directly by the construction, but rather by the interaction of primary construction effects (takings, barriers, noise, etc.) with the special, local characteristics of the impact corridor. For example, the presence of such primary effects as noise

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the loss of parking spaces for tenants and the inability of moving vans to get close to the entrances of the buildings. (Interview with Mr. Newman, Manager, Town Center Plaza, November 5, 1975.)

and dust in the central business district may result in a significant loss of business and a large number of bankruptcies. A primary effect such as a traffic barrier may force redrawing of attendance districts for schools, creating a secondary social effect for the children of some residents, viz. an involuntary change of school.

The same primary effect may produce different secondary effects, depending on local conditions. Thus, the noise and dust that produced a large number of bankruptcies in one central business district may have interacted with the fact that the area was already in a state of economic decline and instability; in a retail district of considerable stability, the same primary effects might have produced much less damaging secondary effects.

Examples of such different secondary effects arising from the same primary effect occurred in Washington, D.C., during the Metro construction. Retail establishments in the downtown G Street area were far more severely impacted than similar establishments on Connecticut Avenue in the vicinity of the Mayflower Hotel.[12]

Secondary impacts or effects can be experienced across a wide range of functional areas. For example, the loss of valuable recreation area in a densely populated urban neighborhood as a result of its expropriation by contractors for storage may have a significant effect on the attitudes and disposition of residents if park space is at a premium.[13]

Furthermore, the construction phase of a tunnel project could either depress rents and increase vacancy rates, as is currently feared among property owners in Atlanta's central business district[14], or it could spark increased development activity in an area, as was experienced in both Toronto and Montreal according to planners in those cities' transit authorities. The critical factor, therefore, in determining this secondary effect may be the local occupancy rate and demand forecasts for certain types of space uses.

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12 Interview with Mr. Leonard Kolodny, Chief, Retail Bureau, Washington, D.C. Board of Trade

13 London Transport, Draft Report, p. 16.

14 Atlanta Journal, July 17, 1975, "Surviving a Subway."

It is also important to note that the benefits and costs of secondary effects will not fall uniformly on individuals within an impact area. For example, the proprietor of a coffee shop within the impact corridor may experience an increase in business as a result of the presence of construction workers, while a more expensive restaurant nearby may lose customers as a result of the difficulty of access--a primary construction impact[15]. Similarly, the elderly and handicapped may experience far more difficulty in undertaking needed trips than those without such infirmities.[16]

3.5 SOME SPECIAL CONSIDERATIONS

In this section, we will collect some considerations that do not easily fit elsewhere but which deserve attention. There may be others beside those mentioned here, but these are offered as examples.

3.5.1 Time

Tunnel construction results in transient effects--that is, the construction is not permanent. Rather, the various factors causing disruption, like the equipment, will be removed when the construction is finished. However, it must be questioned whether the impacts resulting from construction are truly transient or not. Certain social, economic, or environmental effects may be such that if they exist for a certain length of time, they may then result in permanent impacts.

The easiest examples of this are economic ones. Construction may result in lessened retail business when access is restricted. Smaller profits, or even losses, may result for the businesses affected. A large and presently profitable business may be able and willing to sustain such losses until the construction is over, in anticipation of increased business afterwards (due

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[15] London Transport, Draft Report, p. 6.

[16] The London Transport Draft Report gives a specific example:

> "...it was found that a blind couple were unable to make journeys to and from their home near the works because of the various footpath diversions. To overcome this, they were provided with a taxi twice a day for the duration of the work in their area. This was a very small cost on the project." (pp. 24-25.)

to improved access because of the subway). But of course there is no guarantee that such increased business will in fact come to be.[17] And for some businesses, the disruptions caused by tunnel construction are the last straw. This can be seen along G Street in Washington, D.C. where quite a few empty stores attest to the severe economic impact of Metro construction. Though some of these stores clearly were marginal with a high rate of failure to be expected, not all of them were; some were long established and formerly prosperous.[18]

Environmental and social effects may also become permanent if they are sustained beyond a certain length of time. Noise can cause permanent hearing damage: vibration can cause permanent structural damage; pollution beyond a certain point may make a stream irreversibly unclean. Similarly, certain social disruptions may become permanent if they last beyond a certain time: a neighborhood that is split by the barrier of a tunnel construction project may turn into two neighborhoods and not be able to be united again if the barrier lasts more than (say) a year. Church going patterns may be permanently changed as may many other patterns of social life.

It would be very useful if a figure could be found for the number of months or weeks that an effect has to last for it to become permanent. It is unlikely that the length of time can be pinpointed exactly, but we may be able to discover (if not in the course of this research then at a later time) what the maximum time is for which certain kinds of disruptions can be sustained before becoming irreversible.

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[17] After two-and-one-half years of construction along G Street in Washington, recovery did not immediately occur after the street was restored and may never take place. "No, our business has not begun picking up. I don't expect it will ever get back to where it was. People form all new shopping habits, buying habits, you know. But I think this is because of the general malaise affecting all cities today, not just the subway construction." (Richard Steen, manager of Lewis & Thomas Saltz's clothing store, quoted in "I Lost My Shirt," Atlanta Journal, June 17, 1975.)

[18] Maison's, a fashionable millinery store, that moved from one location on G Street to another because of the construction, expects to close soon. (ibid.)

3.5.2 Uncertainty

One of the most damaging effects of a large construction project (whether it be a tunnel or something else) is the uncertainty as to whether it is in fact going to take place and if it is, when.

From the moment that a tunnel construction project is announced as likely, the economy and the social fabric of the impact area will be affected.[19] Property values may go up or down, depending on whether the area is thought to be benefiting from the project or not. Until a precise location for the tunnel is determined, the economic disruption will affect all the possible routes it might take, three or four times the finally affected area. Similarly, the social life of the areas in question will be affected: some persons will move out, others will form groups to fight the project, some groups will form to support it. All long-term action, however, is likely to cease until there is more certainty about what is going to happen. Residential building will probably fall off and it is unlikely that any commercial structures will be put up until the precise route is determined. Temporary solutions will be sought for such problems as school overcrowding or lack of some social service facilities. Fire, police, and garbage services may deteriorate if it is thought that the neighborhood will soon be in change.

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19 The uncertainty about what is going to happen and the inability to obtain precise information is among the most frustrating experiences that affected residents can have. If these residents do not receive the information to which they are entitled, they may become sufficiently enraged to take legal action which, at a minimum, can delay and increase the costs, of a tunnel construction project. In Washington, D.C., some residents of Tiber Island, an apartment and condominium complex near the Waterfront station, now being built, first learned of the impending construction in 1971. By 1974 they felt that they still had not received sufficient information and filed suit against WMATA. Part of their complaint reads: "...several residents of Tiber Island repeatedly attempted to contact responsible officials at WMATA for the purpose of obtaining detailed information concerning plans for the M Street project. These residents sought to be as well informed as possible. In the event that WMATA's plans appeared to jeopardize the health, welfare or safety of Tiber Island or of any of its residents, those concerned citizens wanted to have enough information to enable them to suggest constructive alternatives to WMATA. All efforts aimed at obtaining technical information were unsuccessful." (Tiber Island Condominium et al. vs. Washington Metropolitan Area Transit Authority)

3.5.3 Scheduling Probabilities

A quite different kind of uncertainty plays a role when construction has actually started. Typically, residents and merchants who are affected by the construction want to know the construction schedule, i.e., what is going to take place at what time. What they most dislike is not knowing what is going to happen until a construction crew arrives and starts tearing up the street. Residents want to know how long a certain phase--say excavation--is going to last. Merchants are interested in knowing when access to their stores will become restricted and how long this will last, so that they can plan sales around this and take it into account in ordering merchandise.[20]

Thus it is important that someone get in touch with affected persons and tell them about the construction schedule. But it is also important to stay in touch with them, to make them aware of scheduling changes as they become necessary due to unforeseen difficulties, strikes, unavailability of materials, and the like. If this is not done, the disruptive effects will be increased in size several times, unnecessarily leading to ill will and perhaps even to law suits.

3.5.4 Work Schedules

We have already indicated that the length of time during which a disruptive effects lasts may be crucial in determining whether there will be a permanent impact or not. For this reason, anything that can be done to speed the construction probably should be done.[21] In a business area that is severely disrupted by cut-and-cover operations, it may be worthwhile to work

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[20] This was one of the crucial items of information that the residents of Tiber Island were interested in. See footnote 19.

[21] This was one reason why WMATA went back on its promise to residents and merchants along M Street, S.W. to keep two lanes of traffic open in each direction at all times during the construction. Doing so would have prolonged the period of time during which the street was partially torn up and would have resulted in greater overall disruptions as well as greater costs for the project. Apparently the residents and merchants accepted this argument, when they were informed at a public meeting that only one lane of traffic would be maintained in each direction. (Interview with Walter Mergelsberg, construction department of WMATA, October 17, 1975.)

more than one eight-hour shift, in order to get rid of the disruption as quickly as possible. Since it is a business area, considerations of noise and light presumably are non-existent or slight. In a residential area, on the other hand, there probably should not be work at night, although this is an option that perhaps should at least be explored with the affected residents.[22] They, too, may be willing to put up with construction until nine in the evening, if it speeds the entire construction process up appreciably.

3.5.5 Construction Benefits

Although it is hard to think of environmental benefits arising from tunnel construction, there may be a few social and economic benefits.

Economic benefits may accrue to some businesses in the impact area (such as short-order lunch rooms) because of the influx of construction workers.[23] There may be a regional economic benefit in that the construction provides work for quite a few people. There may be an economic benefit to some merchants arising from the economic loss of others: merchants on F Street in Washington benefited from increased business that had formerly gone to merchants on G Street (which was torn up for a long time).

The tunnel construction may lead to a community social benefit: it may make for greater neighborhood cohesion, or even lead to an area thinking of itself as a neighborhood, when before it had been divided. This is a curious benefit in the sense that it is a strength that arises in response to

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[22] The Tiber Island residents who initiated legal action against WMATA received an agreement that no trucks would operate between 7:00 p.m. and 7:00 a.m. and that the noise levels resulting from other construction machinery during the same hours would be very low, not exceeding 55dBA though short-term levels of 60 dBA were permitted even between 7:00 p.m. and 7:00 a.m. (Letter from John R. Kennedy, General Counsel of WMATA, to Thomas H. Truitt, Esq. re Tiber Island Condominium et al. vs. WMATA, Civil Action N. 74-947, July 1, 1974.)

[23] Interviews by Abt Associates staff of merchants in the Waterside Mall on M Street, S.W. in Washington indicated that lunch business increased in the delicatessen store because of construction workers. Other merchants also guessed that the People's Drug Store experienced an increase at its lunch counter, but the manager of the drug store was only willing to say that overall business was down. (Interviews by Ruth Brannon, November 1975.)

a pain--like a person in danger discovering strengths he never knew he had.[24] In planning for a large-scale construction project, such as a tunnel, in coping with it, or in fighting against it, the neighborhood may begin to discover itself and reveal some strengths that it had but did not know about.

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[24] The threat of the WMATA Metro construction caused some of the residents of Tiber Island to combine and engage in joint action. See footnotes 17, 18, 20 above.

4. THE AFFECTED GROUPS AND THE CAUSAL AGENTS: A MATRIX OF CONSTRUCTION IMPACTS

4.1 INTRODUCTION

In Chapter 3 we identified the causal agents through which tunnel construction brings about effects. Review of literature as well as observation of tunnels under construction indicated that there are four major causal agents to which impacts can be traced, viz. traffic interference, takings of properties, environmental disturbances, and utility disruptions.

It is next necessary to identify those on whom the construction impacts fall--those who suffer (or benefit from) the impacts of tunnel constructions. The following categories include all those who are subjected to impacts. Impacts may fall on individual persons, and families, on businesses (i.e., establishments organized for money-making purposes), and on institutions (privately or governmentally organized to provide services rather than to make money).

Individual persons or families may be affected by tunnel construction either in their capacity as residents of the impact area, or as employees of businesses in that area, or as patrons of those businesses, or as owners (of property or businesses) in the impact area. Finally, individual persons may be especially affected because they are part of one or several special populations--the aged, the very young, the handicapped, the poor, etc.

Businesses will of course be subdivided into different kinds--manufacturing, retail, wholesale, service, and perhaps others.

Some institutions, as we have already indicated, are govermental and through taxation provide protection of life and property, health services, sanitation services, regulation and licensing of motor vehicles, and the like. Other important governmental institutions are schools, public libraries, hospitals and the like. There are also private institutions that provide services; these, too, may include schools, hospitals, and libraries as well as churches, clubs, athletic organizations and similar associations.

4.2 MATRIX

Given these categories of agents that cause impacts and of groups that suffer impacts, a matrix can now be constructed. Across the top of the matrix, the column headings will indicate causal agents; along the left margin, the row headings will list affected groups.

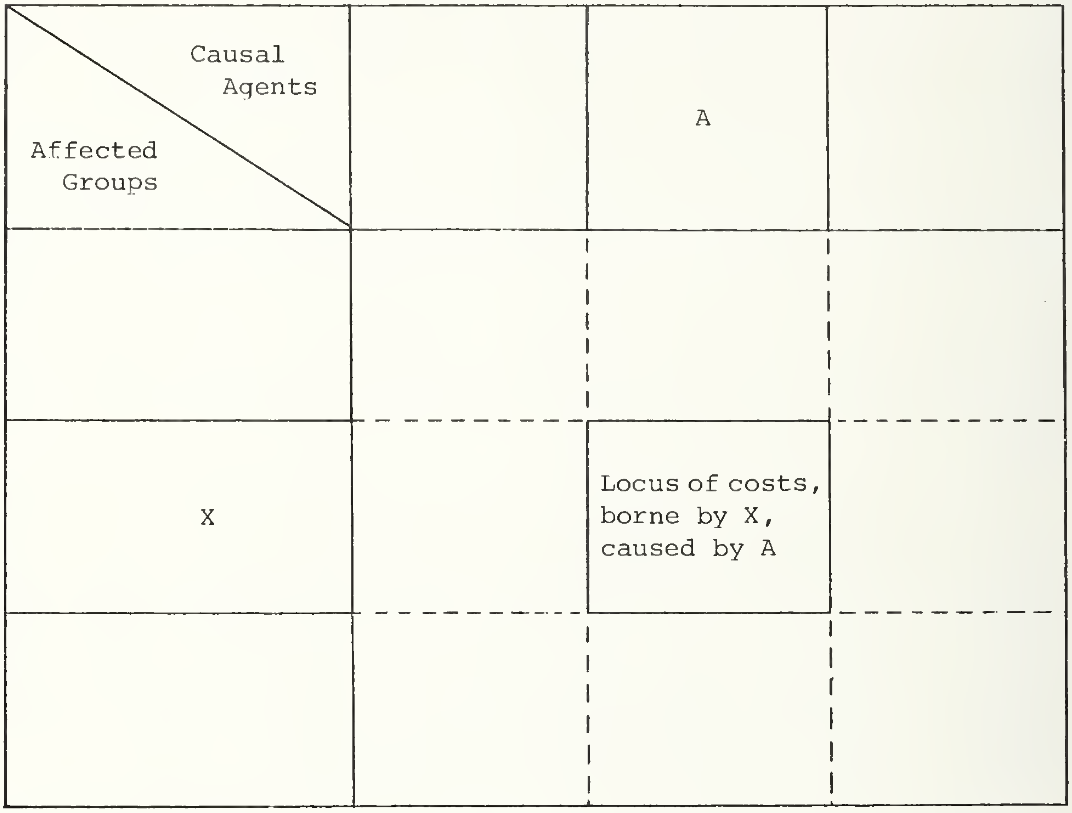

FIGURE 1. SCHEMATIC MATRIX

4.2.1 Column Headings

a. Traffic interference. This includes barriers, detours, slowing down of traffic, lane reduction, etc. It also includes temporary removal of sidewalks, footbridges, and the like. Traffic interference may be either

   1) vehicular and/or

   2) pedestrian.

b. Takings of properties. Buildings and/or land may need to be taken for the tunnel construction. In the matrix we can distinguish between takings of

1) businesses

2) residences

3) public properties (such as parks, libraries, schools, playgrounds, etc.) and

4) community institutions (private hospitals, schools, fraternal clubs, churches, etc.).

c. Environmental disturbances. Construction and construction machinery cause changes in the environment. These in turn, cause impacts on various groups or persons. Among the environmental causes that have impacts, we list the following:

1) noise pollution

2) air pollution

3) water pollution

4) heat

5) vibration

6) solid waste disposal

7) visual impact.

d. Utility disruptions. Particularly in cut-and-cover operations and to a lesser extent in bored construction, utilities (water, electricity, gas, sewers, and telephone) have to be relocated either temporarily or permanently. In either case, there will be interruptions of service. These may be:

1) planned or

2) unplanned.

Even planned interruptions will have some disruptive effects, especially if they are lengthy. Unplanned ones--i.e., if a line is cut either because the machine operator made a mistake or because the existence of the line was not known--are of course much more disruptive.

4.2.2 Row Headings

These are the groups (or individuals) that bear the costs that are caused by the causal agents listed at the top margin of the matrix. The listings of the groups that follows is such that many persons will show up in more than one group and possibly bear costs as members of more than one group. In each case, the cell entry must reflect the locus of cost to such a person insofar as he or she is a member of the group listed at the left margin.

a. Business

   1) manufacturing

   2) retail

   3) wholesale

   4) service

b. Employees

c. Patrons

d. Residents

e. Local government service providers

   1) protection of life and property (police, fire department)

   2) provision of other services (welfare, health, sanitation, employment security, motor vehicle department, etc.)

f. Owners

g. Institutions (libraries, schools, hospitals, etc.)

h. Special populations (aged, young, handicapped, etc.).

4.2.3 The Cells

Given these entries into the columns and into the rows, what is displayed in the cells of the matrix? It is the locus of costs (not the costs themselves). Causal agent A brings about impacts (costs) to Group X in a topical area or aspect. The cells display this area or aspect.

For an example, consider the cell at the intersection of "interference with vehicular traffic" (the causal agent) with "patrons" (the affected group). The cell indicates the locus of the cost, the area in which the cost will be incurred. What then is the locus of costs incurred by patrons as a result of vehicular traffic interference? What, in other words, is the content of cell F1 (see Fig. 2)? The locus of economic costs is the journey to a store (it may be more time-consuming, use more gas, involve use of a taxi); another locus is the kind of store available to the would-be patron: he or she may have to buy merchandise that is more costly than, or that is different in kind from, what he/she is used to. Which of these costs will in fact be incurred cannot of course be ascertained from the matrix: that depends on the local conditions; for example, it depends on whether in fact vehicular traffic is interfered with. Even if there is such interference, the quantity of the cost will depend on the local conditions: it is clearly impossible to know a priori whether the store whose access is being interfered with is a discount store or an expensive boutiques, and whether a patron who has to go elsewhere will therefore spend more or less money.

CAUSAL AGENTS / AFFECTED GROUPS			Traffic interference		Takings of				Environmental Disturbances							Utility disruptions	
			Vehicular 1	Pedestrian 2	Businesses 3	Residences 4	Public Properties 5	Community Institutions 6	Noise Pollution 7	Air Pollution 8	Water Pollution 9	Heat 10	Vibration 11	Solid Waste Disposal 12	Visual Impact 13	Planned 14	Unplanned 15
BUSINESS	manufacturing	A															
	retail	B															
	wholesale	C															
	service	D															
EMPLOYEES		E															
PATRONS		F															
RESIDENTS		G															
LOCAL GOVERNMENT SERVICE PROVIDERS		H															
OWNERS		I															
INSTITUTIONS		J															
SPECIAL POPULATIONS		K															

FIGURE 2. THE BLANK MATRIX READY TO DISPLAY LOCI OF SOCIAL OR ECONOMIC IMPACTS ARISING FROM A TUNNEL CONSTRUCTION PROJECT.

The locus for social costs to patrons arising from vehicular traffic interference would also be displayed in cell F1. This locus is the availability of different kinds of shopping facilities: with difficult access, patrons may find that their choice of stores is limited and/or that they are forced into stores with which they are not familiar or in which they are not comfortable.

Most environmental costs are listed as the headings of columns 7 through 13 (noise pollution, air pollution, etc.). Environmental costs are costs to the environment. That is, the environment as a whole is worse because there is water pollution, or air pollution, or heat pollution, etc. When we go on to ask what the costs of this environmental disturbance are to people, we find that the answers are given in terms of economic or social costs: air pollution results in social costs--in health hazards, for example. It also results in economic costs--manufacturing or retail businesses that require clean air have costs increased because of the need to clean air that has been dirtied by construction activities.

Thus as far as environmental disturbances are concerned, the interesting consequences to a social scientist are those economic or social ones that affect people. In order to avoid these consequences, or at least to lessen them, one must of course attend to the environmental causes: if air pollution is caused by construction machinery, the best way to lessen the costs (economic and social) of such pollution is to lessen the pollution or even to avoid it altogether. Thus environmental disturbances must be looked at in two ways: their causes are physical events like the operation of certain kinds of machinery or the employment of certain kinds of techniques; these causes are sometimes susceptible to modification and change. Their consequences are social and economic impacts, of varying degrees of severity, and affecting different people and groups differently. These consequences are of course, found in the cells of the matrix, as social and economic impacts.

Occasionally, the cells of the matrix may also be used to display loci of environmental impacts. For example, vehicular traffic interference (column 1) will result in inefficient operation of internal combustion engines. For most of the groups listed along the left margin, therefore, there will be impacts in the area (locus) of air quality. Similarly, some kinds of takings--particularly of recreational areas--will result in visual impacts and land use costs to residents and employees of local businesses.

But for the most part, the cells of the matrix will display loci of economic and social costs.

In general, then, the locus of costs defines the general area within which--depending on local conditions--costs (or even benefits) may be encountered by the affected group as a results of the causal agent under consideration.[1] Sometimes, a cell may identify more than one locus of

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[1] This "locus of costs" is not too different from what are called "elements of concern" in a report prepared by Alan M. Voorhees & Associates for the Federal Highway Administration. These elements of concern are those "which may be impacted as a result of the imposition of an alternative facility configuration /tunnel/ in a subarea. These elements of concern--broadly grouped into social, economic, and physicial environment categories--represent the aspects of the environment which are critical to overall quality and to which can be attached objective measures of impact." A Study of Social, Economic and Environmental (SEE) Impacts and Land Use Planning Related to Urban Highway Tunnel Location. Interim Report. Prepared for the Federal Highway Administration, Office of Research, Environmental Design and Control Division, April 1975, by Alan M. Voorhees & Associates, Inc. in Association with JRB Associates Inc., p. 47.

The report lists 17 elements of concern (See p. 48):

Social

Neighborhood Cohesion
Sense of Neighborhood
Availability of Services and Facilities

Economic

Existence of Business and Industrial Properties
Geographic Extent of Market and Employment Areas
Level of Property Values
Expenditures for Public Services
Relocation Consequences
Compatibility with Plans

Physicial Environment

Biota
Ground Stability
Erosion/Sedimentation
Natural Water
Air Quality
Overall Auditory Quality
Ground Vibration
Overall Visual Quality

Unlike the cells of the matrix, however, these elements of concern do not indicate either on whom the costs fall nor what are the agents causing these costs.

costs. For each locus, there are a number of variables which should be measured (if possible) in order to arrive at a numerical figure for the costs in an actual situation.

We now turn to a closer examination of the content of the cells.

4.3 CONTENT OF THE CELLS: LOCUS OF ECONOMIC IMPACTS

Beginning with the first row of the matrix, these are the loci of economic impacts.

BUSINESS: Manufacturing		locus of economic costs
A1	Traffic interference: vehicular.	- deliveries of goods and services (purchases) - shipping - labor supply
A2	Traffic interference: pedestrian.	- labor supply
A3	Takings of business.	- facility
A4	Takings of residences.	- labor supply
A5	Takings of public property.	(blank)
A6	Takings of community institutions.	(blank)
A7-A13	Environmental disturbances	- tenability of premises
A14	Utility disruptions: planned.	- purchase of goods, services - shipping - production - labor supply - scheduling/bottlenecks - maintenance - operations

BUSINESS: retail		
B1	Traffic interference: vehicular.	- deliveries of goods and services (purchases) - shipping - labor supply - patronage
B2	Traffic interference: pedestrian.	- labor supply - patronage

BUSINESS: retail (continued)		locus of economic costs
B3	Takings of businesses.	- own facility
		- neighboring facilities (image phenomenon)
B4	Takings of residences.	- labor supply
		- patronage
B5	Takings of public property.	- patronage
B6	Takings of community institutions.	- patronage
B7-B13	Environmental distrubances.	- tenability of premises
B14	Utility disruption: planned.	- deliveries of goods and services (purchases)
		- shipping
		- patronage
		- operation/scheduling
		- labor supply
B15	Utility disruption: unplanned.	- deliveries of goods and services (purchases)
		- shipping
		- patronage
		- operation/scheduling
		- maintenance
		- labor supply

BUSINESS: wholesale		
C1	Traffic interference: vehicular.	- deliveries of goods and services (purchases)
		- shipping
		- labor supply
		- patronage
C2	Traffic interference: pedestrian.	- labor supply
C3	Takings of businesses.	- facility
		- neighboring facilities (image phenomenon)
C4	Takings of residences.	- labor supply
C5	Takings of public property.	(blank)
C6	Takings of community institutions	(probably blank; maybe some clientele, sales)

BUSINESS: wholesale (continued)	locus of economic costs
C7-C13 Environmental disturbances	- tenability of premises
C14-C15 Utility disruptions (planned and unplanned).	- deliveries (purchases) of goods and services - shipping - patronage - operation/scheduling - labor supply

BUSINESS: service	
D1 Traffic interference: vehicular.	- labor supply - patronage - advertising - deliveries (purchases) of goods and services
D2 Traffic interference: pedestrian.	- labor supply - patronage - advertising
D3 Takings of businesses.	- facility - neighboring facilities
D4 Takings of residences.	- labor supply - patronage - advertising
D5 Takings of public property.	- patronage
D6 Takings of community institutions.	- patronage - advertising
D7-D13 Environmental distrubances	- tenability of premises
D14-D15 Utility disruptions: planned or unplanned	- delivery (purchases) of goods and services - shipping - patronage - operation/scheduling - merchandising - labor supply

EMPLOYEES[2]		locus of economic costs
E1	Traffic interference: vehicular.	- journey to work
		- work schedule
E2	Traffic interference: pedestrian.	- journey to work
E3	Takings of businesses.	- if business is employer, job
		- if business is provider of desired services/products, consumption
E4	Takings of residences.	- if employment is retail/service based, jobs and/or wages
		- if residence is home, journey to work
E5	Takings of public property.	- job, wages
E6	Taking of community institutions.	- jobs, wages
E7-E13	Environmental disturbances	- job, wages,
		- job amenities
E14-15	Utility disruptions: planned or unplanned	- work schedule
		- job, wages
		- job amenities

PATRONS[3]		
F1	Traffic interference: vehicular.	- journey to shop (patronage) and purchases
		- deliveries
F2	Traffic interference: pedestrian.	- journey to shop (patronage) and purchases
		- deliveries
F3	Takings of businesses.	- journey to shop (patronage) and purchases

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[2] The term "job" is used whether or not a job currently exists; "wages" refers to how wages may change, if sales or hours of job are affected; and "job amenities" describes the desirability and amenities of a job.

[3] "Journey to public properties" refers to the journey necessary to get to the now nearest public property; "neighborhood amenities" refers to the convenience of having these public properties in the neighborhood; "purchases" refers to whether or not any given product/service can be purchased, and at what price.

PATRONS (continued)		locus of economic costs
F4	Takings of residences.	(blank) (N.B.: affects patrons qua residents)
F5	Takings of public properties.	- journey to public properties - neighborhood amenities
F6	Takings of community institutions.	- journey to community institutions - neighborhood amenities
F7-F13	Environmental disturbances	- neighborhood amenities
F14-15	Utility disruptions: planned and unplanned	- scheduling - access to stores

RESIDENTS

G1	Traffic interference: vehicular.	- journey to work (access) - journey to shop (access_ - deliveries (access) - emergencies (access)
G2	Traffic interference: pedestrian.	- journey to work (access) - journey to shop (access)
G3	Takings of businesses.	- journey to work, and job - journey to shop, and purchases - neighborhood amenities (option-demand)
G4	Takings of residences.	- if own residences, housing - if neighboring residences neighborhoods
G5	Takings of public properties.	- neighborhood amenities
G6	Takings of community institutions.	- neighborhood amenities
G7-G13	Environmental distrubances	- neighborhood amenities
G14-15	Utility disruptions: planned and unplanned.	- emergencies - scheduling

LOCAL GOVERNMENT SERVICE PROVIDERS[4]

H1	Traffic interference: vehicular.	- delivery of services; production of services

[4] Recipients are "patrons"; employees are "employees."

LOCAL GOVERNMENT SERVICE PROVIDERS (continued)		locus of economic costs
H1	Traffic interference: vehicular.	- patronage (e.g., more/less police needed because crime goes up/down, and because it takes more/less police to deliver previous level of services)
		- scheduling
		- labor supply
H2	Traffic interverence: pedestrian.	- access
		- patronage
		- scheduling
		- labor supply
		- delivery of services
H3	Takings of businesses.	- patronage (more/less fires)
H4	Takings of residences.	- patronage (more/less fires)
H5	Takings of public property.	- patronage (more/less fires)
H6	Takings of community institutions	- facility (own building)
		- patronage
H7-H13	Environmental distrubances	- patronage
		- maintenance
		- labor supply
H14-15	Utility disruptions: planned and unplanned.	- delivery and production of services
		- patronage
		- operations/scheduling
		- maintenance
		- labor supply

OWNERS (not owners of businesses. This category is treated under "business."

I1	Traffic interference: vehicular.	- access
		- maintenance
		- labor supply
I2	Traffic interference: pedestrian.	- access
		- maintenance
		- labor supply
I3	Takings of businesses.	- facility

OWNERS (continued)		locus of economic costs
I4	Takings of residences.	- facility
I5	Takings of public property.	(blank; owners of public properties are the public, i.e., patrons)
I6	Takings of community institutions.	(blank; see I5)
I7-I13	Environmental disturbances	- maintenance
I14-15	Utility disruptions: planned and unplanned	- maintenance - maintenance

INSTITUTIONS (public and private, including libraries, clubs, hospitals, schools, etc.)

J1	Traffic interference: vehicular	- patronage/access - deliveries - labor supply
J2	Traffic interference: pedestrain.	- patronage/access - labor supply
J3	Takings of businesses.	- patronage
J4	Takings of residences.	- patronage - labor supply
J5	Takings of public property.	(blank)
J6	Takings of community institutions.	- facility
J7-J13	Environmental disturbances	- tenability of premises
J14-15	Utility disruptions: planned and unplanned	- patronage - deliveries - maintenance - operations

SPECIAL POPULATIONS[5] (aged, young, handicapped, minorities, and women; impacts for all of these special populations are similar, but discussion of locus changes for the groups.)

K1	Traffic interference; vehicular.	- access - accidents

[5] Impact is "special" services; everything else is taken up under categories "patron." "resident," etc. In this context, the terms "special" is not to be confused with the use of the term in economics (e.g., special costs).

SPECIAL POPULATIONS (continued)		locus of economic costs
K2	Traffic interference: pedestrian.	- access - accidents
K3	Takings of businesses.	- special services, goods - neighborhood amenities
K4	Takings of residences.	(blank; as residents, see "Residents")
K5	Takings of public property.	- special services, facilities
K6	Takings of community institutions	- special services, facilities
K7-K13	Environmental disturbances	- health - special services - facilities
K14-15	Utility disruptions: planned and unplanned	-special services - access

4.4 CONTENT OF THE CELLS: LOCUS OF SOCIAL IMPACTS

The listings in the previous section detailed some of the loci of economic impacts; let us now turn to the social impacts and their loci.

A1 through D13	All impacts on businesses are by definition economic - no social impacts.	

EMPLOYEES		locus of social costs
E1	Traffic interference: vehicular.	- access more difficult and time consuming
E2	Traffic interference: pedestrian.	- access more difficult and dangerous
E3	Takings of businesses.	- unemployment
E4	Takings of residences.	- may no longer be able to walk or bicycle or even get to work
E5	Takings of public property.	- public areas inaccessible before and after work, during lunch
E6	Taking of community institutions.	- institutional visits can no longer be made before and after work, during lunch
E7-E13	Environmental disturbances	- working conditions
E14-E15	Utility disruptions: planned and unplanned	- work production - vacation time and pay

PATRONS		locus of social costs
F1	Traffic interference: vehicular.	- access
F2	Traffic interference: pedestrain.	- access
F3	Takings of businesses	- convenience for doing business
F4	Takings of residences.	- access
F5	Takings of public properties.	- access before and after doing business
F6	Takings of community institutions.	- access before and after doing bueiness
F7-F13	Environmental disturbances	- comfort
		- attractiveness of environs
		- speed of service
F14-15	Utility disruptions: planned and unplanned	- comfort
		- speed of service

RESIDENTS		
G1	Traffic interference: vehicular.	- access
G2	Traffic interference: pedestrain.	- access and safety
G3	Takings of businesses.	- access and convenience
G4	Takings of residences.	- relocation
G5	Takings of public properties.	- access
G6	Takings of community institutions.	- access
G7-G13	Environmental distrubances	- health, safety
		- comfort, attractiveness of neighborhood
		- social interaction
G14-15	Utility disruptions: planned and unplanned	- convenience
		- health, safety

LOCAL GOVERNMENT SERVICE PROVIDERS[6]		
H1-H2	Traffic interference, vehicular and pedestrian	- work load
		- schedules

[6] Social effects are particularly felt by providers like police and fire departments, which are directly affected by the more difficult access and longer journeys through the construction area. Other service providers, like governmental offices, are affected in the same way as businessness and/or employees.

LOCAL GOVERNMENT SERVICE PROVIDERS (continued)	locus of social costs
H3-H6 Takings of businesses, etc.	- vandalism
	- safety, health
	- working conditions
H7-H13 Environmental disturbances	- health, safety
	- crime
H14-15 Utility disruptions	- health, safety
	- complaints, attitudes

OWNERS[7]

I1-I2 Traffic interference	- protection, safety
	- attitudes
I3-I6 Takings	- loss of property
	- attitudes, beliefs
I7-I13 Environmental disturbances	- health, safety
	- loss of property
	- lifestyle
I14-15 Utility disruptions	- health, safety
	- schedules

INSTITUTIONS

J1-J2 Traffic interference	- utility and availability of services
	- safety
J3-J6 Takings	- level of services
	- attitudes
	- support
	- viability
J7-J13 Environmental disturbances	- safety, health
	- availability and use of services
J14-15 Utility disruptions	- use of services
	- attitudes

[7] Refers to absentee owners; otherwise effects are those of businesses or residents.

SPECIAL POPULATIONS	locus of social costs
K1-K2 Traffic interference	- safety, health
	- attitudes
K3-K6 Takings	- availability of services
	- safety, health
	- lifestyle
	- recreation
K7-K13 Environmental disturbances	- health, safety
	- lifestyle
K14-15 Utility disruptions	- health, safety
	- availability of special services

Now that we have identified the loci of both economic and social costs for various affected groups, it becomes necessary to turn to the actual costs themselves. Since each cost requires a fairly extensive dicussion, we shall only go into details for two specific kinds of cost. We turn to these examples of costs in the next two chapters.

5. ECONOMIC IMPACTS ON RETAIL BUSINESS

In this chapter, we shall discuss, as an important example, the economic costs borne by one group, viz. retail businesses, that arise from the several causal factors. Similarly, in Chapter 6, we shall discuss the social costs that are borne by another group, viz., residents. Both the economic costs discussed in this chapter, and the social costs to be discussed in the next one, are those that *might* be incurred if a tunnel project is implemented. The same costs must also be examined if *no* project is implemented, to see if they are incurred (and if they are, what their size is). Which costs will in fact be incurred, either by building or by not building a project, will depend on local conditions. We have given some indications in footnotes of some actual costs that have been identified either in the literature or through some of the limited field work (largely in Washington, D.C.) that was done in connection with this study.

5.1 COSTS ARISING FROM VEHICULAR TRAFFIC INTERFERENCE (B.1)

Vehicular traffic interference produces economic costs in the area of:

a. deliveries

b. shipping

c. labor supply

d. patronage.

5.1.1 Deliveries

If deliveries of goods and services to retail businesses are slowed or stopped, the business will incur additional costs to the extent that these delivery slippages reduce or postpone sales. For example, if new or seasonal lines of merchandise are seriously delayed, the merchandise cannot be displayed or sold. To the extent that such interferences with deliveries can be foreseen (i.e., that the business is told in advance when the interference will occur), rescheduling of the deliveries can reduce these costs. However, rescheduling involves other costs, either in inventory accumulation (i.e., early delivery and early payment) or in night/weekend overtime. Unplanned interruption will incur the same costs of reduced sales, in addition to the costs of disposing of the goods which cannot be delivered. Depending on the disposal procedure, these costs can include the costs of later redelivery, storage, or unanticipated night/weekend overtime. It may be possible to make deliveries to a nearby place and to hand-truck the goods to the receiving dock. While such a procedure would result in the delivery of the goods, it would entail additional costs.[1]

One further cost of vehicular interference will be the additional time necessary to provide maintenance and other services to the retail business. For example, the cleaning service employees may have to walk to the retail establishment. The costs of such services would escalate in proportion to the additional time required to perform such services.

Measurement of Delivery Costs - In order to measure whether deliveries have been affected and whether this results in costs to the businesses affected, some or all of these variables will have to be measured:

a. length of delivery time (time between the placement of an order and its receipt)
b. method of delivery
c. cost of delivery
d. scheduling of delivery
e. amount of inventory
f. scheduling of employees.

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[1] See for example Atlanta Journal, June 16, 1975, "Traffic Experts Hunting Routes for Big Trucks." The article discusses the need to find new access routes and new curb-side loading areas for buses and delivery trucks in the downtown area of Atlanta, because of the disruptions expected to arise from the tunneling for MARTA. In a similar vein, Business Week, August 18, 1975, in an article entitled "Atlanta's Transit Trauma" quotes Charles Johnson, Engineering Director of Atlanta's Department of Environment and Streets, on the access problem that will result along Peachtree Street: "There are 140 businesses in that corridor and 80 have a single entrance."

In Washington, D.C., a People's Drug Store in the Waterside Mall on M Street, S.W. is feeling effects of the construction of the Waterfront Station by cut-and-cover methods directly in front. The manager of the store reports difficulty in receiving deliveries. A large parking lot has been largely taken over for contractor storage and consequently patrons park along what used to be loading areas. (Interview, November 5, 1975.)

5.1.2 Shipping

Vehicular interference will raise shipping costs just as it raises delivery costs. To the extent that the goods cannot be shipped, they cannot be distributed to customers. Even if the goods are available for distribution, if trucks cannot pick up the goods, the goods cannot be delivered. In some cases it may be possible to arrange for shipment from other locations (e.g., a branch store or warehouse), but such a procedure may raise the cost of shipping. The other alternatives of hand loading or night/weekend loading also involve costs. Unplanned interruptions may involve similar types of costs, if ad hoc procedures of delivery can be implemented rapidly. To the extent that planned and unplanned shipping interruptions cannot be rerouted or rescheduled, customer frustration at delivery postponement (or cancellation) may result in permanent loss of customers and sales. Since shipping goods out and receiving supplies are closely related functions, the same examples apply to both functions.

Measurement of Shipping Costs. The variables that need to be measured in order to determine whether shipping costs are increasing are very similar to those needed to be measured for deliveries:

a. length of shipping times (time between placement of an order and its shipment)
b. method of shipment
c. cost of shipment
d. scheduling of shipments
e. unfilled orders
f. amount of inventory
g. scheduling of employees.

5.1.3 Labor Supply

Vehicular interference will create difficulties in maintaining a steady labor force. Some employees may even quit rather than negotiate a long and difficult walk. In this case, labor force turnover costs--recruitment and training--will be incurred. At a minimum, there may be increased absenteeism and tardiness. The resulting inefficiencies are directly translatable into increased costs.[2]

Measurement of Labor Supply Costs. In order to measure these costs, the following variables will have to be considered:

a. quit rates

b. job turnover rates

c. new hires

d. rate of absenteeism

e. method of journeying to work

f. parking facilities for employees.

5.1.4 Patronage

To the extent that the retail business is dependent on vehicular-borne customers, its sales will decline.[3] Unless the operating costs can be appropriately reduced (e.g., through layoffs of unnecessary sales personnel), the business will lose money. While operating costs can be trimmed, the fixed costs of such items as rent, utilities, and management personnel cannot be significantly reduced. Hence, losses are likely.

To the extent that the sales decline is unplanned, additional costs will be incurred for inventory accumulation and storage.

Rescheduled business hours (additional nights, weekends) may allow some businesses, such as department stores, to attract the same volume of customers as before construction. Additional costs of operating would result from such rescheduling. New merchandising techniques (for instance, increasing newspaper/television advertising, or mail and telephone order

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[2] Atlanta Journal, June 16, 1975, "MARTA Ready or Not..The Big Squeeze." The Problem of anticipated delays in commutation time for CBD destined workers was cited, specifically the case of a David Wallace who is employed in a law firm and for whom the rerouting of Bus #31, which currently affords him nearly door-to-door service, will mean significantly longer trip times. The elimination of parking spaces and street capacity in the CBD will also frustrate many commutation trips according to planning estimates presented in the article.

[3] Interview with Norman Funk, Public Relations Director, Toronto Transit Commission, Toronto, Ontario, 6/24/75. According to Mr. Funk, businesses which suffered greatest losses in Toronto during rapid transit tunneling were those which were auto related in character and which were dependent on vehicles borne customers. These included filling stations and automotive repair shops.

services) may recapture some of the customers. Such sales merchandising techniques will result in additional costs of operation.[4]

Measurement of Patronage Costs. In order to ascertain the extent and quantity of losses of patronage resulting from tunnel construction, the following variables will have to measured:

a. total level of sales
b. amount of average sale
c. composition of sales
d. number of purchases
e. hours of operation
f. merchandising techniques and costs thereof
g. profits
h. average cost per unit of sale
i. marginal cost per unit of sale
j. parking facilities for customers
k. number of customers.

5.1.5 General Qualifications

The preceding discussion of four kinds of cost is subject to some qualifications. One arises from the duration of the vehicular interference. If the interference is brief, it is possible that costs will be slight. Delivery and shipping slippages of a few weeks are likely to have minimal impact. But the longer and more total the interference, the greater the costs are likely to be. In the extreme, the businsess will shut down.[5] Short of closing, a business may have to redefine its character and its market, relying for instance more on mail or on pedestrian traffic.

[4] Interview with Cody Pfanstiel, Director of Community Relations, WMATA, July 15, 1975. Stores impacted by tunnel construction in Washington's G Street area were encouraged to hold special sales promotions centered on the theme of the construction and celebration of its milestones, in order to recover sales otherwise lost because of the construction.

[5] The experience of merchants along G Street, N.W. in Washington, D.C. is that despite the fact that the street and sidewalks have been restored, business is still far below the pre-construction level. (Atlanta Journal, June 17, 1975, "I Lost My Shirt"). It is difficult to know whether all of the G Street merchants' problems were due to the tunnel construction or not. Merchants along Connecticut Ave., where WMATA also constructed a tunnel by cut-and-cover methods, apparently fared much better. The manager of Raleigh Haberdashery on Connecticut Ave. claimed that his business had not suffered at all from the construction. (Interview, October 17, 1975.)

Another qualifying factor will be the size of the business. The larger the business, the more easily it will be able to absorb the temporary costs of vehicular interference. Larger stores will also be able to adapt more readily to the interference through such short-run measures as temporary layoffs (since it has more employees to lay off), altered business hours, and altered distribution procedures (i.e., branch stores).[6]

Another factor to be considered is the time of the year. If the vehicular interference occurs during the inclement winter months, employees and customers are less willing to walk and merchandise is more apt be be damaged in receiving and shipping. Hot, humid summer wheather can cause similar results. In both cases, such events directly translate into additional costs. Seasonality also affects sales. Certain seasons (e.g., Christmas, Easter) are peak sales times. Should the vehicular interference occur during these peak seasons, the retail business will suffer greatly. While the business may be able to absorb reduced sales during low months (February, for instance), sales during the peak months carry the business over low times. Hence, vehicular interference during a few peak sales months may make a critical impact on the business's yearly total financial picture.[7]

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[6] According to Mr. Richard Steen of Lewis & Saltz, the store's suburban branch largely "carried" the G Street store during the disruptive period of the tunnel construction. (Atlanta Journal, June 17m 1975, "I Lost My Shirt.) The same article alludes to the fact that the small, single unit stores along G Street had greater difficulty in surviving the losses suffered as a result of the construction disruption than bigger chain stores. In an interview, Mr. Leonard Klodny, Retail Bureau Chief, Washington Board of Trade, expressed a similar opinion.

Mr. O'Connor, manager of the People's Drug Store on M Street, S.W., indicated that his store had suffered a decline in business of 10 - 15% from subway construction. But, he said, People's Drug Stores can sustain the loss and will remain in the area in the hope that the subway, once it is completed, will greatly increase their business.

[7] Cody Pfanstiel, Director of Community Relations, WMATA, indicated that because of the critical nature of the pre-Christmas period to retail merchants, efforts are made, whenever possible, to close down work in retail areas between Thanksgiving and Christmas. (Interview, July 15, 1975.) Walter Mergelsberg, Construction Engineer of WMATA, while agreeing that every effort is made to keep streets in commercial districts free of construction-related tie-ups during the Christmas shopping season, also acknowledged that unanticipated delays associated with construction often make it impossible to achieve this goal. We already noted in Chapter 3, that M Street, S.W. was torn up between 3rd and 5th Street during the entire Christmas season of 1975.

As for all businesses, economic theory discusses thresholds of cost increases which are critical to business decisions.[8] So long as the business is making a profit, it is unlikely to make any critical decisions--such as moving to a new location. Once the costs increase to the point where losses are incurred, the business will begin to consider new strategies--new locations, new marketing devices, new clientele. But so long as the business is capturing enough revenue to meet its variable costs of operation, it is likely to stay in operation, even though it may not be meeting its fixed costs (such as rent), although it will probably follow new strategies. However, once revenues are reduced below the level necessary to meet the variable costs of operation, losses can be minimized by stopping operations altogether, leaving losses equal just to total, sunk, fixed costs. Once the interference has been reduced to the point where costs go down and revenues go up enough to to meet variable costs, the business will begin its operation again. However, in the process of the interim closing, the business may lose some of its permanent, return customers (who have found new stores to purchase from).

Hence, the business may consider its long run operations and stay in business despite the fact that the business is not meeting its variable costs--if it thinks it can recoup losses due to interference, after the interference has ended.[9]

5.2 INTERFERENCE WITH PEDESTRIAN TRAFFIC (B.2)

Interference with pedestrian traffic produces economic costs in the areas of:

a. Labor supply and

b. Patronage.

5.2.1 Labor Supply

To the extent that employees walk some distance to work, pedestrian interference will create some difficulties in maintaining a steady labor force. The longer and more difficult the walk becomes, the more employees

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[8] Richard H. Leftwich, The Price System and Resource Allocation (New York: Holt, Rinehart, and Winston, 1966), Chapter 9.

[9] See the People's Drug Store case discussed in footnote 6 above.

are likely to be late, absent, or to quit. The result will be increased costs of recruitment, training, and reduced efficiency. It must be remembered that all employees are pedestrians, if only during their walk from the parking lot or bus stop. Hence, all employees will be affected, at least to a limited extent.

The business may be able to mitigate such effects by installing a shuttle service between the entrance and a common meeting place. Obviously, such a service will create costs. Furthermore, if vehicular interference coincides with pedestrian interference, the business cannot mitigate pedestrian effects.

5.2.2 Patronage

To the extent that the retail business is dependent on pedestrian traffic, its sales will decline. Again, all customers, except those who order by mail and telephone, are pedestrains, if only during their walk from the parking lot or bus stop. Hence, all in-person customers will be affected.[10] Shuttle service may mitigate the pedestrian inconvenience, unless there is also vehicular interference.

This discussion has focussed on cost increases and profit reductions that may arise from difficulties pedestrians have as a result of construction. However, occasionally, pedestrian patronage may be positively affected by construction. This is due to the large number of construction workers in the neighborhood of the retail business. Because the construction workers are also consumers (e.g., lunchtime purchases), their presence can lead to

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[10] Interview with Mr. James Corbett, Business Relocation Supervisor, District of Columbia Redevelopment Land Agency, 12/10/75. According to the relocation head for an urban renewal project in the G Street area of Washington, stores which suffered greatest loss during construction were those which were most dependent on pedestrian "walk-in" trade. Indeed, the continued absence of pre-construction levels of pedestrian traffic along G Street, despite restoration of the sidewalk, has continued to depress the retail climate.

Mrs. Brill, owner of a travel agency in the Waterside Mall and head of the Mall Merchants Association, claims that business from residents across the streets is down for all stores. She blames this on the difficulty of crossing M Street since the cut-and-cover construction for the Waterfront station began in September 1975. (Interview, October 17, 1975).

pedestrian patronage increases.[11]

Measurement of costs arising from pedestrian interference. Because labor supply and patronage are the elements affected, the same variables need to be measured here as those listed above where labor supply and patronage were considered as affected by vehicular interference.

5.3 TAKING OF BUSINESSES (B.3)

This produces economic costs in the areas of:

a. own facility and

b. neighboring facilities.

5.3.1 Own Facility

If the tunnel construction takes the physicial structure housing the retail business, the business must stop operations at that site. It then must decide whether or not to relocate, and if it does relocate, where and how. Because a retail business is critically dependent on personal visitation patronage, it must evaluate: (1) whether its current (pre-construction) customers will now come to its new location, and (2) whether the business will be able to attract new customers at its new location. If it does decide to move, the business will have to pay for the costs of moving (which may or may not be compensated).[12] If it decides to go out of business, the business incurs the additional costs associated with closure, e.g., severance pay for employees.

[11] Interview with the Manager of a Waterside Mall Butcher Shop, Nov. 6, 1975. Despite the fact that business has dropped approximately 10% since the advent of construction, potential losses have been somewhat off-set by purchases of construction workers, chiefly snack items.

[12] While the physicial costs associated with relocation, when a project involves a taking, are compensated by law, the costs associated with business lost during the transition are not. Additionally, if no direct taking is involved, the retailer must either pay the cost of temporary or permanent relocation himself, or suffer the losses which will most probably accrue from the construction dislocation. Cases have been reported in Atlanta of businesses who have already moved out of the impact area prior to construction, in order to avoid such losses (see Atlanta Journal, June 19, 1975, "Store Owners vs. Subway, A Mismatch.").

Measurement. In order to measure the cost to a business of its facility being taken, some of the variables that must be looked at include:

a. changes in location

b. cost of relocation

c. cost of closings

d. date of taking.

5.3.2 Neighboring Facilities

Retail businesses tend to locate adjacent to or in close proximity to other retail businessess because of the "anchor tenant" phenomenon. Big retail stores tend to draw many customers and potential customers. Therefore, little retail stores like to locate nearby to gain some of the overflow patronage. In other words, the big retail stores tend to anchor the other tenants. Similarly, groups of smaller stores can create the same phenomenon, and together can form a drawing card greater than any one of the stores could create individually.

Therefore, when neighboring facilities are taken over by the construction process, some drawing power is lost for the remaining retail stores.[13] The result will be a reduction in sales. To compensate, the remaining businesses may try new marketing strategies to draw back the customers. Such strategies will involve costs, e.g., costs of additional newspaper advertising.

Measurement. Variables to examine in order to determine the cost to a retail business of taking neighboring businesses include:

a. composition of neighboring stores

b. total level of sales

c. level of average sales

d. number of purchases

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[13] Interview with George Murphy, Project Engineer, Parsons, Brinckerhoff, Quade & Douglas, July 15, 1975. The drawing power of G Street in Washington D.C. has been reduced not only because a number of stores have disappeared on account of relocation or bankruptcy, but also because two major department stores, Lansberg's and Kahn's, both near G Street, have recently closed. Their departure has probably further weakened the viability of the retail area, whether or not the closings were caused by the tunnel construction.

e. merchandising techniques and their costs
f. profits
g. average cost per unit of sale
h. marginal cost per unit of sale
i. composition of sales
j. date of taking.

5.4 TAKING OF RESIDENCES (B.4)

This produces economic costs in the areas of:

a. labor supply and
b. patronage.

5.4.1 Labor Supply

To the extent that the retail business employs local persons whose residence has been taken by the construction process, the business will have problems maintaining a steady, dependable labor force. Relocated employees may quit, rather than negotiate a longer journey to work. In this case, labor force turnover costs of recruitment and training would rise. At a minimum, there may be increased absenteeism and tardiness. The resulting inefficiencies are directly translatable into costs.

An extreme case of the above situation occurs when the employee whose residence is taken is the owner of the business. If the owner has located his business intentionally close to his residence, then taking his residence is identical to taking his business. If the owner cannot relocate his residence in a nearby area, he may move his business too, so that he can remain in close proximity to it.

5.4.2 Patronage

To the extent that a retail business is dependent on sales to local residents, taking residences and the ensuing loss of customers will reduce the revenue of the business. Unless costs go down correspondingly, the business will suffer relative cost increases. It is likely the costs will increase, especially for that subset of costs called "merchandizing," as the business attempts to recoup revenues through increased advertising and new promotional schemes. Additional costs will be associated with such attempts.

Measurement. The variables to examine in order to measure what the costs are in the areas of labor supply and patronage will be very similar to the variables already listed above under 5.1.3 and 5.1.4. There the labor supply and patronage were affected by traffic problems, but the determination of the amount of effect will require measurement of the same variables here. In addition, the date of the takings must be ascertained here, and--for the effect on patronage--a determination must be made of where customers' residences are located.

5.5 TAKING OF PUBLIC PROPERTIES AND COMMUNITY INSTITUTIONS (B.5, B.6)

This will reduce the patronage of those retail businesses which provide goods and services to individuals using the public properties or the institutions. These businesses would include, for example, sporting goods stores next to parks and book stores next to schools. Fewer customers mean less revenues. There are likely to be few retail stores so affected. But to the extent that the public properties or the institutions attract customers to the general area, the stores will lose these customers.

Measurement

All the variables relating to patronage will have to be examined. Of particular importance is the determination of the percentage of sales that is dependent either on the public properties or on the institutions taken.

5.6 ENVIRONMENTAL DISTURBANCES (B.7 - B.13)

Environmental disturbances may make retail business less tenable and produce costs in the areas of:

a. maintenance, operations, and patronage

b. labor supply.

5.6.1 Maintenance, Operation, and Patronage

Any construction activity which reduces the "quality" or "ambience" of the retail store or its merchandise will increase costs and/or reduce sales. Dirt, for example, may enter the store as air pollution and damage the store's goods. Unless cleaned, the dirt will result in customers buying less. Additional cleaning and maintenance of the store will result in additional cost. An alternative is to lower the price of the goods to compensate for lower quality. This will result in reduced revenues. But even more frequent cleanings may not maintain the store's previous level of quality.

Events external to the store's building, however, cannot be remedied by the store. Street noise, air pollution, vibrations, etc., will reduce the desirability of shopping in any of the retail stores near the construction. The result will be a reduction in patronage and sales.[14]

On the other hand, air, noise, and water pollution, etc., may mean that residents make additional purchases from the retail stores of items designed to reduce the impact of the environmental insults (e.g., vacuum cleaners, earphones). Alternatively, the residents may forego, at least temporarily, the purchase of items which might be ruined by the environmental effects of the construction (e.g., drapery, which will only get dirty; automobiles, which may get ruined). In the extreme, the residences may become so untenable that the residents move. To the extent that these residents are patrons of the retail stores, retail store sales will decline.

Measurement. Insofar as patronage is reduced by environmental disturbances, the same variables need to be measured as were mentioned earlier. Since there may be more need for maintenance, the following variables also should be measured:

a. level and cost of maintenance

b. quality of merchandise (e.g., is more merchandise being returned than before the construction?)

c. amount of dirt, noise, water pollution etc., which is outside of the store

d. amount of dirt, noise, water pollution etc., which is inside the store

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[14] Mr. Harry Shapiro of Maison's, a women's clothing store at 13th and G Streets, N.W., in Washington mentioned an increased need to wash windows during the construction period. He further related that mud was frequently tracked into the store by both employees and customers. Because the establishment catered to a relatively wealthy clinentele, this problem was thought to contribute to the significant decline in sales during METRO construction. (The Atlanta Journal, "I Lost My Shirt," June 17, 1975.) It is difficult, of course, to know whether to attribute a decline in sales to environmental disturbances, to traffic interference, or to causes unrelated to tunnel construction.

e. amount of any increase in vandalism

f. starting and ending dates of environmental insults

g. dates of peak environmental insults.

5.6.2 Labor Supply

Construction activity resulting in air pollution, noise, vibrations, etc., will create difficulties in maintaining a steady, motivated labor force. Employees may quit rather than tolerate such undesirable working conditions. In this case, labor force turnover costs of recruitment and training would arise. At a minimum, there will be a reduction in efficiency, as the employees attempt to circumvent or reduce the impacts of air pollution, noise, etc. The resulting inefficiencies and new tasks (e.g., additional dusting off of merchandise) are directly translatable into additional costs.[15]

The efficiency of workers who are undergoing environmental insults in their home probably will decrease. In the extreme, the residences may become so untenable that the residents move. To the extent that such residents are employees of the retail store, the labor supply effects will be comparable to the taking of residences. The retail businesses will have problems maintaining a steady, dependable work force, as the relocated employees quit or perform less dependably. The economic situation will have much to do with the willingness of employees to endure environmental hardships.

Measurement. Insofar as labor supply is affected by environmental disturbances, the same variables need to be examined as were mentioned earlier. In addition, the following should also be measured:

a. cost of maintenance employees

b. amount of dirt, noise, pollution, etc., outside the door of the store

c. amount of dirt, noise, pollution, etc., inside the store

d. starting and ending dates of environmental disturbances.

[15] Interview with Glen Slickler, Branch Manager, American Security & Trust Waterside Mall Washington, D.C., 12/12/75. Mr. Slickler related the fact that the constant noise of the construction activity has produced headaches among bank employees, particularly during the pile driving phase of the operation. In addition, he has received complaints from both employees and customers concerning smoke produced by the construction equipment, particularly pile drivers.

5.7 UTILITY DISRUPTIONS: PLANNED (B.14)

These produce costs to retail businesses in the areas of:

a. deliveries,

b. shipping,

c. operation,

d. patronage, and

e. labor supply.

5.7.1 Deliveries

Deliveries will have to be scheduled at times not affected by the utility disruption. If these deliveries are at night or over the weekend, the retailer may have to reimburse the delivery service for the necessary overtime. If the deliveries have to be postponed some number of days or weeks, the retailer may incur additional storage and redelivery charges.

5.7.2 Shipping

Shipments will have to be scheduled at times not affected by the disruption. If these deliveries are at night or over the weekend, the retailer will have to pay his employers for overtime work. Shipments may be possible for alternative locations (i.e., branch stores) at some additional cost.

5.7.3 Operation

The retailer will have to reorganize his plans of operation, at least for his warehouse operations. Such plans will involve time, effort, and cost. He may also have to reschedule his customer-oriented operations, and change his hours of business and marketing plans (e.g., sale dates).

5.7.4 Patronage

Customers who are interested in quality of service and goods may find the quality of both services and goods are reduced. Rather than reschedule their shopping visits and accept delayed shipments, the customers may postpone or simply eliminate anticipated purchases. To meet current needs, customers may go to different retailers. The more frequent the disruptions, and the resultant reductions in quality of service and goods, the more the customers will discount the quality of goods and services available from the affected retailer and look for different retailers. After some number of disruptions, the customer will become permanently disenchanted with the retailer, and will no longer be a return customer.

5.7.5 Labor Supply

As the retailer attempts to reschedule his operations around the planned disruptions, he will have to reschedule the hours of work supplied by his employees. Increased frustration and dissatisfaction with overtime work on the part of his employees will reduce their efficiency. If the employer cannot meet all his needs by rescheduling his current work force, he may have to recruit and train additional employees, at some cost.

5.8 UTILITY DISRUPTIONS: UNPLANNED (B.15)

These produce costs to retail businesses in the areas of:

a. deliveries,
b. shipping,
c. operation,
d. patronage, and
e. labor supply.

5.8.1 Deliveries

Unplanned utility disruptions may increase the cost of deliveries by causing delivery slippages, which in turn may reduce or postpone sales; e.g., "sale" goods which do not arrive in time for the "sale" cannot be sold. If the retailer is forced to accept these goods, but does not receive them until after they are needed (i.e., after the "sale"), then he must store them or sell them at even lower prices. Costs result in both cases.

In most cases, the delivery can be rescheduled, so that the merchant receives his merchandise reasonably within schedule, but at a less convenient time; for instance, at night or on weekends. In addition to overtime pay for his own employees, the retailer will (probably) have to pay the delivery agent for the extra, unplanned delivery. Furthermore, unplanned disruptions may result in damaged shipments (e.g., food deliveries).

5.8.2 Shipping

Unplanned utility disruptions will raise shipping costs for similar reasons. If the utility disruption postpones shipping, customers will not receive their goods when expected, and may cancel their order. It may be posssible to arrange for shipping from alternative locations, but such a procedure may raise the costs of shipping. If the shipment is postponed or rescheduled, the retailer may have to pay his employees overtime.

5.8.3 Operation

Unplanned utility disruptions will affect the general operation of the retail business. Because plans are not followed ad hoc procedures will have to be implemented. At best, such procedures will reduce the time available for employees to perform ordinary tasks. Bottlenecks, slippages, and misplacements may result. In the extreme, routine operations may become so confused as to result in chaos. For example, electricity may fail, and employees and customers alike will not be able to see. Injuries to goods and people alike may result. Compensation and litigation will increase costs.

5.8.4 Patronage

Customers who are interested in quality service and goods may find the quality of both service and goods reduced. They may postpone or simply eliminate anticipated purchases. To meet their current needs, the customers may go to different retailers for their purchases. The more frequent the unplanned disruptions, the more the customers will discount the quality of service and goods available to the retailer and look for different retailers. After some number of disruptions, the customer will become permanently disenchanted with the retailer and will no longer be a return customer.

5.8.5 Labor Supply

Unplanned utility disruptions will create difficulties for the retailer in maintaining a steady labor force. Employees may quit rather than continue to work under such confused, disoriented circumstances. In this case, labor force turnover costs or recruitment and training will rise. At a minimum, there may be increased frustration and confusion, and dissatisfaction with overtime work. The resulting inefficiencies are directly translatable into increased costs.

Measurement. Since both planned and unplanned utility disruptions affect deliveries, shipping, patronage, and labor supply, the variables to be measured are those already listed for these topics. In addition, the hours and number of disruptions must be noted. For operations of retail businesses, the following variables must be measured:

a. changes in operating procedures
b. changes in overhead costs
c. changes in merchandising
d. changes in hours of operation
e. changes in scheduling of employees.

6. SOCIAL IMPACTS ON RESIDENTS

In this chapter, we shall examine some of the costs that may fall on residents in an area where tunnel construction is going on. As in the case of economic costs, local conditions will determine which costs are actually borne by a given set of residents. These local conditions include the method of construction, the timing of it, the distance from the construction site, and any special regulations that the residents may have succeeded in imposing on the contractor. As in the previous chapter, we shall indicate in footnotes whenever we have evidence from the literature search or from our data collection that some of these costs actually were incurred in a tunnel construction project.

We have chosen row G of the matrix--impacts on residents--for examination in this chapter. We shall pay particular attention to G4--the impact on residents of their own residences being taken because of the tunnel construction. The social cost of being involuntarily relocated can be very great and therefore needs to be examined carefully in order to discover any and all ways in which this cost might be lessened.

6.1 INTERFERENCE WITH VEHICULAR TRAFFIC (G.1)

Restriction of vehicular traffic impacts residents of an area in terms of driving out, in, and through. If it is difficult to leave one's residence, a number of impacts can result. A worker might be required to get up earlier in the morning in order to be at work on time; a high school or college student who drives to school would be similarly affected. If residents cannot park close to their homes because of the construction, they will have to walk, sometimes in inclement weather, a distance to their cars. Besides the loss of time and comfort involved in "driving out" problems, there is a loss of sense of security. Residents whose cars are parked far away might worry about their cars being stolen and might feel insecure in knowing that, in an emergency, their cars are not immediately available.[1]

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[1] In constructing the extension of the Picadilly Line to Heathrow Airport, 24 residences had their garages made inaccessible for varying periods of time. London Transport provided temporary garages; however, use of these involved

The second area of interference is driving in. At the end of a working day, residents must deal with barriers and detours before arriving home. In the winter, it is dark by supper time, and residents may feel uncomfortable walking at night. The lack of close access affects residents in terms of visitors--friends, emergency vehicles, and taxis meet interference. Furthermore, the reduction in parking spaces that often accompanies construction causes a loss of time and convenience to those who drive in, whether they are residents or visitors.

In terms of difficulties in driving through an impacted area, loss of time and increased chance of accidents are most significant impacts. Detours entail removal of traffic from one street to another. The new street might previously have been a low-traffic area. Time loss comes from the detour configuration itself and from the probable traffic jams that occur when a narrow, low-use street suddenly becomes a corridor. Increased accidents arise from the many trenches and barriers involved in the construction, the narrowness and unfamiliarity of the detour route, and the behavior of pedestrians, especially children, who are unaccustomed to the increase in traffic in the detour street. The issues of driving through a construction area involve not only residents, but also all those who pass through the area.[2]

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an additional walk for several of the residents. In consideration of the inconvenience the residents were also paid £200 each. (Report from London Transport, p. 3 and conversations with D. G. Jobling, October 30, 1975.)

[2]Traffic along M Street, S.W. between 5th and 3rd Streets is very congested, particularly during the rush hour. Because of the cut-and-cover construction, traffic has been reduced to one lane in each direction and that one lane is narrow, being located on what used to be the sidewalk. Taxis hesitate to come into this area, because during the rush hour it often takes 10 minutes to negotiate two blocks. (Observation by Abt staff, November-December, 1975.)

In Boston, during the construction of the southern extension of the Orange Line, emergency vehicle access was at times made difficult, particularly when the intersection of Kneeland and Stuart Streets was closed. Added police were stationed in the "cut-off" area to report on possible emergencies. Although the affected area is not primarily residential, the problem would be similar in a residential area. (Visit to South Cove Station, July 16, 1975.)

Difficulty of access to their homes on account of subway tunnel construction was also one of the concerns of Tiber Island residents in Washington, D.C. Their inability to get an accurate estimate of how restricted their access would be and what alternative means of access had been planned is cited in their complaint against WMATA. (Tiber Island Condonimium et al. vs. Washington Metropolitan Transit Authority, p. 8)

Measurement

Variables to measure, in order to determine the social cost arising from vehicular traffic interference include these:

a. number of cars diverted into residential street during rush hour

b. added distance from new parking space to home, compared to former distance

c. length of time required to drive through an affected area compared to former time

d. number of accidents during construction period

e. severity of accidents (expressed in dollar value of damages)

f. time added to average commuting time of residents.

6.2 INTERFERENCE WITH PEDESTRIAN TRAFFIC (G.2)

Pedestrian traffic ordinarily moves along sidewalks and crosses streets at intersections. In addition, pedestrians walk in parking lots on paths approaching buildings from the sidewalk, and sometimes across empty lots. Sidewalks removed are usually replaced by temporary wooden walkways, but walkways often are installed on only one side of the street. Thus walking is not permitted on one side which formerly had a sidewalk. This reassignment of walking areas affects the walkers, who previously walked on the forbidden side in order to reach homes, shops, etc., on that side; and it affects the residents and shopowners on that side who must contend with the limitation of access. Homes and businesses on the side of the street with the wooden walkway are not necessarily free of interference. Such walkways often do not permit ingress and egress in the middle, thus requiring pedestrians to walk around the structure to reach their destinations. The walkways often have walls on the curb side, and thus prevent visual contact (window shopping, etc.) between pedestrians and buildings.

Pedestrian interference at intersections usually consists of overpasses, underpasses and detours--all of which cause loss of time and convenience. Such detours can be particularly difficult for elderly and handicapped pedestrians, who often cannot manage the steps and grades involved. Other pedestrian interference generally consists of barriers to accustomed walk areas such as empty lots. Such interference generally results in a time loss.

All barriers and temporary structures increase the likelihood of accidents, although their quality is usually limited to sprained ankles, stubbed toes, etc. An exception is the serious problem of lack of pedestrian visibility at intersections. Pedestrians emerging suddenly from covered walkways and stepping off the curb could be involved in accidents it cars turning do not expect a pedestrian to emerge. The pedestrian, in turn, cannot see the turning cars.

As in the case of vehicle interference, pedestrians may be not only residents, but other passersby in the area.[3]

Measurement

To ascertain the social cost arising from interference with pedestrian traffic, some of the following variables must be measured:

a. Added walking distance for residents for routine trips

b. Number of trips foregone because of hazards, together with destination of these trips

c. Added cost for use of vehicles (taxis) on trips that were formerly done on foot

d. Number and severity of pedestrian accidents on construction-related sidewalks.

6.3 TAKING OF BUSINESSES (G.3)

The loss of business to area residents has a greater or lesser impact, depending on the uniqueness of the business and the demand for it.

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[3] Fewer people walk (in the U.S.) than drive cars to their residences. Consequently, temporary sidewalks tend to be of inferior quality and often seem to be an afterthought. On M Street in Washington, the temporary sidewalk is on the former grass area. On D Street, S.W. (not a residential area), a temporary raised sidewalk has been erected during the construction of the L'Enfant Plaza station. While this gives added safety (because pedestrian and automobile traffic are separated), the raised wooden sidewalk is narrow and requires several steep steps to be negotiated.

Those who are dependent on sidewalks will be inconvenienced by relocation. London Transport's report notes that a blind couple was provided with taxi transportation twice a day while the sidewalk to which they had been accustomed was temporarily relocated.

In Boston, the MBTA is being sued by a woman who claims she injured herself by stepping into a hole in the sidewalk during construction of the South Cove tunnel and station.

In some cases, the taking of a business would not even be noticed. For example, if a building containing a grocery store with a mail-order business above it were taken, the grocery store would be missed, but not the mail-order business, which had little connection with local activities. Of course, if the grocery store was overpriced and/or close to a more comprehensive supermarket, its loss might not have much impact on residents either, unless it had other attractions, such as staying open very late.

The types of business likely to be most strongly missed are the unique ones, such as the only laundromat in the area, or the popular ones, such as the traditional local tavern. In both cases, the loss in social terms revolves around loss of familiar places. In the case of the laundromat, a time loss also results. In the case of the tavern, the loss goes much deeper--companionship, routine, and a local landmark.

Measurement

The social impact of the taking of businesses can initially be measured by an assessment of the number of patrons who previously used the establishment and the distance that they must travel to meet their need elsewhere. Intangible losses, such as the loss of the tavern meeting place, can be measured only in terms of the number of regular customers it had.

Methods for amelioration of such takings are the issuance of warnings to customers, with a list of nearby substitutes, their addresses, and their hours.

6.4 TAKING OF RESIDENCES (G.4)

The social impacts of displacement and relocation fall into three categories:

a. financial burden of relocation
b. disruption of move
c. loss of familiar environment and adjustment of new location.

The costs associated with relocation are primarily an "economic" impact, but the economics of a household are so bound to its functioning, status, and way its members relate to each other and their surroundings that the social aspects of this impact must also be considered.

Studies of relocation have revealed two common characteristics of relocatees' rehousing situations:

a. the replacement housing to which relocates move is generally better quality than that from which they were displaced.

b. the replacement housing is more expensive, and relocatees pay a higher proportion of their income for housing.[4]

While relocation may lead to an apparent improvement in a household's housing, the increased costs associated with that housing may force cut-backs in spending for other essentials such as food and clothing and for other needs such as education, entertainment, transportation, etc., or may necessitate another household member's employment.

Because of the costs of relocation, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL 91-646) (hereafter referred to as the "Uniform Act") was passed providing extensive financial assistance to displaced owners and tenants:

In addition to the fair market value of the acquired property, owners-occupants meeting certain eligibility requirements, may receive up to $15,000 to cover the"reasonable cost" of a comparable, decent, safe, and sanitary dwelling which is "reasonably accessible to public services and places of employemnt and available on the private market"; increased interest costs required to finance a comparable replacement dwelling; and incidental expenses required for the purchase.

Tenants meeting certain eligibility requirements may receive up to $4000 to cover the amount necessary to rent, "for a period not to exceed 4 years, a decent, safe, and sanitary dwelling of standards adequate to accommodate such person in areas not generally less desireable in regard to public utilities and public and commerical facilities, and reasonably accessible to his place of employment."

$2000 plus matching funds up to an additional $2000 (for a maximum of $4000) is also payable towards a downpayment for tenants wishing to

[4] Mogey, John, et al. Social effects of Eminent Domain--Changes in Households after Involuntary Relocation for Southwest Expressway (I-95) Boston, 1968-1970, Boston University, July, 1971, pp. 11-12.

Thursz, Daniel. Where Are They Now? Health and Welfare Council of the National Capital Areas, Washington, D.C., 1966.

purchase replacement housing. This provision has enabled many displaced tenants to become homeowners, a change having substantial effects on the social as well as economic status of the household. The $15,000 and $4,000 limitations may be exceeded under the provisions of Section 206 (a) of the Uniform Act. If comparable sale or rental housing is not available, the displacing agency may take whatever action is needed to provide such housing. This may mean simply making payments in excess of the normal limitations or it may mean construction of comparable housing for relocatees. Such housing of "last resort" has not been implemented on a large scale, but several states receiving federal funds have made use of it in a variety of ways to ensure the project can proceed to construction in an expeditious manner.

Besides the above replacement housing payment provisions, payment is also made for moving expenses.

These payments have greatly eased the financial burden of relocation and have been largely responsible for the general improvement in the housing of relocated families. Such improvement may lead to an rise in a household's perception of its social status, and increase in a sense of security and well-being, and, in cases where pre-relocation housing did not meet standards of "decent, safe, and sanitary" housing, may also have positive implications for a household's health and safety.

Case folders in the files of the Massachusetts Department of Public Works contain instances in which it appears that the existence of financial benefits plus the necessity to relocate may have acted as an incentive or opportunity for family members to make changes in their living situation they might otherwise not have made: a married couple may separate; a grown child may decide to relocate to his or her own home; a parent might assist a grown child to purchase a home. (Relocation case files for projects on the I-95 North and Rte 52 projects in Massachusetts contain instances of such events. Although the displacement was for a highway, it was carried out under the Uniform Act and is readily comparable to displacement for urban renewal, transit, etc., with respect to its social effects.)

Some of the financial burden is noncompensable under existing law. After the 4-year limitation on a rent supplement payment, tenants may be unable to afford the dwelling and be forced to relocate again, this time on their own, or pay a substantially larger proportion of their income for rent. Owners of higher valued homes have to absorb the increased taxes, since the law now makes no provision for them. A larger dwelling may mean higher heat and utility bills (estimates of heat and utility costs used by utility companies are generally based on numbers of rooms in the dwelling, among other things) and increased maintenance expenses, none of which are compensable under existing law.

The financial burdens fall more heavily on some types of households than others. Elderly and low-income families, for example, can be expected to have the most difficulty and may have to change spending priorities, use savings to meet regular living expenses, or depend on relatives for contributions.[5] All these have heavy social implications in that they narrow the household's range of choices in living style and may create or increase their dependency on other persons or institutions. In fact, relocation itself, even in its positive aspects, represents a limitation on choice: relocatees do not have the option to remain where they are and must move, usually within fairly rigid time constraints which may narrow choices even further.

The disruption of the move is a relatively short-term impact, involving the time and effort spent in a search for a new dwelling as well as the preparations for the move itself: making arrangements for a mover or vehicle for a self-move, packing, cleaning, painting the new dwelling if necessary. The settling in process involves unpacking, arranging furniture, making arrangements for telephone, heating fuel, electricity, gas, settling children in a new school, finding new shopping areas and transportation routes, etc. The costs of this process are mainly time costs and could be fairly well estimated by careful interviewing of relocated residents.

For mobile young adults, the moving process might be time-consuming but not emotionally burdensome. For an elderly person or persons handicapped or in poor health, who find it difficult to get around, it may not only be very time-consuming and expensive but also emotionally upsetting and physically harmful as many new people, institutions and situations must be dealt with

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[5] Goldstein, S., and Zimmer, G. Residential Displacement and Resettlement of the Aged. Rhode Island Division on Aging, Providence, 1960.

and old sources of assistance may no longer be available to provide both physicial help and emotional support.[6] Heart attacks and strokes, while not common, are not unheard of at this stage of the process and may be related in part to the stress associated with the disruption.

The loss of a familiar environment and adjustment to a new location constitute the most elusive of impacts to measure but may be the most truly disruptive and the ones most likely to produce resistance to the whole relocation process.

Experience in relocation, as well as studies like the Mogey work (see Footnote 4) has shown that long-time residents of a neighborhood can be expected to experience relatively more hardship than short-term residents. Complex support networks have been built up over the years, and, for many elderly people and low income families, are what enable them to live with relative independence on very low or fixed incomes. The presence of relatives or close friends may enable an elderly or handicapped person who cannot get around alone to do shopping, pay bills, see the doctor, etc.; it may enable a single parent or both household heads to work to support a family without expensive baby-sitting or day-care services.

Adjustment to new surroundings will be most difficult for those with fewest resources--financial, physical, emotional. It will vary too with the degree of change that has taken place: a family moving from a single family home to another in the same neighborhood may have far fewer adjustment problems than an elderly woman who moves from her single family residence to a high rise housing project for the elderly.

A study of relocation for Boston's West End urban renewal project found that servere disruption was experienced by working class households, who in this case, lived in a closely knit community.[7]

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[6] Nash, W.W. and Voss, J.R. Analyzing the Socio-Economic Impacts of Urban Highways. HRB Bulletin 268, 1960, pp. 80-94.

Study of the Relocation of Elderly Persons. Institute for Environmental Studies, University of Pennsylvania, Philadelphia, 6 vols., 1966.

[7] Fried, Marc. Grieving for a Lost Home: Psychological Costs of Relocation. In the Urban Condition (Duhl, L. J., Ed.), Basic Books, Inc., N.Y., 1963.

Displacement also has definite impacts on residents who remain. Acquisition procedures and construction timetables may mean homes and businesses are acquired and vacated well in advance of demolition and construction. Vacant structures are prime candidates for vandalism, fires, and can be hazardous to neighborhood children. Isolated occupied structures among vacant ones are more likely to be victims of crime.

Measurement

The variables that need to be examined in order to ascertain the social costs fo relocation include the following:

a. present rents paid or other current housing costs
b. rents or other housing costs for similar (safe, sanitary, and decent) housing in the same neighborhood or nearby neighborhood.
c. state of the housing market (vancancy rates, quantity of new housing going up)
d. amenities and facilities available in the neighborhood: churches, schools, parks, shopping centers, and the like
e. perceived characteristics of the neighborhood (good, bad, high crime, safe, ethnic, middle-aged, in-transition).

6.5 TAKING OF PUBLIC PROPERTY AND COMMUNITY INSTITUTIONS (G.5, G.6)

Like the taking of businesses, the impact of the taking of public property depends on the importance of such property to the local residents. The loss of a neighborhood school could be a serious inconvenience to families with school age children, but of no importance or even advantageous to childless residents. The categories of impact are most likely to be:

a. loss of recreation facilities and
b. loss of public resources.

In terms of recreation facilities, playgrounds and parks need not be the only areas considered. For some residents, the public library is a major recreation area; for others it might be the bowling alley. In many cases, the loss of recreation areas means the absence of a safe, accustomed way of spending leisure time.[8]

The loss of public resources refers to the loss of schools, libraries, and government offices as service providers. Those who feel those losses most are likely to be those who use them the most.

Measurement

Variables to measure would be these:

a. number of kind of institutions lost

b. utilization of park, institution, etc., by patrons from available records such as turnstile figures, tickets sold, books checked, etc.,

c. school attendance figures, and

d. hospital and health care center patronage figures.

Costs can probably also be calculated from the monies needed to provide substitute services or facilities: costs of bookmobiles, mobile health centers, or costs of new schools and other institutions if these are permanently taken because of the tunnel construction. Included in the social costs must be the time and money costs of transportation for would-be patrons, if these now have to go to other, more distant facilities.

6.6 ENVIRONMENTAL DISTURBANCES (G.7-G.13)

These disturbances affect residents in several different ways:

a. as they affect residents' own homes and make them less desirable, attractive, pleasant and safe to be in;

b. as they affect residents' health and safety;

c. as they affect the neighborhood in general and reduce its amenities and change its overall character.

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[8] Takings for rapid transit tunneling are usually kept to a minimum, if only to keep costs down. However, in cut-and-cover construction because of "the necessity of constructing stations from the surface, it is inevitable that there will be some displacing of businesses and/or properties." In construction by deep boring, "displacement may occur to create working sites, station sites, and sites for ventilation shafts" (London Transport, Draft Report, pp.1, 6). Since all construction requires working sites, parks have a fatal attraction to contractors and transit authorities for this purposes. (Conversation with Mr. Littleboy, London Transport Planning Division. Even Royal Parks are sometimes taken for this purpose, according to Mr. Littleboy.) The reason for this, of course, is the lack of available open space in cities. Even old cemeteries are used for working sites, if the proper permissions can be obtained. (Mr. Littleboy)

The most obvious impacts of environmental disturbances will, of course, be economic: if houses or apartments are subjected to severe noises, or dust, or ground movements, their economic value will go down. This will be reflected in lower re-sale value of house or lower rents that can be realized for apartments. Additional economic effects will follow from these in domino fashion: lower property values, lower taxes, fewer jobs because there will be less maintenance and repair, etc.

Here our concern, however, is with social effects. Obviously, the economic distress that may be caused by environmental factors will translate itself into social impacts. Some people will move out in the face of these environmental disturbances; others will stay. Neighborhood cohesion will suffer as a result and the neighborhood may take on the characteristic of one in transition. Residents will suffer anxiety about who is going to move next; should they move as well? Established friendships will break up. Splits may develop in the neighborhood between those who advocate sticking it out and those who advocate getting out "while the getting is good." Some of these splits may occur within families, leading to strife and discontent.

Health and safety of residents may be affected by excessive noise, dust in the air, dirt on the roads and by increased exposure to rodents which may be disturbed by changed water levels and by excavations.

Environmental disturbances are the effects that can most readily be anticipated by residents--they know that construction machinery is going to produce some or all of these stresses. Their attitudes toward the project, toward the transit authority, and toward governmental authority in general will be seriously affected by how fairly and swiftly their complaints and anxieties are dealth with. Residents' image of themselves will also be affected by their dealings with governmental bureaus: they will either perceive themselves as having some control over their own lives or as people who can be pushed around and to whom no serious attention is paid by those in power.

6.6.1 Noise

This is probably the most obvious and most easily anticipated effect of large scale construction. It is also feared as being very disturbing, long-lasting, and something that has effects on both health and on economic well-being. Residents of Tiber Island, in their complaint, stated that "the environmental factors ignored by WMATA include, but are not limited to, the prevailing noise levels in the Tiber Island community throughout the day and at night, which levels will be drastically heightened by WMATA during the estimated three-year period of construction at Tiber Island community in at least four respects."[9] The complaint then refers to the affidavit of an expert in an auditory matters, a Dr. Dickman. She cites four respects in which Tiber Island may be adversely affected by construction noise; all of these effects are likely to be found in any tunnel construction project.

a. "During the daytime hours, the allowable noise levels will probably result in significant outdoor speech communication interference for certain residents.

b. "The allowable noise levels will undoubtedly result in a high degree of annoyance to a substantial number of residents, particularly in view of the extended time period and twenty-four presence of offending noise.

c. "It is also probably that the projected noise levels will result in psychological distress for certain community members.

d. "The allowable noise levels in the evening will undoubtedly also result in sleep interference for certain community residents."[10]

In the compromise settlement reached by WMATA and the Tiber Island residents, allowable noise levels were specified which WMATA promised not to exceed.[11] Apparently, the agreement was pretty well kept, except for two occasions when construction (and associated noise) went on beyond the agreed-upon hour of 7:00 p.m.[12]

In constructing the new Hounslow West station, as part of the extension of the Picadilly Line to Heathrow Airport, London Transport needed to buy several small apartment buildings to make room for the relocated station. However, there was also one building which did not need to be taken,

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[9] Tiber Island Conominium et al. vs. Washington Metropolitan Area Transit Authority, p. 5.

[10] Affidavit of Dr. Donna McCord Dickmann, pp. 2-3.

[11] Letter from John R. Kennedy, General Counsel, to Thomas H. Truitt, July 1, 1974.

[12] Interviews with Tiber Island residents, November 1975.

since it was just beyond where the new station was going up. Still, the building was so close to the construction area with its associated noises, vibrations, etc., that London Transport offered to buy it. Apparently, this was a cooperatively owned building; two of the four owners accepted the offer and sold; two, however, did not.[13]

It is interesting to note that the question of noise disturbance came up at all for residents along the extension of the Picadilly Line. The extension goes to Heathrow Airport and the residents live every day with the noise generated by arriving and departing aircraft. Heathrow is a very busy airport; Boeing 747's and 707's use the airport routinely and Concordes do so occasionally. Most of the residents affected by the tunnel construction live right under the major approach and take-off pattern. Nevertheless, as the resident engineer pointed out, the construction noise bothered them. They had got used to the aircraft noise, but the noise from the construction machinery was new and unusual.[14]

London Transport apparently has had considerable experience with complaints about noise:

> Daytime working in a heavy traffic area does not normally give rise to noise complaints. At night, however, when traffic has virtually ceased, the contractor is contractually obliged to take all necessary precautions to reduce the noise of compressors, concrete mixers, cranes and similar plant....When a particularly noisy operation has got to be carried out at night it is general practice to warn local resident and apologise in advance by adopting public relations methods. This procedure has a psychological effect on site neighbors and generally results in all but isolated complaints being eliminated.[15]

Apparently the kind of neighborhood that is being disturbed makes a difference to the level of complaint. During the construction of the Fleet Line, tunnelling proceeded under expensive and exclusive residential property:

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[13] Conversation with D.G. Jobling, Construction Manager, London Transport, October 30, 1975.

[14] Conversation with James Fergusson, Resident Engineer, October 30, 1975.

[15] London Transport, Draft Report, p. 28

> Although electrically operated compressors were housed in the running tunnels and special instructions for night working were diligently honoured by the contractor, complaints about noise and unsightliness continued for many months from titled residents living in high class property well away from the site.[16]

Finally, a particular example is given that arose during the same construction of the Fleet Line:

> It should also be recorded that some complaints were received from individuals whose only knowledge of the work was from noises within the tunnels some 20-30m below their homes. An example illustrating the extreme nature of this problem concerned a person who had obtained medical advice for her sleeplessness and after many weeks of taking sleeping tablets without success appealed to the Resident Engineer for assistance. The main tunneling had passed below the person's house without her knowledge but the excavation by hand of cross-passages by two or three miners had been too noisy! The problem was solved by paying a fortnight's hotel expenses for the lady during which time the particular work was completed.[17]

6.6.2 Vibration

In addition to noise, this is probably the other environmental cause that can directly affect residences. Although with sound engineering practices, there should be very little settlement in buildings as a result of tunneling and other construction activity, it is quite possible that residents may become very anxious about the effect of heavy machinery working close to their homes. And the fear of damage to their property (and possibly even the fear of injury resulting from the shaking and settling of their homes) may have a very unsettling effect on the residents, however unfounded their fears may really be.

As far as actual social damage from vibration and settlement is concerned, only one instance surfaced in our limited investigation. The construction work on the South Cove Station in Boston was at one point suspended for several hours, because a very delicate operation was being

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[16] London Transport, Draft Report, p. 31.

[17] Ibid., p. 34.

performed at the near-by New England Medical Center of Tuft University.[18] Since in this one instance construction ceased, any real damage to health or life was avoided; it is not known whether other surgery was postponed because of the construction (and at what cost to health) or whether surgery that actually was performed gave less satisfactory results than could otherwise have been expected.

6.6.3 Air and Water Pollution, Heat, Solid Waste Disposal, Visual Impact

These impacts affect the neighborhood as a whole and make it a less desirable place in which to live. Various kinds of pollution make recreation areas undersirable, for example, and thus detract from the quality of the neighborhood. Noise pollution will also detract from the utility of recreation areas, particularly parks which are meant to provide opportunities for relaxation and quiet. Gross air pollution--such as cinders in the air--will make outdoor games, like tennis, much less enjoyable than they would be in clean air. Water pollution will affect water sports: beaches or swimming pools that are dirtied as the result of construction mud will not afford the recreational opportunities they were meant to.

Dirt, in general, will make a neighborhood less attractive. The major villain here is likely to be the removal of spoils from tunnel construction--dump trucks may spill some of their load on the street; when rain is added, there will be mud and an unsafe as well as unattractive-looking situation.

All of these environmental insults will have effects on institutions in the neighborhood: not only parks, but also schools, hospitals, churches and the like will suffer. Their usage is likely to go down if the environment becomes too hostile, and this will be reflected in residents' view of their own neighborhood as well as in the opinion of others.

6.6.4 Measurement

It is difficult to get at the precise quantity fo the <u>social</u> costs that arise from environmental disturbances. Economic measures probably have to be used as surrogates. The following can be measured:

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[18] Visit to South Cove Station, July 16, 1975.

a. turnover rates of houses and apartments

b. patronage of parks, libraries, and other public institutions

c. patronage of private, profit-making institutions that contribute to neighborhood quality: movie theatres, bowling alleys, taverns

d. additional costs incurred for street cleaning, clean-up of beaches, parks, etc.

e. increased complaints (as reflected in medical records) of sleeplessness, eye irritation, noise-induced headaches, etc.

Measurement of these variables is only the beginning of the measurement task. What one really wants to get at is the attitudes and feelings of the residents about their neighborhood while it is suffering construction-induced environmental insults, as well as objective measures--if they exist--of physicial and psychological ailments induced by these insults. Also important are the social costs to the real or imagined utility of neighborhood institutions like parks and libraries. The economic cost of their disuse or lesser use can be measured; the social cost must be inferred from the economic cost.

6.7 UTILITY DISRUPTIONS: PLANNED AND UNPLANNED (G.14-G.15)

If such disruptions occur, they will have impacts in the areas of health, safety, comfort and convenience.

The loss of electricity is serious for residents who use electric heat or electrically fired burners. Unheated homes become safety hazards, if residents substitute unsafe kerosene heaters. Telephone service interruptions can pose a problem in an emergency. Water supply interruptions cause inconvenience and can be dangerous in case of fire.

The impacts will be the same in kind whether or not the disruption is planned, but are likely to be more severe if they are unplanned, because preparations can not be made to cope in the case of unplanned interruptions.

Measurement

Again, one would begin with surrogate measures:

a. number and length of interruptions

b. number and kind of activities that were either foregone or interrupted (conversations, meetings, etc.)

c. cost of ameliorative measures (for example, cost of providing extra police protection while street lights are out; cost of stationing fire apparatus nearby while alarm systems are not working).

From these "hard" measures one would then infer, or measure by interview, residents' feelings about their safety, health and convenience.

7. MEASURING ECONOMIC, SOCIAL AND ENVIRONMENTAL IMPACTS

In Chapters 5 and 6 we have already given indications of which variables must be examined--what kind of data must be collected--if the economic and social costs of tunnel construction are to be measured. In this chapter, we shall discuss the measurement of impacts as a separate topic, with a section devoted to each of the three kinds of impacts.

7.1 ECONOMIC IMPACTS

Economic measurement involves ascertaining and aggregating the changed patterns of usage of scarce resources which have alternative uses in different situations. Measurement of the economic impacts of tunnel construction involves valuing those changes generated by the construction process. In market economies like that of the U.S., resource usage or valuation customarily is measured in terms of dollars or changes in dollars. Therefore, at the most basic level, measuring the economic impacts of tunnel construction simply involves quantifying the dollar valuation of the impacts of the construction process. Numerous conceptual abstractions, assumptions, and cautions are embedded in the preceeding sentences. For example, tunnel construction will create some economic impacts which are not readily susceptible to pecuniary quantification. Some of these complexities are examined below by focusing on some of the words and phrases used in this paragraph.

7.1.1 Measurement and Valuation

Measurement involves quantification into numbers. The most useful numbers are those which are most readily aggregated. Dollars are commonly used as the lowest common denominator in economic measurement. For example, construction generates employment, which generates income, which can be measured in dollars. Construction also generates barriers, which alter property values, which can be measured in dollars. Because both impacts can be measured in dollars, they can be aggregated into one measure. But construction barriers also result in increased travel time. For those individuals who have a limited amount of time to perform market activities (e.g., consultants on a business-trip, people going to work) time is translatable into dollars. If the person is late, someone must pay some cost--whether it be in the form of docked pay, unpaid overtime, or lost business. However, to some individuals, the costs of travel time may be offset by psychic benefits. For example the bicycle commuter may view his journey to work as a pleasurable activity and may not care about prompt arrival. Furthermore, other individuals not involved in market activities may also have competing demands for their time (e.g., babysitter fees). An additional problem here is valuing different units of time. Is a one minute delay, every day for 60 days, the same as one 60 minute delay?

To the extent that economic impacts involve market transactions (such as reduced business), they are readily quantifiable into dollars. Those dollar measures of various impacts can then be aggregated into one common measure. This procedure however, involves accepting the market valuation placed on any impact. But market imperfections may in fact mean that the market price is a socially incorrect valuation.

Economic activities also occur in non-market situations, e.g., the journey-to-work. It would be most desirable to quantify non-market economic transactions in terms of dollars. To some extent this may be possible. For example, various assumptions relating the value of time to hourly wage levels can be made to infer the dollar value of this non-market transaction. However, some non-market transactions, e.g., the psychic satisfaction derived from work, can not be translated into dollars. Still, to the extent that different non-market phenomena have impacts which can be measured in the same (albeit non-dollar) units, they still can be aggregated into the lowest common denominator of non-dollar units. Economic measures would then include both non-dollar quantities (aggregated into their lowest common denominator such as units of psychic satisfaction), as well as dollars.

7.1.2 Changed Patterns

Tunnel construction impacts relate to changes generated by the construction process alone. These impacts must be abstracted from the impacts of other, simultaneous events. Economic recession, poor management, changed consumer tastes, etc. also may be affecting business and individuals in the construction corridor. Measures of these impacts must be factored out of the construction impact measures. This separation may be very difficult. A compounding factor is the projection of both the construction and nonconstruction measures for the uncertain, future period of the construction. A further complication is caused by the intertwining of construction and nonconstruction measures. For example, otherwise unemployed construction workers spend their wages; this spending creates multiplier effects which may or may not eventually affect business in the construction corridor.

7.1.3 Uses: Distribution

The production and consumption resources affected by tunnel construction have alternative uses to various individuals and groups of individuals. Simply adding up all the impact measures to these different individuals ignores the distributional consequences of the project. There are two implicit assumptions to such a procedure; (1) that the marginal utility of time and money is constant and equal for all individuals concerned; and (2) that the impacts of construction are randomly distributed. Neither assumption is correct. For example, large businesses can survive disruption and retain their clientele for a longer period of time than can smaller businesses. And tunnel construction is not a random process. One specific area is affected--the construction corridor--while other areas remain more or less unaffected. Furthermore, some area residents and businesses are more affected (those who lose homes or clientele) than others. Therefore, distributional issues need to be considered.

Distributional considerations can be included by specifically allowing for shadow price weights to particular groups of gainers and losers, such that the benefits and costs to different groups are given different weights.

The issue becomes the proper choice of weights. In fact, these weights must be determined by society, through the political process. Since the weights may, in fact, not be known to the evaluator, he can either ignore distribution issues or make a variety of arbitrary assumptions about the particular weights. An alternative is to present disaggregated results by different classes of individuals, along with several sets of results aggregated with different distributional assumptions, (e.g., costs to older residents are valued more than costs to newer residents, etc.); such a procedure allows the political decision makers the opportunity to decide what weights are most appropriate.

7.1.4 Uses: Valuation

A single construction consequence can have multiple, connected impacts. While it is important to measure all the impacts, it is also important to measure the impacts only once. If impacts are counted more than once, double-counting will confuse the results. For example, construction will create dirt; dirt will cause residents to move, moving will reduce residence values and reduce the business of local merchants; reduced property values will reduce taxes. Which one or combination of the above impacts should be measured? To eliminate potential under- or overcounting, only the net change in value at each stage should be measured. This procedure is to distinguish from the typical (and incorrect) procedure of summing the value of all the costs and benefits of all the intermediate and final results.

7.1.5 Different Situations

The measured impacts of construction depend on the occurrence of particular situations. In retrospect, after the completion of the construction, it will be known that a certain street underwent cut-and-cover methods for 18 months. However, prior to construction during the impact evaluation, only estimates of the cut-and-cover time will be available. In projecting the measured impact prior to the construction, some assumptions about the expected conditions must be made: will the construction time be 15, 18, or 24 months? Different degrees of uncertainity surround these different possibilities. The typical impact measurement relates to only one of these events. Without studying previous impact studies, it is not clear how this one state is chosen--it may be that the single most likely state is evaluated--or it may be that that state which minimizes the disruptive effects is chosen for evaluation. In any event, it is clear that an impact evaluation which chooses to measure the impacts of only one of these possible scenarios (say the 18 month case) is disregarding useful and important information, even if the selected scenario is the most probable scenario.

Consider the following. There is a 60% chance that the street will be covered for 18 months, a 30% chance that the street will be covered for 24 months, and a 10% chance that the street will be covered for 12 months. In the first case the cost will be 18 x (where x is social dollar value); the second, the cost will be 30 x; and in the third, the cost will be 15 x. What is the expected cost of the tunnel?

One procedure for calculating the expected cost is to weight the expected costs by their expected probabilities. In the above example, the expected cost is: $(.6 \times 18) + (.3 \times 30) + (.1 \times 15) \quad X = \underline{21.3x}$

7.2 SOCIAL IMPACTS

7.2.1 Rating Side

In order to rate a social impact, something must be known about the present-day characteristics of the neighborhood or area. For example, if a community already suffers from economic depression, then an impact which further reduces the number of jobs and income of residents would be very severe. Such an impact might not be felt nearly so severely in an area that was overcrowded and would not mind seeing a reduction in the number of small shops.

Most of the effects resulting from tunnel construction will be disruptive and will have negative, i.e., bad, impacts. At least, theoretically, however, social impacts can be rated on a scale like the following that includes beneficial, as well as adverse effects:

++ Very Positive
+ Positive
o Neutral
- Negative
-- Very Negative.

This rating system deals with two generic issues simultaneously: the direction of impact and the magnitude of impact. We have already noted that a given impact can, in fact, have more than one value assigned to it. Impacts may be rated differently according to what persons one affected, how they are affected, where they are located, and so forth. The scheme is ordinal in that, for example, a value of ++ represents a greater positive effect than the value of +. It is not a ratio scale, however: an impact rated ++ is not twice as great as one rated +, but rather the first impact is relatively greater than the second. Therefore, one might have the following effects and assessments for a given variable:

Rise in overall income for the impact area	++
Decrease in income for minority labor force in impact area with low education	-.

The rating must take into account various factors, including:

a. who is going to suffer disproportionate costs and their capacity to bear the cost

b. the types of costs that will be suffered

c. the character of the costs (e.g., affecting health, legal services, self-support, education)

d. the distribution of the costs (numbers of people, types of problems, etc.)

e. the number of persons affected.

These ratings must not be viewed as additive across different categories of impacts. A social impact to residents in the tunnel construction area might be more difficult access to health services and might be rated --; this impact cannot be simply added to another social impact on owners of businesses, such as greater crime in the area, which might be rated -. Nor can positive impacts (benefits) in one topical area to one affected group be simply traded off against negative impacts (costs) in another topical area to another group.

In terms of our matrix, impacts in one cell of the matrix cannot be added to, or traded off against, impacts in another cell. Only the social impacts in one cell of the matrix can be compared directly with one another.

The ratings will be based on a variety of data, some of them hard and some of them soft. Even the hard data will vary in the way in which they are measured (dollars, number of persons, number of jobs, number of facilities). In short, uniformity of measures is absent.

This raises an impaortant question: Why not convert these social effects to dollar values; i.e., monetize them? There are various ways of monetizing social outcomes. One way is to measure the creation of social goods in terms of assigned monetary values, so that the worth of a given phenomenon which is disrupted (accessibility to service providers, the value of an hour's peaceful silence, etc.) can be expressed in dollar terms. Decreases in monetized value are equated with social costs. Another way utilizes the concept of value hierarchies. For example, by taking into account protection from traffic accidents, noise, access to community service, etc., one can generate a proxy measure of "security" which has a high social value. Its disruption, then, constitutes a high social cost.

But while it may be advantageous to use dollar amounts as units of measure (especially since the user if familiar with them), dollar amounts are not representative of the full range of values cherished as "social well-being" and which might be disrupted by tunnel construction. Another reason for not monetizing social effects is that it may not be appropriate. The experience of job satisfaction, of enjoyment of time with the family, of experiencing an aesthetically pleasing vista varies with different people, and while individuals will allocate income or make decisions which have dollar implications, many social experiences will not be assigned the same dollar values by different individuals.

7.2.2 Relocation Impacts

Of all the impacts caused by tunnel construction (or any large-scale construction, for that matter), those caused by the involuntary relocation of residents whose homes or apartments are taken for construction purposes are probably the most severe. Social costs are closely tied to economic costs, and both measurement and amelioration techniques reflect this.

Measuring relocation impacts is tied closely to planning an effective relocation program. Available data may vary at different planning stages, but the measurement techniques are basically the same. The technique consists of identifying those potentially affected residents who have been shown in the past to experience the greatest difficulty relocating and identifying the types of impacts most likely to be felt (see Chapter 6). An effective relocation program must also plan ways to deal with the actual relocation of households and businesses and can also provide for positive impacts in some cases.

Once impacts and receivers have been identified, "measurement" can be highly subjective. Tradeoffs among groups may have to be made. Impacts may be ranked, or rated, according to anticipated severity and whether they are positive or negative. No accepted system exists for ranking (or even measuring) the social impacts of relocation but some considerations might be:

a. which groups can be expected to face the greatest disparity between what they can afford to spend for housing and what the cost is for available units meeting their needs?

b. are there groups for which there appear to be <u>no</u> available housing meeting their needs?

c. does the neighborhood appear to be a desireable one from the standpoint of residents?

d. is housing expected to be available in the same neighborhood?

e. is it expected to be available in nearby neighborhoods or areas that residents perceive as being good places to live?

f. are there strongly-rooted institutions in the neighborhood? (e.g., churches, schools) to which residents have close ties?

g. are there ethnic concentrations in the affected area?

h. are there serious drawbacks or disadvantages to living in the area?

i. how can residents be perceived as benefitting from the proposed project (if at all)?

The above are suggestions as to what questions to ask when analyzing the data collected on the affected areas. They may enable the planner to see impacts which might be more easily borne and thus acceptable prices to pay; they may also help identify those effects which would have such severe and detrimental implications for residents and community that serious measures must be taken to mitigate them or the displacement avoided entirely.

Before such questions as noted above can be asked or answered, data must be collected on characteristics of displacees, affected neighborhoods, and the housing market.

Sources of data might be federal and state census, studies and surveys by local planning and redevelopment agencies, local officials, area realtors, registries of deeds, lists of polls, city directories, etc. Data are needed on: estimated incomes; sources of incomes; proportion of elderly, female-headed households, one-person households, minority groups;

estimated household size; lengths of residence; age distributions; tenure (owners/renters); dwelling structure types; approximate size, age of dwelling units; state of repair. Once these data have been collected, a preliminary description of potential relocatees can be prepared.

The second component of the assessment of impacts of displacement is an evaluation of the affected neighborhood. A visual survey of the area by persons experienced in relocation planning should reveal general physical features, public and commercial facilities, recreation facilities, land use mix, street traffic, accessibility and convenience, ethnic composition. Examination of census data and conversations with area realtors can produce information on vacancy and turnover rates of housing in the neighborhood and on housing demand characteristics of the area. These data can indicate with a high degree of accuracy how residents view their neighborhood. Very low vacancy and turnover rates (compared to other neighborhoods and the community as a whole) indicate a high degree of resident satisfaction, particularly when supported by relatively long lengths of residence, high proportions of home ownership, well-cared for units and structures, and the like. Another correlation to look for are large rental units in good condition for low costs. Areas that have them are usually inhabited by long time residents, especially elderly, since rents tend to rise more slowly when tenancy is by the same person. Landlords are frequently willing to accept a lower rent in exchange for a reliable tenant.

Data collected on resident characteristics and for the neighborhood evaluation will, of course, also be used for the assessment of social impacts of the project. The third variable needed to be examined for an accurate projection of impacts on relocatees is the housing market. The availability of housing that is comparable to that lived in as well as decent, safe, and sanitary, is critical to the relocation process. In many cases, negative impacts can be lessened if households have a wide choice of comparable housing meeting their needs and within their financial means, particularly if it is close to the area of the takings. Unfortunately, an area that is perceived as a desireable place to live by its residents is also least likely to have housing available.

Housing market data can be obtained from primary sources such as sample newspaper listings (collected over a long enough period to account for seasonal variations, compiled by structure type, size, cost, and location); building permit data; conversations with area realtors; examination of Multiple Listings, if available, or other sources of real estate data.

Correlation between housing expected to be available and housing needs of relocatees should be made. Relocatees' housing needs can be estimated from information on income, household size, and age. If projected housing supplies do not appear adequate to meet the anticipated needs, relocation can be expected to be difficult for both the agency and relocatees and impacts will be more severe. If differentiation among relocation problems on various alternatives can be made, a selection of an alternative with fewer displacements of displacements of households with resources to give them a better position to compete for limited housing supplies might be an option.

If projected relocation impacts are unavoidable by route selection, facility design, or construction techniques, those impacts must be assessed in greater detail once a decision is made to construct the facility and a final location is selected. Measurement at this stage is best accomplished by direct interviews of all affected households in which information is collected on household composition, age, income and income source, place of employment, means of transportation to work, schools, shopping, etc., housing characteristics, relocation needs and preferences, attitudes towards present heighborhood, special needs to be considered in relocation (medical problems, etc.), reasons for relocation preferences, presence of nearby relatives and friends, membership in neighborhood or community organizations.

It is not possible to over-emphasize the need for experienced relocation staff to compile and interpret this data. Existing methodologies (e.g., Jon E. Burkhardt's social interaction index) for measuring resident attachments to a neighborhood (and thus, for predicting those areas which would be likely to experience the most severe social disruption from public projects) are highly subjective in their assumptions and are useful only in conjunction with other indicators, if at all. It is far more useful to collect descriptive data on a potentially affected population, ascertain which groups appear, based on past studies (see Chapter 6) to be most sensitive to the social impacts of dislocation, and either avoid or minimize takings in those groups or take steps to mitigate the expected impacts as early as possible in the planning process (see Chapter 9). Time and effort needed to plan for the "worst case" is minimal (even if found at later stages to be not necessary for various reasons) compared to the monetary costs to the project and social costs to relocatees, their neighborhood, and the community as a whole, if severe relocation problems and impacts are not planned for (and construction of the project consequently delayed).

7.2.3 Non-Compensable Social Costs

If all social impacts could be expressed in dollar terms, then those who suffer disruptions could presumably be compensated for their losses and equity would again be established. But it is difficult if not impaossible to put a dollar value on some social costs, such as the loss of a pleasing vista, or the loss of convenient access to a needed service provider.

If a person, before construction began, could walk in four minutes to a pharmacy to get a prescription filled which he needed everyday (as a diabetic person might), but after construction, because of the barrier, the walk takes nine minutes and is hazardous because he has to cross the excavation on a bridge of temporary decking that often becomes wet and muddy, what is the person's loss? In some sense, there is no dollar loss at all: He can still get his medicine, but it takes him a little longer to do so. Nevertheless, the person's loss may be very great. He may have been easily able to walk four minutes and may even have enjoyed it. But nine minutes may be longer than he can easily walk. The added hazard of crossing over an excavation may make the walk very unattractive to him. He may therefore not get his prescription filled regularly anymore, with serious consequences to his health. Or he may be forced to rely on another person--perhaps a friend or relative--to fill the prescription for him. This would put him in the position of becoming dependent on another person for a needed service. The added five minute walk has therefore caused the person to lose some significant independence; he has lost some control over his own life. What is the dollar value of this loss of independence? Can it be compensated by some amount of dollars?

If the mere addition of some walking time to obtain a needed service can lead to non-compensable costs, more severe disruptions such as those associated with relocation will lead to more, and larger, non-compensable costs.

Even if relocation costs are paid and even if assistance is given to relocatees, there may still be great and uncompensable losses arising from such factors as lack of familiarity with a new neighborhood, inability to sustain significant changes in life style, loss of well-known support systems (stores, services, churches, etc.), loss of friends. Most of the more dire consequenses will fall on special population groups, such as the elderly and handicapped. But it is important to consider their plight. Of course, disruptions will be relatively easily borne by young, well-to-do, upwardly mobile, physically healthy, well-employed, white middle class persons. The problem is how to deal with social costs when they fall on those who cannot bear them easily. It seems hard if not impossible to put a dollar value on "loss of independence" or "loss of control over one's own life." But certainly, if one tried, the monetary value would be very great.

The notion that there may be some social losses for which a sufferer can't be made whole through the payment of money raises a host of problems. (Generally, courts assume that damages can be expressed in dollars and that when they have been paid, justice has been done). Should such "noncompensable" costs ever be permitted? If they must be incurred, are there some ways, other than dollar payments, by which the damages can be repaired? For example, could the person who needs a daily prescription be satisfied if the drugs were delivered to his residence at the expense of the agency that is building the tunnel? Or is this also a loss of independence that is unacceptable? This is clearly something that requires further study.

7.3 ENVIRONMENTAL IMPACTS

We indicated earlier, in Chapter 4, that the impacts arising from environmental disturbances, such as noise, vibration, heat, etc. are of a different kind from the economic and social impacts. Disturbances of the environment are just that: changes in the environment in which man lives, brought about by various aspects of the tunnel construction and thus not "normal." (Every day, heat is generated in the environment by the sun. Every urban location in the United States has a large amount of constant background noise arising from the operation of cars and other machinery. Neither the sun's heat nor the background noise of machinery is considered to be a disturbance, because they are regular, expected, and felt to be harmless. Of course, if there is a heat wave and a dry spell, then the environment is seen to be adversely affected by a heat disturbance. If noise from cars reaches very high levels--during a traffic jam on a holiday weekend--then that noise is experienced as an environmental disturbance. And clearly, what is accepted as normal background noise now would have been thought to be an intolerable disturbance in the days before there were internal or external combustion engines.)

Environmental impacts in turn give rise to impacts on persons and groups. These impacts are social and/or economic. For example, vibration arising from construction may cause a building to settle and to become structurally unsound so that it has to be torn down. This becomes an economic impact to the owner of the building. Similarly, noise from construction machinery is an environmental impact. It may, however, become a social impact when it affects the hearing of residents exposed to it.

Thus, environmental impacts are of interest really only when they are translated into social and economic impacts. That is why, in our matrix, environmental disturbances are listed among the causal factors that bring about social or economic costs.

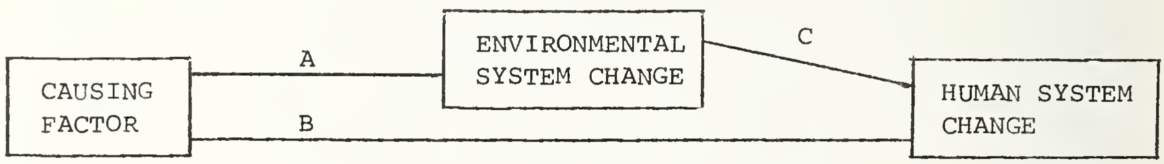
Accepted measurements exist for most of the environmental disturbances (noise, vibration, heat), although not so much appears to be known about how to measure the effects of muck disposal. The reader is referred to Appendix I, where environmental impacts of construction are discussed.

The following discussion deals with some of the problems of measuring environmental impacts insofar as they directly impact on persons.

7.3.1 Measurement

> Measurement of environmental changes such as noise level, sedimentation, air pollution, visual intrusion, or possible flooding constitutes the core of most environmental impact studies. While these measures appear to be objective, they are usually limited by professional perceptions of environment and impact.
>
> Donald Appleyard & Frances M. Carp, "The BART Residential Impact Study: An Empirical Study of Environmental Impact" in Environmental Impact Assessment: Guidelines and Commentary edited by Thomas G. Dickert with Katherine R. Domeny. Berkeley: University Extension, University of California, 1974, p. 73.

It is important, in the measurement of environmental changes to realize that the purpose of the measurement is two-fold: to measure the relative change in the environmental system, and to measure the relative change in the human system. The change in the human system may be directly linked to the factor causing the impact itself, (e.g., noise directly affects the human body) or indirectly through the environmental changes (e.g., sedimentation causes destruction of stream-bottom life, which upsets the aesthetic quality of the stream for human beings.)



In terms of objectivity, the measurement of these changes can be ranked as A, B, C. It is very important to remember that the measurement loses objectivity because of persons' perception of the environmental change, persons' other concerns, and the severity and timing of the impact on the persons.

7.3.2 Perception

The extent and degree to which a person understands and relates to the factors causing the change very often determines his/her perception of the severity of the change. For example, if the person feels that the new rapid transit will facilitate his or her ability to travel in the urban area, then that person does not perceive the impact of the construction as being as severe as a person who does not expect to use the transit system. Again, if a person understands that the responsible authorities have made every feasible effort to diminish the factors causing the impact, then that person will probably endure the impact with more tolerance than a person who believes that the causing factors could easily have been attenuated to a greater extent.

7.3.3 Priority of Concerns

The magnitude of a person's reaction to some factor causing change will depend in a large part on the relative importance of the impact of that factor on his/her life. The impact can be social, economic or physicial.

A common example notes that persons who are very hungry cannot be concerned about air pollution, which may cause cancer in 25 years; their concern is to satisfy the hunger pains now. This does not mean that they suffer a smaller impact on their systems, but they cannot afford the luxury of solving long range problems while short-term problems are more pressing.

7.3.4 Severity and Timing

The severity of a probable impact is usually discussed in terms of the magnitude and the importance of the impact:

> The scientist has the choice of ending his input at one of two places; he can end his participation after there has been a determination of the magnitude of an environmental impact; or he can deal with the magnitude and importance of an environmental impact but stop short of making any recommendations about whether or not the project should be constructed.
>
> Luna B. Leopold, "The Use of Data in Environmental Impact Assessment," *op. cit.*, p. 31.

It is the magnitude which is most often measured; the importance of the change is very much a subjective matter, dependent on the methods used to mseaure the change, the persons making the evaluation, and the value system of the person who is subjected to the change.

Although it is the magnitude of the change which is most often measured, the factors which are measured do also reflect a value system. For example, the environmental change which is measured reflects a consensus of the important variables which are affected: cubic yards of muck are counted, but not the ants or worms in them. The means by which the factors are measured--how finely or grossly they measure, how costly they are--also reflect a consensus of value systems.

There also has developed a consensus of who is to do the measuring: members of self-policing professional societies, persons licensed by the responsible goverment, recognized authorities, or persons highly trained in specific disciplines.

Thus, any measurement of environmental change in response to some factor causing that change may appear to the unexperienced or non-technical person as being completely objective, when in fact that measurement is based on a history of assumptions, technical developments, and consensus of value judgements.

7.3.5 Factors Causing Environmental Systems Change

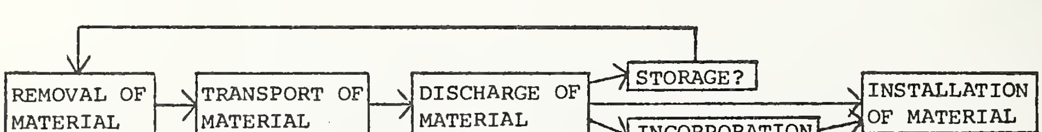
In discussing the environmental disruptions caused by tunnel construction, it may be useful to identify the sources of disruption (i.e., in this case, pollution) in terms of where and when they occur in the construction process. This may be more useful than identifying a "laundry list" of possible sources of pollution.

Thus, rather than saying that "gasoline engines" and "diesel engines" are sources of air pollution, that "jackhammers" and "air compressors" are sources of noise pollution, etc., we will try to identify where in the construction process events occur that are or could be causes of environmental pollution.

For example, it may be possible to analyze the tunnel construction process in such a way that it can be seen to involve the following activities (not necessarily sequential);

a. Installation of materials
b. Removal of material
c. Installation of equipment
d. Use of equipment on site
e. Removal of equipment
f. Use of labor force.

Each of these activities can, of course, be further broken down; i.e., the material to be installed may be sand or gravel, or asphalt, or concrete, etc. Use of human labor involves, among other things, provision of parking facilities and of waste facilities. In each of these activities, physicial change occurs which results in environmental change. For example, for the installation of materials--sand and gravel--the following occurs:



Each of the above steps can produce one or more forms of pollutants. For example, the removal of sand from a river can cause water pollution (sedimentation), air pollution (from equipment) and dust (particulate matter suspended in air, if the material is dry). The transport of sand can cause air pollution--the type and extent depending upon the diesel or gasoline driven transport--in the form of gas, dust, and noise. The discharge of material at the site can cause noise and dust. Depending upon the material and whether it is stored at the site, there can be an aesthetic impact. The utilization of a vacant lot or parking space for storage of sand permits a constant source of supply at the construction site, but is not usually a typical and acceptable land use for the area. The removal from storage should reactivate the prior analysis, using the storage location as the place of material removal.

If the sand is incorporated into some mix, such as mortar, then the mixing equipment has to be identified and its pollutants considered. Finally, consideration has to be given to the mechanism and process by which the installation of the material is placed into its final form. If the sand is used as a base, and has to be rolled, then the noise and air pollution from this process must be considered.

The difficulty with the above analysis is that although the information for estimating the environmental change may be available (i.e., the noise level for a large, loaded vehicle, traveling 40 mph, is xdBa 50 feet from the highway), the dust that may be discharged to the surrounding environment may vary considerably due to the precautions which are taken to reduce this discharge (i.e., the wetting of the sand, the induced air flow and filtering of the air surrounding the discharge site, etc.) Therefore, it is possible, through models and prior experience to estimate the measurements that one could expect from factors causing change, but to categorically state that specific environmental system changes or human system changes will take place, given a determined causing factor, does not recognize that many of these potential changes can be ameliorated or eliminated through proper operating procedures. In these cases, questions have to be asked such as: What assurance can be given that enforcement of the standards will be undertaken? What remedies are available if they are not? What remedies are available if there is no standard? (Still left unresolved is, what happens if standards are enforced but undersirable changes still occur?)

7.3.6 Unplanned Physical Disruption

In the previous section we have discussed environmental disruptions that come about through planned activities and where the disruptions themselves, if not planned, are at least anticipated. It is known that there will be dust and noise pollution around a tunnel construction site.

But there are also unplanned disruptions. They include the disruption of utilities (e.g., cutting a water main by mistake), the settling of structures, the destruction of artifacts, and the secondary impacts resulting off-site.

It is of course known that buildings may settle and that contractors' equipment occasionally cuts utility lines, either because of lack of skill by the equipment operator or because the location of the lines was not known. It is hoped that these kinds of events will be avoided and their impact is not, therefore, predicted.

The destruction of artifacts may be predicted to some extent, knowing the prior uses of the area through which the tunnel is to be located. However, not until the construction is being undertaken is one able to ascertain the location and value of the artifacts. Upon discovery of an artifact, the question then has to be raised as to its value: is it so valuable that all construction should be halted in order to preserve it?

Off-site, secondary impacts result from use of land which is related to the construction site: what value does the borrow site have from which the sand and gravel is removed; what value has the site at which the muck and debris was deposited? If development is to occur at these sites, made possible by land fill/leveling, what impact will this have on the locality? These are questions which have to be raised, but on which there are few data.

8. AGGREGATING IMPACTS

There are two problems to be considered here: first, that of aggregating impacts of the same general kind, viz. aggregating economic impacts, aggregating environmental impacts, and aggregating social impacts. Second, aggregating across social, economic, and environmental impacts to arrive, if possible, at a total "disruptive cost."

8.1 ECONOMIC IMPACTS

Tunnel construction occurs over a period of time. It has many different costs and benefits. Aggregating these present and future costs and benefits into comparable units involves calculation of the "present value" of the construction, as seen during the time period of the evaluation. More concretely, I would rather spend a dollar next year than spend it today, if only because I can earn interest on the dollar. Therefore, costs (and benefits) incurred tomorrow cost (are worth) less than costs (and benefits) incurred today. Aggregating these costs and benefits over time involves two issues:

a. formulation of aggregation procedures

b. choice of discount rate

8.1.1 Aggregation Procedure

The simplest, correct aggregation formulation of present value is:

$$V = \sum_{t=0}^{T} \frac{(b_t - c_t)}{(1+S)^t}$$

where V = present value

b_t = social benefits in year t, where t=0, 1,...T.

c_2 = social costs in year t, where t=0, 1,...T.

S = social rate of discount.

This formulation obviously depends on translating as many benefits and costs as possible into dollars. Non-pecuniary (or non-translatable) benefits and costs should still be evaluated in whatever measurement units are available, and should be presented as additional supporting (or moderating) evidence of the benefits and costs of the tunnel.

8.1.2 Discount Rate

The discount rate translates the value of tomorrow's benefits and costs into today's units. Choice of the correct discount rate is a very complicated procedure[1], but must be carefully selected. The critical importance of the discount rate stems from the inevitable uneveness over time of benefits and costs. If a tunnel costs $1 today, but has $1.25 in benefits observed tomorrow, different discount rates can imply that the benefits of the construction are greater than, less than, or the same as the costs. The higher discount rates imply that less weight is given to future costs and benefits. Therefore, one way to reduce the costs of tunnel construction, other things being equal, is to prolong the construction process (in the limit, to postpone it indefinitely). Also, high discount rates tend to accentuate construction costs (which are incurred in the early stages of the project), while reducing benefits (which happen later). Obviously, manipulating the discount rate can affect the evaluation outcome. Hence there is a need to use correct procedures to choose the discount rate.

8.2 ENVIRONMENTAL IMPACTS

Aggregating environmental impacts presents a problem because different factors are being measured. Noise is measured in decibels, whereas the pollution of air and water is measured in measures of weight of particles in a given volume. The environmental effects of construction on land will also be measured in weight--tons of sand or gravel extracted from borrowing sites and trucks to the construction site, or in measures of volume, as when one speaks of cubic yeards of gravel trucked in or cubic yeards of muck removed from thetunnel site.

It is difficult to see how one can aggregate and/or compare decibels with cubic yards. Is it worthwhile to endure 10 additional decibels

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[1] An excellent discussion of these issues is found in Feldstein, Martin, "Choice of Technique in the Public Sector: A Simplification", Economic Journal, 1970.

of noise for two months in order to save 500 pounds of matter being thrown into the air? (The example is purely imaginary, but serves to make the point: if a louder piece of machinery pollutes the air less, is this a worthwhile trade-off?) How can decibels of noise and pounds of solid matter be compared or traded off?

One way around this difficulty of aggregating impacts that are, in effect, "apples" and "oranges" is to find a common measure for the impacts, such as dollars. One possible way of doing this would be to determine a dollar figure for avoiding the environmental impact. That is, how much would it cost <u>not</u> to pollute the air with the engines of the construction machinery? How much would it cost to prevent the noise pollution caused by some of the machinery? One difficulty here, of course, is that it is not possible to avoid all impact--there are no totally non-polluting internal combustion engines nor can any machine be run without producing some noise. Thus the problem becomes one of determining what it would cost to bring the environmental impact down to acceptable levels, once it has been established what acceptable levels are. These levels are to a certain extent subjective and also culturally determined. What is an acceptable noise level to one person may not be acceptable to another. What is an acceptable land use impact to twentieth century American culture (such as the creation of large gravel pits for purposes of construction) may not be an acceptable use to someone brought up in the American Indian cultural tradition of living in harmony with the land.

Another way of measuring the dollar amount of environmental impact is to determine the damage that the impacts would cause. Noise can cause hearing loss. If it is possible to put a dollar value on hearing loss and to estimate how many persons would suffer such a loss, then that could be considered a measure of the impact. Similarly, if air pollution causes various kinds of respiratory ailments, and if a dollar value can be put on contracting such a disease (based on how long the disease lasts, how much it costs in medical costs to cure it, how much worktime is lost) and if an estimate can be made on how many persons are likely to contract these diseases, then a dollar cost can be established for air pollution.

There are difficulties with this method, however. Not only are the estimates involved difficult to make, but there will also be no way to measure some of the damages caused: noise, in addition to causing hearing loss, also causes discomfort, perhaps anxiety, in many people. What is the dollar cost of these damages? Disease has associated costs besides the obvious ones of medical care and lost work, such as the discomfort to the patient, the anxiety of his family, and the greater anxiety of the patient. How are these damages to be measured? Certain kinds of impacts, such as the aesthetic damage done by borrowing pits and wetlands that are filled with muck, cannot be expressed in dollars at all. What is the dollar value of a pleasing view that has been lost? Again, if the construction destroys or threatens to destroy some archeologically important artifacts, what is the cost of that destruction? What a collector would pay for the artifacts? What a museum would pay? How can one measure the knowledge not obtained because the artifacts have been destroyed?

It would seem that the most reasonable position to take as regards aggregating and comparing physicial environmental effects is to say that each effect can be compared with other effects of the same kind. That is, we can compare the noise impact of, say, cut-and-cover construction with the noise impact of boring. Or, we can compare the noise impact that is likely to be generated if the tunnel follows route A with the impact expected if the tunnel follows route B. But noise impacts cannot be directly compared with air pollution impacts, or water pollution impacts, etc. We may try to make these impacts comparable through the use of dollar measurements, but this must be done very cautiously and is subject to all kinds of difficulties.

But there is an even more important question that ought to be considered. Not only is the aggregation of environmental impacts difficult and sometimes even unfeasible, it may even be wrong to attempt at all. Even attempting to aggregate impacts implies that one considers impacts comparable or at least that one wishes they <u>were</u> comparable. Those who succeed in making all impacts comparable usually do so by means of the dollar measure, an easily understood and familiar tool. But as soon as different kinds of impacts are translated into dollars, trade-offs can begin to be made. If both noise pollution and water pollution can be expressed as dollars (by whatever method), then it seems that a certain amount of noise pollution can be traded off against some water pollution. This kind of trading off encourages trying to minimize some environmental impacts (namely, those that can easily be lessened), while keeping other impacts high (namely, those that can only be lessened with difficulty), so that the sum total of environmental impacts, as expressed in dollars, is low.

It may be that a more sensible approach to dealing with environmental impacts would not attempt to aggregate them and would avoid, therefore, trade-offs between different kinds of impacts. This approach would say that planners should at all times be aware of the environmental impact of their projects and that, when the anticipated impacts have been measured, they should use this as feedback for trying to minimize each kind of impact. If planners have done this, before the actual construction of a tunnel begins, then it will not be necessary or even sensible to try to aggregate effects of different kinds. Each kind of impact will already have been minimized as much as possible at the planning stage. Aggregating effects--finding a common denominator such as dollars for all of them--would only serve to hide the need that each kind of effect, separately, should have been minimized, at the planning stage, long before construction began.

8.3 SOCIAL IMPACTS

The same caveat with which we closed the last section on environmental impacts also applies to the attempt to aggregate social impacts. First, how can the various kinds of social effects be compared? How can disruption of family life be compared to, or aggregated with, disruptions or absence of health services? Second, if one attempts to find a common measure for these different kinds of effects--again dollars are the most likely measure--this seems to invite invidious trade-offs such as trading greater disruptions in health services for lesser disruptions in education.

It seems, however, possible to get at this problem in a different way. Rather than attempting to aggregate individual social effects, we may be able to identify some simple social effects which, however, deal with the more general social characteristics of the impacts. Three such more general social effects have been proposed.[1] They are:

a. effects on the general quality of life of the people.

b. effects on the relative social position of groups of people.

c. effects upon the social well-begin of communities and their social institutions.

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[1] See Fitzsimmons, Stuart & Wolff, A Social Assessment Manual, 1975. Section 8.3 has been largely drawn from this report which was prepared by Abt Associates for the Bureau of Reclamation, U.S. Department of the Interior.

8.3.1 Quality of Life

Quality of Life refers to the overall nature of impacts on the individual and his/her family and to the effects which such changes, in turn, may have on the individual's perception of the opportunities for personal and family development. A recent national study conducted by the Environmental Protection Agency in connection with work on the meaning of quality of life suggested that a variety of social goals exist for individuals and families which can be important in the quality of life. Among these are: good health, healthy development of children, happy family life, opportunity for a reasonable income and a reasonable standard of living, decent home and neighborhood, peace of mind and emotional maturity, recreation, community stability, and so forth. An individual's stage of life, the overall economic security of his/her situation, and his/her present location in the community are all relevant in the assessment of an individual's quality of life.

It is useful to identify some of the current knowlege which is available on the concept of quality of life. The following findings are documented in Rabel J. Burdge's A Summary of Sociological Studies of Water Resources Dealing with Social Goals and the "Quality of Life" (1973).

a. quality of life impacts will be different if one is displaced vs. not displaced.

b. quality of life impacts will be different depending upon who is involved and what they value (e.g., younger people may value recreation, farmers the certainty of crop development, the elderly a sense of security).

c. quality of life impacts will be different if one is in a position of strength (e.g., economically, in terms of age, legally) rather than a position of weakness (e.g., poor, elderly, unable to secure legal help.)

d. quality of life impacts will be different if one is able to maintain one's sense of community and have neighbors who share one's beliefs, as compared with a situation where one is thrust into a new community, especially if that community has a new life style (e.g., rural to urban, comfortable economic circumstances to marginal existance).

e. quality of life impacts will be different if one is leaving a situation with which one has only marginal attachment rather than leaving a place where one has strong roots and deep attachments.

f. quality of life impacts will be different depending on whether one is anticipating a favorable future in his/her new circumstances or whether one is anticipating a personal or family crisis in a new situation.

In a more psychological sense, quality of life can include concern over stability in family relationships. friendships, love and companionship.

We are mainly concerned here with how the individual is likely to react to construction impacts in the aggregate and how they affect his or her expectations for his or her future life. We are interested in: how protracted, painful, and resented experiences associated with the construction might be; the extent of uncertainty introduced into people's lives; decreases or increases in the interest in community life and local institutions; and whether the sense of pride a person feels as a member of the community is lessened because of the construction impacts.

8.3.2 Relative Social Position

In relative Social Position we are concerned with the extent to which the various adverse (and beneficial) social effects of constructing a tunnel would be equitably distributed among various members of the community. We are also interested in the capacity of different groups of people to bear such costs. It may well be that in some areas, the position of a group of individuals is so bad that the group is unable to bear any cost, i.e., in the case of extreme poverty or social isolation. (Special attention would have to be given to such a group in the event of the implementation of the tunnel project.)

In order to assess the equity of the distribution of effects, it is useful to identify the groups of individuals who will be affected. In some cases, these groups will be fairly formal, such as ethnic groups, income groups, education groups, groups by geographic location, and so forth. In other cases, there may be an informal grouping of people, such as people living in a small cluster of poverty or an information association of local businessmen or large business owners.

Various measures are used in assessing equity of distribution; these include the changes in the distribution of income, job opportunities, services provided by formal agencies to residents, housing availability, employment available outside the community, educational opportunities, recreation opportunities, etc. Again, different groups may benefit or lose differently from implementation of a plan. The real opportunities in the future for various groups are also a concern in the area of Relative Social Position.

8.3.3 Social Well-Being

While Quality of Life is an expression of the degree to which individuals and families enjoy their lives in good health, in economic security, and in general peace of mind about the present and future, social well-being can be evaluated at a higher level of aggregation, i.e., the level of the <u>community and its constituent groups</u>. Social well-being <u>contributes</u> to the quality of life. The effects of impacts are assessed on formal institutions (such as schools, churches, and local government, etc.) and informal groups of people (businessmen, fraternal orders, local leisure groups, special interest groups) that collectively reflect the values, goals, and life activities of people in the community. Most important, the future capacity of the community to sustain itself in a character consistent with the desires of its residents and institutions must be assessed.

The following are some of the evaluation categories of social well-being:

a. the viability and stability of organizations and institutions such as schools, churches, clubs, colleges, and the like, especially as they contribute to the quality of life of individuals.

b. improvement of conditions associated with the achievement of economic stability and improved personal income.

c. achievement of a desirable population distribution in terms of male/female balance in various age groups, reasonable dependence ratios of elderly to work-age population, continuity of values such as rural or urbanness, and avoidance of severe problems associated with high density.

d. availability of efficient and rapid transportation.

To the extent that these and perhaps other characteristics of the community are disrupted by the tunnel construction, the quality of life goes down. Overall, the function of this aggregate measure is to assess, on balance, the probably future character and viability of the community and its institutions.

8.4 AGGREGATING SOCIAL, ECONOMIC, AND ENVIRONMENTAL IMPACTS

It is clear from what we have already said in the earlier sections of this chapter, that such aggregation is a typical "apples and oranges" problem. For the most part if cannot be done, and--what is more--it should not be done.

It will sometimes by the case that some impacts from different categories will be measured in the same units. In that case, the units can be compared and aggregated. Most economic impacts will be measured in dollars; some social effects may properly also be measured in dollars. Some economic effects may, to give another instance, be expressed in terms of time (e.g., traffic delay caused by construction adds a certain number of minutes to commuting time for some people). Some social effects may also be measured in time: we have mentioned the added time to reach a pharmacy because of restricted access due to the barrier effect. In these cases, what is aggregated and compared are the units of measurement; information about the impacts other than their numerical value is lost.

For the most part, however, different kinds of impacts should only be compared with impacts of the same kind. Intellectually, this is the only comparison that makes sense. From a social-philosphical point of view, keeping different kinds of impacts distinct avoids merging them in a common measure, such as dollars, with consequent trade-offs between costs and benefits or between different costs that ought not to be made.

If it is possible to get a reading on what we have called "aggregate social effects" viz. quality of life, relative social position and social well-being, then a large measure of the aggregating will already have been done. The determination of how these aggregate social effects are impacted by tunnel construction will probably have to be done by interviewing some of the residents likely to be affected by the tunnel construction. If, for example, it is their perception that tunnel construction will lead to a lessening of their self-development or their personal opportunities (relating to quality of life), that it will lead to less equality of opportunity and that some groups will bear more of the burdens of the construction than others (relating to relative social position), and that the character of their community will deteriorate and that the quality of public services will become worse (relating to social well-being), then an important statement concerning the overall impact of the tunnel construction can be made. Different residents will, of course, given different answers. The assessment of the social, environmental and economic impacts of tunnel construction will involve getting as complete a set of answers to these questions about quality of life, relative social position, and social well-being as possible.

9. A BRIEF VIEW OF HOW TO LESSEN IMPACTS

The ultimate purpose in identifying impacts that are associated with tunnel construction, in predicting which ones are going to occur in a given project, and in measuring how severe these impacts are going to be is the ability to change routes and construction procedures in order to lessen the costs that have to be borne by the affected individuals and groups. While it was not part of the explicit purpose of this study to enumerate all the various ways in which impacts might be lessened, some possible ways of doing so became apparent in the course of the research.

As has been the case throughout this report, we are less concerned with strictly environmental disturbances than with social and economic costs. Strictly environmental impacts are well known and measurement techniques for them exist; so do proven methods for lessening them. For example, there are standard methods for measuring noise and known ways of how to lessen the noise created by construction machinery.[1] The same is true of other environmental disturbances like air, water and heat pollution, solid waste disposal, etc. Our major interest here is in what can be done about social and economic costs. Of course, insofar as environmental disturbances are translated into social and economic costs, lessening the environmental costs will also lessen the subsequent social and economic costs. Thus it is certainly important to continue to try to reduce the environmental insults resulting from construction.

In what follows we shall deal with four ways which seem promising for dealing directly with social and economic costs:

- 9.1 Planning and other institutional procedures
- 9.2 Community relations
- 9.3 New construction techniques
- 9.4 Monetary compensation.

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[1] See for example Patterson, Ely, Swanson, Regulation of Construction Activity Noise, a report prepared by Bolt Beranek and Newman, Inc., in which different types of construction machinery are discussed and what techniques exist for muffling them, together with the cost of doing so.

9.1 PLANNING AND OTHER INSTITUTIONAL PROCEDURES

A good many impacts can be lessened if not avoided altogether by proper planning. It is obvious that the tunnel route can and should be planned in such a way as to minimize the need for taking residential and business properties. By following the public right-of-way in cut-and-cover construction takings can be minimized. Where this is not possible, planning to construct the tunnel by deep boring methods will keep the disruptions down.[2]

A second area where planning can be helpful in avoiding or minimizing costs is in the relocation of utilities. The more carefully these are mapped and plans are made for working around them, the fewer planned or unplanned disruptions there will be.[3]

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[2] From the Second Draft of the Parsons, Brinckerhoff, Quade & Douglas report: "Subway construction sometimes results in the taking of some businesses and residences along the right-of-way. This occurs most frequently with the cut-and-cover method when the alignment must make the transition from one street to another" (p. 27). "For both social and economic reasons the policies for taking properties are directed toward taking as little property as possible. In the transit planning process usually maximum advantage is taken of existing transit or established railroad or highway rights-of-way" (p. 28).

The Draft Report of London Transport makes the same points: "Even using modern construction methods, cut-and-cover work clearly results in greater surface disruption than bored tunneling (p. 19). "In planning the route of the cut-and-cover railway every effort was made to follow existing roads and where possible, to site the new railway under verges and service roads, thus leaving the main carriageway as free as possible" (p. 20).

[3] See Birkmyer and Richardson, Systems Analysis of Rapid Transit Underground Construction, who speak very concisely about utilities relocation: "Although this is a prime cost event in underground construction, few technological advances for improving the current methods of relocating, supporting, or restoring utilities can be expected. The best way of dealing with utilities is to avoid them, if possible" (p. 8-15). Although the authors' recommendation is made from the point of view of reducing monetary costs to transit authorities, if it were followed it would also reduce economic and social costs to the individuals or groups affected by potential utilities disruptions.

See also London Transport's Draft Report: "In a major cut-and-cover construction it is inevitable that some accidents will occur where service mains are damaged or broken. The extent of this during the course of the contract, however, should be small if proper care is taken in locating and replacing services which are in the way" (p. 3).

A third opportunity for reducing impacts through planning arises whenever it is possible to plan the rapid transit tunnel project jointly with another construction project. It may then be possible to avoid tearing up an area of a city twice and, in fact, to accomplish two or more civic improvements at the disruptive cost of just one. In Boston, when the area around the New England Medical Center was being redeveloped, the opportunity was taken at the same time to build a section of subway tunnel and a station which was planned for that area but would not normally have been built for five to seven years.[4] The so-called South Cove subway and station, now finished, waits for the rest of the Orange Line relocation to be implemented. Obviously a great many disruptions were avoided, since at the time of construction there were few residents or businesses in the area. There was, of course an added financial cost to the owner, the Massachusetts Bay Transit Autority: capital is tied up in the construction and no revenue will be derived from the project for some time. But from the point of view of potentially affected individuals and groups, the early construction was a bargain.

An obvious way to lessen undesirable impacts is to require the contractor to avoid them. Contracts can contain requirements running from the very general (to abide by all applicable existing federal and state regulations concerning the environment, etc.) to the very specific (requiring the contractor not to exceed certain moise standards at certain times, requiring him to wash the wheels of his dump trucks, to maintain a certain number of lanes for vehicular traffic at all times, to dump the spoils in a prescribed spot, and others). Clearly, the more precise the contractual requirements, the easier it will be to avoid unanticipated social, economic, or environmental costs to people in the impact area.

Unfortunately, stringent contractual restrictions also will leave few opportunities for the contractor to find shortcuts which might save him (and the transit authority) money. Thus, there appears to be a general reluctance to bind the contractor too stringently. Muck disposal is a good example of this. Conversations with persons at WMATA and at London Transport indicate that transit authorities prefer not to know where the spoils of

[4]Visit to South Cove Station, July 16, 1975.

tunnel construction go. They are content to specify that spoils shall be disposed of in a legal manner.[5]

Finally, disruptions would probably be less painful if transit authorities had better internal communication mechanisms. It is well known that external communications, between the transit authority and residents and other affected groups, ought to be good. If residents clearly know what is going to happen and why, then they will often put up with a lot of disruption. But it is also important that different offices and bureaus within a transit authority have good communications mechanisms. Otherwise, one part of an authority may say one thing, while another part does or says something else. In the matter of traffic being maintained along M Street, S.W. in Washington, D.C., the design office of WMATA promised two lanes in each direction, without, apparently, consulting with the construction department. As a result, residents had to be told that they had been promised something which could not be done.[6] In this case, fortunately, the residents and owners did not protest too strenuously, but it is easy to imagine cases where such backtracking would lead to troubles with the community.

9.2 COMMUNITY RELATIONS

The example just given leads us to the entire subject of community relations. Obviously, residents must be informed about planned tunnel construction. A draft environmental impact statement must be prepared

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[5] Conversation with Walter Mergelsberg, WMATA, October 17, 1975. WMATA doesn't want to be in the real estate business and buy sites for muck disposal. Furthermore, they are afraid that contractors are going to be able to demand reimbursement if they can show that WMATA forced them to dispose of spoils in a more costly fashion than they would otherwise have done.

The only exception to WMATA's ignorance of where the spoils are going is the muck to be excavated for the tubes under the Washington Channel. This channel is under the jurisdiction of the Corps of Engineers, and the Corps would not give permission for the tube to be constructed until it knew that the muck would be disposed of in such a way as not to cause environmental problems.

London Transport similarly does not know where the muck goes, according to D.G. Jobling (conversations, October 30, 1975). London Transport does guard against "fly tipping" or dumping in unauthorized places.

[6] Conversation with Walter Mergelsberg, October 17, 1975.

and citizens must have an opportunity to comment on the proposed project. If the final environmental impact statement is accepted, residents and businesses in the impact area must be kept informed, so that they can know when construction will actually begin. If construction involves the relocation of any businesses or persons, then those affected must be given early warning in order to make the relocation process as painless as possible and in order to give those affected all required and possible help.

It is not easy, however, to have good community relations. Public meetings, a commonly used and even prescribed method, do not necessarily lead to good relations with the community. We again refer to the situation along M Street, S.W. in Washington, D.C., where residents felt that the public hearings on the proposed tunnel and station did little in the way of giving them concrete information; they viewed the meeting, the materials distributed by WMATA and follow-up efforts as cosmetic devices to lull the residents into accepting the inevitable without giving them sufficient information to protest or assent intelligently.[7]

Some of the literature is very explicit about the equivocal effect of public meetings. The following quotation is concerned with hearings about freeways, but is completely applicable to the tunnel planning situation:

> Public hearings...are widely used in freeway planning as a means for presenting the results of technical studies and are presumed to allow the public an opportunity to comment on the plans. Unfortunately, scheduling of the public hearings tends to polarize community opinions based on little information. Instead of tolerant discussion of the broad questions of values and goals, they resemble protest rallies. Contributors speak with the fervor and earnestness of those committed to a particular position, rather than as spokesmen for groups willing to seek negotiated solutions.[8]

The same author emphasizes the importance in getting sound information to the affected citizens in his conclusion:

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[7] Tiber Island Condominium vs. Washington Metropolitan Area Transit Authority.

[8] Gordon J. Fielding, "Structuring Citizen Involvement in Freeway Planning" in Highway Research Record #380, pp. 23-24.

> The real challenge is to design a communication system that will facilitate the diffusion of reliable information about the consequences of highway improvement, the community benefits that can accrue from an appropriately located and esthetically planned freeway, and how disadvantages can be minimized by prior planning.

Substitute the word "tunnel" for "freeway" or "highway" and the prescription becomes applicable to our concern.

The problems of how to convince affected citizens, both as individuals and as groups, that massive public projects such as rapid transit tunnels are in their best interest (or in the best interest of the city or region) are becoming more rather than less difficult. Citizens are less likely to accept the opinion of planners or other "experts" that a project is in the public interest. They feel, properly, that they are entitled to make input into the planning process and to make modifications in the proposed project. If their rights are not respected, if the citizens feel ignored, they will protest and take all possible action, including legal action, to frustrate the project's coming to fruition.

> In the past, policies in the abstract public interest resulted in programs such as urban renewal, the disruptive effects of which fell upon the relatively unorganized and politically voiceless inner city populations. Now it is the white middle class neighborhood that feels its interest threatened--not just by the problems but by the massive interventions that are brought to bear on contemporary urban ills. Integrity of the neighborhood thus becomes a bulwark against the encroachment of public policy in such diverse areas as school integration, the construction of new freeways, and the provision of lower-income, integrated housing.[10]

Again, one can easily add rapid transit tunnel construction, a solution to the urban transportation problem, as one of the massive interventions that arouse neighborhood resistance.

Thus, it is clear that good community relations, good communications with affected individuals and groups, are essential in order to get

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[9] Ibid., p. 30.

[10] Hudson, Wachs, Schofer, "Local Impact Evaluation in the Design of Large-Scale Urban Systems" in Journal of the American Institute of Planners, Vol. 40, No. 4, July 1974, p. 256.

a rapid transit tunnel project built. Citizens' understanding of what the disruptions are going to be and what the ultimate benefits--to them or to the public at large--are going to be will go a long way toward making disruptions acceptable. The problem is how to achieve such good community relations.[11]

9.3 NEW CONSTRUCTION TECHNIQUES

This research did not investigate tunnel construction techniques. No recommendations are or should be offered by the research team who are not engineers.

However, there may be ways in which the disruptive effects of tunnel construction can be minimized through new and better techniques. Obviously, it is better not to create disruptions at all than to find ways of lessening them, just as it is better to lessen disruptions than simply to put up with them. For example, tunnels that are constructed by boring produce fewer surface disruptions than those constructed by cut-and-cover methods, and so from the point of view of disruptions, the boring technique seems superior (though there may be other reasons against it).

Engineers are aware of other methods of reducing impacts.[12] One method of reducing disruptive impacts of subway construction obviously lies in reducing the duration of the impact through speeding up the construction process. A number of possibilities exist. The first is in speeding up the excavation work. Here there have been achievements in improving the capabilities of tunnel boring machinery over the past several years and in handling spoil materials within the tunnels themselves by employing various types of conveyor equipment. The tunnel boring machines still must be looked upon however as special pieces of equipment which are fabricated at considerable expense often to meet the requirements of one particular project with no real further firm commitment beyond that application.

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[11] See the article by Gordon J. Fielding cited in footnote 8 for some suggestions and references to other studies dealing with community involvement in highway planning.

[12] The remainder of Section 9.3 is taken from a report prepared for this research by Parsons, Brinckerhoff, Quade & Douglas.

Water jets have also been used in certain types of soil materials to achieve more rapid excavation. The use of lasers as a technique in hard rock mining is being extensively studied.

Another approach to speeding up construction is to prefabricate whole station or tunnel components which can then be fitted into place as units. This technique may be applicable to cut-and-cover sections and stations where adequate access can be provided for moving the components to the construction site and lifting such heavy loads into place. This process presents a challenge to ingenuity and the opportunity for a wide range of innovations in response to the particular problems encountered at each location. An interesting variation of the basic idea of construction units or modules, for example, was the construction of the Trans Bay tube from Oakland to San Francisco for the BART system. Here, segments of the tunnel were built at a shipyard, floated to the assigned points then sunk into a previously dredged trench in the bay bottom and connected up to form the completed tunnel. While this technique is not applicable to cut-and-cover or subway tunnels in city streets, it helped speed the overall project construction.

In Amsterdam, engineers of the Public Works Service found practical and expeditious in soils encountered there to "sink" large prefabricated caisson segments by excavating underneath them. This was done in combination with freezing the in-place soils by use of liquid nitrogen to make these soils easier to handle during the excavation process.

Within the realm of the city streets the construction of stations which is usually accomplished by cut-and-cover methods and which is a most costly element of the subway construction also creates the most immediate disruption, particularly to traffic. A premium can therefore be placed on construction methods providing less interruption to traffic or restoration of traffic quickly. To this end the use of specially fabricated and fitted ramps or "umbrellas" has been tried. These may be relatively quickly installed over a street or intersection and traffic allowed to resume while construction proceeds underneath. Another technique is so called "upside down" construction where the station roof slab and necessary support structures are poured first, the street is then restored and traffic resumed while construction of the remainder of the station proceeds beneath the roof.

Construction of stations by mining from driven tunnel sections is possible under certain conditions but has not been widely done because of equipment complications and the tendency of the effort to be labor intensive and hence, expensive.[13]

9.4 MONETARY COMPENSATION

If impacts cannot be avoided, then those who suffer must be compensated for any damages. This principle is well established and generally followed. Transit authorities, when they have to use private buildings or land, either purchase them or take them by eminent domain, with appropriate compensation set by the courts. We have discussed already at length the costs incurred by relocation and the provisions that have been made by law for reimbursing those relocated for the damages they suffered.

Once we leave the field of compensation for real property or for relocation costs as defined by the Uniform Relocation Assistance Act, it becomes less clear what compensation can and should be paid. Transit authorities are faced with two opposing mandates: on the one hand, they must properly compensate those who suffered damages through their actions; on the other hand, as public authorities, they must be frugal with the taxpayers' dollars. All too often, it seems, concern for the taxpayers' money wins out--not surprisingly, since there are more taxpayers in a transit authority's territory than persons or groups who have suffered from the construction of the transit tunnel project.[14]

This is not to say that transit authorities simply ignore damages which they have caused. Very often, it is extremely difficult to know whether in fact the tunnel construction caused the alleged damage. In Chapter 5,

[13] For another discussion of how to minimize disruptions of cut-and-cover construction, see the case history of the Heathrow Airport extension in Section 10.2.

[14] This was the view expressed by Mr. Nicholas J. Roll, of the WMATA real estate office. He did not think that any businesses lost any profits because of METRO construction. Businesses in the construction impact area that failed were those, he said, that were on the way down anyhow. Thus, he did not think these failed businesses should have been bought by WMATA; as for the decreased profits, he maintained that WMATA is permitted to pay only for properties, not for lost profits. (Conversation, October 17, 1975.)

we have listed a large number of economic impacts that might be caused by a tunnel construction project, together with some of the variables that need to be considered if that damage is to be measured. But damage that might be caused or, in a given real situation, might have been caused by the tunnel construction is not compensable unless it can also be shown that the damage was truly caused by the construction. And here the difficulties of attribution begin. Were the declining receipts that a store took in during subway construction due to the construction? Or were they due to some other cause, either in part or wholly? The same question can be asked about all other economic effects. Ultimately, they all come down to someone (individual or business) receiving less money than earlier: was this due to the subway construction or not?[15]

When we come to social impacts, the question of compensation becomes even more difficult. Not only are there the same problems of attribution, but there are the additional problems of how to measure the costs in dollars. If compensation is to be paid, a dollar value of the social cost incurred or of the social damage suffered must be established. While some costs can be put into monetary form, certainly not all can--leaving the question of compensation up in the air.

An interesting case was provided by London Transport. In constructing the extension of the Picadilly subway line to Heathrow Airport, a section was built by cut-and cover methods. Twenty-four houses were temporarily cut off from the street, so that the owners could not reach their driveways. London Transport constructed temporary garages for these homeowners. For most of them, however, some inconvenience was still involved in that they had to walk a pretty long distance--about half a block--from their temporary garage to their houses. No complaints were nevertheless received from these homeowners--a pretty surprising fact until conversation brought out that each homeowner had also been paid the sum of £200 for his inconvenience. Obviously, London Transport had monetized the damage done to these homeowners and had

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[15] Evidently, London Transport occasionally pays claims for decreased profits, but only if the business can prove, from its books, that it really suffered. "It is true to say...that any business even marginally affected lodges claims for loss of trade. It is usually necessary to pay some compensation to owner, but proof of loss of trade must be put on the business" (London Transport Report, p. 2.)

arrived at the decision that £200 was the value of the damage. Evidently, the homeowners agreed that the damage was, at least, not greater than that.[16]

Social costs like inconvenience, limited access, added travel time can perhaps have a monetary value put on them. Other social costs, however, are clearly not susceptible to such monetization and for them, monetary compensation seems out of the question.

Let us consider some examples. All the problems of attribution still remain, but let it be supposed that tunnel construction caused some or all of the following damages of a social kind:

irritation (through noise, for example)
family quarrels
unfocused sense of feeling ill
sense of powerlessness vis-a-vis government
loss of independent life style
decreased ability to learn
decreased enjoyment of eating, drinking and other activities.

Perhaps a leaf could be taken out of London Transport's book: without claiming that a given amount of money in any way measured or compensated for some of these social costs, it might still be wise to pay some money to persons who suffer these costs. This might make these people feel sufficiently better so that they might put up with the disruptions and costs. At the same time, the transit authority by voluntarily paying these sums, without acknowledging responsibility for having caused the damages, might be able to avoid long and costly damage suits.

There is no guarantee, of course, that this kind of payment would always achieve the desired effect. As long as the social disruption was small and temporary, people might be willing and happy to accept a "balm" for their troubles. If the disruption were major and long-lasting, however, and certainly if the damage caused by the disruption were permanent, it is doubtful that the affected persons would or should settle for some kind of payment that is based more on feeling than a precise calculation of damages.

[16] Conversation with James Fergusson, resident engineer at the Heathrow extension, October 29, 1975.

For instance, if it seemed that construction noises had permanently damaged a child's ability to concentrate and do well in school, parents should certainly not sign away the child's right to sue for appropriate compensation merely on the basis of a small, but quickly paid, monetary award which the transit authority offered. In fact, the very offer of a few hundred dollars in such a case might be interpreted as a sign of insensitivity on the part of the transit authority and as an attempt to dupe affected persons by "buying them off." It is important, in other words, that the compensation bear some appropriate relation to the alleged damage. This, of course, is precisely what is difficult to do when we are dealing with damages or impacts which are not readily expressed in monetary terms.

10. TWO MINI-CASE STUDIES: WASHINGTON DC AND LONDON, ENGLAND

In this chapter we present in narrative fashion two brief case histories of the impacts of subway construction. The first one deals with the construction of the Waterfront Station of WMATA's Metro system. The second one describes the extension of London's Picadilly Line to Heathrow Airport.

Neither case study was part of the original scope of the research project. The studies are included nevertheless because of their intrinsic interest and the lively manner in which they illustrate the various disruptive effects of tunnel construction. The Washington study is seen largely through the eyes of affected residents and businesses. (Abt Associates' Washington office happens to be in the impact area.) The London study is seen through the eyes of the transit authority owner (London Transport) and its construction manager.

Neither of these studies was originally written for publication in this report. The studies are anecdotal in character and do not claim to be methodologically rigorous. They do, however, touch on many of the steps in the construction process and the impacts which these events have on the adjacent community. Many of the institutional and procedural issues that are often associated with such projects are also touched on in these case histories.

10.1 WATERFRONT STATION

10.1.1 Description of the Station and Adjacent Area

Waterfront station, like almost all of WMATA's Metro stations, is two blocks long, extending from 3rd to 5th Streets, under M Street, S.W. The station itself is being built by cut-and-cover methods; the line segments which adjoin it at either end are being constructed by soft-ground tunneling techniques. (See Figure 3.)

Abutting the station area on the south side of M Street is a modern high rise apartment and townhouse complex, known as Tiber Island. The townhouse component of Tiber Island consists of both condominium and rental units, with the former directly facing the actual construction activity on M Street.

Across from Tiber Island, on the north side of M Street, is Waterside Mall, an enclosed shopping center. The Waterside development also includes two office towers, housing the U.S. Environmental Protection Agency. Adjacent to Waterside is Town Center Plaza, a high rise apartment building.

The entire area was redeveloped approximately fifteen years ago as part of the Southwest Washington Urban Renewal Project. This project involved the demolition of an older low-income neighborhood and its replacement with luxury housing units as well as the previously mentioned office and commercial buildings. The area to the south of the Tiber Island development is low income in character, with public housing projects predominating. Also developed, as part of the Southwest Project, was the waterfront area along Maine Avenue, facing the Washington Channel. This area now houses several seafood restaurants, as well as a private yacht club.

10.1.2 Circumstances of the Investigation and Data Sources

Data for this mini-case study began to be assembled as a result of the combination of a number of fortuitous circumstances. First, Abt Associates' Washington office is located in the Tiber Island complex. Thus, many of the construction events and related disruptive impacts were well known to the corporate staff. The location of the office also afforded the opportunity for frequent on-site observation of the progress of the project and its associated impacts. Second, it was also a lucky accident that the major disruptive elements of the construction, the excavation for the station and putting the decking in place over the hole, occurred during the last three months of this research. Third, after public hearings for the project had been held, but before construction actually began, the residents of the Tiber Island condominiums retained an attorney and undertook civil action against WMATA in an effort to insure that the anticipated disruption would be minimized. We were able to gain access to the legal documentation prepared by both parties to the case. These documents proved to be a valuable data source in this research. Fourth, as part of a general data collection visit to the offices of WMATA, the project team had occasion to

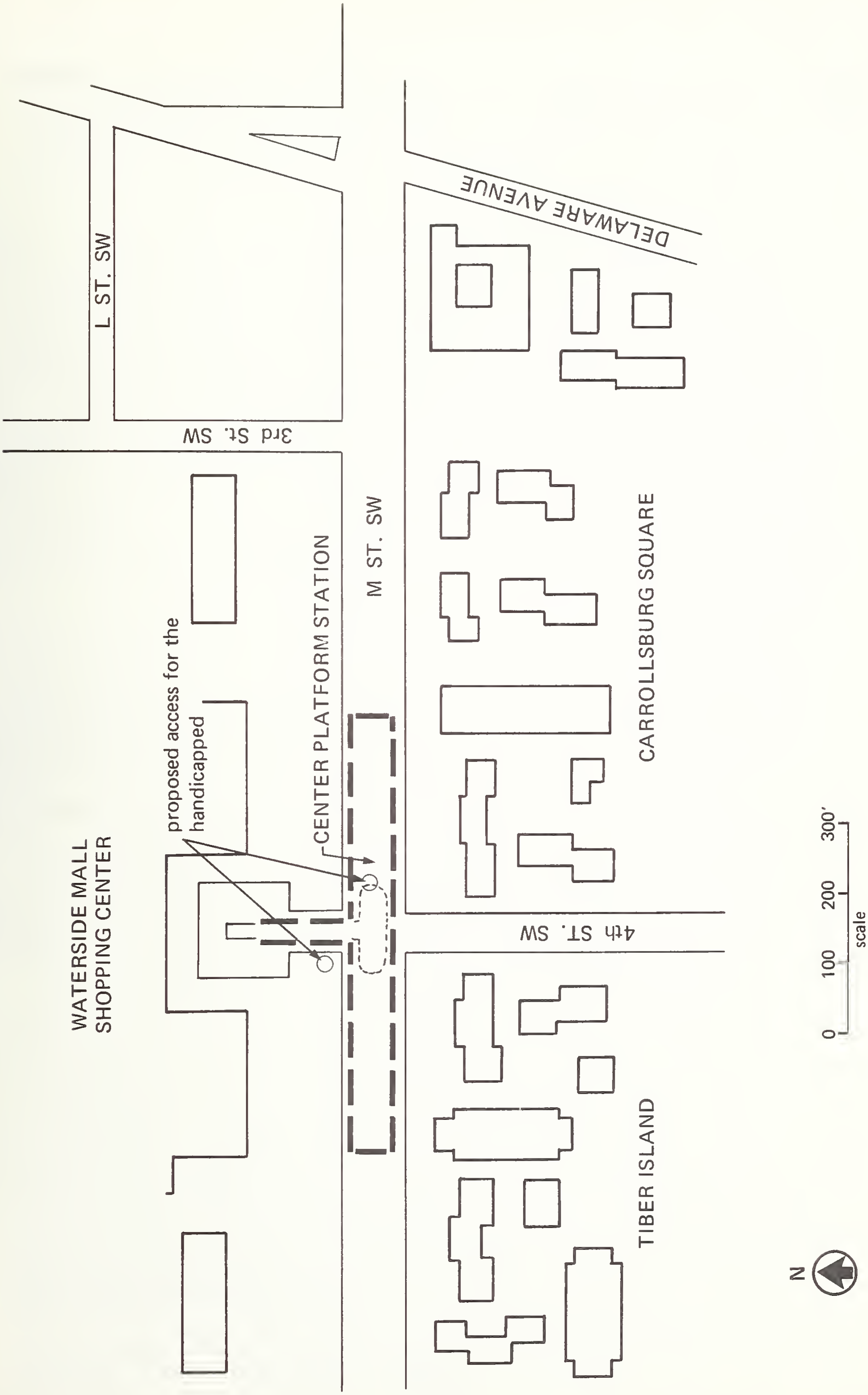

FIGURE 3. WATERFRONT STATION

interview Walter Mergelsberg, who--as luck would have it--was construction engineer for Waterfront Station. Subsequently, we interviewed Raymond Parsons, WMATA's design engineer on the project, in an effort to augment the data base.

In addition to drawing on the data sources cited above, the research team conducted a series of interviews with store managers and residents in the area. Also contacted were nearby institutions, including the local elementary school, as well as the management of the aforementioned yacht club and restaurants. Attorney Charles Fax, the legal representative for the Tiber Island condonimium owners, was interviewed and the relevant documents which were used in the civil action and the subsequent agreement were reviewed. An interview was also conducted with R.G. Mylar, the resident engineer of Bechtel Corporation for the Waterfront Station. Other sources of data included direct on-site observations, over a period of several weeks, of the progress of the construction.

10.1.3 Tiber Island Condominium vs. WMATA

The actual construction of the station did not begin, except for preliminary work, until June of 1975. However, a series of public meetings were held as early as 1971 and continued through 1972, 1973, and 1974. In these meetings representatives of WMATA's Office of Planning and technical support staff distributed "preliminary" information sheets concerning the construction of the proposed station and made themselves available for questioning. Though public meetings were held during the period in question at approximately three month intervals, many of the residents who attended felt that the entire public information process was somewhat less than satisfactory. Many of the residents expressed the opinion that they were unable, during the course of the public meetings, to obtain specific information concerning the nature and extent of the project-related disruptions which might reascnabley be anticipated. Follow-up phone calls made to WMATA offices produced answers which were similarly of a general and non-committal nature. Residents were often told, they say, that the information requested was not as yet available. Indeed requests for information made as late as spring of 1975 were usually answered with the same Preliminary Data Sheet distributed at the public meetings and prepared by the Transit Authority in April of 1971.

It was the frustration experienced by the residents in their efforts to obtain precise information concerning the disruptive impacts of the construction activity which lead to the subsequent civil action, according to Attorney Charles Fax, counsel for the condominium residents.

Fax stated that his clients were not opposed to the location of a subway station in the area abutting their properties. Their concerns centered around issues such as the levels of noise and vibration to be generated both during the construction and after the completion of the project. Other issues raised included the location of the muck holes for the tunneled portions, the locations, height, and physical characteristics of the vent shafts, the location of equipment storage areas, probable disruptions to utilities, and plans for the abatement of dust and mud produced by trucks and other heavy equipment en route from the project site. In general, residents wanted to know the actual construction timetable and the hours of operation. Several of the residents expressed concern about the adequacy of wooden beams as decking material, in view of the reported problems of gaps between segments. Others expressed concern about the creation of a possible "attractive nuisance" at tunneling locations, in view of the many children walking to the nearby elementary school. Information was also wanted on the height and nature of the fencing material around the construction areas.

The dispute between WMATA and the Tiber Island condoninium owners led to the filing of a complaint in the U.S. District Court for the District of Columbia. In the text of the complaint, many of the issues discussed above were formally presented, including the alleged inadequacy of WMATA's public information process, with respect not only to the public hearing, but also to the subsequent telephone calls, letters and visits made to the Authority's offices in search of adequate information. Thirteen questions to which the plaintiffs sought answers were itemized. The fact that WMATA had not prepared an environmental impact statement prior to the completion of the final construction design was cited by the attorney for the plaintiffs. Attached to the complaint was the affidavit of a noise expert, Dr. Donna McCord Dickman; she stated that in her opinion the health and welfare of residents could be adversely affected by the noise levels projected by WMATA during construction.[1]

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[1] Tiber Island Condominium et al. vs. Washington Metropolitan Transit Authority. Civil Action No. 74-947.

The issue of noise impact deserves some comment. Washington is divided into four different zones or types of neighborhood as regards allowable noise levels during Metro construction. Strictly residential areas are accorded the narrowest tolerances, whereas industrial and highway areas are allowed the highest noise levels. The residents of Tiber Island were chagrined to learn that they, as a "semi-residential/commercial" community, faced potential noise levels of up to 80dBAs. In the final agreement which was reached between the residents and WMATA, a compromise range of allowable noise levels was adopted, approximately midway between the boundary levels. Nonetheless, the rationale for the sliding noise scale may be questioned. Is the noise tolerance among dwellers in mixed-use neighborhoods significantly higher than that of persons living in single family residences? This issue of different standards for different areas warrants further research.

A fifteen point out-of-court agreement was reached between the residents and the Authority in July of 1974. Major accomplishments, from the point of view of the residents, were the reduction of allowable noise levels and the limitation of construction activity to the hours between 7:00 a.m. and 7:00 p.m. Provisions covering the location of dome relief vents, and the location of muck removal operations were also included in the agreement. Specifications for the fencing material to be used in conjunction with the muck hole were also stipulated. WMATA pledged that its designated representatives would, throughout the entire period of construction, conduct frequent on-site inspections and maintain close contact with the residents in an effort to insure that the provisions of the agreement were satisfactorily carried out.[2]

While residents and employees located on either side of M Street complained about excessive noise during the pile driving phase of construction (approximately June to October, 1975), there is nothing to suggest that the contractors involved were in violation of the agreement. With respect to the pledge to cease construction activities after 7:00 p.m., there were reports of residents complaining that construction was occurring late at night, one instance at 11:00 p.m. and in another at 1:00 a.m. Following

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[2] Letter from John R. Kennedy, General Counsel, WMATA to Thomas H. Truitt, Esquire, re Tiber Island Condominium et al. vs. WMATA, Civil Action No. 74-947.

these complaints, however, the contractors in question were notified by the Authority and the violations ceased.[3]

The case of the legal action brought by the residents of the Tiber Island complex illustrates how difficult it is for transit authorities adequately to anticipate and plan for public needs relative to construction impacts. The problem in this instance appears to have been not the result of any willful resolve to ignore the issues raised, but rather the cumbersome character of the bureaucracy and its procedures. It is significant indeed that the residents were required to make a major expenditure for attorney's fees in order to elicit a satisfactory response from the Authority concerning project plans and probable impacts. Certainly, the residents were entitled to obtain this information quickly and free of charge.[4]

The problem of poor communications between the community on the one side and the Authority, the contractor, and the consultant engineer on the other is one which emerged elsewhere in the mini-case study. Residents's phone calls made to WMATA long after the signing of the agreement still produced vague responses. On the other hand, the resident engineer for the Waterfront Station, R.G. Mylar, undertook a public relations program on his own; he publicized his phone number and made himself available to residents each Friday morning.[5]

In Toronto, the communications problem was partially solved by the creation of the position of ombudsman within the transit authority to handle specific complaints and questions. This procedure had highly satisfactory results, according to Mr. Norman Funk, of the public relations department of the Toronto Transit Commission.

[3] Interview with Mrs. Kaufman (one of the parties to the action of Tiber Island Condominium vs. WMATA).

[4] The case of the Tiber Island civil action is in many ways similar to the more famous (in Washington) Yuma Street case. It was this latter case which resulted in a court ruling that obliged WMATA to prepare an Environmental Impact Statement, despite the fact that funds for the project had been committed prior to the passage of the Environmental Protection Act by the Congress. In both the Yuma Street and the Tiber Island case, the action was taken by persons who were homeowners and who were generally upper income professionals. Joseph Saunders, the moving force behind the Yuma Street case, was himself an attorney. It should be noted that apartment dwellers, who would have far less of a financial stake in their housing unit, were not a party to either legal action.

[5] Interview, January 22, 1976.

10.1.4 Traffic Disruption along M Street

According to Walter Mergelsberg, WMATA's construction engineer for the Waterfront Station, the residents and merchants along M Street had originally been promised that two lanes of traffic would be maintained in each direction along M Street during the excavation and decking operations. Because of engineering considerations, that promise had to be broken and the decision to allow only one lane in either direction was subsequently reached. He further attributed the change in plans to the failure of the design engineers who had stipulated two lanes to check with the construction engineers on possible problems.

The problem with keeping a total of four lanes open at all times, according to Mergelsberg, is that it would have required the contractor to excavate M Street to only one quarter of its width at any one time. Then temporary pilings would have had to be driven, the excavated quarter would have been decked over, and the contractor would then repeat this operation for the next quarter width of M Street. By keeping only two lanes of traffic going at all times, Mergelsberg noted, the total disruptive period would be shortened considerably over what it would have been with the other plan.

It was Mergelsberg's professional view, which he conveyed to the Merchants' Association of the Waterside Mall, that the disruptive period would last a total of six weeks--three weeks for the block from 5th to 4th Streets and another three weeks for the block from 4th to 3rd Streets. The entire decking operation would be completed by Thanksgiving, he thought, in an effort to provide the Mall with full access along M Street during the Christmas shopping season.[6]

According to Mrs. Brill, owner of Accent Travel in the Mall and president of the Merchants' Association, the group had been appraised of the decision to keep only two lanes of traffic operative; they were generally of the opinion that the trade-off of two extra lanes for the sake of speedier completion was justifiable and in their best interest. In fact, however, the decking operations had not been completed as of January, 1976.

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[6] This interview took place on October 17, 1975.

Though some of the decking was in place, none of the decked portions was opened to either pedestrian or vehicular traffic. Indeed, the lane of traffic that was left on each side went along what had been the sidewalk; the sidewalk on the south side of M Street had been temporarily relocated on the lawns of the condominiums facing M Street. In addition, rather than finishing the decking of one block before beginning the excavation of the second one, as promised, the contractor had both blocks under excavation in December and January (see Figure 4).

According to Raymond Parsons, WMATA's design engineer for the Waterfront Station, it is probable that cost rather than engineering considerations resulted in the reduction to one lane. Further, cost probably accounted for the fact that the second promise of completion of the decking by Thanksgiving was not kept. Parsons pointed out that open cut construction is approximately half as expensive as cut-and-cover. Therefore, the longer a contractor can avoid decking, the less costly the operation. The design engineer went on to say that the contract had been awarded with definite specifications pertaining to the decking and to time tables; these should be adhered to. The responsibility for insuring that the contractor performs the job according to specifications rests with the Authority's consulting engineering firm, Bechtel Corporation, according to Parsons.[7]

R. G. Mylar, Bechtel's resident engineer, agreed with the contractor and the construction department of WMATA that keeping four lanes of traffic open would have delayed completion of the job intolerably. He ascribed some of the delay in getting the decking down to the fact that the contractor's plans for interfacing with the tunneled line segments at either end of the station had not yet been approved.[8]

10.1.5 Losses to Retail Businesses

Most of the shops within the Waterside Mall are designed to serve the needs of the Southwest neighborhood. The retail establishments include food shops, a drug store, fast food restaurants, a branch bank, a travel

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[7] Interview, January 15, 1976.

[8] Interview, January 22, 1976.

agency, a florist, a record shop, a cinema and a liquor store. Many of the store owners had complained of problems even prior to the advent of Metro construction. In fact, a number of stores had vacated the Mall prior to construction because of poor business. Some of the merchants interviewed blamed high crime in the Southwest area, while others cited the high rents charged as the principal reason. Thus the Waterside Mall was apparently highly vulnerable even independently of construction impacts.

During interviews, merchants of the Waterside Mall expressed concern not only about the loss of four traffic lanes along M Street, but also about the loss of parking in front of the Mall. The parking lot there has largely been taken over as a storage site for construction materials, though some replacement parking spaces were added by WMATA elsewhere. Part of the merchants' complaints has to do with the fact that the owner of the Mall and the parking lot was reimbursed financially for the taking of the parking lot, while the merchants--whose businesses stood to suffer because of the loss--received nothing. In fact, the merchants formed their Association and retained an attorney as much to represent their interests against the Mall owner as against WMATA.

All of the merchants interviewed expressed the opinion that the construction operations had resulted in some loss of business, but few were willing to give any figures or even percentage estimates. This is in part due to the fact that there are other causal factors present which could be responsible for the declines, for example, the reluctance of people to frequent the Mall at night because of fear of crime.

Nonetheless, certain trends do emerge from the interviews. Since construction began, there seems to have been a decline in business from outside the Southwest area, particularly from the Virginia and Maryland suburbs. This trend was observed by the owner of the liquor store; because of the District's low taxes on alcoholic spirits, he used to do much business with out of state residents. The loss of business at night, particularly by licensed restaurants, was fairly evident, according to the manager of a beer and pizza parlour. Though some stores in part offset these losses with additional business generated by construction workers at noon (for example, a delicatessen store), this new business was not considered very significant.

FIGURE 4: M STREET, S.W., WHERE THE WATERFRONT STATION IS UNDER CONSTRUCTION: DECEMBER, 1975.

Another point of contention between the merchants and WMATA dealt with the subject of proper signage. The merchants expressed dissatisfaction with the Authority's slowness in putting up directional signs to assist patrons in finding new access routes to the Mall. After several requests, signs were finally erected, but they referred to the Mall by an improper name (Waterfront Mall rather than Waterside Mall), leading to further ill feelings.

10.1.6 Impacts on Owners and Residents of Buildings

Non-commercial properties within the Waterfront Station impact area are experiencing disruptive impacts as well. According to the manager of a highrise apartment building adjacent to the shopping mall, apartments facing the construction site have experienced a more rapid turnover than those located elsewhere. This has added to the overall operating costs, in view of the frequent need to repaint and make other repairs. He also mentioned that the apartment building vibrated during periods of blasting.[9] Tenants in the building complained about the presence of mice in the area, the difficulty in obtaining parking spaces, and the difficulty which moving vans and other delivery trucks have in reaching them. They also frequently mentioned the access problem resulting from the traffic congestion along M Street. Residents of the Tiber Island complex across the street complained about water leaking into their basements. We have already discussed at length their complaints about the noise and vibration disruptions which they anticipated.

10.2 EXTENSION OF THE PICCADILLY LINE TO HEATHROW AIRPORT[10]

Work on the ground on this project started in April, 1971. The railway is now open to Hatton Cross, the intermediate station, and is expected to be open to Heathrow Central in 1977.

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[9] Interview with Mr. Newman, manager of Town Plaza Center.

[10] This case history is taken from a report prepared by London Transport Executive.

10.2.1 Brief Description of Work

The project is to extend the Piccadilly Line from Hounslow West to a new station in the central area at Heathrow with an intermediate station at Hatton Cross, the total length of the extension being approximately 3½ miles. (See Figure 5.) Of this, 2¼ miles are basically cut-and-cover type of construction except for a short length where the railway comes into the open to cross a small river. The remaining length between Hatton Cross and Heathrow Central is in twin bored tunnels passing under the operational airfield. The central station is of cut-and-cover construction, although the railway here is at a depth of some 45 feet.

At Hounslow West the point of connection to the existing surface railway is just to the east of the existing station. This suits the new alignment and gives sufficient distance for the railway to gain depth to pass under the roads. This involved building a new station at Hounslow West, although for the time being the existing ticket hall is retained. The railway is then aligned on the south side of the Bath Road, being as far as possible located under the verge and service road.

At Henlys Corner the railway passes under the road junction on a long curve bringing it onto the north side of the Great South West Road where it is located partially under the carriageway. After a short distance, a reverse curve takes the line under a wide verge where the tunnel was built with minimum interference to traffic. The first tunnel section ends just west of Parkway and the railway then passes over the River Crane and again into tunnel directly under the Eastern Perimeter Road, passing in front of the B.O.A.C. maintenance building and Champions Factory to Hatton Cross station situated just west of Hatton Road. The remaining length is under the operational airfield entering the central area just under the Queens Building. The alignment in the central area and that of the overrun tunnels is so designed that the railway could be further extended to Perry Oaks should the need ever arise.

10.2.2 Reasons for Adopting Cut-and-Cover over Part of the Route through an Urban Area

In the planning stage the question of whether to build a cut-and-cover railway or a deep tube railway to Hatton Cross was looked at very carefully. Even using modern construction methods, cut-and-cover work clearly results in greater surface disruption than bored tunneling. In examining the initial proposals for a deep tube level there were also several severe disadvantages. The first was that at Hounslow West, to gain depth and to bring the railway on its correct alignment, it would have been necessary to reconstruct the railway almost back to Hounslow Central. Another point which of course must be taken into account, is the fact that a deep tube station is not so convenient for passengers. Escalators or lifts have to be installed and the time taken from the train to the surface level is considerably increased.

A further consideration was that specialist tunnel labor, which is often in short supply, was not required for the cut-and-cover work except for a small gang to build sewer headings. In the event this was important as the cut-and-cover works coincided with the Fleet Line tunneling works.

A cost assessment was also carried out and at that time it was estimated that to build in tunnel between Hounslow West and Hatton Cross would be 10 percent more expensive than building in cut-and-cover. This figure was subsequently verified by comparing the actual cost of cut-and-cover work with the estimated cost of the tunnel work using rates extracted from the tender for the tunnel portion of the works under the operational airfield.

10.2.3 Route Planning

In planning the route of the cut-and-cover railway every effort was made to follow existing roads and, where possible, to site the new railway under verges and service roads, thus leaving the main carriageway as free as possible. The attached drawing shows the tunnel location in relation to the roads and the main diversions that were necessary. At the Hounslow West end it was necessary to buy up some 20 residential properties to allow the construction of Hounslow West station. It should be noted, however, that on completion of the works there is now a substantial site which can be redeveloped with either houses, office or other commercial premises and the station is specifically designed to take some building loads. Apart from this there was no direct interference with any private property.

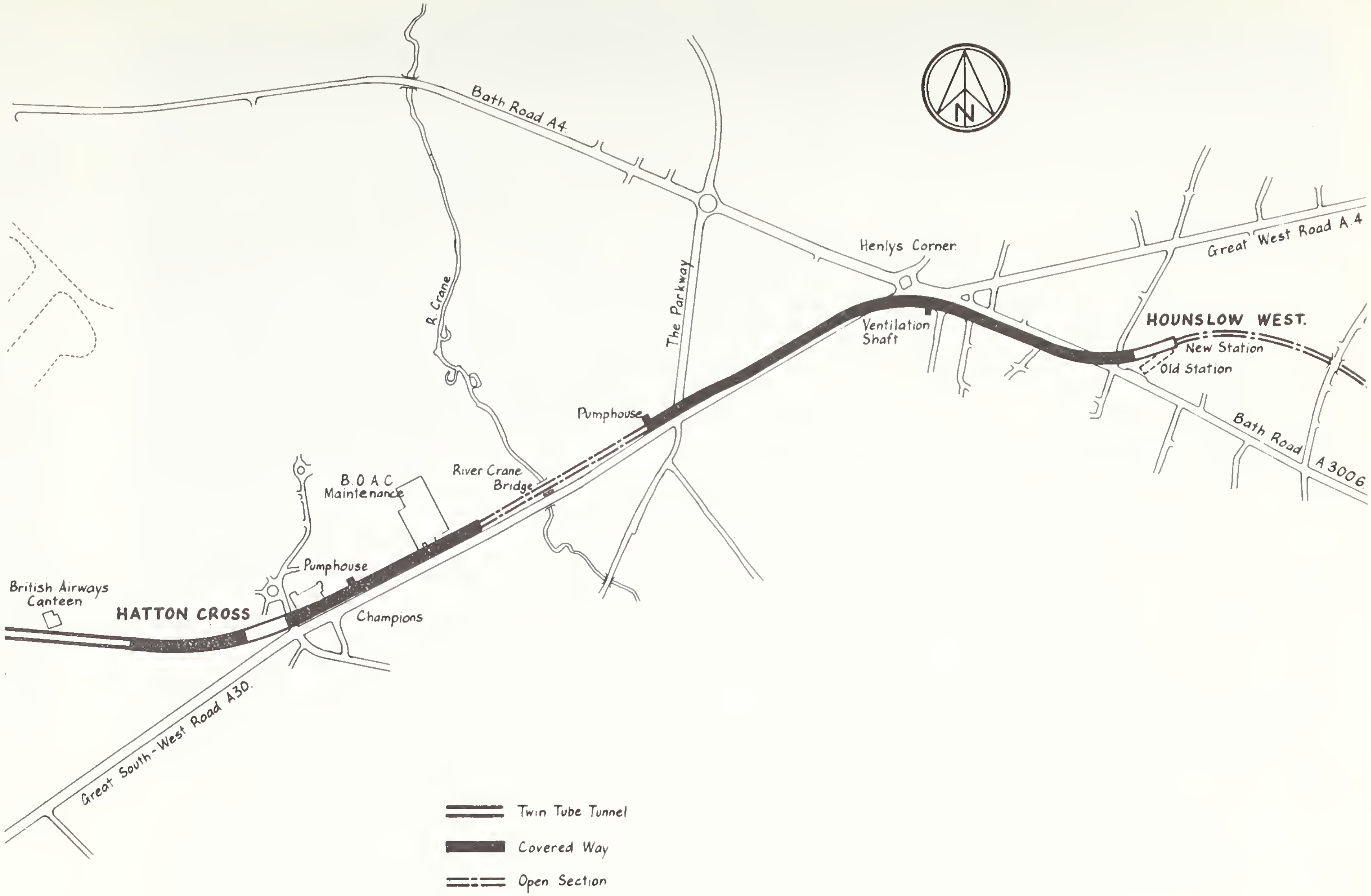

Fig. 5. Route Plan of Heathrow Extension

10.2.4 Design Considerations

In designing the cut-and-cover work careful thought was given to the type of construction that would give the least interference to the public and residents whilst actually carrying out the work. Also, as the result of an undertaking entered into through the Parliamentary stages, it was necessary to design the railway to be mounted on track trays carried on rubber blocks to prevent groundborne vibrations reaching the properties.

During the design stages several basic methods of construction were considered but the method chosen was believed to give the least possible surface interference. It was considered that only comparatively short lengths would be open at any one time and then the surface interference would be for the shortest possible duration.

The basic procedure was to construct secant pile walls from surface level using benoto piling rigs. Secant piles are so called because they intersect each other during construction with the resulting advantage of a nearly watertight joint. On the project, 35.6 inch diameter piles were bored generally at 32 inch centers giving a 31.2 inch contact interface between adjacent piles. Initially, alternate piles only are cast, the intermediate male piles being completed on the following day when the concrete previously placed has set, yet is still green. Generally only the male piles are reinforced to avoid difficulties when cutting into the adjacent piles.

The method of operation of the piling rig is to force a steel casing into the ground by means of hydraulic rams; a secondary transverse ram imparts a twisting motion to the casing at the same time. A grab removes material from inside the casing while sinking progresses, the casing always being kept a little in advance of the grab. When the excavation reaches the required depth, reinforcing steel is placed in the casing and concrete is then poured in to form a normal insitu pile. As the concrete rises, the casing is gradually withdrawn, again with the twisting motion which leaves a distinctive zig-zag finish on the concrete. (See Figure 6.)

By this means it was only necessary to occupy the surface over the top of one wall at a time, although obviously the whole width was occupied

FIGURE 6: A BENOTO PILING RIG WORKING. NO COMPLAINTS OF NOISE WERE RECEIVED FROM THE RESIDENTS OF THE HOUSES, EVEN THOUGH THE MACHINE IS VERY CLOSE TO THEM.

where this was practicable. Also, during this operation it was quite practicable to restore temporary crossing for householders to get their cars to their garages overnight. When both walls were completed a shallow excavation was taken down to the level of the top of the secant piles (about five feet on average) and a continuous capping beam constructed. The roof, which is designed to act as a prop between the walls, was constructed next using precast, prestressed, inverted "T" beams with an insitu concrete infill and topping. The waterproofing and protective concrete screed were laid next, followed by backfilling. At this stage the surface reinstatement was carried out. All excavation and the rest of the construction was then carried out underneath the roof from selected openings left for this purpose. By this method it was possible to restore the surface about five or six weeks after work in a location was started. Obviously this only happened where it was necessary as a longer period enabled a longer length of roof to be completed in one operation. (See Figure 7.)

Apart from mimimizing the duration of surface occupation, this method had several other notable advantages:

1. It completely eliminated traditional sheet piling which is unacceptably noisy in built up areas.
2. The benoto piling rigs were extremely quiet in operation, especially after a second silencer had been fitted to each machine.
3. The method was extremely versatile in piling for road diversions and service diversions. It was possible to occupy a small area in the initial stages of the work, drive two short lengths of wall say 30 feet long, construct the roof on the walls and reinstate the surface. At this stage roads crossing the line of the tunnel and services could be diverted across this short length of roof giving freedom for constructing long lengths of tunnels between these short sections.
4. The use of diaphragm walls was considered but eventually not used because of the problems of spillage of betonite mud on the adjacent carriageways and footpaths and also because it was not nearly so suited for carrying out the short lengths of tunnel that were a prerequisite of the main tunneling work.

Considerable experimental work went into designing the track deck and rubber mounting blocks to obtain the correct properties for insulating

FIGURE 7. PERMANENT TUNNEL ROOF BEING INSTALLED. NOTE THE SMALL AMOUNT OF EXCAVATION THAT HAS AS YET BEEN MADE. IN THE FOREGROUND, THE EXCAVATION IS BEING BACKFILLED, IMMEDIATELY BEHIND THE ROOF CONSTRUCTION.

train vibrations from the surrounding ground. It may be worthwhile noting that following satisfactory experiences elsewhere it was decided to build the rubber blocks in for the life of the railway and there is no means of changing the blocks should, in service, they deteriorate.

Where the railway came into the open it was necessary to protect the portion in cutting by reinforced parapet walls as, in all cases, it was alongside a road carrying heavy goods traffic. To prevent the stark appearance of some half a mile of six-foot high concrete wall the external shutters were lined with a molded fiberglass shuttering panel to give a sculptured finish to the wall. Figure 8 shows the very successful effect which was obtained.

10.2.5 Construction Techniques

One of the first problems to be faced in the construction of the cut-and-cover portion of the works near to and alongside main roads in a residential area was the presence of a very large number of statutory undertakers' services and Council sewers. The G.P.O. services were particularly difficult being the main routes leading to the airport. It was considered that the successful undertaking of the works would be largely dependent on very careful coordination and planning for the diversion of services. With this in view a senior engineer led a small section dealing only with service diversions. Because of the length of time required for some of the service diversions--the G.P.O. required two years in some areas--a lot of this planning was carried out prior to the letting of the contract and certain service diversion work was commenced some months before the main contract.

It was decided that a number of short lengths of tunnel wall and roof would be constructed in advance of the main work at suitable points and the services diverted over them thus leaving lengths of tunnel free for unimpeded progress. During the first year the main contractor's work was controlled entirely by service diversions. No fewer than ten statutory authorities had to move their equipment and at times all were on the site at once.

Although each statutory authority carried out its own work, careful planning by the Resident Engineer ensured that work by all authorities

FIGURE 8. THE VISUAL IMPACT OF THIS RETAINING WALL WAS IMPROVED BY GIVING IT A SCULPTURED FINISH OBTAINED WITH FIBREGLASS PANELS.

went on within defined areas at any one time and kept interference to the public to a minimum. In addition to the service problems traffic had to be kept flowing smoothly at all times and this necessitated considerable negotiations with the relevant authorities on the many road diversions. Where roads crossed the line of construction, it was necessary to build short lengths of wall and roof to the tunnels so that the roads could be diverted over a piece of finished roof and construction could be carried out on the site of the original road. In all seven short sections were constructed in advance for this purpose.

It may be worthwhile noting that all road diversion works were designed by London Transport engineers in conjunction with the road authority as the work proceeded and the contractor was instructed to build them in accordance with the drawings and specifications produced. He was then paid for whatever work he carried out as measured work at agreed rates. This ensured an adequate standard of temporary road works which are often very poor because they are treated as included items in the document and the contractor must, therefore, carry them out at his own expense against a lump sum allowance and tries to reduce the quality to save money. This is a highly important point in preserving proper facilities for the road user.

10.2.6 Public Relations

Considerable lengths of the cut-and-cover works were very close to residential properties and in one case the secant pile wall was within a few feet of the front gates. It was essential to maintain contact with the local householders and the Resident Engineer and his staff made personal contact with as many householders as possible, to explain to the residents what was going on and how they would be affected.

Circular letters advising of any major changes and major operations were sent to the residents. Regular meetings were held with the local Chamber of Commerce in relation to part of the works that affected a row of shops. By conforming as far as possible with their views the impact of the work, and certainly complaints resulting from the work were reduced. Various problems arose as a result of this consultation; for instance, it was found that a blind couple were unable to make their journeys to and from their home near the works because of the various footpath diversions. To overcome this they were provided with a taxi twice a day for the duration of the work in their area. This was a very small cost on the project. Also problems occurred with refuse collection but by agreement with the Council a plastic bag method of collection was introduced in the affected locations, the additional cost to the Council being offset against a small road improvement instituted as part of the permanent reinstatement works.

10.2.7 Dust, Mud and Noise

In an endeavor to keep these down to acceptable proportions certain measures were instituted. All plant was required to be silenced to a greater degree than normally found on heavy construction plant and any plant found not to comply was removed from the site. Wherever possible plant was housed underground in completed parts of the work and in many cases electrically driven plant adopted.

Although the working site was continually changing as the work progressed, the contractor was required to use long term, well defined site exits. These were to be provided with hard standing and equipment for cleaning lorry wheels. The contractor also provided a mechanical road sweeper which was used daily on the public roads. The access points in the tunnel roof for the main excavation and completion of the tunnel were sited as far away as possible from residential properties.

10.2.8 Reinstatement

Surface reinstatements were carried out as quickly as possible after backfilling over the tunnel had taken place. Considerable improvements were made in reinstating various old road layouts and in many cases these resulted in some financial savings to London Transport as the road authority made a contribution towards the improvement. Great care was taken with the reinstatement of gardens and verged areas. This was not left to the main contractor but carried out by London Transport's own specialist department and a very high standard was obtained. All trees were replanted with well established saplings and where disturbance had taken place householders' gardens were restored to a high standard. The quality of reinstatement in the early parts of the work did a lot to allay the fears of people who were affected in the later stages of the works.

The construction of the railway in driven tunnel between Hatton Cross station and Heathrow Central station is not described. It was built under an operational airfield and had little or no impact on the public or the airport. Again the Central station, although built by cut-and-cover methods to a platform level of 45 feet down, was within a self-contained triangular site in the center of the airport and had little affect on the public or the operation of the airport.

11. DIRECTIONS OF FUTURE IMPACT ASSESSMENT RESEARCH

Any attempt to discuss what future research should do must be based on two considerations: first, what has already been accomplished, and second, what are the ultimate goals that are to be achieved. Future research must build on what has already been done in order to bring us closer to the ultimate goals.

11.1 GOALS OF RESEARCH ON DISRUPTIVE EFFECTS OF RAPID TRANSIT TUNNELING

Obviously, the ultimate determination of what the goals should be like must be made by the U.S. Department of Transportation. It seems clear, however, that at the present time that goal is the development of a set of Guidelines to be used by transit authorities, by transportation departments, by design engineers, by contractors and perhaps by others who are involved in urban transportation tunnel construction. The guidelines should be embedded in a Manual which will provide detailed instructions on how to implement these guidelines.

The Guidelines will set standards relating to construction impacts (social, environmental, and economic). Some impacts will be found completely unacceptable, while other impacts will be acceptable, provided they do not exceed certain levels, or other thresholds. For example, a certain amount of noise may be acceptable, taking into account the kind of neighborhood, the time of day, the overall duration of the noise-producing machinery's operation. Another example would be that a park or similar public property which may be taken in order to provide contractor storage space, if nothing else is available.

The Guidelines will also provide rules for compensation of those on whom the impacts fall. What must be done or may be done will be spelled out, in order to make those who are injured by the construction impacts whole again. These rules will indicate how much money should be paid to compensate for different kinds of impacts; what alternative non-monetary compensation can be provided to offset disruptive impacts (such things as providing alternative services, help in finding replacement housing); what if anything can be done about impacts that may not be compensable by money (psychological trauma, change in lifestyle, and the like).

The Manual, then, will deal with the problems of implementing these Guidelines. It will provide detailed instructions for steps to be taken by a transit authority in order to forecast what the likely effects of a tunnel construction project are going to be and how severe these impacts are going to be. It will also provide instructions on how to minimize the disruptive effects, by such things as appropriate planning procedures, good community involvement, employment of the right construction techniques, and others. Finally, the Manual will give indications of how to make arrangements, when necessary, for compensation of affected groups.

11.2 RESULTS OF RESEARCH TO DATE THAT BEAR ON FUTURE RESEARCH

The results of our research that are directly relevant to the development of guidelines and a manual are twofold:

First, we have identified possible and likely construction impacts; second, we have identified measurement methods for these impacts and have identified the variables to be considered in measuring economic and social impacts. We have also taken some first steps toward an assessment methodology of impacts by discussing the aggregation of impacts.

These results suggest that the additional work that needs to be done falls into two broad categories:

1. Studies of a theoretical nature that explore some of the background needed for an assessment of impacts; and
2. Data collections to identify actual impacts of construction and to identify what acutal events in the construction sequence produce impacts.

11.3 NEEDED THEORETICAL STUDIES

The following studies are suggested as worthy of being conducted; they deal wih problems of measurement, of aggregation, and of assessment.

Measurement

Measurement of social impacts. Can they be quantified and if so, how? Can they be monetized without distortion? Are there any social effects which cannot be quantified or monetized?

Non-compensable costs. What are the costs which cannot be compensated by dollar payments? What can be substituted for monetary compensation in order to reimburse those who suffer the costs? Is this non-compensability inherent in certain effects or is it due to the low state of the art?

Development of a theory of threshold costs. There is not a linear relation between tunnel construction and economic effects. Rather, there are a series of plateaus. Information is needed on what these plateaus are. The same kind of threshold effect is probably present in environmental effects.

Measurement of particular social impacts, especially those which are of a psychological kind. Among social impacts are or may be such things as:

learning disabilities
difficulties of socialization
stress
anxiety/depression/anger.

If any of these are apparently the consequence of construction, this needs to be ascertained and measurement methods devised.

The relationship of environmental impacts to social cost. Many environmental impacts can be measured with some precision (decibel levels, quantities of fugitive particulate matter in the air, etc.). These changes in environmental conditions have major social impacts, and there is no good methodology available that relates them.

Aggregation

Commensurability of impacts. Are impacts of different kinds commersurable with one another, quantitatively or even qualitatively?

Aggregation within categories. What are the problems of adding or trading off between impacts that are apparently of the same kind? For example, what is the appropriateness of trading $100 of improved recreational facilities against a $50 cost in health?

Aggregation across categories. What is the feasibility or infeasibility of aggregating social and economic and environmental impacts? Can they be traded off against one another? Can this be done if surrogate measures, such as dollars, are used?

Assessment

Attribution. The connection between alleged causes and apparent impacts needs to be studied.

Prediction. There are problems of predicting future impacts from present causal factors.

Reimbursement factors. On the basis of impact assessments, can suitable reimbursement be calculated and how?

The last two, of course, are very general problems and common to much more research than just that of assessing impacts of construction projects.

11.4 DATA COLLECTION ON ACTUAL IMPACTS

While the present research has identified and classified many of the impacts that are expected to occur in tunnel construction, there is still a need to collect data on what impacts in fact are encountered in a real, on-going, rapid transit tunnel project. By examining such a project in detail, it should be possible to determine, for example, what impacts are caused in a low socio-economic residential apartment neighborhood. It should be possible to tell which impacts are due to such factors as traffic diversion, to takings of residences, to loss of community service facilities, etc. A dollar value of these disruptions can then be estimated, or some other surrogate measure of the impact determined.

The results will not be absolutely certain. Many problems of attribution will be encountered: is the decrease in gross receipts of this business completely or even partially due to the construction or to some other factor? Is the vacancy rate of this apartment building due to the construction? To overcome this problem, the situation prior to construction must be taken into account including existing social and economic trends, and the "no build" alternative. Certainty will still not be possible, but results with a high degree of usefulness can be obtained.

Data must also be collected on what kinds of impacts tend to become permanent for some groups or individuals and what kind of impacts disappear completely when the construction has been finished. From these data, it should be possible to predict what kind of impacts will result in a permanent kind of change in the project area: will the tunnel project lower the socio-economic status of a neighborhood or will it raise it? Will a commercial area change from one that consists mainly of neighborhood retail service stores to one that serves a region and that has larger, department-type stores? Is the ethnic composition of the project area likely to change as a result of the tunnel project?

As part of the data collection effort, it must be determined whether it is possible to collect sufficient and reliable data to accurately forecast what construction impacts are going to take place. This kind of methodological effort was also mentioned in Section 10.3 among the theoretical studies that should be conducted.

If these two kinds of research effort are completed, there is good reason to think that our understanding of the impacts which tunnel construction causes in urban areas will be greatly improved. Very useful forecasts will be able to be made of the kinds and severity of the impacts to be expected. With that knowledge, it will in turn be possible to lessen and ameliorate the impacts, so that urban rapid transit tunnels--and other tunnels--can bring about their undoubted benefits, without so seriously and lengthily harming individuals and groups.

APPENDIX: REPORT OF INVENTIONS

A major result has been the development of a matrix which identifies agents (or events) that bring about disruption during tunnel construction and which at the same time identifies persons (or groups) on whom these disruptions fall. The matrix pinpoints loci of disruptive costs. (See Chapter 4, p. 67-84.)

Examples have been provided for two kinds of disruption, and the variables needed to measure these kinds of disruption are identified, i.e., economic disruptions borne by retail businesses (see p. 85-102), and social disruptions borne by residents of the impact area (see p. 103-120).

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