PUGET SOUND REGIONAL TRANSPORTATION STUDY

Summary Report
A symbol representing the four counties and four central cities in the Puget Sound Region, their close cooperation, and their collective approach to the solution of regionwide problems.
This Study was Conducted under the Sponsorship of the:

PUGET SOUND GOVERNMENTAL CONFERENCE
Counties of King, Kitsap, Pierce and Snohomish
Cities of Bremerton, Everett, Seattle and Tacoma

STATE OF WASHINGTON
Washington State Highway Commission

In Cooperation with the:
U.S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads
and
U.S. Department of Housing and Urban Development
STUDY ORGANIZATION

POLICY COMMITTEE
(1962 TO 1965)

Harry Sprinker, Chairman
Commissioner, Pierce County
Ernest A. Cowell (1963 to 1965)
Washington State Highway Commission
Oliver Everett
U.S. Housing and Home Finance Agency
William L. Hall
U.S. Department of Commerce, Bureau of Public Roads
Ernest J. Ketcham (1962 to 1963)
Washington State Highway Commission
Roe P. Rodgers
U.S. Department of Commerce, Bureau of Public Roads
Robert E. Rose
Washington State Department of Commerce and Economic Development

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(1965 TO PRESENT)

Voting Members

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Commissioner, Pierce County
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Successor to be named)
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E. Sam Kraetz
Commissioner Snohomish County
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Commissioner, City of Bremerton
Harold Walsh
Washington State Highway Commission
A member to represent the incorporated areas other than the four major cities in the region. (This position is presently vacant.)

Non-Voting Members

U.S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads
U.S. Department of Housing and Urban Development
Washington State Planning and Community Affairs Agency
Chairman of the Regional Technical Steering Committee
TECHNICAL COMMITTEE
(1962 TO 1965)

Planning Directors
Representing:
City of Bellevue
City of Everett
City of Mercer Island
City of Renton
City of Seattle
City of Tacoma
King County
Kitsap County
Pierce County
Snohomish County
Southwest Snohomish County Joint Planning Council

Engineers
Representing:
City of Bremerton
City of Everett
City of Seattle
City of Tacoma
King County
Kitsap County
Pierce County
Snohomish County

Others
Representing:
Metropolitan Transit Company
Port of Seattle
Puget Sound Governmental Conference
Seattle Transit System
Tacoma Transit System
U.S. Department of Commerce, Bureau of Public Roads
Washington State Department of Highways
Washington State Department of Commerce and Economic Development

TECHNICAL COMMITTEES
(1965 TO PRESENT)

Regional Technical Steering Committee
Bremerton—Kitsap County Technical Advisory Committee
Everett—Snohomish County Technical Advisory Committee
Seattle—King County Technical Advisory Committee
Tacoma—Pierce County Technical Advisory Committee

STUDY DIRECTOR
John K. Mladinov
September 30, 1967

Mr. Harry Sprinker, Chairman
Policy Committee
1046 County-City Building
Tacoma, Washington 98402

Dear Mr. Sprinker:

On behalf of John K. Mladinov, Director of the Puget Sound Regional Transportation Study and the Puget Sound Regional Transportation Planning Program between 1960 and 1966, I am pleased to present this overall report of the Puget Sound Regional Transportation Study.

While this volume contains a thorough review of the fact-finding methodology, the conclusions and recommendations of the Study have been emphasized by placing them close to the front of the report and printing them on buff-colored paper for ready identification. The supporting charts, graphs and tables—representing thousands of man-hours of surveys, interviews, accuracy checks and other research techniques—follow as documentation for the transportation and land-use plans which ultimately evolved.

The contents of the report are essentially the same as those of the draft copy authorized for publication by the Policy Committee at its June 23, 1966 meeting. Recently, the Puget Sound Region has experienced a rapid expansion in its economy and population. Indications are that this expansion will continue in the foreseeable future.

The thorough appraisal of rapid expansion, its impact and implications are properly included in the continuing work program of the Study, which is designed to allow periodic updating, constant evaluation, and, if necessary, adjustments to the plan. The goal, of course, is to provide the most realistic, efficient, desirable and economical solutions to the traffic and transportation problems of the Puget Sound Region—and, in the end, to develop a better regional community in which to live and do business.

Very truly yours,

HERMAN BASMACIYAN
Acting Director

The PUGET SOUND REGIONAL TRANSPORTATION PLANNING PROGRAM is part of the comprehensive, cooperative, and continuing planning effort being carried out in the Puget Sound region. It is a joint undertaking of the Puget Sound Governmental Conference and the Washington State Highway Commission in cooperation with the U. S. Department of Commerce; the U. S. Department of Housing and Urban Development; and the Washington State Department of Commerce and Economic Development. The participants represented by the Puget Sound Governmental Conference are the Counties of King, Kitaco, Pierce, and Snohomish and the Cities of Bremerton, Everett, Seattle, and Tacoma.
ACKNOWLEDGEMENTS

It would be impossible to list here all those who have been instrumental in organizing, carrying out, guiding, or otherwise contributing to the Puget Sound Regional Transportation Study. Such a list would include the names of elected or appointed officials, technical committee members, Study staff members (representing a broad spectrum of professional talent), Puget Sound Governmental Conference staff members and countless others who have directly or indirectly contributed to the efforts of the Study and consequently this Summary Report. Their help is gratefully acknowledged.

Special acknowledgements are due Stephen George, Jr., Deputy Study Director; Fred Utevsky, Assistant Director for Regional Planning; James W. Schmidt, Assistant Director for Traffic and Transportation Planning; and Gary R. Cowan, Assistant Director for Analysis and Research.

The help given by Robert F. Karolevitz, special editorial consultant, in the preparation of this report is gratefully acknowledged.

For the names of the present staff members of the Puget Sound Regional Transportation Planning Program and those of the key members of the Puget Sound Regional Transportation Study staff, please refer to the last page of this report.
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Part I

WHY A REGIONAL TRANSPORTATION STUDY?

THE 'PUGET SOUND REGION'

The so-called "Puget Sound Region" considered in this study is both the victim and beneficiary of geographic location. While the inland waterway which characterizes the area provides the adjacent counties of King, Kitsap, Pierce and Snohomish with unusual scenic beauty and innumerable economic attributes, it (and sizable lakes within the region) presents unique obstacles to area-wide planning and development.

In addition to its attractive natural setting, the Puget Sound Region is young, dynamic and climatically appealing to individuals and industry. As a result, during and since World War II, it has undergone a population expansion which continues unabated. With less than ten percent of Washington State's total area, the region houses more than half of the state's population—and it continues to grow faster than the rest of the state and to become an even more dominant center of economic activity.

As a natural consequence, the four-county complex is suffering growing pains.

THE PROBLEM

Not the least of these growing pains are the present transportation problems, complicated both by the region's economic expansion and natural geography. These impeding difficulties were not entirely unrecognized, and shortly after World War II, officials of Seattle and Tacoma—each in cooperation with the Washington State Department of Highways—undertook local traffic studies. These pioneering efforts laid the foundation for a large number of major street and highway construction projects, since completed or currently underway.

By the late 1950s as growth continued unabated, it was recognized that the early studies had outlived their usefulness. They had not encompassed the burgeoning suburban areas, nor had they fully anticipated the rapidity of travel increase or the change in modes of transportation. In the decade and a half after the war, motor vehicle travel almost tripled, while public transit travel dropped to a quarter of its 1945 level. By 1960 the Puget Sound Region contained 1½ million people; indications were that the population might double in the ensuing 30 years.

What would this do to vehicular and transit travel in the future? How would people move from their homes—to jobs, to shopping centers, to recreation sites—in an area growing continually more congested?

A REGIONAL CONCEPT

The difficulties created by the population upsurge following the war—added to the hiatus on transportation improvements during the national emergency—outstripped the region's revenues for streets, highways and transit. The elected officials responsible for transportation facilities in the four-county area recognized the need for action.

With more and more of the region's travel crossing city and county lines, it was evident that transportation planning would have to transcend jurisdictional boundaries as well. But how can transportation problems of growing magnitude and complexity be tackled without specific knowledge of historical background, current conditions and future potential? Necessarily, a large-scale, all-encompassing planning and research effort would have to provide the basic answers—and in 1961 the Puget Sound Regional Transportation Study was activated.

THE PARTICIPANTS

Unofficially, the PSRTS dates back to October 11, 1957, when Seattle's Mayor Gordon S. Clinton called a meeting of state and local political subdivision officials to discuss the possibilities of a comprehensive transportation survey for the Seattle area. Later it was agreed that a regional study should be undertaken without regard to municipal boundaries and should encompass all forms of transportation. Further, the study was to provide a program for transportation facilities as part of an area-wide development plan.

The first step was a "Scope and Procedures Report" by Parsons, Brinckerhoff, Hall and MacDonald in April, 1959, which, in turn, led to the establishment of the PSRTS. Through their regional intergovernmental coordinating agency—the Puget Sound Governmental Conference—Seattle, Bremerton, Everett and Tacoma, and the counties of King, Kitsap, Pierce and Snohomish sponsored the Study together with the Washington State Highway Commission; the U.S. Department of Commerce, Bureau of Public Roads; U.S.


2. Numerous other single-purpose and limited studies were conducted throughout the region from 1948 to 1960.
Housing and Home Finance Agency; and the Washington State Department of Commerce and Economic Development. A Prospectus prepared by the city and county engineers and planning officials of the region established the foundation for the Study. 3

THE ORGANIZATION

The Basic Study organization (Figure I-1) was created as an advisory group under the direction of a Policy Committee made up of representatives of the sponsors. For administrative purposes, the PSRTS was placed in the Department of Highways, thus following State personnel, payroll, purchasing and other operating procedures. (The overall advisory and administrative organization for the Study is shown in Figure I-2.)

A Technical Committee was established to review and approve the detailed specifications of the Study, as well as work completed and in progress. The committee was made up of city and county engineers and planning directors; planning representatives from the State Department of Highways, Bureau of Public Roads and the Department of

Commerce and Economic Development; and technical representatives of such organizations as port commissions, transit agencies and the Puget Sound Governmental Conference.

In addition, Citizen Advisory Committees were appointed in each county to advise the Study staff and local officials relative to the direction of the Study’s efforts to meet local objectives; to assist in progress reviews; and to keep citizens within their respective areas informed about the Study and its work.

OBJECTIVES

The general objective of the Study was “to formulate a transportation plan as part of a general development plan for the region.” Within this overall framework the Study would evaluate alternative land use development patterns and transportation systems which would assist in formulating the most desirable development pattern for the four-county complex.

The recommended transportation plan would be keyed to the travel requirements predicted for 1985 to 1990, providing major street, highway and mass transit facilities, blended in an efficient system, and commensurate with the financial abilities of the region. Further, the plan would establish a frame of reference for local and State agencies in developing their respective programs within the area to achieve an efficient, economical and integrated transportation system.

Efficient movement of people and goods is vital to any community’s economic well-being. Consequently, the transportation plan would be designed to promote and enhance the region’s industrial and commercial potential, although not at the expense of scenic attributes, historical heritage or established neighborhoods. It must be recognized that, while vitally important, the development of a transportation plan is just one of the factors in the overall community effort to make the region a better place in which to live and do business.

An organization and procedures would be established for a continuing land use and transportation planning program (1) to re-evaluate and adjust the plan to meet changing conditions unanticipated in the original planning, (2) to permit further projection of plans into the future as time goes on, (3) thus to provide long-range objectives for the various governmental jurisdictions, (4) to assist the governmental jurisdictions in carrying out their programs by providing miscellaneous analysis services, and (5) to maintain a regional “bank” of data related to transportation and land use.

4. Ibid.
Figure 11-1
TRANSPORTATION PLANNING PROCESS

BASIC PLANNING STUDIES

- POPULATION
- ECONOMIC BASE
- HISTORICAL GROWTH
- PHYSICAL LIMITATIONS
- REVIEW OF LOCAL PLANS

MAJOR INVENTORIES

- LAND USE
- TRAVEL (ORIGIN AND DESTINATION)
- TRANSPORTATION FACILITIES (EXISTING AND FIRMLY COMMITTED)

ANALYSIS AND RESEARCH

DATA PROCESSING

POPULATION FORECAST

FORECAST OF ECONOMIC ACTIVITY

REGIONAL AND LOCAL GOALS AND OBJECTIVES

ALTERNATIVE REGIONAL LAND USE DEVELOPMENT PATTERNS

TRAVEL FORECASTS

ALTERNATIVE REGIONAL TRANSPORTATION SYSTEMS

EVALUATION OF ALTERNATIVES

RECOMMENDED REGIONAL LAND USE DEVELOPMENT PATTERN

RECOMMENDED REGIONAL TRANSPORTATION SYSTEM

4
Part II
THE SCOPE AND WORK PLAN OF THE STUDY

Transportation planning assumes that travel within an urban area follows an orderly, rational, periodic and, therefore, predictable pattern. Travel is an evidence of human activity, and the combined travel activities of all individuals in a community make up an overall pattern of regularity and order for that area.

Therefore, to forecast travel, it is necessary to forecast human activities and their patterns, and to this basic task the Study staff directed its efforts. A carefully designed work plan was established so that each step would lead pointedly toward the ultimate objectives. The latest and best methods available in the rapidly developing technology of transportation planning were adapted for the research process. Figure II-1 shows the major steps of the transportation planning process.

THE STUDY AREA

The Study plan called for a concentration of effort in the urbanized areas of the four counties involved, since that is where planning needs are most pressing and aggravated. Consequently, a Study Area, (Figure II-2) was drawn to encompass those areas expected to be affected by urbanization within the 1965-1990 planning period. The boundaries included some presently sparsely populated locations where much of the region’s growth will occur.

The Study Area covers, in effect, a “commutershed” of the present and the future. The travel within this “commutershed” actually sets, and will set, the scale and site of major transportation facilities.

That portion of the Puget Sound Region outside the Study Area is not ignored, but travel to and from the latter is currently an extremely small portion of the total movement within the overall region. Problems beyond the urbanized area, consequently, tend to be less severe and can be solved normally by extensions of the transportation system established within the Study Area.

LAND USE AND TRAVEL

The kind and intensity of a region’s land use have a direct bearing upon the amount and type of travel which is generated. The determination and measurement of the relationships between travel and the varied land use activities make possible the forecasting of future travel patterns by predicting land use.

The Study, therefore, undertook a series of separate but highly related travel and land use surveys (with 1961 as the base year) to serve as the foundation for determining future travel. Simultaneously, other planning studies were begun to develop necessary forecasts of population, employment, growth patterns and land consumption. Included were studies of (1) historic and present population and its characteristics, (2) past and current economic activities, including kinds and amount of employment, (3) historic growth patterns and the factors which have influenced them, and (4) physical characteristics of the region, to identify areas where development is feasible.

BASIC FORECASTS

The initial step in forecasting was to estimate the future population on the basis of past birth, death and migration trends. A separate forecast of employment (by each of various economic activities) was also made—and the results of these population and employment forecasts were reconciled.

From these findings—plus those of the other basic planning studies—a prediction of future land use resulted, including expected locations of homes, stores, factories, schools, recreational sites and other land uses.

Forecasts were developed for two alternative land use patterns, which were selected for analysis and test from a number of choices formulated by the Study staff. The first (Plan A) represented a continuation of the present trend of unplanned spread of residential development into the suburbs, while the second (Plan B) patterned residential development into an orderly “Cities-and-Corridors” concept. Analyses of these differing patterns in terms of land use and transportation system requirements for 1965-1990 formed the basis for the Study’s ultimate recommendations.

Forecasts were also made of income, vehicle ownership, dwelling unit type, and density of development for each portion of the region since these factors all have a direct bearing on the travel characteristics of people.

From the base year surveys, the relationships of travel to population, land use, employment type, vehicle ownership, income and other factors were determined. These relationships were applied to the forecasts of population and employment and the characteristics of each in order to forecast the number of trips produced and attracted at each land use activity area (homes, central business districts,
FIGURE 1.2
LOCATION OF STUDY AREA

- STUDY AREA BOUNDARY
- COUNTY BOUNDARIES
- CENTRAL CITIES (1961 Corporate Limits)
- PUGET SOUND REGIONAL TRANSPORTATION STUDY

SCALE IN MILES
The base year travel surveys also established the characteristics which permitted development of future forecasts of trip patterns from point-of-origin to point-of-destination.

TRANSPORTATION SYSTEM RECOMMENDATIONS

The initial transportation system tested for its adequacy to accommodate 1985-1990 travel consisted of streets and highways existing in 1961, supplemented by facilities programmed and budgeted for the ensuing ten years. Since there was no plan for extension and improvement of transit services which existed in the base year, a hypothetically improved transit system was assumed to be in operation for analysis purposes along with the street-and-highway network.

Based on the various factors influencing mode-of-travel choice established from the base year data, forecasts were made of the amounts of transit travel which could be expected in the future on the bus system. The residual travel was then allocated to the highway system.

The “assignment” technique was utilized to estimate the number of transit passengers on individual bus lines and the number of vehicles on each section of the street-and-highway network.

The assigned passenger and traffic loads indicated critical corridors of congestion. In these corridors modifications were made to the transit and highway networks to achieve a balance between travel demand and the capacity provided by the transportation facilities.

Obviously, there is more than one way to meet future travel demands. Consequently, the Study considered numerous alternative systems, each of which was “balanced” and analyzed. Some systems were compatible with the aforementioned Plan A land use pattern, others with Plan B. Buses were utilized entirely on certain transit networks, while others used a combination of rail rapid transit and buses.

Cost estimates—which included maintenance and operation—were prepared for each system tested. The evaluation of transportation costs, the alternative development patterns from a land use planning standpoint and the relationship between the alternative land use development patterns and transportation systems led to the Study’s final recommendations.

Throughout the planning process, the Study staff had continual guidance and assistance from the sponsors, the cooperating agencies and the official PSRTS committees. The responsibilities for the final recommendations, however, rest with the Study staff itself.

While these recommendations are advisory, they are based on extensive research and comprehensive analysis. They have stood the test of close scrutiny and, therefore, deserve serious consideration. Should adjustments be called for, however, the continuing transportation planning program is prepared to evaluate in depth any suggested alternatives. This, after all, is in concert with the philosophy of keeping the study current, extending it further into the future and, in general, retaining a dynamic flexibility to adjust to the area’s growth and vitality.

Meanwhile, the recommendations will provide a sound and rational basis for decision-making in the development of a coordinated comprehensive plan for the Puget Sound Region.
Part III

STUDY RECOMMENDATIONS

The step-by-step process leading to an integrated land use and transportation plan consists of (1) establishing objectives, (2) determining basic facts, (3) developing forecasts based on the collected data, (4) evaluating the findings and forecasts, and (5) converting all to recommendations and specific programs.

What follows are the results of the PSRTS, the analysis and distillation of the Study’s voluminous research, culminating in recommended plans for land use development, transit services, streets-and-highways and cross-Sound facilities.

The documentation supporting these recommendations is appended in Part IV. This information—and details of the fact-finding techniques—is included for technicians, officials and others who may be interested in them professionally or who may require them for other applications. Meanwhile, in this report, the emphasis is upon the recommendations which follow in this section.

Springboard For Planning

To be meaningful, decisions must be based upon facts, and—in a study of this type—upon the forecasts arising from those facts. They provide the springboard for ultimate conclusions and recommendations.

In the adjoining column are key findings and projections intimately related to the future of the Puget Sound Region. While these facts are not an end in themselves, they are the important ingredients in the creation of well-grounded plans.

At this point, consideration must first be given to several basic recommendations which have a major bearing upon the ultimate plans. For this reason, they are discussed prior to the recommended action programs.

Population Expansion

Knowing how many people will live and work in the Puget Sound Region in the 1985-1990 period is of prime significance. Obviously, the region will develop and, in turn, will need transportation and other services to accommodate the growing numbers of individuals. The population figure which was accepted for use in the planning process was established by three independent forecasts, all of which revealed substantially the same results.

The PSRTS staff traced the region’s historic birth, death and migration data and applied forecasts of these factors to U.S. Census projections for the state and nation. The Study’s economic consultant5 predicted the region’s future employment and concurrently forecast a population which would be supported by such an employment level. Subsequently, the State Census Board made a third independent forecast.

As a result of these studies, a 1990 population forecast of 2 3/4 million was established for the Puget Sound Region. This figure should be used for planning purposes throughout the region.

In 1965 the U.S. Census made a downward revision in its previous forecasts because of a continuing substantial decline in birth rates. Should this trend prevail into the future, it could affect the Puget Sound Region forecasts. Expanding industrial growth, on the other hand, may act as a counterbalance to this birth-rate drop.

Regardless, the 2 3/4 million figure is expected to remain valid and will be reached by 1990 or shortly thereafter. Since the Study’s plans are based on a population level rather than a pinpointed date, the recommended programs can be adjusted to the experienced rate of growth if it varies from the forecasts.

Regional Growth Patterns

Because it is impossible to make exact predictions of employment locations, residences and other activity sites in the region, two alternate land use patterns (Plans A and B) were developed. Each was analyzed with differing assumed distributions of future population and employment.

Plan A—the continuation of normal suburban expansion—was analyzed with an assumed highly centralized development in terms of employment, while Plan B—the cities-and-corridors concept—was analyzed with lesser centralization. Both, however, assume optimistic levels with respect to employment in the central business districts of Seattle and Tacoma, Plan A more so than Plan B.

The forecast for the office employment category in downtown Seattle and Tacoma appears to be the most optimistic. The Plan A analysis was based on a forecasted increase in the office employment category of more than 2 1/2 times over the base year for downtown Seattle and almost 2 1/4 times for Tacoma’s central district. The Plan B analysis was based on assumed increases of approximately 1 1/2 and 2 times for the two cities, respectively. The

forecast for the retail employment category is somewhat less optimistic than that for office employment. Nevertheless, to achieve the forecasted levels of retail employment in the downtown areas a reversal of the present trend toward expansion in suburban shopping centers would be required.

Meanwhile, it is well established that future population growth in the region will be primarily in the suburban locales, at a relatively low density. Similarly, there will be considerable employment in these outlying areas, much of it to provide local service needs. The greatest traffic growth will also occur in these sectors which presently lack sufficient arterial networks.

To casual observation, this might seem to indicate an impending tug-of-war between suburbia and the central cities for transportation facilities. This is not necessarily true; a mutually coordinated and mutually beneficial system seems to be more warranted than diverse programs.

In applying the various forecasts to Plans A and B, it was found that there are but minor differences in the transportation facilities required for either. The locations of these facilities—while responsive to the forecasts—are strongly influenced by such topographic factors as water barriers, as well as by existing developments and transportation installations.

All of which leads to another basic question: Which of the alternative forecasts should be used as a basis for decisions in planning and designing future transportation facilities?

After thorough analysis of all factors, the Study staff recommends that:

The more highly centralized forecast of employment should be utilized in planning for and designing transportation facilities to assure fully adequate service for the central cities. (It is important to be on the "safe" side in the central cities since any under-estimate of future travel there would be most difficult and costly to rectify.)

Future transportation decisions based on these more liberal predictions for downtown areas will assure continuation of the central cities as regional hubs within the four counties, which—according to the forecasts of future development patterns—will become even more of a cohesive economic and social unit than they now are.

Unfortunately, the factors which affect future developments and their patterns are so numerous and changeable that neither they nor their influences can be predicted with a high degree of reliability. This fact calls for a further basic recommendation:

A continuing appraisal should be made of growth and development trends in the region—particularly of places and amounts of employment—so adjustments to the regional plans may be made to reflect changing conditions which differ from the forecasts. This is especially important with regard to the central business districts of Seattle and Tacoma, which are the most concentrated areas of trip attraction and have the greatest individual impacts on the transportation system.

Preferred Land Use Pattern

An improved pattern of growth in the Puget Sound Region can be achieved only through integrated planning and programming. The transportation network helps guide this development to some degree, but even more powerful influences are the utility systems and other service facilities such as schools, etc. If these and other influencing factors are not coordinated, a hodge-podge land use pattern can be expected. Therefore, the Study recommends that:

Development in the growing suburban areas of the region should be cooperatively guided and patterned to create an improved environment, to preserve the area's many unique natural attributes and to establish or maintain identifiable and functional communities which will assist in forming rational governmental units.

If they are well integrated, the land use and transportation plans can assist immeasurably in creating an improved environment. As an added advantage, such an organized community form would help to reduce the number and length of trips, thus lessening the need for transportation facilities.

With the foregoing objectives in mind, the cities-and-corridors pattern (Plan B) was formulated. It was designed to take advantage of the natural topographic features of the region, to create systems of open space and to form a separation between planned communities. The majority of the open space corridors suggested in Plan B are included in the open space system developed by the Puget Sound Governmental Conference. Yet, despite these carefully conceived concepts, proper land use development becomes difficult, if not impossible, to achieve without coordinated and cooperative planning across jurisdictional boundaries. Consequently, the PSRTS urges that:

A development pattern such as the cities-and-corridors concept (Plan B) should be adopted by the various governmental agencies in the region as a guide and basis for local and regional programs.
This is a reasonable, logical and effective approach to environmental planning. It is adapted to the present community pattern as well as the physical features of the region.

An early decision on such a land use philosophy is vital because continued growth makes it more difficult and costly to implement improvements in the development pattern. In piece-meal fashion, areas which logically should be reserved for open space consideration are being lost to the unplanned suburban expansion.

The continuing transportation planning program, of course, can investigate modifications and alternatives to the Plan B pattern to assure the best possible and most acceptable land use and transportation patterns reflective of changing conditions.

TRANSPORTATION SYSTEMS

A transportation system is developed in response to a travel pattern. It is a product of the amounts and locations of development and the activities of people, which, in turn, are influenced by the transportation system itself. In short, the latter is an integral part of a particular land use plan.

The two development alternatives considered resulted in two different patterns of amounts and locations of travel. However, the transportation systems developed in response to these two locational patterns were found to be basically the same. Differences were largely in details of operation and design, with the regional framework of needed facilities strikingly similar.

Three factors were primarily responsible for this similarity: (1) the existing development which will have a strong influence on travel patterns for years to come, (2) the constraint imposed on transportation facility sites by the region’s physical features, and (3) the current and soon-to-be-constructed transportation network which greatly affects the locations of additional facilities.

However, the very fact that the transportation systems for the two alternative forecasts are so much alike adds confidence that this basic system will meet future travel needs within the broad range of differences exhibited by the two alternatives. This extensive “spread” has an excellent likelihood of bracketing the levels of development which may actually occur—or both of the alternative forecasts may even exceed them.

The most critical element in a regional transportation plan is to determine the framework of major facilities. Once this skeleton of general corridors is located, the remainder of the network can be planned and integrated. The regional inter-community requirements, though, must be predominant, both for the overall benefit of the area and to avoid disruption and intrusion of local communities. The sites and design of facilities for the latter are dictated purely by local considerations; they are less difficult to plan and construct, and more flexible in adapting to neighborhood conditions.

A regional transportation system is composed of both transit and highway elements in an interlocking and mutually supporting way. The complementary nature of the two must be emphasized; each serves particular types of areas and travel demands. For that reason, their planning must be undertaken concurrently and in an integrated manner, rather than independently.

The proper mixture of transit and highway facilities in the overall system is dependent upon the relative market demands for travel via each. Individual facilities, therefore, constitute vital links in the total chain, with transit and highway elements being interdependent instead of in competition.

Mass Transit

Transit facilities are necessary in a comprehensive transportation system because (1) they provide the only means of conveyance for many people, and (2) they can carry high volumes of passengers—particularly during peak hours—to and from points of concentrated trip generation.

These facilities must, however, be considered in close relationship with highway developments. Bus transit depends upon streets and highways for its roadbed, and users of rapid transit require surface arterials to get to and from train stops. This interdependency is a key factor in the recommendations which follow.

ALTERNATIVE TRANSIT SYSTEMS STUDIED

Mass transportation demonstration programs sponsored by the Housing and Home Finance Agency indicate in general that transit improvements increase transit use by relatively small amounts. Often the increases in usage have been insufficient to permit a continuation of the improvements from an economic standpoint.

Surveys have shown that after a rapid transit line has begun operation, a certain proportion of the riders previously were not transit patrons. This proportion has ranged from 12 percent on the Congress Street (Eisenhower) Expressway line in Chicago, 13 percent in Toronto, 17 percent in
Cleveland, 18 percent on the Skokie Swift line in Chicago, to 35 percent on Boston's Highland Park line.

Still, accepting that better service does tend to increase use, the Study staff formulated and tested several hypothetical transit systems for the Puget Sound Region. All of these systems included more extensive networks than currently exist—particularly in suburban areas—and provided much improved service on an integrated region-wide basis.

Unfortunately, under present franchise and other legal restraints, this regional concept is impossible— to the detriment of transit users and operators alike. Consequently:

To serve the region's travel needs and to assist in the proper development of the area, an extensive system of transit should be instituted, extending into presently unserved areas. This service should be unhampered by arbitrary franchise or other legal limitations to permit an integrated operation across governmental boundaries. Coordination of existing operations can provide an interim solution and should be undertaken in the public interest, as soon as possible.

FINANCIAL SUPPORT FOR TRANSIT

Transit usage in the region has been declining at the rate of approximately 6 percent each year, and operators have been forced to reduce service to make ends meet. Only in recent years have the cities of Tacoma and Seattle begun to provide financial support from public funds to help their municipal transit systems continue reasonable levels of service. No such support, of course, is available to the private transit operators in the region. Since so many of the region's residents depend upon mass conveyance:

An adequate level of transit service must be considered a public necessity, warranting support from public funds. First priority should be given to preserving present levels of transit service, followed by extensions into presently unserved or inadequately served areas.

INFLUENCES ON TYPES OF TRANSIT SERVICE

High income, high auto ownership and low development density result in a tendency toward reduced transit usage. All these factors are characteristic of the Study Area, and most likely will continue for years to come.

Since the region's greatest population growth is expected in the suburbs, obviously that is where improvements and extensions in transit service offer the most promise for increased usage—even though these areas have a low density development pattern.

At present, however, low demand places severe limitations on transit operators in providing adequate service, since profitable operations usually require a high level of trip-making in relatively confined corridors.

For low to medium levels of potential patronage, the bus is the only transit medium with the attributes of economy and flexibility in operation. It requires no capital investment for its roadway. It can be rerouted readily to meet changing needs. Trial extensions to new areas and special peak-hour schedules can be tested at low cost. Service can be upgraded when needed by a wide variety of equipment and road-usage techniques.

Necessarily, of course, a long-range plan for a regional transit system should be established to bring about an orderly and sequential process of extension and expansion. This plan should provide guidelines for day-to-day operations as well as for short-range programs to meet current conditions. The Study specifically recommends that:

Since the predicted 1990 transit demand (except for the immediate Seattle vicinity) is clearly insufficient to warrant consideration at this time of other than bus systems, the long-range plan should be patterned after the system depicted in Figure III-1. Express bus operations should be initiated on present and future freeways and expressways to improve service and thereby attract more patronage.

RAPID TRANSIT POSSIBILITIES

Within the Seattle area, the possible application of a rapid transit system was studied extensively in cooperation with the transit consultant to the Puget Sound Governmental Conference. One of the alternative systems tested included rapid transit in two corridors with the greatest usage potential. Since rapid transit—or any other high-capacity facility—is expensive (estimated by the consultant at upwards of $171 million for 20 miles of line), its application must obviously be considered where the demand is greatest. Generally, a person will use transit only if he can be delivered within easy walking distance of his destination. Likewise, if rapid transit is to provide a significant speed advantage over existing methods, the number of station stops must be limited.

The Seattle central business district is the region's most concentrated area of trip generation (200,000 person trips per day beginning or ending there in 1961, the base year). North-south corridors show the predominant concentrations, while east-west travel is secondary. However, since there are limited locations for Lake Washington crossings, they have potential for heavy travel, too.

Analyses of the tested rapid transit system indicated that usage would increase by 24,000 daily
Figure 10.3
Recommended System of Transit Facilities

- Local bus routes
- Express bus routes
- Ferry routes

Puget Sound Regional Transportation Study

Map of transit facilities in the metropolitan area.
trips in 1990 over that for a bus system operating in the normal traffic stream.\textsuperscript{6} This represents an increase of almost 40 percent over bus transit, considerably higher than that experienced elsewhere when rapid transit replaced a surface transit system.\textsuperscript{7} Thus, it is believed that the usage estimates for Seattle are quite liberal.

**EFFECT OF RAPID TRANSIT ON DOWNTOWN TRAFFIC**

With the rapid transit system which was tested, the number of vehicles destined for downtown Seattle in 1990 is reduced by approximately 8 percent and can therefore be more easily accommodated than with a bus system operating in mixed traffic. However, the total number of vehicles—including buses—estimated for the peak hour in the Seattle central business district in 1990 can be adequately handled under any of the alternative transportation systems tested. The construction of new road facilities since World War II has removed considerable traffic volume from central district streets. They now have volumes well below the 1950 level when congestion reached a post-war peak. The street system in the downtown area as a whole will have adequate capacity to accommodate the projected traffic volumes. For that reason, the vehicular traffic generated by the forecasted downtown employment level does not offer a compelling argument for a rapid transit system.

The predicted 1990 transit passenger volume into the Seattle core can be carried in buses without difficulty. This would still be true if bus usage soars to the level predicted for rapid transit. Thus, rapid transit is not required from the standpoint that downtown street capacity might be inadequate to absorb the traffic load and that the transit passengers could not be carried by buses.

**EFFECT OF RAPID TRANSIT ON DOWNTOWN PARKING**

By attracting greater transit patronage, rapid transit would reduce the number of parking spaces required in downtown Seattle. In 1990—using the higher of the two alternative employment forecasts—the central business district would need 56,001\textsuperscript{8} parking spaces without rapid transit and 49,600 if the 20-mile rapid transit line were built.

This 6,400 reduction amounts to over 11 percent of all parking space requirements, or a savings of $19 million in facilities (assuming they are all parking garages). Even with the high 56,000 figure, downtown Seattle can provide the parking spaces without utilizing any additional land. In the areas of highest land values, parking garages—obviously commercially profitable—are replacing lots. This trend is expected to move gradually outward from the center of the city.

In summary—even without rapid transit—parking spaces required by either of the two alternative forecasts can be provided in downtown Seattle without increasing the amount of land devoted to that purpose.

**EFFECT OF RAPID TRANSIT ON HIGHWAY NEEDS**

Another reason for rapid transit might be to reduce vehicular travel and thus the need for highways and streets.

In tests of the alternative transportation systems, the 20-mile rapid transit line reduced traffic volumes across the Ship Canal by fewer than 5,000 vehicles a day, and that across Lake Washington by considerably less. Meanwhile, the current annual rate of traffic growth at each of these locations is over 5,000 vehicles daily.

Consequently, street-and-highway needs would be little affected by rapid transit and the requirement for any highway facilities would not be eliminated. This bears out the earlier statement that each type of facility serves a particular market—so one cannot be substituted for the other. If rapid transit preempts the planned reversible roadway on the third Lake Washington bridge, it will require additional vehicular capacity across the lake to replace it. In the northwest corridor of Seattle, the reduction in vehicular volumes is not large enough to make the difference between deciding to construct or not to construct a new highway facility there.

**ECONOMIC EVALUATION OF RAPID TRANSIT**

Economic analyses (described in Part IV) were made of the alternative transportation systems to evaluate a possible economic basis for constructing rapid transit.

In brief, the alternative which includes rapid transit (Study System 4, Modification 1) is more costly in terms of capital outlay, travel time, transit and vehicular operation, and accidents. It is less costly, however, in terms of maintenance and parking facility operation. Still, in total evaluation, there is no indication that a transportation system incorporating rapid transit would be less costly than one using buses.

**OTHER CONSIDERATIONS**

There are, of course, factors which cannot be included in an economic evaluation: (1) the value of providing a more reliable and higher level of transit service, (2) reduction in traffic volumes—


\textsuperscript{7} See Part III, Page 10.

\textsuperscript{8} Downtown Seattle had 29,000 parking spaces in the base year, 1961.
particularly in downtown Seattle—as the result of increased transit usage, and (3) decreasing the need for parking facilities in Seattle's central business district.

In addition, rapid transit would assist to lessen air pollution, but since it would reduce 1990 vehicular traffic by approximately one-half of one percent throughout the region, this advantage would be limited. It would be greater in downtown Seattle, though, where auto use would decrease by 8 percent. On the other hand, pollution control devices and new power plants for passenger cars are expected to help overcome much of the polluted air problem by the middle or late 1970s. Thus, the greatest strides towards alleviating air pollution would come from vehicle changes rather than from rapid transit.

Rapid transit, as assumed for the Seattle area, would have a large capacity which would be little used until well past 1990. Consequently, its greatest economic advantages lie in the future; it would have to eliminate sizeable expenditures for other facilities or provide other significant benefits to justify the investment at this time.

Rapid transit improves accessibility to downtown areas, so it might be surmised that this would enhance the competitive position of central business districts. However, in other cities with rapid transit, this enhancement has not necessarily occurred. Because areas adjacent to the line also become easy to reach, there has been some dispersal of office building construction out of the central business districts in these other cities. Toronto is a notable example.

A rapid transit line intrudes less upon normal neighborhood functions and appearances than a freeway or expressway (unless the latter can be located completely underground). However, because the analyses do not indicate that rapid transit would eliminate any vehicular roadways, advantages related to neighborhoods are not a relevant consideration.

Whether Seattle should have a rapid transit facility is not properly an engineering decision but a policy one—and in view of all the foregoing factors, the Study recommends the following:

Since a clear cut and positive finding for rapid transit is not possible from the study analyses, continued consideration, research and public discussion should be given the subject. Particularly, developments in downtown Seattle should be measured and analyzed periodically because the amount of future employment is critical in determining the potential patronage of rapid transit.

First priority with respect to transit should be directed toward maintenance and improvement of the existing services, and public funds should be made available for this purpose because of the great number of citizens dependent upon these services. Since forecasts indicate that increasingly large subsidies will be needed, any other programs which would further burden the public fiscal capacity—and particularly those which would worsen the economic well-being of the existing transit system—should be deferred until the necessary financial arrangements can be made for the present facilities. Meanwhile:

Until the matter of rapid transit is resolved, no actions should be taken which would in any way preclude or hinder the possible future construction of (1) rapid transit facilities through the Seattle central business district, in the city's northwest corridor or across Lake Washington to the Bellevue area, and (2) necessary additional vehicular facilities or added capacity in these locations.

Joint planning of dual purpose and integrated transit and highway facilities should be seriously considered in the Seattle area, particularly in the northwest corridor—where the city's comprehensive plan includes the northwest expressway and where a rapid transit facility has been recommended by the transit consultant to the Puget Sound Governmental Conference.

Until definitive decisions on rapid transit are made, transit planning should be guided by the long-range local and express bus system recommended herein (see Figure III-1, Page 12).

Streets And Highways

It should be reiterated that while the various elements of the transportation system are discussed separately, they are all part of an integrated regional plan.

Secondly, the systems resulting from the two alternative development forecasts—despite substantial differences in detail—turned out to be much the same in their general framework, thus inspiring confidence in the recommendations. As discussed previously, the reasons for these similarities are: (1) existing development strongly affects future travel patterns, (2) the region's physical restraints place severe limitations on where facilities can be located, and (3) existing facilities, plus budgeted or in-progress additions are powerful influences upon future requirements and sites.

Regarding the latter, the region is witnessing extensive construction programs (see Figure IV-62, Page 72) which, in a short span of years, are adding a travel-carrying capacity equal to 80 percent of the total regional arterial system existing in 1961. Thus, the additional mileage of freeways and express-
ways required in the future will be considerably less than that now serving the region or presently under construction.

In developing a streets-and-highways system, the Study staff pursued the following objectives: to achieve the highest level of transportation service while contributing toward the desirable development and functioning of the total region, as well as the area through which a given route passes; to maximize the economic return on the investment; and to minimize the costs to the community.

The facilities added to the study systems for test purposes were each appraised accordingly. Local comprehensive plans were reviewed, and preference was given to facilities already incorporated in such plans—if the planned facility would adequately perform the required function.

There is another basic consideration in transportation planning—whether a traffic facility should be a freeway or a surface arterial. This depends upon the traffic load and the function to be performed. Freeways are designed to carry high volumes of “through” traffic making relatively long trips between somewhat distant points, to relieve presently over-burdened arterials, to absorb future traffic growth, and to accommodate the travel demands with superior service. Surface arterials carry lower volumes of traffic less expeditiously and less safely on generally shorter trips; they also provide access to abutting properties. The at-grade arterials have an upper limit to their carrying capacity, and when that point is reached, either a freeway is necessary, or other surface roads must be established in parallel to accommodate the travel demand. In many cases, however, the future traffic needs may be so great that it may not be possible to attempt expansion of existing arterial capacities.

Properly designed freeways can be assets to a neighborhood and far less damaging to the form and function of the community than several closely spaced arterials. The freeway’s protected right-of-way preserves its carrying capacity, its investment and its safety of operation. In contrast, surface arterials gradually lose effectiveness because of curbside development, cross streets, signalized intersections, pedestrians, parked vehicles and other congesting factors.

Based on these and other considerations detailed in Part IV, the PSRTS staff offers the recommendations for street and highway facilities which follow. These recommendations are advisory only; however, they are a product, not only of the Study research, but of a cooperative and collaborative effort of many individuals and groups—the sponsoring agencies, the various committees, technical representatives and others. As a result, they should be considered a persuasive force in shaping the development of the Puget Sound Region.

FREeways AND EXPRESSWAYS

To meet the region’s future travel demands economically and with as little adverse effect on local neighborhoods—

The system of freeways and expressways shown in Figure III-2 is recommended as the regional plan of freeways and expressways and should be adopted as the guide for all agencies in carrying out their individual programs. This plan should be subject to continuing review, detailing extension and adjustment, if necessary.

The recommended system—skeletal in nature—is in keeping with the Study’s regional land use and transportation plans, as well as with local comprehensive plans. Exact locations and designs of proposed facilities are not shown because much more detailed planning and engineering as well as public hearings and other governmental actions are necessary to establish the specifics of the individual projects and facilities within the regional framework.

These facilities are separate links in an overall chain, each forged individually but operating as a unit for the benefit of the entire region. The specific recommendations for freeways and expressways will be discussed for each of the four county-city areas; similar discussions for local arterials follow later in Part III.

Bremerton – Kitsap County

Much of Kitsap County’s transportation network is keyed to cross-Sound facilities. Therefore, until the necessary long-range decisions are made regarding future cross-Sound routes, as much flexibility as possible should be retained to permit ultimate tie-in with probable bridge locations and ferry routings.

A cross-Sound bridge at the Fauntleroy-Vashon-Southworth vicinity is a major Study recommendation (see Part III, Page 22). Its necessary approach and connecting facilities include a freeway or expressway from the vicinity of Southworth to a Sinclair Inlet fill and bridge west of Port Orchard. Both of these projects should be built even if present ferry service is continued and no bridge materializes. However, if the cross-Sound span is located elsewhere, the need for the Port Orchard-Southworth connection should be re-examined.

The cross-Sound bridge recommendation includes a Rich Passage bridge to Bainbridge Island. This latter facility and the matter of its location, too, should be re-appraised if the former facility is built at some other site or not at all.

9. These recommendations only cover facilities not already budgeted for construction by the early 1970s.
FIGURE 111
RECOMMENDED SYSTEM OF FREEWAYS AND EXPRESSWAYS

- PROPOSED FREEWAYS AND EXPRESSWAYS
- EXISTING AND BUDGETED FREEWAYS AND EXPRESSWAYS
- FERRY ROUTES
- EXISTING AND BUDGETED ARTERIALS

Puget Sound Regional Transportation Study
With the recommended cross-Sound bridge, the presently budgeted Bremerton-Silverdale freeway should be extended from the latter terminus to the Hood Canal Bridge. Without the cross-Sound facility, the northern extension would be less urgent, and full freeway standards may not necessarily be required.

**Everett – Snohomish County**

Construction of the Interstate freeway through Everett and new facilities between Everett, Cavalleri's Corner and the city of Snohomish will provide most of the long-range freeway needs for Snohomish County. However, the Study’s analyses show that Sign Route 9 (Secondary State Highway 1-A), south of its present terminus at Snohomish, will require upgrading in design standards and additional carrying capacity to provide adequate service to Woodinville.

This can be achieved by extending Sign Route 9 southerly to an intersection with the Bothell-Monroe highway in the Maltby area. Freeway or expressway standards are recommended for this extension because it will constitute a major connection between two sections having control of access, and relatively light development along the route makes it possible to obtain control of access at little additional cost.

In southwest Snohomish County, the analyses reveal that the Interstate freeways will have to be augmented with an additional freeway to accommodate continued growth to 1990. A high-type direct connection between Interstate 5 and the R. H. Thomson Freeway—extended north of Seattle to Bothell—is needed to carry traffic to and through Seattle, distributing it to major traffic generation points with minimum impact on the city’s east-west streets. This would also provide Snohomish County residents with a direct route to the University of Washington, Renton, the Green River Valley and other industrial sites, without the necessity to travel on the Interstate freeway through downtown Seattle.

While topography severely limits specific locations for such a route, it is recommended that this freeway connect with Interstate 5 in the Lynnwood area and with the R. H. Thomson extension in the vicinity of Kenmore. Continued development will make such a route more and more difficult to accomplish — but because of its importance in the overall pattern, the connection should be planned now for ultimate construction.10

The R. H. Thomson-Interstate 5 connection near Lynnwood would lend itself to a further extension to connect with the Mukilteo area. This would offer a solution to the capacity problem which will exist on Interstate 5 north of its interchange with Interstate 405 since at this point the four lanes of Interstate 405 merge into the six lanes of Interstate 5. Since both interstate routes will carry heavy traffic volumes, this section of Interstate 5 is expected to be congested in the future. Improvement of Sign Route 525 from Mukilteo and its connection with Interstate 5 should be considered in conjunction with the need to provide additional north-south corridor capacity north of the interchange of Interstate 5 and 405. The extension to Mukilteo should ultimately become a freeway or expressway type connection.

Meanwhile, until the extension northward from the R. H. Thomson Freeway is completed and while Interstate 5 still has available capacity, an interim connection between Mukilteo and Interstate 5 could be provided via one of the existing interchange points on Interstate 5 north of its interchange with 405.

Elsewhere, through the city of Snohomish, increasing traffic volumes will require improvement of the present state highway route. Long-range plans of the State Department of Highways contemplate a freeway or expressway northeast of the city to take through-traffic off business district streets and to complete a consistently high-type route between Everett and Stevens Pass. Such a route is consistent with the recent recommendations of the consultant to the City of Snohomish and should be constructed.

**Seattle – King County**

Nearly two-thirds of the region’s projected population growth will be in King County, a fact which makes obvious the need for additional transportation facilities. Fortunately, though, past and current construction programs will provide sufficient capacity so that no major additional north-south route will be needed through Seattle’s central corridor by 1990. The Northwest Expressway—as shown on the city’s comprehensive plan — is not now recommended as necessary for construction by or before 1990.

In the interim, however, no action should be taken to preclude or hamper the construction of such a facility. If growth trends follow the highly centralized forecast of the Study, the planning for construction of this route should take place well before 1990.

If it is decided to build a rapid transit facility in the northwest corridor, coordination of its planning and design with the Northwest Expressway should be seriously considered to assure the most economical and effective accomplishment of the two programs. This coordinated approach is recommended because the analyses reveal that a rapid transit facility would complement rather than substitute for streets and highways.

Elsewhere in the Seattle and King County area

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10 Since the PSRTS recommendations were announced, the Southwest Snohomish County Regional Planning Commission has completed a comprehensive plan for the area which incorporates this facility.
recommended facilities are: (a) primarily distributional in nature, (b) missing links between completed freeways and expressways, or (c) extensions outward from the city into suburban areas. They include: 11

1. Extension of the Alaskan Way Viaduct route southerly from Spokane Street to the First Avenue South Bridge.

2. Extension southerly and northerly of the R. H. Thomson Freeway.

3. Cross-city connections between the R. H. Thomson Freeway, the Interstate Freeway and the extension of the Alaskan Way Viaduct route in the vicinity of the First Avenue South Bridge.

4. A connection generally in the Madison Street corridor from the R. H. Thomson Freeway to the central business district of Seattle.

5. A short connecting freeway between Interstate 5 and Aurora Avenue north of North 58th Street.

6. An additional short freeway connection from the present Alaskan Way Viaduct and the central business district to the vicinity of Garfield Street. (This could become an initial component of the Northwest Expressway and should be planned in coordination with a possible rapid transit facility.)

7. An extension southwesterly to the Alaskan Way Viaduct of the presently programmed connection between the Interstate Freeway and Aurora Avenue in the Valley Street vicinity.

8. A Lake Washington crossing and its approaches. The PSRTS recommends an additional Lake Washington bridge in the Sand Point-Kirkland area. This location was selected over other possibilities because: (a) it would serve otherwise unsatisfied travel demands north of the present Evergreen Point Bridge, (b) it could readily be fitted into Seattle's circulation plan, (c) it could be integrated easily into the eastside circulation system. 12

Since numerous decisions affecting connecting facilities on both sides of the lake are dependent upon the final choice of location, the resolution of this matter is urgent! However, it is of such magnitude and importance that more detailed study of engineering, planning and traffic factors must precede final selection of the exact site. Meanwhile, the following considerations point up the need for urgency.

If a Sand Point-Kirkland bridge is built, the Seattle approach should include a cross-city freeway in the general vicinity of 50th Street at least as far westward as Aurora Avenue. Further extension to 15th Avenue Northwest (or to the proposed North West Expressway) should also be seriously considered. East of Lake Washington, the approach route to the proposed Redmond-Kirkland-Sand Point bridge should extend easterly to the Redmond area. If the third bridge is not at Sand Point, an east-west freeway or expressway in Seattle is still recommended for the same general route, though it would not be necessary to extend it entirely across the city.

If the Sand Point recommendation is accepted, the improvement of the approach to the Evergreen Point Bridge from Redmond, being investigated by the Department of Highways, would require lower capacity and design standards than it would be necessary if the proposed bridge were built in the vicinity of the present Evergreen Point Bridge. Improvement of this approach is needed in any event, but it should be designed with as much flexibility as possible until the bridge site is chosen. The details of design of the R. H. Thomson Freeway are also dependent upon the specific location of the additional Lake Washington crossing. The same is true of other connecting facilities on both sides of the lake.

The general vicinity of Renton, Tukwila and the Duwamish industrial basin presents the region's most difficult transportation problems. The basic reasons are: (a) lack of an extensive arterial network to begin with, (b) topographic restrictions—the water barriers of Lake Washington, the steep valley walls of the Cedar and Duwamish-Green Rivers, etc.—and (c) the large projected growth of employment and population in the entire surrounding area. A need for certain minimum additional freeways and expressways has been established. Recommended facilities are:

9. Extension of the Valley Freeway (Sign Route 167) into Renton and thence into Seattle to junction with the R. H. Thomson and Interstate 5 Freeways. (This would reduce future large overloads on Interstate 405.)

10. An east-west freeway—at least six lanes—along a possible route from the South 188th Street interchange of Interstate 5 down to the Green River Valley floor, generally in the South 180th Street vicinity, and thence entirely across the valley to the Benson Hill area. (By connecting on the west with King County's multi-lane South 185th Street, this facility would provide the only completely east-west cross-county route south of Lake Washington and north of Kent. There are numerous obstacles to hamper construction of such a freeway, so early intergovernmental agreement is urged before further difficulties arise.)

11. A north-south freeway east of Interstate 405, extending from the recommended east-west route in the general vicinity of South 180th Street (Petrovitsky Road) northerly to a junction with the proposed Redmond-Kirkland-Sand Point bridge route. (This is necessary because the analyses show that Interstate 405 cannot handle future traffic

11. See Part IV, Section 8 for details.
loads as it is, nor—from a practical standpoint—can it be expanded to do so. The area it serves east of Lake Washington is projected to more than triple in population by 1980.

12. An east-west freeway connection between this proposed new Eastside freeway and the North Renton interchange on Interstate 405 and thence to the Boeing and Pacific Car and Foundry areas. (This will provide further traffic distribution and relief to Interstate 405.)

13. Extension of the Seattle-Burien Freeway southerly to a connection with Interstate 5 in the Midway area. (Location and design should permit further extension to Tacoma on a long-range basis.)

14. A new east-west freeway or expressway in the Kent area, connecting the southerly extension of the Burien Freeway on the west to the city of Kent and easterly to the Kent Heights area.

15. Completion of the Valley Freeway on a route extending southward from Auburn to Sumner. (This will provide a direct connection between the population and industrial centers to the north and the Sumner-Puyallup areas, as well as an additional facility for travel from south of Tacoma to employment areas in the Green River Valley, Renton and Bellevue.)

The Everett-Snohomish County section describes a proposed facility connecting the R. H. Thomson and Interstate Freeways in the Kenmore area. A freeway extension northeasterly from Tacoma into King County is similarly discussed in the Tacoma-Pierce County section.

Cross-Sound bridge proposals (see Part III, Page 21) obviously affect Seattle and King County. Should the recommended crossing be accepted, it would entail a westerly extension of the city's programmed Sound Way Expressway to the bridgehead in the Fauntleroy area.

**Tacoma – Pierce County**

Analyses of projected future traffic volumes in the Tacoma area show that capacity problems will develop on the Interstate 5 Freeway east of the Pacific Avenue Interchange. In addition, travel demands by 1990 south of Tacoma will require expansion of the Interstate Freeway to its full eight-lane capability — and even then it will be straining its carrying capacity. Consequently, the additional freeway and expressway facilities recommended are primarily to relieve pressures on Interstate 5. They are:

1. A high-capacity freeway from an interchange with the so-called A Street viaduct connection to Interstate 5 in Tacoma across the Tacoma industrial district. This facility should be oriented to the Auburn and Green River Valley areas and will provide a more direct route between the Tacoma business and industrial districts and Federal Way, Auburn, Interstate 90, and thereby Snoqualmie Pass.

2. A freeway or expressway across the Tacoma industrial district to connect the above recommended route with Interstate 5 east of Tacoma and the Department of Highways' programmed new freeway to Puyallup on the north bank of the Puyallup River. (This will provide more direct service into Tacoma from the Puyallup-Sumner and Milton-Fife areas.)

3. Completion of the Valley Freeway on a route extending southward from Auburn to Sumner (see Recommendation Number 15, this page).

4. Extension of the Sign Route 7 freeway — programmed for construction between Interstate 5 and Sign Route 512 in the vicinity of Parkland — southerly to the Roy-Wye area. (This facility — and the continuation of the route southwesterly through Roy, Yelm, Rainier and Tenino to Interstate 5 near Chehalis-Centralia — will provide an additional through-traffic route to relieve future overloads on Interstate 5 in the Olympia and Fort Lewis areas.)

5. A freeway through the Lakes District extending from Interstate 5 to the approach route to the Tacoma Narrows Bridge (Sign Route 16) in Tacoma. (This facility would generally follow the route of the Hannah-Pierce Expressway being considered by Pierce County and Tacoma in their long-range planning.)

**LOCAL ARTERIALS**

In addition to the recommended freeways and expressways, numerous arterial improvements will be required in the region — some, in fact, where virtually nothing exists at present. These facilities are the responsibility of the local jurisdictions, and yet the arterial networks must function as an integral part of the overall regional program.

Development in much of the region is still relatively sparse and unstabilized, and the platting pattern has not yet been established. Neither have the specific land uses at specific locations been clearly and rigidly defined. Because of the close relationship between land uses and street requirements, future arterial routes cannot be located as precisely as major regional facilities. Only where local development is relatively complete and patterns well established, can the Study be quite definitive in its recommendations. As development progresses, the continuing regional transportation planning program will work closely with the local agencies to define the remaining arterial needs more explicitly to achieve a better and more efficient street-and-highway system.

It would be impossible to describe — or even list — all of the arterial needs revealed by the PSRTS analyses. However, some of the more prominent requirements are pin-pointed in the following
county-by-county discussions. It should be emphasized, though, that the Study appraisals are regional in nature, based primarily on traffic requirements rather than on design standards, structural adequacy and other factors which require detailed local knowledge. This should be kept in mind when reviewing the important arterial needs outlined below.

**Bremerton — Kitsap County**

The completion of the new freeway skirting the city of Bremerton to the west will do much to remove heavy traffic volumes from the present highway routing through Bremerton via narrow city streets. However, there will be an ever-growing need for an improved connection between the highway and the Naval Shipyard and downtown Bremerton. It is recommended that this connection be a multi-lane arterial providing access to the freeway at the Warner Road interchange. It should make use of a new alignment to the city’s central area. Thence widened city streets could operate as a one-way couplet, or a completely new facility paralleling Burwell could be constructed into the central business district.13

A much-discussed proposal for an entrance gate to the Naval Shipyard at the south end of Warren Avenue was confirmed by the Study as a desirable facility to ease the access problem at the government installation. In spite of sizeable obstacles involved, continued consideration of this project is recommended.

An important item of consideration is the Keyport-Lemolo bridge. This bridge would save considerable travel for Bainbridge Island motorists and those from some parts of the North Kitsap peninsula. However, it would add to the increasing capacity problems on Secondary State Highway 21-B (Sign Route 309). A definitive recommendation for or against a Keyport-Lemolo bridge cannot be made at this time because this decision is very much contingent upon the Cross-Sound bridging problem and the ultimate selection of a site for a Sound crossing. The Keyport-Lemolo bridge would have to be evaluated in the light of the Cross-Sound decision as well as from the standpoint of the most effective expenditure of public funds to provide a comprehensive network of bridges and highways within Kitsap County.

**Everett — Snohomish County**

A network of arterial facilities—both east-west and north-south—to serve expanding suburban and new industrial areas is a necessity to the proper development of Snohomish County, particularly in the southwest portion of the County. Normally a one-mile spacing module is considered for major arterials in developed areas.14 However, because of the low density of development in this area, a two-mile interval seems appropriate and would match the spacing between freeway interchanges. Connecting routes to the freeway interchanges south of Everett will be overloaded and critically in need of improvement.

East-west facilities involving new construction are indicated near the Snohomish-King County line to connect the Edmonds area with the town of Brier and areas to the east; the Paine Field area with the Snohomish area; and the Lynnwood area with developments to the east.

Secondary Highways 1-W and 2-B (Sign Route 104) require improvements. The old Pacific Highway (U.S. 99) must be maintained as a high-quality major arterial to accommodate present and future traffic volumes. Every effort should be made to guide roadside development and accesses to prevent deterioration of this important facility.

**Seattle — King County**

If a Sand Point-Kirkland bridge is constructed across Lake Washington, the eastside approach to the Evergreen Point Bridge should be of an arterial nature. Any higher type facility will attract such volumes of traffic from east of Interstate 405 that the entire capacity of the Evergreen Point Bridge would be preempted, thus making it impossible for Bellevue area residents to use the span. The detailed design on this route should be adaptable to the ultimate decision on an additional Lake Washington crossing.

In the Renton vicinity, a number of new and improved arterials are required. Residential areas east of the city—due to more than triple in population—will need improved connections to the city, to Seattle and to industrial employment sites. These improvements should be linked directly to a cross-city-high-type arterial north of the business district and south of the airport. The arterial should be tied into the recommended extension of the Valley Freeway to the R. H. Thomson Freeway discussed on Page 18.

The current industrial employment boom in the Green River Valley obviously necessitates arterial improvements to connect job sites with freeways. Study analyses show that Secondary State Highway 2-M (Sign Route 181) will require more capacity, the existing east-west arterials will need widening, and additional arterial facilities will be necessary.

**Tacoma — Pierce County**

From a capacity standpoint, arterial facilities in Pierce County and Tacoma are—in most instances—in excellent condition to accommodate future traffic loads. Where substantial population growth is projected (the Lakes District and areas south and southeast of Tacoma), facilities will require improvement to handle traffic volumes, though

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13. Since the PSRTS findings were completed, the city of Bremerton has developed a more detailed street plan which incorporates this recommendation.

capacity problems should not be extensive nor severe.

Largely because of the removal of tolls on the Tacoma Narrows Bridge, the Gig Harbor Peninsula is expected to triple in population by 1990. This will require an arterial network to accommodate the growth. The Study cooperated with Pierce County and the city of Gig Harbor in developing detailed estimates of these requirements.\(^15\) This was an example of how the recommended regional-local coordinated approach can work effectively to assure a good plan.

\(^{15}\) A Comprehensive Planning Study for the Gig Harbor Peninsula, Pierce County Planning Department, 1966.

Cross-Sound Facilities

The alternative transportation systems to serve travel across Puget Sound include: (1) the present ferry operation, (2) a cross-Sound bridge (or a tube under the Sound) to be used in conjunction with a limited number of ferries, or (3) several bridges connecting various sections of the Kitsap Peninsula, coupled with a consolidation of present ferry routes.

Alternative 3 was rejected because it combines the worst features of a cross-Sound bridge and the present ferry system: (1) reduced or eliminated service for many walk-on ferry passengers, without compensating advantages, (2) a sizeable financial outlay for a temporary expedient, (3) a reduction in gross ferry revenue, unless present fares are increased, and (4) the inability of such an arrangement to amortize its capital costs, thus requiring funds from other sources.

The tube concept for alternative 2 was ruled out because of engineering and financing limitations. At the shallowest possible crossing—which would serve the central portion of the Study Area—the maximum water depth is 650 feet. A submerged tube could not be designed to withstand the tremendous hydraulic pressures encountered at such depth within practical economic limits—even if such a tube could be constructed.

Moreover, this depth is reached within 2,500 feet of the shoreline, requiring a prohibitive gradient of almost 30 percent, much above the practical capability of vehicles. If the gradient were to be limited to a more reasonable 5 percent, the portal of the tube would have to be more than two miles back from the shoreline. Because of the water depth and gradient limitations, it would not be possible for such a tube to come to the surface on Vashon Island (should this location be chosen). At the possible sites touching on Bainbridge Island, the water depth is even greater and the problem further aggravated.

Boring a tube under the bottom of the Sound—to eliminate hydraulic pressure problems—would be impossible because of the approach gradient and ventilation. It has frequently been suggested that a submerged tube, possibly 50 feet below the water surface, might offer a solution. However, if such a tube were to spring a leak or otherwise incur damage, the entire facility would lose its flotation and sink to the bottom. Because of this, financial houses have indicated it would be impossible to back such a project. As a result, a bridge constructed on floating pontoons is the only possible way to cross Puget Sound—other than by boat—with present materials and technology.

A BRIDGE VS. FERRIES

A cross-Sound bridge will improve accessibility to the Kitsap and Olympic Peninsulas, providing continuously available service. It will have sufficient traffic capacity to accommodate foreseeable daily and seasonal peak loads without congestion. A cross-Sound bridge will have a favorable impact on the entire region, as well as spurring economic growth on the peninsulas. It will reduce transportation costs and make available more business, industrial and home sites.\(^15\)

Initial vehicular toll rates on a cross-Sound bridge would probably be equivalent to present ferry tolls—or possibly somewhat lower. However, labor and operational costs for the present ferry system are increasing faster than traffic volumes, and ferry tolls undoubtedly will be raised. Currently, fare revenues are estimated to be inadequate to meet operating costs. This deficit will grow increasingly until it exceeds the ferry support funds provided by the state legislature. In addition, none of the ferry system's capital costs are being met by fare revenues nor are funds being set aside for depreciation or equipment replacement.

Cross-Sound bridge tolls, on the other hand, will more than cover operating costs with a sufficient surplus, in time, to pay for the capital investment as well. Ultimately, complete elimination of tolls is possible.

From an economic standpoint, a bridge is preferable to the present ferry service. Partially balancing the high initial investment and annual debt service burden of the bridge are the savings of at least $45 million (see Table IV-73, Page 104).

In 1966 alone, a bridge would have eliminated $5 million in ferry expenses; the latter are increasing approximately 6 percent a year. But even at the 1966 level, the ferry operating expenses exceed by at least $1 1/2 million per year the probable inter-

\(^{15}\) Since the Transportation Study was involved only in appraising traffic and economic factors, matters of navigation were not explicitly studied. However, it was assumed that the requirements of shipping on Puget Sound would be met.
est costs on the difference in capital obligations between the two alternative courses of action: (1) a new bridge to operate with limited ferry support, or (2) continuance of the present ferry system.

Savings in time and toll charges by cross-Sound travelers using a bridge will be offset partially by increased vehicular operating costs. In total, a cross-Sound bridge will provide savings which more than justify the expenditure. However, a bridge seriously affects the sizeable number of walk-on ferry passengers whose method of transportation would be eliminated. Nonetheless, it appears that sheer economic necessity dictates elimination of as many ferry operations as possible—and this can be done only by providing an economically preferable substitute.

Basically, transportation service across Puget Sound should be considered a necessary public service to meet the region's economic and recreational needs. It should be maintained and improved in quality to the extent possible within practical bounds of economics. Thus the PSRTS recommends.

Whether a bridge should be built across Puget Sound is a policy decision rather than solely a matter of transportation planning and engineering. Still, a basic requirement for an urban complex is reliable, continuously available transportation service. This can only be achieved with a fixed connection across the Sound. After thorough analysis of the alternatives—including such possible technological developments as hydrofoils and hover-craft—the Study advises that:

From an economic standpoint, a cross-Sound bridge—to provide basic minimum transportation service to an integral part of the Puget Sound urban complex—should be considered an essential part of the regional transportation plan.

CROSS-SOUND BRIDGE LOCATION

When the Transportation Study was undertaken, the only cross-Sound bridge location reported to be possible from an engineering standpoint was between Brace Point in the Fauntleroy vicinity and the Kitsap Peninsula in the Southworth area, via Vashon Island. The Transportation Study's traffic analysis of cross-Sound bridging, therefore, was limited to this single site.

Since that time three other potential bridge sites have been given favorable construction reports by engineering studies. One proposed location, from the Richmond Beach area to Jefferson Point on the Kitsap Peninsula, is too far north to serve the primary travel demand across Puget Sound. The other two sites—(1) from Alki Point in Seattle to Restoration Point on Bainbridge Island, and (2) from West Point in Seattle to Skiff Point on Bainbridge Island—were considered by the Study to have similar traffic potentials and economic impacts upon the Kitsap and Olympic Peninsulas as the Vashon location. Consequently, the analysis of the latter was considered generally applicable to the Alki Point and West Point sites.

More extensive traffic and engineering studies of the alternatives by the Department of Highways have resulted in its recommendation that a bridge at Vashon Island be part of the long-range plan for cross-Sound transportation. This choice was based on evaluations of (1) the traffic volume which would be accommodated, (2) the impact on navigation, (3) the amount of subsidy required, (4) total capital costs involved, (5) the impact on traffic conditions in Seattle, (6) the impact on the remainder of the ferry system, (7) the effect on ferry walk-on passengers, and (8) the relationship to longer-range plans for cross-Sound travel.

On the basis of the data and information available to it, the Transportation Study recommends:

A cross-Sound bridge at the Fauntleroy-VashonSouthworth site, including a Rich Passage bridge to Bainbridge Island. It further recommends that the Edmonds-Kingston ferry service be continued and that a walk-on passenger service between Seattle and Winslow be established (if financially possible).

Financing

The Open Space And Transportation Elements Of The Regional Plan

Analysis of the financing for the recommended regional plan involved two major elements: (1) cost of the open space areas in the land use pattern, and (2) cost of the necessary facilities in the transportation plan.

In the first instance, cost estimates were made of the open space land parcels. An acquisition cost of almost $40 million was established for those portions of the open space system which were vacant but developable for urban uses. No estimates were made for developed properties lying within the open space system nor for land not suitable for urban or other intensive use.

This cost figure, though large, is certainly attainable by the region over a 25-30 year period, particularly since such land acquisition is eligible for federal grants of up to 50 percent of the cost. Because the open space system—much of which is incorporated in the Puget Sound Governmental Conference's Project Open Space—is a key element in

the regional land use plan, every effort should be made for its early acceptance and development.

The cost of recommended transportation facilities is, of course, much higher. It is summarized in Table III-1.

### Table III-1

**ESTIMATED CAPITAL COST OF RECOMMENDED TRANSPORTATION SYSTEM**

<table>
<thead>
<tr>
<th>Facility</th>
<th>Cost ($000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeways and Expressways</td>
<td></td>
</tr>
<tr>
<td>Interstate Freeways</td>
<td>$290,000</td>
</tr>
<tr>
<td>Cross-Sound Project</td>
<td>$465,000</td>
</tr>
<tr>
<td>Other Freeways and Expressways</td>
<td>$765,000</td>
</tr>
<tr>
<td>Total Freeways and Expressways</td>
<td>$1,220,000</td>
</tr>
<tr>
<td>Arterials</td>
<td>240,000</td>
</tr>
<tr>
<td>Transit Facilities</td>
<td>16,000</td>
</tr>
<tr>
<td>Ferries</td>
<td>25,000</td>
</tr>
<tr>
<td>Parking Facilities</td>
<td>54,000</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,535,000</td>
</tr>
</tbody>
</table>

1. For facilities not already constructed prior to 1965.
2. Based on 1964 unit prices and expressed in terms of constant 1964 dollars.
3. From Deirigde Way in Seattle to north end of Sinclair Inlet crossing.

The total estimated capital costs for the recommended transportation system—including arterials—are slightly more than $1½ billion. While this appears to be a staggering amount, more than $570 million (almost 38 percent of the total) is already budgeted in six-year capital improvement programs of cities, counties and the state. An additional 10 percent is represented by the cross-Sound bridge project, which will be almost entirely self-supporting from toll income and financed by revenue bonds. Another 3 percent is involved in parking facilities, which will be financed largely from private funds. Thus, almost half of the estimated total is either budgeted or will not be a drain on normal public funds for transportation purposes.

With so much of the total already scheduled for accomplishment by the early 1970s, the rate of spending on new facilities between then and 1990 should be below the current and near-future rates, even considering inflationary effects, unanticipated projects and projects undertaken for purposes other than providing adequate capacity. Since total revenues available for transportation purposes should increase as the area grows, accomplishment of the regional transportation system should be financially possible. Also it may be possible to place more emphasis on the improvement and maintenance of existing facilities. This, of course, assumes a continuance of a federal-aid-to-highways program of somewhat the current scale—or the substitution of state funds for federal monies, if any long-term curtailment of the latter takes place.

Since the financing of facilities is crucial to the accomplishment of the plan, a continuing appraisal of the region's financial capabilities is called for. Likewise, as the region continues to grow and change, it will be necessary to adjust the recommended plan and extend it further into the future.

This makes a continuing transportation planning program essential. The plan can thus be kept up to date and in tune with the region's current needs.

The PSRTS recommends:

As part of the continuing planning program, a study should be made of past expenditures for transportation facilities and services in the region, and forecasts made of future available resources. This should be done concurrently with discussions to resolve financial and administrative responsibilities for implementation of the plan.

### Implementing The Plan

While the recommendations in this report are advisory and constitute no commitment on the part of the Study sponsors, it was the intention of the latter that a recommended plan—developed through a coordinated and cooperative effort—would form a mutually acceptable framework for decision-making. Further, it was hoped that through voluntary action of the region's many separate jurisdictions, the plan would be put into effect without an over-riding governmental authority.

To implement this truly regional plan—which was created without regard to governmental boundaries or administrative or financial responsibilities—two basic steps are necessary:

1. Acceptance of the plan and agreement on its various components.
2. Intergovernmental discussion to establish administrative and financial responsibilities.

Fully resolving Step 2 may take some time and possibly legislative action. Meanwhile, there is much in the plan where responsibilities are clear under present laws and regulations, so action on these elements can proceed without delay. It is recommended, then, that:

The technical advisory committees to the continuing transportation planning program should develop for the Puget Sound Governmental Conference—and for each individual governmental unit—a recommended allocation of administrative responsibilities for implementing each element of the plan. This should be done concurrently with studies of the financial resources available to each agency in the region for this purpose.

### Project Priorities

Since the recommended plan cannot be built all at one time, the facilities which are most needed and will provide the greatest benefits for the costs involved obviously are those which should be constructed first. However, any attempt at this time to establish specific priorities is quite impossible. The designation of project responsibility and the
funds available to the particular agency will determine how much can be done and at what pace.

In general, the most pressing needs are in the areas of major trip generation and concentration. The greatest good can come from developing major regional facilities outward from these pressure points. Completion of the current programs represented by Study System 2 (Figure IV-62, Page 71) should be considered the first order of business, especially those portions in congested areas. Already the dynamic changes taking place in the region have required some adjustments in these programs.

Also critical is the advance acquisition of right-of-way for recommended facilities in fast-growing areas. A third high-priority action affects certain much-needed projects—some already programmed—which are being held up for want of specific commitments on interlocking facilities. A typical example is the decision on the additional bridge needed across Lake Washington, which affects the R. H. Thomson Freeway, projects on Interstate 405 and other recommended facilities on both sides of the lake.

Other high-priority projects or actions include:

- Integration or effective coordination of transit services across operating boundaries.
- Necessary financing over a long-range period to assure the continuation of no less than the existing transit service.
- Planning and completion of facilities in fast-growing industrial areas—such as the Green River Valley in King County and the Paine Field area of south Snohomish County.
- Facilities to serve the residential areas where development will be triggered by the new industrial growth.
- Cross-town improvements in Seattle serving freeway interchanges and distributing traffic.
- The R. H. Thomson Freeway and its north and south extensions.
- Right-of-way acquisition for the recommended north-south freeway paralleling Interstate 405 east of Lake Washington; also for the recommended Kenmore-to-Lynnwood route in Snohomish County, the Hannah-Pierce Expressway in Pierce County and the route easterly from Tacoma across the industrial district.

In general, it is recommended that:

The technical advisory committees to the continuing transportation planning program should discuss priorities for facilities and develop recommended coordinated programs for financing and scheduling the regional plan.

The Continuing Program

For the first time the Puget Sound Region has a long-range plan covering the area's anticipated growth and needs for 25 years into the future. It is a guide which will require the separate governmental entities involved to work together for its accomplishment. Any other approach will result in less worthy ends and attendant higher costs, inconvenience and sacrifice of the region's values. An early agreement on the plan and the development of coordinated programs for its financing and accomplishment will do much to salvage still valuable features of the region.

It would be naive, however, to expect that the multitude of governmental jurisdictions in the Study Area could agree on all the details of the one unified plan. For that reason it should be reiterated that the Transportation Study's recommendations were the culmination of a four-year work program, having the benefits of continuing review, appraisal and consideration by governmental officials, technical personnel and the public itself. The recommendations reflect the results of more than 2,000 meetings and presentations in which the staff participated. As broad a segment of the four-county complex as possible was involved so that the final plan would be responsive to the thinking of the region's residents and officials alike.

Sponsors of the PSRTS had the foresight to establish a continuing planning program to follow the Study itself. Thus, any differences between agencies on details of the plan can be subject to continual review and analysis by the staff—in cooperation with local and state units—to appraise the regional effects and to achieve agreement.

Further, the continuing planning organization will adjust and update the regional plan to keep it in tune with developments and directed as pointedly as possible toward the ultimate objectives. *The plan, therefore, is not an idle, static document, but a vibrant, current guide to a better region.*
A thorough knowledge of past and present land use and transportation developments and relationships in the Puget Sound Region was vital to the success of the PSRTS. To gain this necessary information, a number of basic planning studies involving land use, travel, and measures of the region's development and economy were undertaken.

Important, too, was a need for an efficient, consistent system of geographic identification so that the vast amount of data could be processed, summarized and compared with ease. Because the four-county Study Area included more than 40 individual cities, there was no uniformity in street numbering or other regionally consistent or meaningful way to identify data by geographic location.

Also, there were no adequate up-to-date maps for the entire region. Consequently, an aerial survey—covering almost 2,500 square miles of the four counties—was made in 1961 to provide a graphic record of the transportation network and the location, intensity, type and extent of land use development.

The aerial photographs were used to establish a system of areal units to which transportation and land use information was referenced. This uniform geographic reference system also made possible the use of electronic data processing equipment.

**Geographic Reference System**

The region was divided into approximately 33,000 grid blocks—city blocks where they existed and their equivalent in the more sparsely developed areas. Each block—the smallest areal unit to which data was summarized—was assigned a separate eight-digit number, representing the north-south and east-west coordinate values in hundredths of a mile. This permitted the aggregation of data to whole or quarter square miles—or to any other size area made up of combined blocks.

The grid blocks were combined into 662 analysis zones, drawn in keeping with topographic barriers and governmental boundaries to define meaningful areas from a planning standpoint. These zones, in turn, were included in 60 analysis districts, a more manageable number of areas for certain types of analyses. The grid blocks could also be summarized into census tracts, counties, and incorporated and unincorporated places for particular analysis purposes. Figure IV-1 shows the basic grid coordinate system in the Study Area and the hierarchy of analysis districts, analysis zones and grid blocks.

21. The aerial photos have also been extensively used by both private and public agencies for varied purposes and constitute not only a valuable by-product of the Transportation Study for current usage but a priceless historical record as well.


**Historical Growth and Development**

A region's physical framework—plus the current technological, economic and social conditions—make up a community's overall character. These same influences shape the future of a region as well. The study of historic growth and development, therefore—when applied judiciously to the future—can give some indication of what lies ahead.

Among the key factors in measuring a community's activities and transportation requirements are the number of people, their occupations, their incomes, their choice of residential areas and their vehicle ownership rate. Consequently, some knowledge of past trends in these categories—when used with due caution—gives a basis for establishing forecasts for the ensuing years.

**POPULATION**

In 1910 the Puget Sound Region contained 42 percent of Washington State's residents (see Figures IV-2 and IV-3 for growth trends). In 1940 the figure rose to 47 percent, and by 1960 the four-county population (1,513,000) amounted to slightly more than one out of every two persons living in the entire state (53 percent).

This rapid growth can be more appreciated when it is realized that it was not until after 1910 that the region reached its first one-half million in population. The next one-half million took only 35 years, and by 1960—just 15 years later—the third one-half million in growth was reached.

**EMPLOYMENT**

A great many trips begin and end at places where people work. This is not just true of the trips by the workers themselves but also by those conducting business, shopping, etc., at employment sites. Apart from the obvious relationship between travel and jobs the location and type of employment at particular places have implications relative to the spatial arrangement of land uses. Certain work activities have specialized land or facilities requirements (deep-water harbors, railheads, etc.); others affect neighboring development by attracting related industries; others are not considered good neighbors because of noise, odors or various other nuisances.
FIGURE IV-1
GEOGRAPHIC REFERENCE SYSTEM FOR STUDY AREA

THE RELATIONSHIP OF AN ANALYSIS DISTRICT TO THE STUDY AREA AND GRID CO-ORDINATES

THE RELATIONSHIP OF AN ANALYSIS ZONE TO AN ANALYSIS DISTRICT AND GRID CO-ORDINATES
DISTRICT NUMBER 36

THE RELATIONSHIP OF A GRID BLOCK TO AN ANALYSIS ZONE AND GRID CO-ORDINATES
ZONE NUMBER 3600

LEGEND
2400 E GRID CO-ORDINATE
= ANALYSIS DISTRICT NUMBER
3600 ANALYSIS ZONE NUMBER
= ANALYSIS DISTRICT, ANALYSIS ZONE OR GRID BLOCK

AN INTERVAL OF 100 IN THE GRID CO-ORDINATE IS EQUIVALENT TO ONE MILE.

PUGET SOUND REGIONAL TRANSPORTATION STUDY

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Therefore, an understanding of the region's past and current employment serves as a base for forecasting future job activities and their specific locational requirements—and for measuring how trip-making is related to employment. To obtain insights into the present situation as well as future potentials, a regional economic study was undertaken.23

Table IV-1 shows how total population and the total civilian labor force have grown since 1940, as well as how the labor force participation ratio—the percentage of the population in the civilian labor force—has changed.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Population</th>
<th>Civilian Labor Force</th>
<th>Labor Force Participation Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>820,202</td>
<td>351,611</td>
<td>42.9%</td>
</tr>
<tr>
<td>1950</td>
<td>1,196,172</td>
<td>475,137</td>
<td>39.7%</td>
</tr>
<tr>
<td>1960</td>
<td>1,512,979</td>
<td>578,028</td>
<td>38.2%</td>
</tr>
</tbody>
</table>

While the region's total employment has increased markedly, changes have taken place in the kinds of jobs. Figure IV-4 shows the total employment in the major categories and the percentage of the total employment which each category represents for 1940 and 1960.

Employment in the extractive industries declined in numbers and percentage between 1940 and 1960. Transportation, communications, utilities and the trade category showed a minor drop in relative importance, while the manufacturing and "all other" categories showed increases. Construction remained virtually unchanged as a proportion of total employment.

It should be noted that the increase in the relative importance of manufacturing employment is attributable to a great degree to one firm. In 1960 The Boeing Company alone had approximately as many workers as were employed by all manufacturing concerns in the region in 1940. With the exception of the change in the relative importance of the manufacturing category—which is accounted for by special circumstances—it is expected that the trends in the relative importance of the various economic sectors will continue into the future.

As a basic framework from which to develop forecasts of the regional economy, employment was divided into a number of categories or "sectors" by the economic consultant to the Study. Table IV-2 shows the number of persons employed in each sector in 1958 and 1961.

INCOME

Closely related to employment is the total income earned by the region's workers, which, in turn, determine their way and style of life. Automobile ownership, among other things, reflects this pattern of living. In addition, it has a direct effect on the number of trips people make and their selection of mode of travel.

2. The 1958 figures are estimates by Arthur D. Little, Inc. The 1961 figures are estimates by the Transportation Study.

Data on personal income is relatively sparse, but estimates have been made by allocating U.S. Department of Commerce figures to counties for the State of Washington. Table IV-3 shows data for selected years. It is obvious that there has been a steady gain in income, even when expressed in terms of constant dollars.

Table IV-3

PERSONAL INCOME FOR THE PUGET SOUND REGION

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Personal Income</th>
<th>Per Capita Personal Income</th>
<th>Per Capita Personal Income in Constant Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>$2,108,000,000</td>
<td>$1,749.09</td>
<td>$1,945.60</td>
</tr>
<tr>
<td>1956</td>
<td>$3,061,000,000</td>
<td>$2,196.46</td>
<td>$2,306.46</td>
</tr>
<tr>
<td>1961</td>
<td>$4,071,000,000</td>
<td>$2,610.01</td>
<td>$2,826.46</td>
</tr>
</tbody>
</table>


VEHICLE OWNERSHIP

Historically, the number of vehicles owned has been increasing at a faster rate than the population. Not only are there more automobiles per 1,000 persons now than in 1940 or 1950 (see Figure IV-5), but the proportion of households which presently own an automobile has risen. A substantial increase in the proportion of households owning more than one car has also occurred. This is particularly important in transportation planning because the household is conventionally used as a basic unit of analysis in the determination of future trip demands. Consequently, an increase in the ownership of automobiles by households is directly reflected in an increase in the number of trips made.
For the western United States between 1952 and 1961, the percentage of households not having an automobile available declined from 28 percent to 18 percent, while the percentage having two or more automobiles increased from 7 to more than 19 percent. The percentage of households with only one car decreased from 65 to 63 percent. In the Puget Sound Region, 19 percent of the households did not have an automobile available, 26 percent had two or more and 55 percent had one.

As in the case of automobiles, the number of privately-owned trucks also increased over the years at a faster rate than the population (see Figure IV-6)—a pointed indication of a continually growing dependence on motor vehicles.

Privately-owned trucks—including panels, pick-ups, station wagons and carry-alls—constituted less than 12 percent of the region's total vehicles in 1960. The 1961 truck-taxi survey showed that approximately 40 percent of the trucks being operated within the Study Area were used almost exclusively for personal purposes. In other words, these vehicles—while registered as trucks—were being used as one would an automobile.

HISTORICAL GROWTH PATTERNS

A study was made of the historical growth in the region to determine why certain types of development occurred in particular places at particular times. Knowledge of the factors which influenced past development patterns may indicate the factors which can be expected to shape future development patterns.

While many conditions which influenced development in early stages of the region's growth are not now important, new factors have arisen. As an example, the need for the pioneer to be near the shores of Puget Sound or navigable streams—the transportation arteries of the period—is no longer a major determinant of development location (except for those industries which require deep water facilities). The almost universal presence of streets, roads and highways—together with the development of motor vehicles—makes all parts of the region almost equally accessible.

Improvements in construction technology likewise make it possible to utilize land with physical conditions which formerly frustrated or prevented development. Thus, it has been possible in recent years to develop water-frontage for residential use quite far removed from urban centers—even though the water is not used as the transportation medium to the city.

The interpretation of the historical growth study, therefore, requires an appreciation of the changes in technology, the economy, personal tastes and affluence which have occurred in the intervening decades. Such changes can also be expected to influence future patterns of the region's land uses in the years ahead. Figure IV-7 shows the historical pattern of urbanization in the Puget Sound Region.

TRAVEL: TRAFFIC VOLUMES AND TRANSIT USAGE

The people of the Puget Sound Region are traveling more, farther and for apparently more reasons than ever before. They are increasing in numbers, too, and they own more automobiles with each passing day, thus contributing greatly to current transportation problems.

Statistics compiled cooperatively by the state, counties and cities indicate that the number of vehicles passing many key locations on the region's
FIGURE IV-7
HISTORICAL PATTERN OF URBANIZATION IN THE PUGET SOUND REGION

- Development before 1920
- Development between 1920 and 1940
- Development between 1940 and 1960

Puget Sound Regional Transportation Study

Scale: 1 in miles

Development before 1920 is noted in dark brown, development between 1920 and 1940 in brown, and development between 1940 and 1960 in orange.
TABLE IV-4
TRAFFIC GROWTH AT SELECTED LOCATIONS

<table>
<thead>
<tr>
<th>Location</th>
<th>Vehicles Per Day 1950</th>
<th>Vehicles Per Day 1965</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aurora Avenue Bridge</td>
<td>43,000</td>
<td>83,000</td>
<td>93.3</td>
</tr>
<tr>
<td>Seattle</td>
<td>81,000</td>
<td>23,000</td>
<td>-71.7</td>
</tr>
<tr>
<td>Lake Washington</td>
<td>42,000</td>
<td>90,000</td>
<td>114.8</td>
</tr>
<tr>
<td>U.S. 99 Divisumish Crossing</td>
<td>20,400</td>
<td>40,000</td>
<td>100.0</td>
</tr>
<tr>
<td>Five Corners, Burien</td>
<td>2,300</td>
<td>11,200</td>
<td>447.7</td>
</tr>
<tr>
<td>Interstate 5 (U.S. 99)</td>
<td>5,600</td>
<td>10,000</td>
<td>123.1</td>
</tr>
<tr>
<td>North of Marysville</td>
<td>1,600</td>
<td>4,600</td>
<td>186.4</td>
</tr>
<tr>
<td>Tacoma Narrows Bridge</td>
<td>2,900</td>
<td>4,400</td>
<td>152.8</td>
</tr>
<tr>
<td>Interstate 405</td>
<td>2,700</td>
<td>16,800</td>
<td>657.7</td>
</tr>
<tr>
<td>North of Factoria</td>
<td>1,600</td>
<td>16,000</td>
<td>876.3</td>
</tr>
<tr>
<td>Lake Washington (Mercer Island) Bridge</td>
<td>42,000</td>
<td>42,000</td>
<td>0.0</td>
</tr>
</tbody>
</table>
| 1. The Interstate 5 freeway was opened to traffic between Mercer Street and Bothell Way N.E. in August 1963. Subsequently sections to the north and south were put into service. In 1961 the freeway was open from downtown Seattle to Everett and carried 84,000 vehicles per day across the Lake Washington ship canal. Traffic on the Aurora Avenue Bridge is lower in 1965 than in 1961 because of the opening of the freeway.
| 2. The Evergreen Point Bridge, a toll facility, was opened to traffic in August 1963. In 1965 it carried 23,000 vehicles per day. Traffic on the Mercer Island Bridge was lower in 1965 than in 1961 because of the opening of the Evergreen Point Bridge in 1963.
| 3. Tolls were removed from the Tacoma Narrows Bridge in May 1965, which caused a sharp increase in traffic. The bridge carried 3,700 vehicles per day in 1964 and over 14,000 in 1966. |

While substantial growth was taking place in the volumes of vehicles on the region’s streets and arterials has increased substantially between 1950 and 1965 as Table IV-4 indicates.

As a matter of fact, registration of privately-owned vehicles and vehicular travel more than doubled between 1948 and 1965, while transit use during this same period fell to less than half its 1948 level. These trends are, in part, interrelated. Figure IV-8 shows the trends in population, vehicle registrations, vehicular travel and transit patronage.

Bus transit patronage in the Puget Sound Region has followed the general pattern found elsewhere in the country, reaching a peak during the war period and then declining consistently until recent years when the rate of fall-off has been less severe.

Table IV-5 shows a comparison of the number of vehicles per day across the various locations and highways, along with the percent change from 1950 to 1965.
annual revenue passengers in 1950 and 1961 for several transit operators in the Study Area. The only operation reporting an increase during that period was the Overlake Transit Company which served mainly the rapidly urbanizing area east of Lake Washington. In 1961 all other operators were carrying one-half, or less, the number of revenue passengers they served in 1960.

Figure IV-9 shows the number of revenue passengers carried by the transit systems of the four major cities in the Puget Sound Region in 1950, 1961 and 1965. The decline in the number of revenue passengers has been at a slower rate between 1961 and 1965 than between 1950 and 1961.

Part IV Section 2

LAND USE PLANNING STUDIES

The preparation of plans for the region's future requires a basic knowledge of those factors which affect the uses of land. Consequently; studies were undertaken to determine: (1) the geographic characteristics of the region, (2) the physical limitations, (3) land use regulations (zoning, subdivision regulations, etc.), and (4) the location of land uses as they are linked to other particular activities. This research was keyed to studies of travel and transportation facilities whenever possible to ascertain how land utilization and travel mutually affect one another.

The various land use studies — which are discussed separately and briefly for convenience — are closely interrelated and interdependent (see Figure IV-10). Only by isolating and understanding the many factors affecting the use for which land is adapted can a sound basis be established for forecasting the type and location of future development which can be expected to take place.

Physical Limitations Affecting Development

The objective of the physical limitations study was to define those factors affecting the potential uses to which land can be put. Basic information was collected on soil types, geology, topography and slopes, drainage characteristics, areas subject to flooding, water resources, air pollution and climate. Also considered were the present land uses and their characteristics, development technology, changing tastes and increasing demands to take land out of vacant, agricultural and open space categories. All this data was summarized as the basis for determining those lands expected to be available for urban development.

An evaluation was also made of the particular type of use for which the region's lands are most suitable. Obviously, not all lands are suitable for all purposes. For example, those areas with undesirable physical characteristics—steep slopes, flood plains, etc.—were largely considered unavailable for future urban development.

Land Use And Floor Space Surveys

Prior to 1961, there was no complete, uniform record of land or floor space uses in the region's

24. Unpublished reports and memoranda providing complete details are available in the Transportation Planning Program office.

1,269 square miles. The Study, therefore, conducted a land use survey to determine the number and types of establishments—and the amount of land consumed by each—in the 1,265 square miles of land where multi-storied non-residential buildings do not predominate. In the region's remaining four square miles, a separate survey measured the floor space utilized by each type of land use activity.26

The land use studies indicate that approximately 949 square miles, or 75 percent, of the 1,269 square miles surveyed in 1961 were vacant or in non-urban uses such as agriculture or forestry (see Figure IV-11). The approximately 320 square miles of developed land was subdivided among the various land uses as shown in Figure IV-12.

FIGURE IV·11
USE OF TOTAL LAND IN 1961

LEGEND

\[ 10\% \] SCALE FOR PERCENTAGE

- RESIDENTIAL
- TRANSPORTATION, COMMUNICATION AND UTILITIES
- INDUSTRIAL
- COMMERCIAL
- PUBLIC AND QUASI-PUBLIC BUILDINGS
- MULTI-STORIED NON-RESIDENTIAL
- MISCELLANEOUS
- VACANT
- STREETS AND HIGHWAYS
- COMMERCIAL

Of the slightly more than 4 square miles of land area included in the floor space survey, approximately 1.5 square miles (34 percent) were in streets, sidewalks, alleys and highway rights-of-way. In the remaining area there were 124 million square feet of floor space, of which 30 percent was utilized by commercial activities (retail, offices and services) as shown in Figure IV-13.

The next most significant space-users were industries and residences, each of which utilized approximately 13 percent of the total floor space. Other major amounts of floor space included 9 percent in transportation and related activities, and 4 percent in public and quasi-public facilities. The remainder (31 percent) was either vacant, under construction or in such miscellaneous uses as parking lots and garages.

The location and intensity of land use in 1961 is depicted in Figure IV-14. The greatest intensity in utilization is in the central cities. As the distance outward from these central cities increases there is a noticeable reduction in the intensity of the use of land. The map also shows that, although the present residential development in the region is quite scattered, employment types of land use are largely concentrated within the region's four central cities and the outlying smaller cities. The cities were established in early periods of local history. They provided the necessary utilities and services to industrial and commercial areas, thus attracting commercial activities (retail, offices and services) as shown in Figure IV-13.

The next most significant space-users were industries and residences, each of which utilized approximately 13 percent of the total floor space. Other major amounts of floor space included 9 percent in transportation and related activities, and 4 percent in public and quasi-public facilities. The remainder (31 percent) was either vacant, under construction or in such miscellaneous uses as parking lots and garages.

FIGURE IV·12
USE OF DEVELOPED LAND IN 1961

LEGEND

\[ 10\% \] SCALE FOR PERCENTAGE

- RESIDENTIAL
- TRANSPORTATION, COMMUNICATION AND UTILITIES
- INDUSTRIAL
- COMMERCIAL
- PUBLIC AND QUASI-PUBLIC BUILDINGS
- MULTI-STORIED NON-RESIDENTIAL
- MISCELLANEOUS
- VACANT
- STREETS AND HIGHWAYS
- COMMERCIAL

and retaining their employment concentrations, even though there has been substantial surrounding growth in recent years. Bellevue is a notable example, with its expansion largely keyed to the opening of the first Lake Washington bridge in 1940.

**Land Use Analyses**

Land use analyses were undertaken to determine: (1) a basic description of the types, locations and amounts of land use activities, (2) interrelationships of land uses which might influence their locations, (3) other factors affecting the location of each particular kind of land use activity, and (4) historic trends to provide a basis for forecasting kinds, amounts and locations of future land uses.

Mathematical models (relationships expressed in equation form) were developed to describe the amount of a particular land use in a particular location as it is related to those factors which influence the individual land use type. The complexity and form of the models were dependent upon the type of land use, its importance in the region and the data available.

In the analyses, the central business districts and other major commercial centers commanded special emphasis because they represent major concentrations of both economic activity and trip attraction. As a result, they have considerable impact upon the ultimate community form, the transportation system and other facilities which serve them.

The land use analyses played an important role in the overall planning process by establishing the vital relationships which influence individual land use types. As such, they provided the foundation for setting the expected future scale and location of development. Understandably, the analysis techniques are lengthy and complex, so they are presented here in brief, selected form. For greater detail and for the categories of economic activity not covered, reference should be made to the Study's staff reports on this subject.27

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or the number of dwelling units, which are, of course, interrelated. In analyzing residential land use, past population growth and its specific locations were examined to determine why the growth occurred in the amount and pattern it did. This analysis took the form of a population growth model, developed to isolate the most significant factors influencing past growth patterns—and determining the relative importance of each of these factors.

Growth and development were affected by unusual conditions in the 1930s and 1940s. Furthermore, technological and social influences have come into being since the 1940s. Therefore, it was decided that the 1950 to 1960 period offered the only meaningful appraisal of factors influencing growth. The statistical techniques used to isolate the factors shaping the amount and location of growth and to determine their relative importance are outlined in a Study staff report. The analysis required measurement of various physical and socio-economic characteristics of a number of census tracts having identical boundaries in both 1950 and 1960.

The results of this analysis showed that significant factors influencing the location of population growth are: (1) the amount of land available for residential development in each particular area of the region, (2) the relative accessibility of each area to places of employment, (3) the income and occupation of the residents of each particular area, (4) the condition of the housing in the area, and (5) the size of the residential lots.

Of these five factors, the amount of land available for residential development and its accessibility to job sites were about twice as important as the other three factors in explaining the 1950 to 1960 population growth of a given area.

A second mathematical model was developed to isolate and determine the relative importance of the factors which caused a decline in population in certain areas between 1950 and 1960. Population decreases were explained largely by the existence of deteriorated housing, coupled with a low income level of residents in these areas.

The use of the mathematical models for forecasting purposes has the implicit assumption that the 1950-60 relationships will continue to hold true in the future. There is no reason, however, to believe that this assumption may not be valid.

For each of the 662 analysis zones in the Study Area, either the growth or the decline factors were measured so that the predicted population changes for the region—and for each county in the region—could be distributed to individual analysis zones by applying the mathematical models.

LOCATION OF ECONOMIC ACTIVITIES

Economic activity may be expressed in terms of land area or space consumed, employment or similar measure. The Study judged that among these, employment was the most meaningful and also the most significant from the standpoint of relating economic activity to trip generating characteristics. Moreover, the forecasts of the economic potential of the region made by Arthur D. Little, Inc., were in terms of employment by category of economic activity.

Based on the land use surveys and the Study’s analysis of the region’s economic potential, 16 economic categories with similar locational and activity characteristics were established. Mathematical models were developed to explain the 1961 locational pattern of each category.

Unlike the case of population distribution, there is no body of historical data on the location and amount of employment (or other measure of economic activity) except for counties as a whole. As a result, it was necessary to base the process solely on data collected by the Study in the base year.

Of the 16 categories of economic activities, the three most important—based on their share of total employment—were: (1) manufacturing, (2) comparison retail, and (3) office services. Besides being important in themselves, the first two also act as magnets in attracting other activities to nearby sites.

Since the locational analyses are complex and detailed, only illustrative examples (for manufacturing industries and commercial centers) will be cited briefly. For further information about the analyses, the land use models and the results, reference should be made to the appropriate Study staff report.

Location of Manufacturing Industries

An analysis of the present location of manufacturing industries was made to determine what factors significantly influenced their choice of specific locations. They included: (1) land availability, (2) proximity of good highway transportation facilities, (3) access to water transportation, (4) railroad service, and (5) relative accessibility to the labor force.

It was found, however, that these factors are not of equal importance to all types of manufacturing. For example, water transportation is much more vital to lumber and wood products manufacturing than to the production of apparel and other finished fabric items. Consequently, manufacturing

29. Charles H. Graves, op. cit.
31. These are: (1) manufacturing, (2) comparison retail, (3) convenience goods retail, (4) office services, (5) repair services, (6) public and quasi-public buildings, (7) government buildings, (8) educational institutions, (9) public parks and zoological gardens, (10) military installations, (11) wholesaling with stocks, (12) employment of domestics and in residences, (13) agriculture, forestry, fisheries and mining, (14) public recreation, (15) transportation, communication and utilities, and (16) construction.
31. Charles H. Graves, op. cit.
was further divided into 15 sub-categories having differing locational requirements. The relative importance placed on each of these five location factors was determined and applied to each sub-category on the assumption that manufacturers seeking future sites would make their selections on the same basis as they did in the past.

The second phase of the analysis sought to determine the various locations where future industrial development could take place. It required an extensive inventory of vacant land and floor space in existing industrial areas and of vacant lands elsewhere within the region which have been zoned for industry or are being developed as industrial parks or industrial areas, or, for some other reason, can be expected to be used for manufacturing industries.

The vacant land in "active" industrial parks32 and in or adjacent to existing industrial areas—was expected to have a greater likelihood of attracting future industrial development than other potential industrial lands. There were about 10,000 acres in this category. Other land—potentially usable for manufacturing industries—totaled about 7,000 acres. Each of the industrial areas was rated in terms of the previously described location factors to determine the sites where employment in manufacturing industries could be expected in the future.

Studies of Commercial Centers

Central business districts of central cities are complex areas, being intensely developed and typified by numerous shopping facilities and offices, high land values and large day-time concentrations of people. Studies33 of the Seattle and Tacoma central business districts included analyses of past trends in retail sales and office floor space construction in these core areas as compared to trends for the rest of the region. These studies showed that since the end of World War II—due to the large growth of population in the suburbs—a substantially greater portion of the region’s retail employment and sales is now in new outlying areas rather than in the central business districts. As a matter of fact—as Figure IV-15 shows—retail sales occurring in the Seattle and Tacoma central business districts in recent years have shown a slow decline. There has been an even greater decline in the number of retail establishments in the downtown areas.

In the office-service activity—which includes finance, insurance and real estate; personal and professional services; and general offices (excluding government)—lack of historic data makes employment or floor space trends unclear. There has been much construction of new office buildings both in and out of the downtown areas. An examination of

32. Charles H. Graves, op. cit.
33. These special studies were conducted by the PSRTS staff under the guidance of Larry Smith and Company.
building permits for recent years did not indicate clearly whether downtown office space was increasing at a faster rate than elsewhere.

While new buildings are being constructed, vacancy rates in older and loft-type structures are apparently much higher than in the past. In addition, some of the construction—particularly in the downtowns—has removed older buildings. Consequently, the new buildings do not represent as great a net increase in floor space as might appear at first glance.

The trend toward automation has affected the composition of downtown office employment. In the insurance and banking businesses, for instance, most downtown employees are executives or personnel associated with accounting and machine processing. These two businesses show increases in the total number of employees, but largely in sales personnel and cashiers in outlying branches. This trend is expected to continue. Therefore, the number of employees in the insurance and banking categories in the downtown areas is not expected to increase materially.

Even with automation and sophisticated communication systems, a large part of the daily business activity is still conducted on a person-to-person basis—for which downtown locations are ideally suited. However, much of the necessary face-to-face business is limited largely to executives. If the latter job component does not change substantially in number, it will have a direct effect on the proportion of the region's total insurance and banking employment which can be expected downtown.

There is a growing recognition, too, that such activities as machine and computer processing functions need not be located in the relatively more expensive and congested downtown space in order to have the necessary communication with management. The establishment by major banks of computer centers outside the downtown areas has already occurred in Tacoma and Seattle.

Even those central district firms which retain a downtown processing center are tending to establish two or three daily shifts to obtain full use of their expensive computers. Extra-shift operations serve to reduce the peak number of employees entering, leaving or remaining in downtown areas at any one time. While the number of workers involved in such activities is not substantial at this time, a trend is apparent; this is an example of changes which make evaluations of the downtown situation extremely difficult. Future periodic reappraisals of central district employment—when compared with base year data—will be helpful in clarifying future trends.

The commercial center analyses show that there has been a long-term downward trend in the number of people destined to central districts for all purposes, including work, despite new downtown construction.34 While it is evident that downtowns are shifting in the composition of their employment,35 it appears that the total has declined since the end of World War II in both Seattle and Tacoma.36 Concern over these trends has resulted in the development of planning studies and the formation of downtown associations in behalf of central district interests.

While the downtown districts have been experiencing inroads in their formerly pre-eminent position, outlying commercial areas have boomed. These latter centers have attracted retail comparison and convenience outlets primarily, but there has also been a notable employment growth in many services, including medical and dental care.

In brief, the commercial center analyses established a basis for predicting and planning the future location and intensity of employment activities in the region's central business districts and the outlying commercial areas.

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36. Comparisons of 1940 and 1961 origin and destination data show a decline in the total number of work trips to downtown Seattle. Also, work trips to downtown Tacoma declined between 1948 and 1961.
CURRENT TRAFFIC AND TRANSPORTATION CONDITIONS

A number of relatively small-scale studies were conducted to evaluate the current physical and operational conditions of the Puget Sound Region's system of transportation facilities, their present adequacy, particular problems, and elements which might have excess capacity available to accommodate future travel growth.

These studies involved surveys of (1) the street-and-highway system, (2) the transit service, and (3) the cross-Sound ferry service.

The resulting data revealed what the region has to work with in the way of a transportation system and, at the same time, provided a basis for evaluating the quality of service of alternative future systems relative to present conditions.

The Street And Highway System

In studying the region's current traffic and transportation conditions, the first task was to define the facilities which make up the arterial network of streets and highways of regional importance.

With the cooperation of all the participating jurisdictions and agencies in the region, the Transportation Study inventoried these facilities as a basis for appraising the quality of current travel service and the system's ability to meet future travel demands. This appraisal included street widths and grades at all principal intersections, curb parking conditions, major traffic control devices, speed limits, access control provisions, facility classifications (i.e., freeway, expressway, surface arterial, etc.), types of development along the facility, and whether transit routes utilized the facility.

A functional classification of the current street and highway system was then made by applying transportation and land use planning criteria to the inventory findings. Consideration was given to such matters as the relationship of the routes to neighborhoods and communities, desirable spacings between routes, the physical characteristics and continuity of the routes, and desirable percentages of the total system which should fall into particular classifications.

A total of 1,647 miles of streets and highways was thus designated as the basic network of major regional facilities in 1961—Highway Study System 1 (see Figure IV-16). Included were 103 miles of access-controlled freeways and expressways, 6.3 percent of the total network mileage.

CAPACITY

Planning for future transportation needs requires estimates of the traffic carrying capacity of each section of the street-and-highway system. The determination of this carrying ability was based on the physical inventory and current capacity standards for urban arterial intersections.37

In calculating the capacity of limited access facilities, the most recent experiences and studies of researchers across the nation were reviewed and standards set accordingly. Capacities were first computed on a peak-hourly basis—the conventional

and most meaningful method—after which they were converted to 24-hourly capacity equivalents.

Table IV-6 shows the resulting design capacities computed for the several types of facilities. A four-lane freeway has a capacity of between 39,800 and 48,500 equivalent passenger cars per day—depending upon the degree of peaking which occurs during the day and directionally during the peak hours.

### Table IV-6

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Number of 12-Foot Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Freeways</td>
<td>29,800 to 48,500</td>
</tr>
<tr>
<td>Expressways</td>
<td>32,800 to 42,400</td>
</tr>
</tbody>
</table>

Curb-to-Curb Widths (No Parking):

<table>
<thead>
<tr>
<th>20 Feet</th>
<th>40 Feet</th>
<th>60 Feet</th>
</tr>
</thead>
</table>
| Surface Arterials:
  Downtown | 3,950 to 5,930 | 7,380 to 11,080 | 14,320 to 21,480 |
  Fringe Business | 8,000 to 12,000 | 15,920 to 21,440 | 29,760 to 41,100 |
  Intermediate | 4,540 to 6,820 | 9,320 to 13,980 | 16,160 to 24,240 |
  Residential | 5,080 to 7,620 | 10,400 to 15,600 | 18,080 to 27,120 |

1. Assuming: 60 to 67 percent directional split and 11 to 13 percent of daily travel during design hour.
2. Assuming: Two-way streets; no parking during peak hour; 40 to 60 percent green signal time; 10 percent left, 10 percent right turns; 60 percent directional split, 11 percent of daily travel during design hour.
3. Assuming: Two-way streets; no parking during peak hour; 40 to 60 percent green signal time; 10 percent left, 10 percent right turns; 67 percent directional split, 11 percent of daily travel during design hour.

### Table IV-7

1961 HIGHWAY NETWORK CAPACITY IN CORDON AREA

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Mileage &amp; Design Capacity in Equivalent Passenger Car Miles Per 24 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterials</td>
<td>Number</td>
</tr>
<tr>
<td>Access Control</td>
<td>1,537</td>
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<tr>
<td>Controlled Access Facilities</td>
<td></td>
</tr>
<tr>
<td>Freeways and Expressways</td>
<td>103</td>
</tr>
<tr>
<td>Ramps</td>
<td>57</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,697</td>
</tr>
</tbody>
</table>

1. Mileage of facilities as coded for computer analysis.

Table IV-7 summarizes the capacity available on Highway Study System 1. The controlled access facilities—which they constitute just over 6 percent of the system's total mileage—provide over 15 percent of the carrying ability.

**Traffic Volumes**

Numerous traffic counts were made throughout the region to determine the usage of the 1961 street-and-highway system.

A composite of all counts permitted an overall view of the base year traffic flow for the area between Fort Lewis on the south, Marysville to the north, Bremerton to the west and Issaquah to the east (Figures IV-17, IV-18, IV-19 and IV-20). U.S. 99 was the region's main traffic artery, with a secondary major corridor of travel east-west across Lake Washington and Mercer Island. In 1961 the region's greatest travel intensity was 83,000 vehicles per day at the Aurora Bridge over the Lake Washington Ship Canal.

The Lake Washington Bridge carried 46,000 vehicles per day. Two million vehicle trips were made daily within the Study Area in 1961, involving 11.6 million vehicle miles of travel at an average speed of 27 miles per hour.

**Comparison of Volume to Capacity**

By comparing the counted traffic volume on each street facility with the capacity of that facility, the points of capacity deficiency—or surplus—were highlighted. By summarizing the figures for all of the facilities within a travel corridor, the adequacy of the network in satisfying travel demands was evaluated.

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Figure IV-21 shows the results of this comparison for a number of travel corridors in the region. As an example, the combined capacity-to-traffic-volume comparison for 1961 for all the bridges crossing the Ship Canal in Seattle revealed a capacity deficiency across the Canal of 74,000 vehicles per day. This is the equivalent of the carrying capacity of eight lanes of freeway.

In other words, if each of the facilities crossing the Ship Canal in 1961 were used to its capacity, the addition of an eight-lane freeway would be needed to serve the 1961 travel volumes adequately. This deficiency in capacity is the obvious indication of the congestion across the Ship Canal which was experienced in 1961.

On a system-wide basis, however, there is a surplus of capacity. Table IV-8 shows that only 53 percent of the capacity provided by the region's 30½ miles of freeway in 1961 was being utilized by the base year travel volumes; 65 percent of the arterial capacity was being used. Of course, capacity and travel volumes are not distributed in the same way, so there are points of capacity deficiency and congestion, as well as locations of capacity surplus.

**TRAVEL TIME**

Time is one of the most important considerations a driver applies in selecting his trip route. Consequently, knowledge of the travel time on streets and highways is important for use in planning new facilities and determining the usage which might be attracted.
The minimizing of travel time is a transportation planning technique utilized widely for allocating future travel to alternative transportation systems. Although several other methods to simulate motorists' route choices (termed "traffic assignment") have been tested, only the minimum time basis has found general use.

Over 900 miles of arterial streets and highways—including limited access facilities—were selected for travel time measurements in 1961. The data collected—both at peak and off-peak hours—ultimately resulted in speed standards for various types of facilities to be used in future highway planning (see Table IV-9). These "level of service" standards are both attainable and desirable speeds which facilities should be planned to achieve. The utilization of desirable speed standards in planning for future regional facilities will insure the proper appraisal of all needs without reference to current deficiencies.

**ACCIDENTS**

Reduction of accidents—and their attendant monetary and social losses—is an important goal in developing future transportation facilities. The latter must not only provide the required capacity, they must also be efficient, economical, convenient and safe.

With the bold assumption that a monetary value can be attached to human injury and death, an annual accident cost should be included in the evaluation of alternative transportation systems. The accident rates and associated costs shown in Table IV-10 were developed from a review of local and national studies.

It may seem paradoxical that both fatality rates and accident costs are higher on partially con-
trolled access facilities than on those with no access
control. The explanation is that the higher speeds
on the expressways cause more severe mishaps than
on arterials with no access control. Expressway
design standards are, of course, lower than those of
freeways. The desirability of providing higher type
traffic facilities in urban areas from a safety stand­
point is thus accentuated.

Accident data for individual facilities in the
region are not in a consistent form nor are they
systematically recorded for ease of analysis. Since
to make meaningful analyses, accident data for
several years must be compiled, it was not practical
to develop an explicit evaluation of the regional
accident experience as affected by facility type. In
general, however, it was possible to corroborate in
the region the national figures cited above by refer­
ing to the annual accident reports for the state
highway system outside of incorporated cities.30

PARKING

Parking facilities are also important in planning
an overall transportation network, since a trans­
portation facility is only as good as its ability to
accommodate the end-of-trip requirements of the
users. Necessarily, then, terminal facilities are an
integral part of the transportation system.

Restrictions in the number of available terminal
facilities can affect future travel to the areas where
limitations exist. This is particularly significant in
concentrated centers if future terminal capacity is
limited.

An inventory of 1961-62 parking facilities within
the central business districts of Seattle, Tacoma,
Everett and Bremerton was undertaken to assess
terminal adequacy (see Table IV-11). When com­
pared to forecasts of future travel, this data helped
determine whether additional facilities would be
needed for the 1985-90 planning period.

<table>
<thead>
<tr>
<th>Central Business District</th>
<th>Number of Parking Spaces in 1961</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seattle</td>
<td>4,854</td>
</tr>
<tr>
<td></td>
<td>24,335</td>
</tr>
<tr>
<td></td>
<td>29,189</td>
</tr>
<tr>
<td>Tacoma</td>
<td>2,042</td>
</tr>
<tr>
<td></td>
<td>3,639</td>
</tr>
<tr>
<td></td>
<td>5,681</td>
</tr>
<tr>
<td>Everett</td>
<td>1,764</td>
</tr>
<tr>
<td></td>
<td>1,566</td>
</tr>
<tr>
<td></td>
<td>3,330</td>
</tr>
<tr>
<td>Bremerton</td>
<td>644</td>
</tr>
<tr>
<td></td>
<td>1,531</td>
</tr>
<tr>
<td></td>
<td>2,175</td>
</tr>
</tbody>
</table>

Transit Service

An inventory was made to appraise the adequacy
of service provided by present transit facilities and
their ability to meet future travel demands. With
the cooperation of both private and public transit
operators, the Study surveyed and summarized such
information as the number of passengers carried,
location of routes, frequency of service, trip transfer
data, and size and age of bus fleets.

The bus routes operated by the various transit
companies in the Study Area are shown in Figure
IV-22 (less some minor loops and turn-arounds
because of the map scale).

Bus service frequency varies considerably from
area to area and by time of day. Table IV-12 shows
the headways (time interval between buses) during
peak and off-peak periods for the Seattle and

<table>
<thead>
<tr>
<th>Transit Operator</th>
<th>Headway in Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seattle Transit System</td>
<td>PM Peak Period Off-Peak Period</td>
</tr>
<tr>
<td>5 Representative Routes</td>
<td>5 to 19 11 to 30</td>
</tr>
<tr>
<td>Tacoma Transit System</td>
<td>12 to 20 15 to 30</td>
</tr>
<tr>
<td>2 Representative Routes</td>
<td></td>
</tr>
</tbody>
</table>

30. Washington State Highway Commission, Rural State Highway System
Accident Report (Olympia: Traffic Engineering Division, Department
Tacoma service areas. Suburban and intercity services operate at peak-period headways of 20 to 30 minutes or longer.

Table IV-13 portrays another way of illustrating the shorter headways of operation during the peak periods. It shows the number of buses operated by the Seattle Transit System by time of day.

<table>
<thead>
<tr>
<th>Hour Periods</th>
<th>Number of Buses in Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 AM - 8:00 AM</td>
<td>355</td>
</tr>
<tr>
<td>10:00 AM - 1:00 PM</td>
<td>174</td>
</tr>
<tr>
<td>3:00 PM - 4:00 PM</td>
<td>338</td>
</tr>
<tr>
<td>5:00 PM - 6:30 PM</td>
<td>363</td>
</tr>
<tr>
<td>10:00 PM - 1:00 AM</td>
<td>84</td>
</tr>
</tbody>
</table>

Seven of the companies providing transit service in the Puget Sound Region carried over 51 million passengers in 1961; the Seattle Transit System alone carried 77 percent of this total. Figures IV-23 and IV-24 show passenger volumes on the bus transit network in the base year. (Because of the map scale, the volume carried by two or more closely parallel routes are shown by a single flow band.)

Speed and headway are the primary determinants of transit attractiveness (whether transit or a private car is used in making a trip). The various transit operators in the region furnished schedules so service speeds could be determined. In addition, information was obtained from other areas and from manufacturers to ascertain attainable service speeds for other types of transit—express buses on freeways, rail rapid transit, etc. This speed information was then used in planning future transit systems.

Just as in the case of streets and highways, capacity values were established for the various types of transit service—buses on surface arterials, buses on freeways mixed with other traffic, buses on reserved lanes of freeways, and various forms of
rapid transit such as monorail or conventional two-rail systems. These were used in evaluating the type of transit needed to serve future travel demands.

The accident experience of transit is extremely favorable, particularly for service on reserved or exclusive rights-of-way. However, the accident levels for any of the common forms of transit are sufficiently low that accident costs do not weigh heavily in transit planning except in comparison to private vehicle travel.

Cross-Sound Service

Cross-Sound transportation is an important link in the regional network, and the cross-Sound ferry service is, in reality, an extension of the highway system. To appraise the ability of ferries to carry future travel demands, an inventory of the service and the physical facilities was made. The survey included such factors as size and age of the ferry boat fleet, the number of revenue passengers carried by route, walk-on passenger statistics, etc.

Base year ferry routes in the Study Area are shown in Figure IV-16 (Page 38). All are operated by Washington State Ferries with the exception of the Seattle-Victoria run. A total of 21 ferry vessels—with a combined capacity of 1,410 vehicles and 17,356 passengers—are in the Washington State Ferries fleet.

Table IV-14 summarizes the number of vehicles and walk-on passengers utilizing the ferry service in 1961. Ferries carried 5,828 vehicles and 7,328 walk-on passengers daily, while the Tacoma Narrows Bridge served an additional 6,560 vehicles. Comparative vehicular volumes for 1965 are also shown.

<table>
<thead>
<tr>
<th>Facility</th>
<th>1961 Average Daily Vessels</th>
<th>1965 Average Daily Vessels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mukilteo-Columbia Beach</td>
<td>176</td>
<td>1,071</td>
</tr>
<tr>
<td>Edmonds-Kingston</td>
<td>113</td>
<td>709</td>
</tr>
<tr>
<td>Seattle-Winslow</td>
<td>3,785</td>
<td>1,361</td>
</tr>
<tr>
<td>Seattle-Bremerton</td>
<td>3,116</td>
<td>821</td>
</tr>
<tr>
<td>Fauntleroy-Yashon</td>
<td>656</td>
<td>1,031</td>
</tr>
<tr>
<td>Yaquina-Southworth</td>
<td>33</td>
<td>66</td>
</tr>
<tr>
<td>Puget Sound-Southworth</td>
<td>429</td>
<td>558</td>
</tr>
<tr>
<td>Point Defiance-Tahlequah</td>
<td>70</td>
<td>212</td>
</tr>
<tr>
<td>Subtotal Ferries</td>
<td>7,328</td>
<td>5,829</td>
</tr>
<tr>
<td>Tacoma Narrows Bridge</td>
<td>—</td>
<td>4,560</td>
</tr>
<tr>
<td>Total All Facilities</td>
<td>7,328</td>
<td>12,389</td>
</tr>
</tbody>
</table>
Travel is the movement of people and goods to overcome the spatial separation between economic, social and other varied activities. The studies discussed in this section were designed to determine past and present travel patterns and their relationships to land use and population characteristics. These are fundamental factors necessary to establish a sound basis for forecasting the amount and pattern of future travel. Although information for travel by all modes was obtained by the same surveys, transit travel is discussed in a later section because it displays patterns and characteristics substantially different from private car travel.

**Interview Surveys**

The Study utilized four different interview surveys to obtain information regarding the travel of persons.

**Home Interview Survey**

Since nearly three-fourths of all travel begins and ends at home, travel information can best be obtained at that source. A statistically selected sample of 34,000 households out of the 474,000 in the most heavily urbanized portion of the Study Area (termed the Cordon Area) provided data about residents and their travel patterns and characteristics.

Over 12 million bits of information about 1961 travel were collected, processed and analyzed. Included were data on the origin, destination, length and purpose of each trip made during a 24-hour weekday; the mode of travel; and the land use at each end of the trip. In addition, various household statistics were recorded—the number of people living in the household; type of dwelling unit; number of licensed drivers and automobiles owned; the age, sex and occupation of each member; and the annual income range of the head of the household. Private car and transit travel information was provided by this survey.

**Truck-Taxi Interview Survey**

Since trips made by trucks and taxis usually do not begin or end at home, the latter is not the best place to collect information about such trips. Therefore, a statistically selected sample of over 8,800 truck and taxi operators throughout the Cordon Area was chosen to provide data about this type of travel. The origin, destination, purpose, length and time-of-day of each trip by each truck and taxi during a 24-hour weekday were recorded.

**Roadside Interview Survey**

Since trips entering or leaving the Study Area are not necessarily made by Study Area residents, the home interview study does not provide complete information about such trips. Consequently, motorists were interviewed at the major roads and highways at the Cordon Area boundary to obtain travel data about each entering and departing vehicle. The data included the origin, destination, purpose and time-of-day of the trip; the number of passengers in the vehicle; and the classification (type) of the vehicle. More than 105,000 motorists were thus interviewed.

**Ferry Vehicle-and-Passenger Survey**

Over 5,200 interviews were conducted in a two-part study: (1) a ferry screenline survey, which yielded travel data about motorists boarding Puget Sound ferries not crossing the Cordon line and therefore not included in the roadside interviews, and (2) a walk-on passenger survey which obtained travel information about all persons boarding the ferries on foot.

**Accuracy Checks**

To verify the adequacy and reliability of the survey information in representing the true conditions being experienced in the region, a number of accuracy checks were made. These tests involved comparisons of selected data obtained from the expanded sample interviews with reliable independent estimates of the same information from other sources.

The results confirmed that the information collected in the various surveys was representative of the distribution of population, employment and vehicle registration within the region and that it portrayed accurately the travel as it actually took place in the region during the base year. The data, therefore, provided a solid foundation for analyzing and establishing relationships between land use and travel and for developing forecasts for the future.

**Travel Survey Findings**

After the adequacy and reliability of the survey data were confirmed, the information was processed...
for analysis and comparison to establish the relationships between travel and the many factors which create and influence it.

**Number Of Trips**

Over 3,554,000 person trips were made each weekday in 1961 in the urbanized portion of the Puget Sound Region. Of this total, approximately 3 million were reported in the home interviews, 318,000 in the truck-taxi and 232,000 in the roadside surveys. Thus, the region’s residents were involved in the great majority of the trips. Therefore the home interview survey is the most important source of travel information.

**Mode Of Travel**

Table IV-15 shows the means by which the total travel was made. The importance of private vehicles in the region’s total transportation picture is apparent since this mode accommodated 91.7 percent of all trips. Public transit constituted 4.5 percent of all trips, while taxis, school buses and ferries accounted for the remainder. (See Figure IV-25 for a breakdown of trips by mode for sub-areas of the region.)

**Spatial Distribution Of Trips**

Figure IV-25 shows the origin and destination of all trips made in the Cordon Area on an average weekday in 1961. The heavy concentration of trips in the central business districts of the four major cities—as well as to the industrial areas in Tacoma, the Duwamish River basin, the Bremerton Naval Shipyard and Everett—illustrates the areas of acute traffic congestion in the Puget Sound Region. The trips are shown in terms of “trip ends” classified into “productions” and “attractions,” and the proportion of trips made by each mode of travel is indicated.41

**Trip Purpose**

The specific reasons why people travel are a major factor in determining travel patterns. The trip purpose is closely related to many other travel factors such as time, length and location of trips.

For example, work trips are concentrated primarily in the morning and evening peak hours. They tend to take more time than other trips, and they are directed to and from places of employment—the central business districts and industrial areas presenting particular concentrations of trip ends. Similarly, trips for other purposes have their own unique characteristics which must be analyzed to develop forecasts for the future.

Almost 80 percent of all weekday trips in the base year began or ended at home. This was most significant in the determination of the methodology for the analysis of trips. Those trips made to or from home—home based trips—were analyzed and forecast separately from trips with neither end at the home—non-home based trips (see Table IV-16).

---

41. For home based trips, the home end is the production end, while the non-home terminus is the attraction end. For all other trips, the origin is the production end, and the destination is the attraction end.
Trips between home and work constituted 29 percent of all home based trips in 1961—or over one-fifth of all trips made in the Cordon Area. A further breakdown of the “first work trips” (the first trip during the day for a work purpose regardless of the origin) revealed that manufacturing, retail and service establishments attracted nearly 60 percent of all first work trips (see Table IV-17).

The average number of occupants in a vehicle is very closely related to trip purpose. Table IV-18 shows the average car occupancy—according to trip purpose—computed by dividing all trips made by other than commercial vehicle drivers and transit riders by the number of private passenger car trips. This knowledge is necessary to develop the relationship between the number of person trips and vehicle trips.42

### Table IV-18

<table>
<thead>
<tr>
<th>Trip Purpose</th>
<th>Person Trips Per Average Weekday in 1961</th>
<th>Percent of Home Based Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Home Based</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work</td>
<td>605,529</td>
<td>22.8</td>
</tr>
<tr>
<td>Shopping</td>
<td>436,990</td>
<td>16.4</td>
</tr>
<tr>
<td>Social-Recreation</td>
<td>422,262</td>
<td>14.1</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>417,492</td>
<td>20.5</td>
</tr>
<tr>
<td>School</td>
<td>234,838</td>
<td>7.8</td>
</tr>
<tr>
<td><strong>TOTAL HOME BASED</strong></td>
<td>2,387,011</td>
<td>79.4</td>
</tr>
<tr>
<td><strong>Non-Home Based</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>618,195</td>
<td>26.4</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>3,005,206</td>
<td>100.0</td>
</tr>
</tbody>
</table>

1. Internal trips only.

1961 Origin and Destination Survey

The morning arrival and evening departure peaks attributable to work trips are typical of all major employment centers in the region. Work trips constitute over 85 percent of all trips made during the peak periods.

**Trip Length**

Trip length is another vital characteristic since it has a direct bearing on the volumes using each segment of the transportation system—and thereby on the system requirements. While trip length can be expressed in terms of distance, travel time seems to be most significant to urban travelers and is therefore used almost universally for transportation planning. The average length of trips made in 1961 by auto, truck and taxi for the various trip purposes is shown in Figure IV-28.

Average trip lengths varied between 13.1 minutes for home based shopping purposes and 23.5 minutes for home based work purposes. Thus, it is evident

42. The figures in the table represent a conversion factor between the non-tripstat and the non-passenger car person trips and passenger car trips. Therefore, they are not true occupancy values.
that work trips constitute the largest portion of travel in the region, both in numbers and in duration. Furthermore, work purpose trips converge on relatively small employment center areas—and, to further aggravate matters, they are concentrated into two comparatively short periods of the day. Figures IV-29 and IV-30 show the percentage trip length distribution of work and shopping purpose auto driver trips.

**Household Characteristics**

Table IV-19 shows the number of trips made by members of households (of varying sizes) during an average weekday in the base year.

The number of trips per household consistently increases as household size becomes greater. However, a clear relationship between household size and trip-making per person is not apparent due to a number of interacting factors. For example, in the smaller households both husband and wife usually work (and thus make work trips and raise the average), while in the larger households it is unlikely that the wife is employed—she is probably occupied at home with the children, therefore making only occasional shopping or miscellaneous trips.

**Table IV-19**

<table>
<thead>
<tr>
<th>Number of Persons in Household</th>
<th>Auto Driver Trips</th>
<th>Person Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Household</td>
<td>Per Person</td>
</tr>
<tr>
<td>1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>2</td>
<td>3.6</td>
<td>1.9</td>
</tr>
<tr>
<td>3</td>
<td>5.5</td>
<td>1.8</td>
</tr>
<tr>
<td>4</td>
<td>6.5</td>
<td>1.6</td>
</tr>
<tr>
<td>5</td>
<td>7.1</td>
<td>1.4</td>
</tr>
<tr>
<td>6 and 7</td>
<td>7.3</td>
<td>1.1</td>
</tr>
<tr>
<td>8 and over</td>
<td>8.1</td>
<td>1.1</td>
</tr>
<tr>
<td>All Households</td>
<td>4.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table IV-20 shows the number of trips made by members of each household in relation to the number of automobiles owned at the household.

**Table IV-20**

<table>
<thead>
<tr>
<th>Number of Autos Owned by Household</th>
<th>Average Number of Trips Per Household Per Weekday in 1961</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Auto Driver Trips: 0.1 Person Trips: 1.4</td>
</tr>
<tr>
<td>1</td>
<td>4.2</td>
</tr>
<tr>
<td>2</td>
<td>7.4</td>
</tr>
<tr>
<td>3</td>
<td>10.0</td>
</tr>
<tr>
<td>4 and Over</td>
<td>14.8</td>
</tr>
<tr>
<td>All Households</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Trip-making rises steadily with increasing auto ownership. A direct relationship is indicated with income also (see Table IV-21).

**Table IV-21**

<table>
<thead>
<tr>
<th>Median Annual Income of the Head of Household</th>
<th>Average Number of 1961 Weekday Person Trips Per Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $4,000</td>
<td>3.85</td>
</tr>
<tr>
<td>$4,000 to $5,999</td>
<td>7.54</td>
</tr>
<tr>
<td>$6,000 to $7,999</td>
<td>9.32</td>
</tr>
<tr>
<td>$8,000 to $9,999</td>
<td>10.23</td>
</tr>
<tr>
<td>$10,000 and over</td>
<td>11.18</td>
</tr>
<tr>
<td>All Income Groups</td>
<td>7.00</td>
</tr>
</tbody>
</table>
Auto ownership also tends to increase with income (see Table IV-22).

TABLE IV-22
RELATIONSHIP BETWEEN NUMBER OF AUTOS PER HOUSEHOLD AND INCOME OF THE HEAD OF THE HOUSEHOLD

<table>
<thead>
<tr>
<th>Median Annual Income of the Head of Household</th>
<th>Number of Autos Per Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than $4,000</td>
<td>0.65</td>
</tr>
<tr>
<td>$4,000 to $5,999</td>
<td>1.18</td>
</tr>
<tr>
<td>$6,000 to $7,999</td>
<td>1.37</td>
</tr>
<tr>
<td>$8,000 to $9,999</td>
<td>1.48</td>
</tr>
<tr>
<td>$10,000 and over</td>
<td>1.67</td>
</tr>
<tr>
<td>All Income Groups</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Trip-making also differs according to an individual's dwelling unit type. For instance, residents of large apartments (which are often located near one another where land use zoning permits) have reduced trip needs because many service facilities are usually within walking distance in areas with such concentrations of population. Table IV-23 shows how the number of person trips per day varies according to dwelling unit type.

TABLE IV-23
RELATIONSHIP BETWEEN NUMBER OF TRIPS AND DWELLING UNIT TYPE

<table>
<thead>
<tr>
<th>Type of Dwelling Unit Structure</th>
<th>Average Number of 1961 Weekday Person Trips Per Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Family Units</td>
<td>8.15</td>
</tr>
<tr>
<td>2, 3, and 4 Unit Structures</td>
<td>5.40</td>
</tr>
<tr>
<td>5 and More Unit Structures</td>
<td>3.91</td>
</tr>
<tr>
<td>Rooming Houses, Motels, and Hotels</td>
<td>1.60</td>
</tr>
<tr>
<td>All Structure Types</td>
<td>7.00</td>
</tr>
</tbody>
</table>

Summary

It can be seen from the preceding tables that the travel survey data established significant relationships of various factors with respect to travel. These relationships, in turn, were applied to forecasts of population, income, auto ownership, dwelling unit types, etc., in developing forecasts of travel for the future.
Part IV   Section 5

TRANSIT TRAVEL SURVEYS

The base year home interview surveys yielded information on both private vehicle and bus transit travel. The latter data and subsequent analyses of the factors which influence transit use formed the basis for developing forecasts of future transit patronage.

As in the private vehicle surveys, several accuracy checks were made to verify the adequacy and reliability of the transit travel data.

Transit Survey Findings

More than 161,000 transit trips—4.5 percent of the total regional person trips—were made during an average weekday in 1961. Approximately 156,000 were reported in the Study Area portion east of Puget Sound; an additional 5,300 took place west of the Sound.

Figure IV-31 shows the number of base year transit trips classified by trip purpose. Of all transit trips, 91 percent had either an origin or destination at home. Of these home based transit trips, nearly 50 percent were for work purposes. Only 29 percent of the total person trips—made by all travel modes in the region—were home based work trips. Thus transit travel is oriented to the home more than travel by all modes.

The transit flow maps (Figures IV-23 and IV-24 on Page 43) demonstrate the concentration of transit trips to and from the central cities. Figure IV-32 further amplifies this point.

Nearly one out of four transit trips have origins in the Seattle central business district, while three out of four begin generally within the Seattle city limits. With the exception of Tacoma—where one-eighth of the region’s transit trips have their origins—there are no other areas of heavy transit trip concentration.

Transit trips, like private vehicle trips, show peaks during short periods of time (see Figure IV-33). The morning peak is sharp, rising and falling rapidly in time, while the afternoon peak is spread over a longer period. Figure IV-34 shows how the trip purpose composition of transit travel varies throughout the day. During the 6 to 7 a.m. period, home based work trips make up over 88 percent of all transit usage, reflecting the relatively uniform starting hour of work. In the afternoon, however, the highest percentage of home based

1961 Origin and Destination Survey

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Figure IV-31 shows the number of base year transit trips classified by trip purpose. Of all transit trips, 91 percent had either an origin or destination at home. Of these home based transit trips, nearly 50 percent were for work purposes. Only 29 percent of the total person trips—made by all travel modes in the region—were home based work trips. Thus transit travel is oriented to the home more than travel by all modes.

The transit flow maps (Figures IV-23 and IV-24 on Page 43) demonstrate the concentration of transit trips to and from the central cities. Figure IV-32 further amplifies this point.

Nearly one out of four transit trips have origins in the Seattle central business district, while three out of four begin generally within the Seattle city limits. With the exception of Tacoma—where one-eighth of the region’s transit trips have their origins—there are no other areas of heavy transit trip concentration.

Transit trips, like private vehicle trips, show peaks during short periods of time (see Figure IV-33). The morning peak is sharp, rising and falling rapidly in time, while the afternoon peak is spread over a longer period. Figure IV-34 shows how the trip purpose composition of transit travel varies throughout the day. During the 6 to 7 a.m. period, home based work trips make up over 88 percent of all transit usage, reflecting the relatively uniform starting hour of work. In the afternoon, however, the highest percentage of home based

1961 Origin and Destination Survey

Transit Survey Findings

More than 161,000 transit trips—4.5 percent of the total regional person trips—were made during an average weekday in 1961. Approximately 156,000 were reported in the Study Area portion east of Puget Sound; an additional 5,300 took place west of the Sound.

As in the private vehicle surveys, several accuracy checks were made to verify the adequacy and reliability of the transit travel data.

Transit Survey Findings

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work trips is 67.6 percent. This is because trips with non-work purposes, not tied to a fixed schedule, are also being made during the afternoon hours.

Table IV-24 shows the number of transit trips by age group of the tripmaker.

### TABLE IV-24

**TRANSIT TRIPS BY AGE GROUP OF TRIPMAKERS**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Transit Person Trips Per Weekday in 1961</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 15</td>
<td>18,163</td>
<td>11.3</td>
</tr>
<tr>
<td>16 to 19</td>
<td>18,466</td>
<td>11.6</td>
</tr>
<tr>
<td>20 to 29</td>
<td>21,161</td>
<td>13.1</td>
</tr>
<tr>
<td>30 to 39</td>
<td>17,189</td>
<td>10.6</td>
</tr>
<tr>
<td>40 to 49</td>
<td>26,265</td>
<td>16.3</td>
</tr>
<tr>
<td>50 to 59</td>
<td>26,273</td>
<td>16.3</td>
</tr>
<tr>
<td>60 to 69</td>
<td>18,535</td>
<td>12.1</td>
</tr>
<tr>
<td>70 and Over, and Unreported</td>
<td>14,114</td>
<td>8.7</td>
</tr>
<tr>
<td>All Age Groups</td>
<td>161,345</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Over 11 percent of transit trips are made by those in the 5-to-15 age group, who are obviously non-drivers. Undoubtedly a proportion of the older age groups is also unable to drive for one reason or another. While those over 60 made more than 20 percent of the transit trips, they represented approximately 13 percent of the total population in 1960.

Table IV-25 shows the characteristics of transit tripmakers with emphasis on whether or not they rode transit by choice.

### TABLE IV-25

**TRANSIT TRIPS GROUPED BY CHARACTERISTICS OF TRIPMAKERS**

<table>
<thead>
<tr>
<th>Characteristics of Tripmaker</th>
<th>Transit Person Trips Per Weekday in 1961</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Household with no Auto</td>
<td>52,734</td>
<td>32.7</td>
</tr>
<tr>
<td>Non-Driver</td>
<td>53,393</td>
<td>33.1</td>
</tr>
<tr>
<td>No Auto Available to Tripmaker</td>
<td>23,240</td>
<td>14.5</td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td>129,487</td>
<td>80.3</td>
</tr>
<tr>
<td>Other</td>
<td>31,858</td>
<td>19.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>161,345</td>
<td>100.0</td>
</tr>
</tbody>
</table>

“Captive” tripmakers—those to whom no other mode of travel was available at the time of the trip—made over 80 percent of all transit trips. Planners must provide facilities for these “captive” tripmakers who depend on public transportation. Normal population increases will result in more who are “too young to drive,” while greater life expectancy will add to the ranks of senior citizens. This will tend to increase the number of “captive” transit riders, while growing auto ownership will tend to reduce the number of those who have no auto available to them.
Figure IV-35 shows the average length of transit trips by trip purpose. Of interest is the relatively small difference in trip length averages. Work trips have the longest average (37.3 minutes) and shopping trips the shortest (31.6 minutes). By comparison, auto driver trip lengths average 23.5 minutes for work and 13.1 minutes for shopping (see Figure IV-28, Page 48).

A trip length frequency distribution by trip purpose was also developed for transit trips from the travel survey data (see Figures IV-36 and IV-37). It can be seen that there are very few trips made by transit that are less than 15 minutes in length, in contrast to travel by private car (see Figures IV-29 and IV-30, Page 49).

Factors Affecting Transit Use

The division of total person travel between transit and private vehicle is called modal split and is affected by three major factors: (1) the relative attractiveness of the highway system compared to the transit network, (2) the purpose of the trip, and (3) the characteristics of the tripmaker. The Study developed a modal split technique to determine the proportion of the future movement of persons which can be expected to use the bus and rapid transit modes of travel.

QUALITY OF SERVICE

Trips made by transit as a percentage of the total number of person trips are higher in and

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45. James W. Schmidt, Modal Split Rationale, Staff Report No. 11; Herman Basmacyan and James W. Schmidt, Development and Application of a Modal Split Model for the Puget Sound Region, Staff Report No. 12 (Seattle: PSRTS, 1964).
around the central cities—where transit routes are concentrated—than in the overall region. Figure IV-38 shows transit trips as a percent of total person trips for each major area of the region. In the Seattle area, 10 percent of the total person trips are made by transit, while in Tacoma that percentage is half as large. The percentage declines as the city size and density get smaller.

Figure IV-38 shows transit trips as a percent of total person trips by location.

Trip Purpose

Figure IV-40 shows the wide variation in transit usage according to trip purpose, ranging from 10.6 percent for home based work to 2.4 percent for non-home based.

CHARACTERISTICS OF THE TRIPMAKER

Income

The income of the head of the household is a characteristic which appears to be directly related to transit usage (see Figures IV-41 and IV-42). While the total number of person trips per household increases as income goes up, transit trips decrease—both in number and as a percentage of total trips.

Auto Ownership

The definite relationship that exists between auto ownership and transit usage is shown in Figures IV-43 and IV-44. Both the number of transit trips and the percentage of person trips made by transit decline with increasing auto ownership. The slight increase in transit trips shown at the very high auto ownership level may be attributable to statistical instability due to the relatively small number of households at this auto ownership level.

Residential Density

The density of residential development has a direct effect on the quality and extensiveness of transit service since it determines the amount of potential patronage. In addition, those who live in the higher density areas tend to have a low car ownership level and other characteristics which are conducive to greater transit usage. The relation-

53
ship between residential density (expressed in terms of the type of residential structure) and transit usage, is illustrated in Figures IV-45 and IV-46.
SUMMARY

From the analyses and forecasts of the various factors influencing mode-of-travel choice, predictions of the amount of transit usage to be expected in the future for any assumed or planned systems of transit and highways can be made with confidence. A contingency, of course, is that no radical changes take place in personal tastes, way of life or the relative characteristics of transit vehicles or private cars in the years ahead.

Effect of Rapid Transit

The introduction of rapid transit would alter the relative comparison between transit vehicles and private vehicles, since rapid transit would offer significantly greater comfort, reliability and safety than is provided by buses operating in the normal traffic stream. Therefore, substantial modifications were made in the modal split procedure for predicting expected rapid transit usage. These modifications were based upon data from areas where rapid transit presently exists (Toronto, Chicago and Philadelphia) and from studies and plans for rapid transit in San Francisco and Washington, D.C.

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LAND USE PLANNING AND DEVELOPMENT FORECASTS

Since people and their daily activities are vital to the transportation planning process, two basic forecasts—of population and economic development—had to be made as a basis for determining the extent of future regional growth and the travel that will be generated. This section outlines the methods used to forecast these two key elements—and summarizes the results obtained.

Population

The land required to serve the needs of the population—and the location of this developed land—is related to the number of people living in the region and their characteristics. Thus, knowledge of the future population is basic to the determination of the region's future land use activities and the transportation facilities which will be needed to serve them.

The population forecast for the region was based primarily upon estimates of future birth and death rates; projections of the proportion of the nation's population which can be expected to locate in the State; and, in turn, the proportion of the State's total population which can be expected to locate within the region. The projection assumed continued migration into the State and reflected U.S. Census projections for birth and death rates, as well as for national and statewide population.\(^47\)

Washington State has been growing faster than the nation as a whole, while the Puget Sound Region has been outgaining the rest of the State. Washington had 1.28 percent of the nation's total population in 1920, and 1.59 percent in 1960; it is projected to have 1.66 percent in 1990. The Puget Sound Region had 47 percent of the State's population in 1920, 50 percent in 1950, 53 percent in 1960—and the 1990 projection is 58 percent. In 1960 the region's population was 1,513,000; the forecast for 1990 is 2,750,000.\(^48\)

With the regional total established, a forecast for each county was developed in collaboration with the Planning Directors Committee of the Puget Sound Regional Planning Council (see Figures IV-47 and IV-48).

The population for each county as a percent of the region's total for 1950, 1960, and 1990 is shown in Figure IV-49.

STUDY AREA FORECAST

The Study Area is the portion of the four counties expected to be urbanized by 1990. The population

\(^{47}\) For the detailed procedures used in developing the population forecast, see John R. Walker, Population Study for the Puget Sound Region, unpublished paper (Seattle: PSRTS, 1962).

\(^{48}\) Other independent forecasts have since produced essentially the same results, thus lending confidence to the Study's figures. See in particular the report of Arthur D. Little, Inc., op. cit.; and Population Forecasts, State of Washington, 1965 to 1985; State Planning Series No. 4 (Olympia, Wash.: Washington State Census Board, Department of Commerce and Economic Development, 1966).
forecast for this area was derived from the county forecasts by estimating the percentage of the total population which would be residing within the Study Area in 1990 (see Figure IV-50).

The proportion of the region’s total population living inside the Study Area is not expected to change materially. However, nominal changes are anticipated in the distribution of this population by county. The forecast of the Study Area population in 1990 is summarized in Figures IV-51 and IV-52.

For every 100 persons living in the Study Area in 1961, there will be almost 175 by 1990. The largest percentage increase is expected in Snohomish County, though in total numbers, King County accounts for over 60 percent of the forecasted growth (see Table IV-26).

\[
\begin{array}{cccc}
\text{Population Growth 1961 to 1990} & \\
\text{Study Area} & \text{Number} & \text{Percent of Total} \\
\hline
\text{King County} & 642,171 & 63.23 \\
\text{Kitsap County} & 42,762 & 3.94 \\
\text{Pierce County} & 165,432 & 15.33 \\
\text{Snohomish County} & 188,518 & 17.68 \\
\text{TOTAL STUDY AREA} & 1,075,833 & 100.00 \\
\end{array}
\]
In summary, the population forecast for the Puget Sound Region indicates an increase of approximately 80 percent over the 1960 level—or, in round figures to a total of 2½ million people. The urbanized portion—the Study Area—will grow to over 2½ million residents from the base year's 1½ million.

An important aspect to bear in mind, though, is that the Transportation Study's planning is based upon satisfying the land use and travel needs for this forecasted total whether it is reached in 1985, 1990 or 1995. If the region's growth deviates significantly from the projected rate, the Study's plans are still valid. Programs to implement the plans would simply have to be adjusted to match the growth actually experienced.

Economic Outlook

To establish a sound basis for land use and transportation planning, a forecast of economic activities is required. This forecast must be in terms of specific quantities and locations, since the trip forecasts must, likewise, be made for specific sites. Employment—because of its relationship to travel—was selected by the Study as a logical measure of economic activity.

To develop a sound forecast of employment, it is necessary to consider the various employment categories separately, since not all can be expected to change to the same degree. Each category also has differing site location characteristics. The final overall employment forecast, therefore, is a sum of the individual forecasts for each of a number of separate economic activity categories as shown earlier in Table IV-2, Page 28.

Based on data from a survey of local manufacturers and from a variety of supplementary sources, a mathematical model (a modified "input-output" type) was developed. This model—supplemented by independent forecasts for domestics, government employees and military personnel—was used to develop the employment forecasts presented in Table IV-27. The wide variation in the anticipated growth in the individual employment categories is striking, ranging from a decline of over 44 percent in agriculture, forestry and fisheries to an increase of almost 210 percent in entertainment and recreational services. The overall growth in employment is projected to be 68.8 percent, becoming more

### TABLE IV-27
TOTAL EMPLOYMENT IN THE PUget SOUND REGION

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing Industries:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lumber</td>
<td>15.0</td>
<td>20.1</td>
<td>34.0</td>
</tr>
<tr>
<td>Furniture</td>
<td>2.3</td>
<td>2.9</td>
<td>26.1</td>
</tr>
<tr>
<td>Stone, Clay</td>
<td>3.2</td>
<td>4.8</td>
<td>50.0</td>
</tr>
<tr>
<td>Primary Metals</td>
<td>3.4</td>
<td>4.5</td>
<td>91.2</td>
</tr>
<tr>
<td>Fabricated Metals</td>
<td>5.6</td>
<td>15.0</td>
<td>167.9</td>
</tr>
<tr>
<td>Machinery</td>
<td>4.1</td>
<td>4.0</td>
<td>48.3</td>
</tr>
<tr>
<td>Electrical Machinery</td>
<td>2.2</td>
<td>4.4</td>
<td>195.9</td>
</tr>
<tr>
<td>Food</td>
<td>13.6</td>
<td>24.5</td>
<td>80.2</td>
</tr>
<tr>
<td>Apparel</td>
<td>3.1</td>
<td>8.4</td>
<td>174.2</td>
</tr>
<tr>
<td>Printing and Publishing</td>
<td>6.0</td>
<td>12.2</td>
<td>103.3</td>
</tr>
<tr>
<td>Chemicals</td>
<td>2.3</td>
<td>5.4</td>
<td>134.8</td>
</tr>
<tr>
<td>Petroleum</td>
<td>0.3</td>
<td>0.4</td>
<td>33.3</td>
</tr>
<tr>
<td>Paper</td>
<td>4.0</td>
<td>7.0</td>
<td>75.0</td>
</tr>
<tr>
<td>Transportation Equipment</td>
<td>68.9</td>
<td>74.9</td>
<td>9.7</td>
</tr>
<tr>
<td>Miscellaneous Manufacturing</td>
<td>2.7</td>
<td>7.2</td>
<td>167.7</td>
</tr>
<tr>
<td>Total Manufacturing</td>
<td>138.7</td>
<td>198.7</td>
<td>43.3</td>
</tr>
<tr>
<td>Non-Manufacturing: (&quot;Unallocated Sector&quot;)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture, Forestry, and Fisheries</td>
<td>13.7</td>
<td>7.6</td>
<td>-44.5</td>
</tr>
<tr>
<td>Mining</td>
<td>0.6</td>
<td>1.3</td>
<td>116.7</td>
</tr>
<tr>
<td>Construction</td>
<td>37.2</td>
<td>73.9</td>
<td>100.7</td>
</tr>
<tr>
<td>Transportation, Communications, &amp; Utilities</td>
<td>49.3</td>
<td>48.8</td>
<td>9.4</td>
</tr>
<tr>
<td>Wholesale Trade</td>
<td>28.3</td>
<td>66.3</td>
<td>134.3</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>94.3</td>
<td>156.5</td>
<td>66.0</td>
</tr>
<tr>
<td>Finance, Insurance, &amp; Real Estate</td>
<td>32.3</td>
<td>88.4</td>
<td>177.3</td>
</tr>
<tr>
<td>Business, Repair, &amp; Personal Services</td>
<td>37.5</td>
<td>46.1</td>
<td>22.9</td>
</tr>
<tr>
<td>Entertainment &amp; Recreational Services</td>
<td>4.7</td>
<td>14.5</td>
<td>200.5</td>
</tr>
<tr>
<td>Professional &amp; Related Services</td>
<td>47.6</td>
<td>107.9</td>
<td>126.7</td>
</tr>
<tr>
<td>Total Unallocated Sector</td>
<td>345.5</td>
<td>631.2</td>
<td>82.7</td>
</tr>
<tr>
<td>Total Manufacturing &amp; Unallocated</td>
<td>484.2</td>
<td>829.9</td>
<td>71.4</td>
</tr>
<tr>
<td>Other Civilian Employment:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestics</td>
<td>14.7</td>
<td>22.8</td>
<td>55.1</td>
</tr>
<tr>
<td>Government Manufacturing</td>
<td>1.5</td>
<td>2.0</td>
<td>33.3</td>
</tr>
<tr>
<td>Government</td>
<td>59.7</td>
<td>102.5</td>
<td>71.7</td>
</tr>
<tr>
<td>Total Other Civilian Employment</td>
<td>75.9</td>
<td>127.3</td>
<td>67.7</td>
</tr>
<tr>
<td>Subtotal Civilian Employment</td>
<td>560.1</td>
<td>957.2</td>
<td>70.9</td>
</tr>
<tr>
<td>Military</td>
<td>34.8</td>
<td>36.0</td>
<td>3.9</td>
</tr>
<tr>
<td>TOTAL EMPLOYMENT</td>
<td>594.9</td>
<td>992.0</td>
<td>66.8</td>
</tr>
</tbody>
</table>

\[i. \text{The 1961 figures are estimates by the Transportation Study, while the 1990 forecasts were prepared by Arthur D. Little, Inc.}\]

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49. Arthur D. Little, Inc., op. cit. (See Page 8)
heavily oriented to service rather than manufacturing types.

The amount of projected employment helps to determine future trip-making totals. Similarly, forecasted changes in the composition of the total labor force indicate an alteration in the trip-making patterns—since the locational characteristics of the various employment categories are different. The much faster growth rates predicted for the service industries, compared to manufacturing, suggest that travel to commercial centers will increase at a faster rate than travel to industrial areas. Therefore, a forecast of future travel patterns must consider changes in the makeup of the future economy.

**STUDY AREA FORECAST**

As in the case of population projections, the total regional employment forecast had to be translated to a forecast for the Study Area. The resulting forecasts for each of the employment categories are shown in Table IV-28. The figures are presented in detail for the Cordon Area (the most intensively analyzed sector) and to a lesser degree for the Study Area. This is the forecast of 1990 employment used as a basis for developing forecasts of future land use activities and their resultant effects on travel.

**Plan A and Plan B Concepts**

As a basis for developing a sound regional plan, the Study was assigned the task of formulating and evaluating a series of alternative land use patterns, two of which were subsequently analyzed in detail. The alternative concepts were scaled to a population of 5 million (expected to be reached in the year 2020 or thereabouts). This would allow sufficient time to permit a gradual transition to a desired urban form.

One of the alternatives analyzed in detail was Plan A, representing a continuation of the current unplanned spread of residential development into the suburbs. The second was Plan B, a planned pattern of cities-and-corridors; this concept was selected for detailed analysis and evaluation by the regional planning directors, planning commissions and local governing bodies from several concepts developed by the Study staff. Analysis of Plans A and B—which differed in land use as well as transportation system requirements as they might occur in 1985 to 1990—formed the basis for the Study's ultimate recommendations.

Both Plans A and B were defined in terms of amounts of population and employment which could be expected by 1985 to 1990 in each analysis zone. The population and land use models developed from the basic planning studies were used to determine these expected distributions of future population and employment. Since the policies and objectives applied to each alternative land use pattern were different, the resulting land use and employment forecasts for each analysis zone differed.

**PLAN A OBJECTIVES AND ASSUMPTIONS**

Plan A's basic objective was to determine where the land-consuming activities would be located if the region continued to grow according to present trends and policies—which with regard to residential development. The latter included such considerations as the absence of a regional open space program51 and the uncoordinated plans and zoning ordinances of the various political jurisdictions in the region.

**THE PLAN A PATTERN**

The generalized Plan A land use pattern for the 1985-to-1990 development is shown in Figure IV-53. Most apparent is the substantial spread outward of low-density residential development, following no recognizable pattern nor exhibiting a particular orientation to its parent community. Employment activities tend to be concentrated in the same general locations as in 1961. The implication of this growth pattern is an increased dependence on private autos to accommodate the travel in the low-density suburban areas and an increased length of trips to places of work and shopping in the central cities.

**Residential Holding Capacity**

Figure IV-54 shows the proportion of the residential holding capacity52 of each analysis zone which the 1961 development was already utilizing. Expectedly, the areas closest to city centers were already at their holding capacity in the base year. Figure IV-55 depicts how the Plan A population projection for each analysis zone compares to the holding capacity. In comparison to Figure IV-54, this portrays vividly the spreading of growth outward from the central cities.

**Employment Locations (Lack of Trend Data)**

Plan A represents a continuation of present trends only with respect to residential development.

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50. Charles H. Graves, op. cit., Staff Report No. 15 and Rajanikant N. Joshi, op. cit., Staff Report No. 17 (See Page 34).
51. A regional open space plan has been developed since by the Puget Sound Governmental Conference.
52. The maximum population which can be accommodated in a given area under current zoning provisions.
Employment Concentrations

The forecasts used for the analysis of Plan A for 1985 to 1990 indicate 0.71 jobs in the Seattle city limits for every person living there, in contrast to the comparable figure of 0.50 in 1961. The Tacoma figures are 0.54 and 0.36, respectively. The Plan A analysis assumptions must therefore be considered as representing a pattern of centralized employment with a dispersed population.

The Seattle central business district was assumed to have a 1985-to-1990 employment of more than 127,000, or an increase of 80 percent over 1961 levels. In Tacoma the comparable employment figure was 18,000, also representing an 80 percent increase over 1961.

The forecasted population and employment distributions for 1985 to 1990 for Plan A for each of

The U.S. Census furnishes decade-by-decade information on the location of population, but there is no comparable data with respect to the location of employment. Only in the case of retail employment in the central business districts is U.S. Census data available—and then only since 1948 for Seattle and 1954 for Tacoma. As was pointed out in Part IV, Section 2, these Census of Business figures show that retail sales, retail employment and the number of retail establishments have declined in both the Seattle and Tacoma downtowns since 1948 and 1954, respectively.

The most meaningful available figures that reflect downtown employment were derived from a 1946 travel study for Seattle which showed a greater number of people with downtown destinations than in 1961. Similar results for the period from 1948 to 1961 were obtained for Tacoma. 53 This was true for work, shopping and other trip purposes. It is certain, therefore, that downtown areas experienced an overall employment loss in view of this decline in person destinations to downtown areas. For purposes of analysis, however, the employment figures assigned to the Seattle and Tacoma central business districts represented a substantial (80 percent) growth in employment there.

53. Walker and Cowan, op. cit., Staff Report No. 3, Revised (See Page 37).
the Study's analysis districts—as compared to 1961—are shown in Figures IV-56 and IV-57.

PLAN B OBJECTIVES AND ASSUMPTIONS

The basic objectives of the analysis of Plan B was to determine the distribution of land-consuming activities if the region grew according to consistent region-wide policies directed toward achieving a desirable development pattern. The cities-and-corridors pattern combines the best features of the Study's various alternatives. The Plan B land use policies which differ from existing policies are:

1. Belts of open space—including lands in agricultural, forest, recreational and similar uses—will be utilized to provide for the region's open space needs and to separate the cities and towns, giving each a definite individual identity.

2. Job activities will be located in the employment centers of the central cities and the large peripheral cities. The smaller satellite communities will have primarily service categories of employment.

3. Areas adjacent to employment centers and along major transportation corridors will be reserved for higher density residential uses, with the density declining as the distance from job sites and major transportation facilities increases.

4. Selective redevelopment will take place in the future when necessary to create or strengthen such key areas as town centers and the open space systems separating the planned towns.

THE PLAN B PATTERN

Assuming these policies to be in force, the resulting generalized land use pattern for 1985 to 1990, based on the cities-and-corridors concept, is shown

---

in Figure IV-58. The map illustrates how the open space system can give definition and direction to the region's urbanized areas in the form of planned towns.

Residential Holding Capacity

The proportion of the residential holding capacity of each analysis zone which would be consumed by the Plan B 1985-to-1990 development is shown in Figure IV-59. The Plan B policies and assumptions are reflected in the distribution of land uses in many ways. For example, some areas are forecasted to house fewer people than in Plan A because the open space bands will remove certain lands from development. On the other hand, Plan B does not adhere rigidly to existing zoning provisions but recognizes the tendency for residential densities to increase adjacent to such areas as town centers. Thus, these were forecasted to have a higher population in Plan B than in Plan A.

The forecasted population and employment distributions for 1985 to 1990 for Plan B for each of the Study's analysis districts—as compared to 1961—are shown in Figures IV-60 and IV-61.

Employment Locations and Concentrations

The employment assigned for the analysis of Plan B represents a substantial increase in the central cities with respect to the future location of employment—a 36 percent increase for Seattle's downtown and a 50 percent rise for Tacoma's. The employment outside the central cities is conceived to be primarily in employment complexes in the outlying communities, supplemented by industrial areas generally as they are presently existing or planned.

The Plan B employment—being an integral part of the planned outlying communities—is thus less widely dispersed throughout the suburban areas than in Plan A. However, the values assigned to the analysis of Plan B do represent a lesser growth rate in the central cities than the values used for the analysis of Plan A, and they reflect present trends involving the development of outlying industrial parks, shopping centers and other employment opportunities.
These analysis values for Plan B represent 0.55 jobs in the Seattle city limits for every person living there compared to the 1961 value of 0.50. The comparable figures for Tacoma are 0.45 and 0.36, respectively.

The relationship between the location of population and employment in Plan B therefore implies a lesser length of trip for work, shopping and other purposes than would be the case for Plan A.

Forecast of Household and Population Characteristics

The characteristics of each area—analysis zone—within the region determine the number of trips which will be produced in or attracted to the particular analysis zone. These characteristics include: (1) the type of development in the zone, (2) the number and size of households, (3) the residential density, (4) average income of the head of each household, and (5) the average automobile ownership. These characteristics were forecasted for each analysis zone for Plan A and Plan B.

Income of Head of Household

Since income is an important personal characteristic directly related to trip-making—and since the household was used by the Study as a measure for forecasting travel—forecasts were developed (in consultation with staff planners in each local area) for the median income for the head of the household for each analysis zone in the region. The home interview survey provided the 1961 data on which the forecast was based. The results showed a base year median income of $5,312—with an expected increase to $6,534 by 1990 (in terms of constant dollars with 1954 as the base).55

Number and Size of Households

Forecasts were made of the number of people who would be living in each analysis zone in each of three dwelling unit types: single family units, multi-family structures with fewer than 20 units per structure, and multi-family structures with more than 20 units. These results were further translated into a forecast of the number of households in each of the structure types.

Table IV-29 shows the forecast of total households for the Study Area, an increase of 80 percent over 1961. The slight differences between Plan A and Plan B among the counties are accounted for by such factors as an upward adjustment in the size of the Polaris facility in Kitsap County made for the analysis of Plan B and a cross-Sound bridge—with its associated effects on growth—assumed as a part of Plan B.

It is estimated that the combined effect of the two above-mentioned factors will increase the number of households in Kitsap County in 1990 by 1,500 compared to the Plan A assumptions. The relatively minor effect which the cross-Sound bridge is expected to have on the number of households can be attributed to two considerations: (1) it is not possible to have the bridge constructed and in operation much before 1980, and (2) its anticipated toll rate will be similar to the present ferry toll rate (approximately $1.50 for car and driver). Such a high toll will not tend to stimulate significant commuter-type growth across the Sound during the ten-year period between 1980 and 1990.

Because it was forecasted that the proportion of each dwelling unit type would differ from the base year ratio—and the average household size differs for each dwelling unit type—a new average household size was developed for each analysis zone. The results for the Study Area are shown in Table IV-30.

Automobile Ownership

The forecast of auto ownership reflects the past upward trends and the effect of the forecasted increase in personal income. Auto ownership is expected to grow at a faster rate than population, but the growth is projected at a slower pace than has been the case in the past.

66. Ibid.
67. R. R. Nath, op. cit., Staff Report No. 17 (See Page 34).
68. The additional population forecasted for Kitsap County in 1990 with a cross-Sound Bridge is 8,500. As a comparison, the Gig Harbor Peninsula had a population growth of approximately 1,500 between 1960 and 1965 when the Tacoma Narrows Bridge toll was 50 cents. Between 1950 and 1960 Mercer Island experienced a population increase of approximately 7,000 at a time when the Lake Washington Bridge was toll-free.
The forecast of the number of automobiles owned or normally garaged at households in each county is shown in Table IV-31. Table IV-32 shows the forecasted average number of automobiles per household.

This is not a forecast of the number of passenger cars expected to be registered in the Study Area since it does not include passenger cars owned by companies or governmental agencies which are not customarily garaged at a home.

Table IV-33 shows the forecast of commercial vehicles expected to be registered in each county.

### Table IV-31

**Total Number of Automobiles Owned or Garaged at Households**

<table>
<thead>
<tr>
<th>Area</th>
<th>1961</th>
<th>1990 Plan A</th>
<th>1990 Plan B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cordon Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>King County</td>
<td>242,704</td>
<td>753,500</td>
<td>750,000</td>
</tr>
<tr>
<td>King County Portion</td>
<td>22,007</td>
<td>44,500</td>
<td>46,500</td>
</tr>
<tr>
<td>Pierce County</td>
<td>94,277</td>
<td>193,500</td>
<td>195,000</td>
</tr>
<tr>
<td>Snohomish County</td>
<td>67,305</td>
<td>160,000</td>
<td>183,000</td>
</tr>
<tr>
<td>TOTAL CORDON AREA</td>
<td>320,095</td>
<td>1,164,500</td>
<td>1,154,500</td>
</tr>
<tr>
<td>Remainder of Study Area</td>
<td>7,856</td>
<td>21,000</td>
<td>23,113</td>
</tr>
<tr>
<td>TOTAL STUDY AREA</td>
<td>327,951</td>
<td>1,185,500</td>
<td>1,177,613</td>
</tr>
</tbody>
</table>

### Table IV-32

**Average Number of Automobiles Owned or Garaged Per Household**

<table>
<thead>
<tr>
<th>Area</th>
<th>1961</th>
<th>1990 Plan A</th>
<th>1990 Plan B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cordon Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>King County</td>
<td>1.084</td>
<td>1.411</td>
<td>1.411</td>
</tr>
<tr>
<td>King County Portion</td>
<td>1.013</td>
<td>1.336</td>
<td>1.336</td>
</tr>
<tr>
<td>Pierce County</td>
<td>1.094</td>
<td>1.422</td>
<td>1.422</td>
</tr>
<tr>
<td>Snohomish County</td>
<td>1.230</td>
<td>1.876</td>
<td>1.876</td>
</tr>
<tr>
<td>TOTAL CORDON AREA</td>
<td>1.097</td>
<td>1.422</td>
<td>1.422</td>
</tr>
<tr>
<td>Remainder of Study Area</td>
<td>1.167</td>
<td>1.517</td>
<td>1.520</td>
</tr>
<tr>
<td>TOTAL STUDY AREA</td>
<td>1.098</td>
<td>1.434</td>
<td>1.434</td>
</tr>
</tbody>
</table>

### Table IV-33

**Total Number of Commercial Vehicles Registered Within the Cordon Area**

<table>
<thead>
<tr>
<th>Cordon Area Portion of the Counties</th>
<th>1960</th>
<th>1990 Plan A</th>
<th>1990 Plan B</th>
</tr>
</thead>
<tbody>
<tr>
<td>King County</td>
<td>41,866</td>
<td>89,760</td>
<td>89,760</td>
</tr>
<tr>
<td>King County Portion</td>
<td>3,980</td>
<td>8,240</td>
<td>8,240</td>
</tr>
<tr>
<td>Pierce County</td>
<td>15,046</td>
<td>28,056</td>
<td>28,056</td>
</tr>
<tr>
<td>Snohomish County</td>
<td>10,362</td>
<td>30,352</td>
<td>30,352</td>
</tr>
<tr>
<td>TOTAL</td>
<td>76,405</td>
<td>162,433</td>
<td>163,433</td>
</tr>
</tbody>
</table>

Residential Densities

The density of residential development in each analysis zone was computed in terms of the total developed acreage (persons per gross acre in urban development) as well as in terms of the acreage developed in residential uses (persons per net acre). The overall results are shown in Tables IV-34 and IV-35.

The forecast was based on the forecasted growth in the number of each type of dwelling unit in each analysis zone and on estimates of future lot sizes, using current zoning for Plan A and the planning principles inherent in the concept for Plan B.

### Table IV-34

**Gross Residential Density**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>King County</td>
<td>3.12</td>
<td>5.40</td>
<td>5.38</td>
</tr>
<tr>
<td>Kitsap County</td>
<td>1.47</td>
<td>2.58</td>
<td>2.70</td>
</tr>
<tr>
<td>Pierce County</td>
<td>2.00</td>
<td>3.18</td>
<td>3.19</td>
</tr>
<tr>
<td>Snohomish County</td>
<td>1.13</td>
<td>2.42</td>
<td>2.42</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2.32</td>
<td>4.04</td>
<td>4.04</td>
</tr>
</tbody>
</table>

### Table IV-35

**Net Residential Density**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>King County</td>
<td>20.54</td>
<td>17.93</td>
<td>20.28</td>
</tr>
<tr>
<td>Kitsap County</td>
<td>17.21</td>
<td>15.38</td>
<td>15.21</td>
</tr>
<tr>
<td>Pierce County</td>
<td>17.14</td>
<td>15.94</td>
<td>17.26</td>
</tr>
<tr>
<td>Snohomish County</td>
<td>14.73</td>
<td>14.05</td>
<td>15.76</td>
</tr>
<tr>
<td>TOTAL</td>
<td>18.84</td>
<td>16.81</td>
<td>18.70</td>
</tr>
</tbody>
</table>

Summary

The preceding forecasts—along with others for population and employment—constitute the foundation for forecasting trips. For each analysis zone two separate forecasts—one for Plan A and one for Plan B—were prepared for each of these factors. While only summary results have been shown in this report, actual forecasts were prepared for each analysis zone—and it was at this level that trip forecasts were computed.


61. Ibid.
TRAVEL FORECASTS

Section 6 describes the forecasts of population, employment and characteristics of population and households. These forecasts provided the basis for developing forecasts of travel.

The forecast of the number of trip origins and destinations in each analysis zone and the trip interchange patterns between pairs of analysis zones is a complex process, and yet it is extremely critical from the standpoint of determining future transportation facility needs. This section discusses the procedures utilized to forecast the travel associated with Land Use Plan A and Plan B and summarizes the results.

Forecasts of Total Person Trips

The Transportation Study approach was to analyze and forecast travel by people (person trips) rather than travel by vehicle. The forecast procedures accounted for the factors which the analysis of the 1961 data showed were significant. Because of notable differences in the characteristics of the various kinds of trips, separate forecasts were made for (1) the home end of home based person trips, (2) the non-home end of person trips beginning or ending at home, (3) non-home based trips, and (4) trips across the cordon boundary and Puget Sound.

Home End of Home Based Trips

The 1961 travel data for each zone was analyzed in relation to the residential density and population characteristics of the zone. Person trip generation rates, in terms of trips per household, were computed for each trip purpose from the base year survey data for each combination of density and population characteristics. 61 These trip generation rates were applied in accordance with the forecasts for each analysis zone of the residential density and the characteristics of the residents. 62 The result was the person trip forecast for the home end of home based trips in each analysis zone. These, in total, are presented in Table IV-36.

The forecasts indicate an increase of more than 85 percent over 1961 in total home based person trips. The slight difference between Plans A and B is due almost entirely to a lesser number of school trips in the latter since reduced distances to schools in the more compact suburban communities of Plan B will permit more of the school trips to be made by walking.

Non-Home End of Home Based Trips

The degree to which trips from the home are attracted to other areas is dependent upon the type and intensity of activities taking place in each area. Trip attraction rates relating trip attracting characteristics of each type of land use activity to measures of the intensity of the activity were computed from the 1961 data. 63 Thus the level of person trip attraction for each purpose of home based trips was defined for each type of land use activity.

Table IV-37 shows the factors which were found to determine the trip-attracting characteristics for the various home based trip types. Trip generation rates—computed from these characteristics—were applied to the forecasts of future activity in each analysis zone to forecast the number of home based trips which would be attracted to each zone.

Non-Home Based Trips

Non-home based trips—which neither begin nor end at the trip-maker's residence—were subdivided into (1) trips by commercial vehicles, and (2) trips by residents of the Study Area. While neither of these categories has a beginning or ending at the home, their number, nonetheless, is determined by the characteristics of the home. Consequently, a trip generation rate was calculated and applied similarly to the home based trips.

### Table IV-36

<table>
<thead>
<tr>
<th>Home Based Trips Within Cordon Area</th>
<th>1961</th>
<th>1990</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Person Trips Per Average Weekday</strong></td>
<td>1990</td>
<td>1961</td>
<td></td>
</tr>
<tr>
<td><strong>Trip Purpose</strong></td>
<td><strong>A</strong></td>
<td><strong>B</strong></td>
<td><strong>A</strong></td>
</tr>
<tr>
<td>Home Based Work</td>
<td>465,529</td>
<td>1,177,893</td>
<td>1,170,457</td>
</tr>
<tr>
<td>Home Based Shopping</td>
<td>423,890</td>
<td>916,586</td>
<td>916,586</td>
</tr>
<tr>
<td>Home Based Social-Recreation</td>
<td>422,252</td>
<td>1,043,252</td>
<td>1,043,252</td>
</tr>
<tr>
<td>Home Based Miscellaneous</td>
<td>417,692</td>
<td>928,076</td>
<td>910,316</td>
</tr>
<tr>
<td>Home Based School</td>
<td>234,838</td>
<td>513,611</td>
<td>495,157</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>2,287,011</td>
<td>4,465,547</td>
<td>4,400,763</td>
</tr>
</tbody>
</table>

1. Trips made in trucks used solely for personal use are not included in the 1961 figures but are included in the forecasts.


62. It was assumed that for each combination of population characteristics and residential density, the future trip generation rate would be the same as in 1961. There is no historic data to verify whether these rates have remained constant or not. This then, is a matter for periodic re-examination.

63. Cowan and Walker, op. cit., Staff Report No. 16 (This page).
tion rates for these non-home based person trips and commercial vehicle trips were keyed to the characteristics of each analysis zone. This yielded the number of commercial vehicle trips and the non-home based trips which residents of the region could be expected to make (see Table IV-38).

### Table IV-38

<table>
<thead>
<tr>
<th>Type of Trip</th>
<th>Total Person Trips Per Average Weekday</th>
<th>1961</th>
<th>1990 Plan A</th>
<th>1990 Plan B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Home Based</td>
<td>618,195</td>
<td>1,211,158</td>
<td>1,210,895</td>
<td></td>
</tr>
<tr>
<td>Commercial Vehicle</td>
<td>317,926</td>
<td>523,967</td>
<td>528,730</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>936,121</td>
<td>1,735,125</td>
<td>1,739,625</td>
<td></td>
</tr>
</tbody>
</table>

1. Includes only trips produced within the Cordon boundary.
2. The 1961 commercial vehicle figure includes 41,498 person trips made in trucks kept exclusively for personal use. Comparable trips in the Plan A and Plan B forecasts are included as person trips for the individual trip purposes rather than as commercial vehicle trips.

### Trips Crossing the Cordon Boundary

To complete the trip picture, a forecast was made of trips taken within the Study Area by non-residents. To do this, the historic trend of traffic growth was analyzed at all major crossings of the cordon boundary and extended into the future, taking into account the extraneous factors which might have distorted the trend in past years. The resulting forecast is summarized in Table IV-39.

### Table IV-39

<table>
<thead>
<tr>
<th>Trip Purpose</th>
<th>Total Person Trips Per Average Weekday</th>
<th>1961</th>
<th>1990 Plan A</th>
<th>1990 Plan B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Based Work</td>
<td>60,817</td>
<td>101,589</td>
<td>101,589</td>
<td></td>
</tr>
<tr>
<td>Home Based Shopping</td>
<td>24,072</td>
<td>50,998</td>
<td>51,206</td>
<td></td>
</tr>
<tr>
<td>Home Based Social-Recreation</td>
<td>46,250</td>
<td>122,582</td>
<td>122,948</td>
<td></td>
</tr>
<tr>
<td>Home Based Miscellaneous</td>
<td>39,542</td>
<td>91,110</td>
<td>92,340</td>
<td></td>
</tr>
<tr>
<td>Home Based School</td>
<td>2,136</td>
<td>4,594</td>
<td>4,594</td>
<td></td>
</tr>
<tr>
<td>Non-Home Based</td>
<td>17,186</td>
<td>44,522</td>
<td>44,526</td>
<td></td>
</tr>
<tr>
<td>Commercial Vehicle</td>
<td>20,368</td>
<td>31,792</td>
<td>32,844</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>210,441</td>
<td>481,116</td>
<td>482,146</td>
<td></td>
</tr>
<tr>
<td>Through Trips</td>
<td>21,308</td>
<td>46,064</td>
<td>46,054</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>231,749</td>
<td>497,170</td>
<td>498,200</td>
<td></td>
</tr>
</tbody>
</table>

1. Not including trips made in trucks kept exclusively for personal use. The 1961 figure includes 5,659 person trips representing passengers in commercial vehicles.

### Cross-Sound Trips

Because the area west of Puget Sound is materially different from the remainder of the Study Area in travel characteristics (and is expected to remain so), the travel there was treated separately. This required a forecast to be made of future travel across the Sound. The forecast was based on an examination of historical trends, analyses of 1961 data, the distribution of population on both sides of the Sound and the effect of projected changes in cross-Sound transportation facilities (see Table IV-40). (The effects of a cross-Sound bridge were included in the Plan B figures.)

### Summary of Total Person Trips

The total person trip forecasts are shown in Table IV-41.

### Table IV-40

<table>
<thead>
<tr>
<th>Trip Purpose</th>
<th>Person Trips Per Average Weekday</th>
<th>1961</th>
<th>1990 Plan A</th>
<th>1990 Plan B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Based Work</td>
<td>10,057</td>
<td>21,497</td>
<td>24,404</td>
<td></td>
</tr>
<tr>
<td>Home Based Shopping</td>
<td>2,671</td>
<td>4,988</td>
<td>4,700</td>
<td></td>
</tr>
<tr>
<td>Home Based Social-Recreation</td>
<td>4,403</td>
<td>9,476</td>
<td>12,608</td>
<td></td>
</tr>
<tr>
<td>Home Based Miscellaneous</td>
<td>3,254</td>
<td>6,471</td>
<td>7,921</td>
<td></td>
</tr>
<tr>
<td>Home Based School</td>
<td>1,074</td>
<td>1,744</td>
<td>2,073</td>
<td></td>
</tr>
<tr>
<td>Non-Home Based</td>
<td>1,850</td>
<td>3,088</td>
<td>4,866</td>
<td></td>
</tr>
<tr>
<td>Commercial Vehicle</td>
<td>1,662</td>
<td>2,530</td>
<td>3,100</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>26,741</td>
<td>50,701</td>
<td>61,360</td>
<td></td>
</tr>
<tr>
<td>Through Trips</td>
<td>3,125</td>
<td>4,063</td>
<td>7,693</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>29,866</td>
<td>54,764</td>
<td>69,053</td>
<td></td>
</tr>
</tbody>
</table>

1. Trips utilizing the Mukilteo to Columbia Beach, Yarrow to Southworth and Point Defiance to Tolequah crossings are not included.

In spite of the fact that the base year and forecast figures do not refer to exactly identical areas, total trip-making—for either Plan A or B—is expected to increase by almost 90 percent, thus indicating the magnitude of the problem facing the region in the next 25 years.64

### Forecast of Transit Trips

Once the forecast of total person trips was completed, the portion of the total which could be expected to use mass transit was determined by means of the modal split process.65

While the forecast of the total number of person trips was dependent solely upon characteristics of population, employment and residential density, the proportion of the total which will use each mode is dependent also upon the characteristics of the respective transportation systems. The forecasts of regional transit usage for alternative transit systems and land use patterns are shown in Table

64. In 1990 approximately 102,000 weekday person trips will be generated in the portion of the Study Area outside the Cordon Area.
65. Schmidt, op. cit., Staff Report No. 13 and Basmaciyan and Schmidt, op. cit., Staff Report No. 22 (See Page 82).
IV-42. One of the forecasts is for Plan A with a transit system featuring an extensive express bus operation, together with feeder and local service routes. Another Plan A forecast shown is based on a rapid transit system operating in conjunction with local, feeder and express bus routes. For comparative purposes, Table IV-42 shows the forecast for Plan B assuming an extensive express bus system, operating together with feeder and local service routes. Each forecast also assumed a highway network limited to the facilities currently in existence, plus those committed for construction in the near future only.

Since they are based upon a highway system limited to present and committed facilities, the transit forecasts shown in Table IV-42 reflect conditions where the transit service is given a minimum of highway competition. The alternative forecasts of transit ridership also served to reveal whether the way facilities over and beyond current programs—forecasted for each zone. This was done in a manner limited to present and committed facilities, the non-home end of the transit trips was based upon the homes in each analysis zone. The forecast of travel attracted to extensive transit systems could be estimated where the transit service is given a minimum base year's. The transit system incorporating rapid transit, of course, attracted a higher usage than non-home end trips which will consequently, as a final step, the forecast of commercial vehicle trips was converted into passenger car equivalents. The alternative forecasts of person trips passing completely through the Study Area, (see Table IV-44).

The modal split process developed the forecast of the proportion of transit trips made to or from the homes in each analysis zone. The forecast of the non-home end of the transit trips was based upon the type and intensity of the development forecasted for each zone. This was done in a manner similar to the previously described forecast of the non-home end of home based person trips; the result was the forecast of the transit trips attracted to each analysis zone.

Forecast of Vehicle Trips

With the proportion of total person trips by mass transit determined, the remainder consisted of trips which will be made by automobiles and trucks. The latter person trips were converted into vehicle trips by applying car occupancy factors.

Because of their size and operating characteristics, trucks have an effect on the carrying capacity of facilities disproportionate to their numbers. Consequently, a final step, the forecast of commercial vehicle trips was converted into passenger car equivalents. Table IV-43 summarizes the results of these conversions and forecasts.

The forecast of person trips crossing the cordon boundary was also converted into vehicle trips using car occupancy factors. This was also done for the person trips passing completely through the Study Area, (see Table IV-44).

Table IV-45 summarizes the total vehicle trip forecasts. Even allowing for the differences due to

---

TABLE IV-42

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Passenger Trips Per Average Weekday</td>
<td>Plan A With Bus System</td>
<td>Plan A With Rapid Transit</td>
<td>Plan B With Bus System</td>
<td></td>
</tr>
<tr>
<td>Home Based Work</td>
<td>72,724</td>
<td>89,760</td>
<td>107,940</td>
<td>64,740</td>
</tr>
<tr>
<td>Home Based Shopping</td>
<td>23,664</td>
<td>31,010</td>
<td>33,122</td>
<td>25,294</td>
</tr>
<tr>
<td>Home Based Social-</td>
<td>10,575</td>
<td>13,104</td>
<td>14,719</td>
<td>9,007</td>
</tr>
<tr>
<td>Recreation</td>
<td>31,100</td>
<td>37,973</td>
<td>37,973</td>
<td>22,274</td>
</tr>
<tr>
<td>Home Based Miscellaneous</td>
<td>19,130</td>
<td>25,573</td>
<td>27,481</td>
<td>18,264</td>
</tr>
<tr>
<td>TOTAL</td>
<td>126,093</td>
<td>159,527</td>
<td>181,292</td>
<td>119,924</td>
</tr>
</tbody>
</table>

1. Includes 3,990 transit trips across Puget Sound via the cross-Sound bridge. These are additional trips generated in the part of the study area west of Puget Sound.

TABLE IV-43

<table>
<thead>
<tr>
<th>VEHICLE TRIPS WITHIN THE STUDY AREA</th>
<th>1990</th>
<th>1990</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Trips Per Average Weekday</td>
<td>Plan A With Bus System</td>
<td>Plan A With Rapid Transit</td>
<td>Plan B With Bus System</td>
</tr>
<tr>
<td>Home Based Work</td>
<td>400,002</td>
<td>914,161</td>
<td>850,827</td>
</tr>
<tr>
<td>Home Based Shopping</td>
<td>262,997</td>
<td>577,576</td>
<td>575,767</td>
</tr>
<tr>
<td>Home Based Social-Recreation</td>
<td>234,125</td>
<td>458,629</td>
<td>457,979</td>
</tr>
<tr>
<td>Home Based Miscellaneous</td>
<td>341,701</td>
<td>720,098</td>
<td>722,986</td>
</tr>
<tr>
<td>Home Based School</td>
<td>24,430</td>
<td>46,608</td>
<td>46,608</td>
</tr>
<tr>
<td>Subtotal, Home Based</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Home Based</td>
<td>1,285,285</td>
<td>2,721,004</td>
<td>2,499,087</td>
</tr>
<tr>
<td>Commercial Vehicle</td>
<td>317,926</td>
<td>566,005</td>
<td>566,005</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,155,033</td>
<td>4,204,290</td>
<td>4,177,223</td>
</tr>
</tbody>
</table>

1. The 1961 figures are for the Cordon Area in terms of actual vehicles (not passenger car equivalents). Trips made by trucks kept exclusively for personal use are included in the commercial vehicle figures.

Vehicles Trips Crossing the Study Area Boundary

<table>
<thead>
<tr>
<th>VEHICLE TRIPS CROSSING THE STUDY AREA BOUNDARY</th>
<th>1961</th>
<th>1990</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Trips Per Average Weekday</td>
<td>Plan A</td>
<td>Plan A</td>
<td>Plan B</td>
</tr>
<tr>
<td>Home Based Work</td>
<td>49,600</td>
<td>72,822</td>
<td>72,822</td>
</tr>
<tr>
<td>Home Based Shopping</td>
<td>11,977</td>
<td>25,548</td>
<td>25,547</td>
</tr>
<tr>
<td>Home Based Social-Recreation</td>
<td>1,360</td>
<td>2,700</td>
<td>2,700</td>
</tr>
<tr>
<td>Home Based Miscellaneous</td>
<td>20,619</td>
<td>40,026</td>
<td>48,126</td>
</tr>
<tr>
<td>Home Based School</td>
<td>1,285</td>
<td>2,700</td>
<td>2,700</td>
</tr>
<tr>
<td>Subtotal, Home Based</td>
<td>77,292</td>
<td>200,044</td>
<td>200,352</td>
</tr>
<tr>
<td>Non-Home Based</td>
<td>20,620</td>
<td>26,428</td>
<td>26,428</td>
</tr>
<tr>
<td>Commercial Vehicle</td>
<td>13,422</td>
<td>30,666</td>
<td>70,144</td>
</tr>
<tr>
<td>Subtotal</td>
<td>121,006</td>
<td>295,518</td>
<td>295,930</td>
</tr>
<tr>
<td>Through Trips</td>
<td>9,279</td>
<td>28,290</td>
<td>28,290</td>
</tr>
<tr>
<td>TOTAL</td>
<td>130,285</td>
<td>323,808</td>
<td>324,220</td>
</tr>
</tbody>
</table>

1. The 1961 figures are for the study Area in terms of actual vehicles (not passenger car equivalents). Trips made by trucks kept exclusively for personal use are included in the commercial vehicle figure.

2. The figures are for the Study Area and Are in terms of passenger car equivalents. The figures for commercial vehicles do not include trips by trucks kept exclusively for personal use.
The dissimilar areas considered and the effect of truck-to-car conversions, both Plan A and Plan B show increases in vehicle trips of approximately 175 percent for the total region—175 percent for Plan A and almost 250 percent for Plan B. In both instances, much of this growth is brought about by the elimination of tolls on the Tacoma Narrows Bridge.

Plan B—which includes a cross-Sound bridge—exhibits a greater amount of development on the west side of the Sound than does Plan A, thus increasing the number of vehicle trips across the Sound compared to ferry service only. The forecasted increase for either plan, however, is even greater than increases for the total region—175 percent for Plan A and almost 250 percent for Plan B. In both instances, much of this growth is brought about by the elimination of tolls on the Tacoma Narrows Bridge.

Application of Trip Distribution Model

The results of the work to this point have been in terms of transit trips and vehicle trips which would be produced and attracted to each analysis zone to and from each major road, highway or ferry route entering or leaving the Study Area. To be meaningful for transportation system planning purposes, this trip end forecast for each analysis zone had to be converted to trips between points. The “linking” of these trip ends to form trips was accomplished by a trip distribution model.

This model—derived from analyses of data from the base year travel surveys—is a mathematical expression which describes trip length characteristics for each trip purpose. The model was calibrated to assure that, when applied to the base year trip end data, it accurately reproduced the actual travel taking place at that time. When applied to forecasts of future trip ends, the model can predict with a reasonable degree of confidence the amount of future travel which can be expected between all points in the region. The model was applied to each trip purpose, each travel mode and each side of Puget Sound separately.

Table IV-47 shows the result—in vehicle hours of travel—of applying the trip distribution model to the Plan A and B forecasts.

The chart shows that the total vehicle hours of travel are expected to increase almost two-fold by 1990. Plan B develops a lower total, since the closer proximity of residences to places of work, shopping and other trip attractions tend to shorten trip lengths.

Table IV-48 shows the equivalent data for mass transit trips in terms of person hours of travel. By this measure, transit travel is expected to increase for both Plans A and B. The greatest increase, of course, is for Plan A with rapid transit, since the increased speed of service is more than counter-balanced by the greater patronage.

68. In 1990 approximately 68,000 passenger car equivalent trips are expected to have incurred in the portion of the study area outside the Corbin line.
TABLE IV-4B
TOTAL HOURS OF PERSON TRAVEL
BY MASS TRANSIT

<table>
<thead>
<tr>
<th>Total Person Hours of Travel Per Average Weekday</th>
<th>1990</th>
<th>1990</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan A With Bus System</td>
<td>Plan A With Rapid Transit</td>
<td>Plan B With Bus System</td>
</tr>
<tr>
<td>Trip Purpose</td>
<td>1961</td>
<td>1990</td>
<td>1990</td>
</tr>
<tr>
<td>Home Based Work</td>
<td>26,570</td>
<td>61,317</td>
<td>40,205</td>
</tr>
<tr>
<td>Home Based Shopping</td>
<td>8,429</td>
<td>18,593</td>
<td>17,826</td>
</tr>
<tr>
<td>Home Based Social-Recreation</td>
<td>2,742</td>
<td>6,900</td>
<td>8,541</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>6,464</td>
<td>15,289</td>
<td>15,634</td>
</tr>
<tr>
<td>TOTAL</td>
<td>45,027</td>
<td>91,999</td>
<td>102,188</td>
</tr>
</tbody>
</table>

1. These figures are only for the part of the Study Area east of Puget Sound.

However, even for Plan A with a bus transit system, the total person travel time involved in transit trips will be more than double the 1961 values. This reflects not only the forecasted increase in total transit patronage, but also the greater overall suburban dispersal of the future population with its consequent effect on trip length.

Part IV  Section 8
TRANSPORTATION SYSTEM PLANNING

The essential qualities of overall transportation planning on a regional basis are: (1) formulating land use and development plans as an integral part of the transportation plan, (2) planning for transportation on an overall systems basis, with each segment of the system being a vital link related to and dependent upon the others, and (3) planning for transit concurrently with—and in coordination with—planning for streets and highways.

Before any meaningful planning can be carried out, the objectives must be clearly set forth. According to the Study Prospectus, the ultimate transportation plan was to be more than simply a response to future travel demands. It was to be:

—A “best” plan for a given regional land use plan.
—An “optimum” transportation system to meet regional transportation needs.
—An encouragement and a service to desirable patterns of land use, promoting desirable development.

In addition to the basic premises established by the Prospectus, such implicit objectives as economy, safety and flexibility are fundamental to any transportation planning, as are the restraining influences which might affect future transportation facilities. These include: (1) topographic characteristics of the region, (2) existing or firmly committed transportation facilities and development, and (3) transportation technology as it exists and as it may be expected to develop in the foreseeable future.

Throughout the transportation planning process, of course, it is the regional system which is being examined and considered. It is neither possible nor appropriate for purely local service facilities to be planned. Likewise, even the major regional facilities are not so exhaustively investigated that firm location and design features are identified. Further, it is unnecessary and inappropriate to deal with the detailed scale of other than major transportation routes or their location and design specifications. Route locations within possibly as much as half a mile of the lines delineated for planning purposes will generally serve the same purpose. Interchange points, though selected, are not detailed.

This degree of detail is adequate to compare alternative systems and to evaluate them with respect to their ability to meet the overall objectives. Once a plan has been adopted and programs of implementation developed, then more detailed studies—to assist in refinement of location and design—can be made as part of the continuing transportation planning process.

With objectives established and restraints in mind, the next step for the Transportation Study was to carry out the methodical transportation planning process—the delineation and testing of alternative transit, street and highway networks on an integrated and systems basis; evaluating them; and, finally, determining the plan which would best meet the overall goals.

Building Blocks of Transportation System Planning

The components of the regional transportation systems are: (1) a highway network, including freeways, expressways and arterials; (2) a mass transit system, which may include rapid transit and/or express and feeder buses; (3) a combination ferry-bridge system for cross-Sound travel; and (4) terminal or parking facilities at the region’s major employment and commercial centers.69

69. Air and rail transportation facilities which provide service for persons and goods to, from and within the region are not part of the Study program—but the ground travel to and from the terminals of these facilities is included.
These components are inseparable. The first three accommodate portions of the total person travel and therefore must be analyzed together, while the fourth results from the other three and is affected by—and also affects—their forecasts.

A number of complete systems were developed and tested to determine an overall transportation plan to serve the region’s travel needs. The first system tested was the network of transportation facilities available in 1961, termed Study System 1. This network—which was the basic building block for all other study systems—consisted of all freeway, expressway, arterial, bus, bridge and ferry facilities of regional significance operating in the base year.

From this foundation, other transportation systems were delineated, tested and analyzed. Their principal components are summarized in Table IV-49.

**Study System 2**

Study System 2 represents the system of transportation facilities so firmly and definitely committed that there remains little, if any, opportunity to introduce adjustments or revisions—even if this might seem desirable on the basis of study findings.

**HIGHWAY FACILITIES**

Figure IV-62 shows the highway components of System 2. The limited access facilities in System 2 include, in addition to those in System 1, the portions of the federal interstate highway system (I-5, I-405 and I-90) not in service in 1961; the Tacoma-Puyallup-Sumner Freeway (Sign Route 410); a freeway connection from the Tacoma Narrows Bridge to I-5 through Tacoma (SR 16); the Mountain Highway Freeway (SR 7) from I-5 in Tacoma to SR 512 near Parkland; the freeway from I-5 south of Tacoma to Puyallup (SR 512); the Valley Freeway (SR 167) from Renton to Auburn; the Echo Lake route (SR 18) from the vicinity of Auburn to I-90 near North Bend; the West Marginal Way Freeway (SR 99 Temporary) from I-5 south of Seattle to SR 509 in Seattle at the First Avenue South Bridge; the Burien Freeway (SR 509) from Seattle (including a new parallel First Avenue South Bridge) to Burien; the freeway connection (SR 518) between the Burien Freeway (SR 509) and the interchange of I-5 and I-405 near Tukwila; the freeway connection along Connecticut Street between I-5 and the Alaskan Way Viaduct; the freeway connection along Mercer Street between I-5 and Aurora Avenue; the Evergreen Point Bridge and its east and west approaches (SR 520); the Bothell-to-Monroe Expressway (SR 202); Stevens pass Highway (SR 2) east of Everett to Cavello’s Corner and to Snohomish; a freeway route from the vicinity of Bremerton to Silverdale (SR 3); the Sound Way Expressway from the First Avenue South Bridge to the Fauntleroy area; the R. H. Thomson Freeway from Rainier Avenue to N.E.

![Map of Freeways, Expressways, and Arterials](image-url)
study able to describe the overall scale of the current growth to specific corridors as shown in Table IV-50 provide a better indication of local capacity increases.

The magnitude of the current and budgeted street and highway construction program can be better gauged in terms of the overall capacity which it will add to the 1961 arterial system. System 1 in the base year had a traffic carrying capacity of over 18,000,000 vehicle miles daily, of which 2,800,000—almost 1/6 of the total—were provided by controlled access facilities. By the early 1970s, System 2 will have a capacity of almost 32,500,000 vehicle miles daily—an increase of almost 80 percent over the 1961 level. The significance of this large increase should be fully comprehended. It means that in approximately ten years eight-tenths as much capacity will be added as was constructed in more than a century of the region’s prior history.

While comparison on a regionwide basis is valuable to describe the overall scale of the current construction programs, capacity comparisons across specific corridors as shown in Table IV-50 provide a better indication of local capacity increases.

| Facilities across Ship Canal in Seattle | 164,000 | 383,000 |
| Lake Washington bridges | 35,000 | 179,000 |
| North-south facilities between Puget Sound and Kenmore, near the King-Snohomish County line | 55,000 | 114,000 |
| North-south facilities north of Lynnwood | 32,000 | 92,000 |
| North-south facilities between Puget Sound and the East Valley Highway south of Seattle | 80,000 | 229,000 |
| North-south facilities between Puget Sound and the East Valley Highway in the Federal Way-Auburn area | 39,000 | 133,000 |
| Across the Puyallup River in Tacoma | 40,000 | 120,000 |
| North-south facilities from South Tacoma Way to Portland Avenue | 129,000 | 149,000 |

1. In passenger car equivalents per day.
2. The 1961 network of highway facilities; see Figure IV-16 on page 38.
3. The network of firmly committed and budgeted facilities expected to be in operation in the early 1970s.
4. Including new Interstate freeway opened in 1961 and the planned six-lane tube under the Ship Canal as part of the R. H. Thomson Freeway.
5. Including the Evergreen Point Bridge opened in 1963, and the additional bridge parallel to the first span at Mercer Island scheduled for 1972.
6. Including the Burien Freeway, the Tacoma-to-Seattle Freeway and the Valley Freeway between Renton and Kent.
7. Including the Mountain Highway Freeway.

Because there is nothing comparable to the committed network of street-and-highway facilities, the Study staff undertook the layout of a long-range bus transit system adequate to accommodate future growth to 1990. A test network of express and feeder bus routes was delineated, which—for study purposes—was assumed to operate in conjunction with the highway facilities of Study System 2. The principal feature of this bus network is the extensive use of limited-stop express buses, providing a greatly increased and extended service to the suburban areas, where such improvement can expect to develop the greatest increase in transit usage.

As much as possible, of course, the bus system in the central cities is also oriented toward express operation, utilizing freeways and expressways wherever practical. Figure IV-63 shows Transit Study System 2.

Implicit in Transit Study System 2 is the assumption that transit operations in the future will be free of artificial hindrances—such as franchise restrictions—which prohibit bus operators from providing integrated service and thus reduce the quality of service. It also assumes that transit services across the boundaries of governmental jurisdictions will be coordinated or integrated to

70. The layout of transit systems and their analyses were carried out in cooperation with DeLune Cather & Company, transit consultant to the Puget Sound Governmental Conference.
avoid the present duplication of certain routes. The Transit Study System 2 network consists of 740 miles of bus routes, compared to 575 route miles in 1961,71 which indicates the degree of assumed extension.

CROSS-SOUND FACILITIES

Study System 2 included only the committed facilities for cross-Sound travel, the lone modification being the assumed removal of tolls on the Tacoma Narrows Bridge, which was accomplished by legislative act in 1965. At the time service was assumed. in 1961,71 which indicates the degree being the assumed removal of tolls on the mainland.

New ferries to program of revision in the system of plan for extension. Consequently, the 1965 Transit miles appropriate route be selected and financial feasibility studies be undertaken for a bridge or bridges across Puget Sound to link the Kitsap Peninsula with the mainland.

While these legislative actions imply that a cross-Sound bridge shall be built, there has been no commitment in this regard since the matter is still in an investigative stage. Therefore, the only actions relative to cross-Sound transportation since Study System 2 was delineated have been removal of the Narrows Bridge tolls and the new ferry order. The basic assumptions of System 2 are thus still valid. A further assumption was that ferry tolls would be essentially the same as at present, that ferry service on present routes would be augmented in keeping with future growth in traffic demand and that there would be nominal improvements in ferry schedules which faster vessels might make possible.

Study System 2 Test Results

Although all components of the regional transportation system are planned, tested and considered together, the test results of each are discussed separately for convenience and ease of understanding. (All references to volumes of usage for the transit system are in terms of 24-hour weekday passenger totals, while the highway and cross-Sound vehicular volumes are in terms of passenger vehicle equivalents for a 24-hour weekday period—unless specifically noted otherwise.)

TRANSIT FACILITIES

Through the application of modal split procedures, a determination was made of the proportion of total person trip forecast for Plan A for 1990 which would be attracted to the use of Transit Study System 2 (see Table IV-51).

<table>
<thead>
<tr>
<th>Trip Purpose</th>
<th>1961</th>
<th>1990 Plan A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Based:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work</td>
<td>709,564 (49,825) 9.8</td>
<td>1,177,006 (85,061) 7.2</td>
</tr>
<tr>
<td>Shopping</td>
<td>414,340 (23,197) 5.6</td>
<td>607,469 (30,549) 3.8</td>
</tr>
<tr>
<td>Social</td>
<td>871,410 (10,316) 1.9</td>
<td>1,060,901 (12,725) 1.2</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>276,216 (18,726) 3.9</td>
<td>916,195 (25,179) 2.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,138,776 (121,074) 5.7</td>
<td>3,946,390 (154,508) 3.9</td>
</tr>
</tbody>
</table>

1. Does not include trips entering or leaving the Study Area east of Puget Sound.

While System 2 attracted a regionwide transit patronage of approximately 155,000 — 26 percent greater than the 121,000 in 1961—the transit usage to and from the Seattle central business district increased by more than 75 percent, and by almost 50 percent to and from the Tacoma central business district (see Table IV-52).

<table>
<thead>
<tr>
<th>Trip Purpose</th>
<th>1961</th>
<th>1990 Plan A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Based:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work</td>
<td>101,460 (33,099) 33.1</td>
<td>177,838 (41,627) 34.3</td>
</tr>
<tr>
<td>Non-Work</td>
<td>97,082 (30,509) 32.3</td>
<td>165,804 (41,641) 29.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>198,542 (63,608) 35.4</td>
<td>343,642 (83,268) 33.2</td>
</tr>
<tr>
<td>Central Business District:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home Based:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work</td>
<td>14,916 (3,670) 24.7</td>
<td>26,120 (4,606) 25.5</td>
</tr>
<tr>
<td>Non-Work</td>
<td>28,715 (4,821) 16.2</td>
<td>37,520 (4,183) 11.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>43,631 (8,491) 19.4</td>
<td>63,640 (8,789) 19.5</td>
</tr>
</tbody>
</table>

1. Does not include trips entering or leaving the Study Area east of Puget Sound.

While the number of transit trips in the region will be higher in 1990 than in 1961, the percentage of total person trips made by transit will decrease from 5.7 percent in 1961 to 3.9 percent in 1990. This reflects the effect of projected suburban growth at relatively low densities with widely dispersed trip destinations, coupled with increased incomes and automobile ownership, all of which serve to reduce transit usage.

71. Not included is the mileage of turn-arounds at route ends nor the duplication of route miles represented by transit lines which are coincident or parallel in one another in close proximity.
The trip distribution and assignment processes were used to estimate the volume of transit usage for each bus route in Transit Study System 2. The results are shown in the form of flow maps in Figures IV-64 and IV-65. The increased transit flow toward the central business districts is indicated by comparing these illustrations with the 1961 conditions shown in Figures IV-22 and IV-23 (Pages 42 and 43).

Transit primarily serves travel between home and work, especially work places in the central business districts. The concentration of employment designated for the downtowns in the Plan A analysis reflects a high degree of employment centralization and, consequently, centralization of transit travel.\(^72\) Since work trips are made almost entirely during the morning and afternoon peak hours when there is a minimum of other travel, comparisons of transit usage for work purposes are particularly pertinent. It is during the peak hours of travel that transit can play an important role in serving workers and can help reduce peak-hour traffic congestion.

Table IV-53 shows examples of Plan A 1990 bus transit forecasts compared to 1961 usage for three key locations in the Study Area.

### Table IV-53

<table>
<thead>
<tr>
<th>Location</th>
<th>1961 Total Passengers Per Weekday</th>
<th>1990 Total Passengers Per Weekday</th>
<th>Passengers To And From Work 1961 Per Weekday</th>
<th>Passengers To And From Work 1990 Per Weekday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing the Ship Canal in Seattle</td>
<td>40,000</td>
<td>42,000</td>
<td>18,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Crossing Lake Washington</td>
<td>3,000</td>
<td>17,000</td>
<td>2,000</td>
<td>10,500</td>
</tr>
<tr>
<td>Crossing a Screenline South of Downtown Tacoma, from A Street to K Street</td>
<td>9,400</td>
<td>12,500</td>
<td>3,700</td>
<td>7,300</td>
</tr>
</tbody>
</table>

Table IV-54 shows the number of express buses needed to carry the forecasted Plan A 1990 peak-hour transit usage at selected locations.

The heaviest traveled section is the Interstate Freeway north of the Seattle central business district, where 64 buses per hour will carry more than

### Table IV-54

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of Buses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evergreen Point Bridge</td>
<td>18</td>
</tr>
<tr>
<td>Mercer Island Bridge</td>
<td>27</td>
</tr>
<tr>
<td>East Channel Bridge</td>
<td>23</td>
</tr>
<tr>
<td>A Street Viaduct in Tacoma</td>
<td>16</td>
</tr>
<tr>
<td>Interstate Freeway</td>
<td></td>
</tr>
<tr>
<td>North of Seattle Central Business District</td>
<td>64</td>
</tr>
<tr>
<td>South of Seattle Central Business District</td>
<td>47</td>
</tr>
<tr>
<td>At Snohomish - King County Line</td>
<td>14</td>
</tr>
<tr>
<td>North of Tukwila</td>
<td>15</td>
</tr>
</tbody>
</table>

\(^72\) The Plan A analysis used a downtown employment increase over 1961 levels of 80 percent for both Seattle and Tacoma. This represents a rise in the proportion of the Study Area's total employment located in downtown Seattle from 14.0 percent in 1961, to 15.5 percent for Plan A, with a comparable change from 2.0 to 2.3 percent for downtown Tacoma.
3,500 passengers. During the morning peak hour an estimated total of 460 buses will be arriving in the Seattle downtown from all directions and almost 120 in downtown Tacoma. This compares with the 1961 values of 360 and 80, respectively.

The transit headways (and thus the number of buses) needed to accommodate the forecasted passenger values were evaluated and found to be in keeping with the headway assumptions which were used as a basis for calculating the number of patrons which would be attracted to transit.

A more detailed description of the Transit Study System 2 analysis and results is contained in Staff Report No. 19.73

CROSS-SOUND FACILITIES

Cross-Sound travel facilities for Plan A include a toll-free Tacoma Narrows Bridge, together with a continuation of current ferry routings operating with toll schedules essentially equivalent to 1961 values, and with a quality and frequency of service similar to that in 1961.

Forecasts were made of traffic for each cross-Sound facility. These were based on: (1) appraisals of the amount and location of the forecasted population and employment on both sides of Puget Sound for Plan A for 1990, (2) examination of past trends in cross-Sound facility usage (including the effect of past toll increases, relative improvement of highway approach routes and the characteristics of the ferry services provided), and (3) the effect of the removal of tolls from the Tacoma Narrows Bridge.

Since the ferry system performs a mass transit service across Puget Sound by carrying walk-on passengers as well as vehicles, the forecasts were made in terms of both person trips and vehicle trips (see Table IV-55). It was presumed that sufficient ferry capacity would be provided at each ferry route in keeping with the growth in traffic.74

<table>
<thead>
<tr>
<th>Cross-Sound Facility</th>
<th>1961 Total Person Trips</th>
<th>1990 Total Person Trips</th>
<th>1961 Percent Increase</th>
<th>1990 Percent Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mukilteo-Columbia Beach</td>
<td>1,855</td>
<td>3,008</td>
<td>62.2</td>
<td>75.6</td>
</tr>
<tr>
<td>Edmonds-Kingston</td>
<td>1,909</td>
<td>3,869</td>
<td>102.7</td>
<td>112.2</td>
</tr>
<tr>
<td>Seattle-Winlow</td>
<td>5,230</td>
<td>8,242</td>
<td>57.6</td>
<td>102.7</td>
</tr>
<tr>
<td>Seattle-Bremerton</td>
<td>4,665</td>
<td>3,442</td>
<td>95.7</td>
<td>-8.4</td>
</tr>
<tr>
<td>Fauntleroy-Vashon</td>
<td>2,688</td>
<td>3,992</td>
<td>49.7</td>
<td>70.0</td>
</tr>
<tr>
<td>Vashon-Southworth</td>
<td>173</td>
<td>240</td>
<td>50.2</td>
<td>62.2</td>
</tr>
<tr>
<td>Fauntleroy-Southworth</td>
<td>1,511</td>
<td>2,456</td>
<td>62.5</td>
<td>98.4</td>
</tr>
<tr>
<td>SUBTOTAL—Ferries</td>
<td>18,201</td>
<td>25,469</td>
<td>39.9</td>
<td>80.8</td>
</tr>
<tr>
<td>Tacoma Narrows Bridge</td>
<td>11,713</td>
<td>15,343</td>
<td>21.9</td>
<td>268.7</td>
</tr>
<tr>
<td>TOTAL—Cross-Sound</td>
<td>29,914</td>
<td>40,832</td>
<td>103.4</td>
<td>176.7</td>
</tr>
</tbody>
</table>

1. Average weekday total person trip and vehicular traffic volumes.

The fact that cross-Sound travel is expected to more than double by 1990 is immediately apparent. An increase of over 175 percent is forecasted in vehicular volume and of over 100 percent in the volume of person trips. It can be seen that the Tacoma Narrows Bridge is expected to experience the largest growth of all cross-Sound facilities.

While the ferry routes are expected to experience a general growth in traffic, the forecasted change from 1961 levels differs substantially from route to route. Only the Seattle-Bremerton route is expected to experience a decrease by 1990.

In continuation of a long-term trend, it is anticipated that an increasing proportion of the total person trip travel across the Sound will be in vehicles, with a declining occupancy of each vehicle.

73. Gendell, op. cit., Staff Report No. 19, (See Page 13).
74. See Page 73.
Thus, the forecasted increase in vehicular travel (over 175 percent) is greater than the forecasted increase of slightly more than 100 percent in person trip travel. This difference is especially apparent for ferry routes which carry large volumes of walk-on passengers (Seattle-Winslow, for instance).

HIGHWAY FACILITIES

Once the amount of person travel which would be attracted to Transit Study System 2 was determined, the remainder was converted into travel in terms of passenger vehicle equivalents. The trip distribution and traffic assignment processes were used to estimate the volume of vehicular traffic which Plan A in 1990 would impose on each link of the regional network of street-and-highway facilities.

Figure IV-66 shows the traffic demand flow diagram for the freeway and expressway routes in Highway Study System 2. As indicated, the major corridors of travel demand in 1990 for Plan A are in a north-south direction, primarily along the line of the Interstate 5 Freeway. This is a carry-over and an extension of the 1961 conditions (see Figure IV-17, Page 39). The Interstate 405 loop around Lake Washington is likewise in a heavy north-south travel demand corridor. The two Lake Washington bridge routes are also primary travel demand corridors, but in an east-west direction.

Although these were predominant travel corridors in 1961, the much higher traffic volumes which characterize the 1990 travel demand pattern are readily seen by comparing Figures IV-17 and IV-66. These two illustrations show to the same scale the 1961 and 1990 Plan A volumes, respectively.

The magnitude of the travel demands is revealed in Table IV-56. This large growth in traffic volumes on the region's major arteries will result from the expected population and economic expansion and the attraction which the freeway and expressway facilities have to motorists.

The travel demand which would result if the 1990 Plan A travel were to be imposed on the near-

### TABLE IV-56

<table>
<thead>
<tr>
<th>Location</th>
<th>1961</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aurora Bridge across Ship Canal in Seattle</td>
<td>83,000</td>
<td>273,000</td>
</tr>
<tr>
<td>U.S. 99 Bridge across Puyallup River</td>
<td>31,000</td>
<td>128,000</td>
</tr>
<tr>
<td>Alaskan Way Viaduct</td>
<td>44,000</td>
<td>236,000</td>
</tr>
<tr>
<td>U.S. 99 south of 41st Street in Everett</td>
<td>15,000</td>
<td>46,000</td>
</tr>
<tr>
<td>Lake Washington Bridge at Mercer Island</td>
<td>23,000</td>
<td>119,000</td>
</tr>
<tr>
<td>Evergreen Point Bridge</td>
<td>23,000</td>
<td>127,000</td>
</tr>
</tbody>
</table>

1. 1965 average daily vehicular volume.

76. For the sake of clarity, only the controlled access routes are included in this illustration, even though traffic demands were determined for all sections of routes in the study system. The traffic assignment technique determines the amount of traffic which would desire to use each route, assuming the route has sufficient capacity to accommodate the traffic without developing congestion and thus reducing the average daily operating speed below the established level of service speed standards.
future transportation network (System 2) was developed to pinpoint where demands would exceed facility capacity. It is at such locations that transportation planning efforts must be primarily directed.

Of the total mileage of controlled access facilities in Study System 2, 55 percent was found to have a 1990 Plan A travel demand in excess of the practical capacity of the facility—and 15 percent had a demand equal to or greater than twice the practical capacity. In comparison, in 1961 the transportation system had less than 20 percent of the freeway and expressway mileage operating above a practical capacity level.

**Corridor Comparisons of Travel Demands and Capacity**

The comparison of travel demand to capacity on a section-to-section basis to establish possible deficiencies tends to be somewhat misleading since it does not account for alternate major arterial routes which may be in reasonable proximity and which may have unused capacity.

When the route which offers the highest level of service in a corridor experiences traffic volumes approaching or exceeding its capacity, some travelers will use alternative routes in the corridor. This will tend to achieve better utilization of capacity available in the corridor. Consequently, comparisons of travel demand and facility capacity can be made most meaningfully on the basis of general traffic corridors rather than individual facilities.

Figure IV-67 shows the comparisons of travel demand and total corridor capacity for selected corridors. The width of the corridor is designated by the length of the so-called “screenline” in the illustration. All arterial facilities which cross the screenline are included in the comparison for the particular corridor. The widths of the corridors have been established to include major routes which can be considered effective alternative paths of travel between areas of substantial trip generation.

The screenline capacity evaluations are shown in terms of capacity deficiencies (or surpluses), expressed in terms of thousands of passenger vehicle equivalents per day. As a frame of reference, a single lane of a freeway has a design capacity of approximately 10,000 passenger vehicle equivalents per day, a surface arterial between 2,300 and 4,000.76

Major corridor deficiencies were observed along the Interstate 5 and 405 routes as well as across a number of east-west corridors in the south King County area and east of Lake Washington. West of Puget Sound, capacity deficiencies were disclosed west of the downtown Bremerton area and across the Port Washington Narrows bridges. Except for the Puyallup River location, no major corridor deficiencies were observed in the Tacoma and Puyallup areas, nor in the Everett area (assuming that each is able to finance and complete current capital improvement programs).

In some locations capacity deficiencies in a corridor are at least partially balanced by capacity surpluses in an adjacent corridor. Therefore, it would be possible for longer trips to shift to corridors with surplus capacity. To determine the extent to which this might be possible requires detailed analysis of flow patterns.

The substantial corridor deficiencies indicate that major shortcomings would develop if the network committed for construction by the early 1970s were required to accommodate 1990 Plan A travel. The location of these deficiencies—and analysis of the flow patterns of travel through the corridors of deficiency—identify where additional

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76. The particular value depends upon the characteristics of the area through which the arterial passes, the signal timing at intersections, the amount of pedestrian interference, etc.
capacity must be added, either in the form of widening streets or providing entirely new facilities. Such projects would have to be included in construction programs after the early 1970s. The needed design characteristics of the necessary additional routes are also indicated from the analysis.

Regionwide System and Travel Comparisons

Table IV-57 shows in summary form the results of the assignment of 1980 Plan A to travel to Highway Study System 2. Facility mileage has increased by 475 from 1961 levels, with 298 of these representing freeways and expressways (and their ramps) added to the 1961 system by recent and near-future construction programs (see Table IV-7, Page 39).

The magnitude of the increase in vehicle miles of travel is particularly critical, especially in comparison with the capacity increase of only 80 percent. The difference between these two figures emphasizes the need for continuing construction programs beyond the early 1970s — and verifies the findings described earlier that such construction programs will be providing a transportation system which will be more heavily loaded in comparison to the system's 1961 carrying capacity if only currently budgeted projects are constructed.

Table IV-58 shows the proportion of the region's total facility mileage, carrying capacity, vehicle hours and vehicle miles of travel demand on each facility type of Highway Study System 2. While interstate freeways will constitute less than 8 percent of System 2 mileage, they will provide over 25 percent of the capacity, and—in accommodating 1990 Plan A travel — will attract 44 percent of the vehicle miles of travel demand.

Special Link and Zone Analyses

After the overloaded sections of the network are identified through the traffic assignment process, two analytical tools are available to the transportation planner to develop an efficient system of facilities with adequate capacity to serve the travel demand.

The first tool is the so-called "selected link" analysis, which yields data relative to the origin and destination patterns and routing of all trips utilizing a specified section (selected link) of the network. The second tool is the "selected zone" analysis, which produces similar data for all trips originating in a specified analysis zone or group of zones.

With the aid of detailed information obtained from the selected link and zone analyses, it is possible to designate facilities which will help relieve overloaded sections of the original network.

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**Table IV-57**

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Daily Vehicle Hours of Travel (000's)</th>
<th>Daily Vehicle Miles of Travel (000's)</th>
<th>Ratio of Travel Demand to Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstate Freeways</td>
<td>164</td>
<td>230</td>
<td>12,513</td>
</tr>
<tr>
<td>Other Freeways</td>
<td>124</td>
<td>77</td>
<td>5,133</td>
</tr>
<tr>
<td>Expressways</td>
<td>71</td>
<td>26</td>
<td>1,417</td>
</tr>
<tr>
<td>Ramps</td>
<td>49</td>
<td>23</td>
<td>500</td>
</tr>
<tr>
<td><strong>SUBTOTAL—Controlled Access Facilities</strong></td>
<td>408</td>
<td>364</td>
<td>15,257</td>
</tr>
<tr>
<td>Surface Arterials</td>
<td>1,714</td>
<td>337</td>
<td>17,186</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>2,122</td>
<td>761</td>
<td>32,443</td>
</tr>
</tbody>
</table>

1. This is the facility mileage coded for computer processing. It differs from actual physical route mileage because many major facilities with complex interchanges are coded as two one-way facilities, which, in effect, causes the mileage as coded to be double the actual route miles in such instances. On the other hand, in instances where two facilities are parallel and in close proximity, with both serving the same function and area, they are frequently consolidated in the facility coding. This causes the mileage as coded to be less than actual route miles. Thus, these two conditions affecting the mileage tend to offset one another. Ramp mileage shown is that coded for computer processing. Only those instances where interchanges are complex, and the design of at least partially separate facilities is not yet completed, are ramps coded as separate facilities. Thus, this figure is not meant to be all-inclusive for ramps in the Study System.

2. The vehicle hours of travel are for trips assigned to the highway network. Not included are (a) travel time for travel on the so-called local link, the local streets which connect each analysis zone to the arterial network, (b) time consumed at the beginning and ending of each trip in parking and walking to the trip terminus, or (c) the travel time involved in trips remaining entirely within the analysis zone of trip origin (so-called intrazonal trips). The figures in Table IV-67 on Page 69 include the time involved in these, however.

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**Table IV-58**

<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Percent of Total Vehicle Miles of Travel Demand</th>
<th>Percent of Total Vehicle Miles of Travel Assigned</th>
<th>Percent of Total Vehicle Miles of Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstate Freeways</td>
<td>7.8</td>
<td>33.9</td>
<td>25.2</td>
</tr>
<tr>
<td>Other Freeways</td>
<td>5.8</td>
<td>11.0</td>
<td>15.8</td>
</tr>
<tr>
<td>Expressways</td>
<td>3.3</td>
<td>3.7</td>
<td>4.4</td>
</tr>
<tr>
<td>Ramps</td>
<td>2.3</td>
<td>3.3</td>
<td>4.4</td>
</tr>
<tr>
<td><strong>SUBTOTAL—Controlled Access Facilities</strong></td>
<td>19.2</td>
<td>51.9</td>
<td>47.0</td>
</tr>
<tr>
<td>Surface Arterials</td>
<td>80.8</td>
<td>48.1</td>
<td>53.6</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

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77. This consisted of all analysis zones making up the Seattle central business district.
In analyzing the results of the tests of Highway Study System 2, one selected zone analysis78 and 10 selected link analyses79 were made. From the examination of data from these analyses, determinations were made of the minimum number of facilities — and their general type and location — required as additions to Highway Study System 2 to resolve the major shortcomings of that system in accommodating 1990 Plan A travel.

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Study System 3

The analysis and evaluation of the tests of Study System 2 revealed numerous shortcomings of the currently committed highway network in meeting the 1980 travel demands generated by the Plan A development pattern. The transit component of Study System 2, on the other hand, was found to be adequate to accommodate the future transit travel needs quite satisfactorily with but minor adjustment.

Through analysis of the test results of the bus transit and highway study systems, the necessary transit and highway system adjustments were pinpointed. Essential additions and modifications to Study System 2 — necessary to accommodate future travel adequately and efficiently — created the regional network of transportation facilities termed Study System 3.

HIGHWAY FACILITIES

The amount of total travel demand and the types and lengths of trips which they would serve determined the particular character (functional class) of individual facilities needed to resolve the problems revealed by the analysis of Study System 2. In those cases where any one of several possible facilities would meet the future need equally well, preference for inclusion in System 2 was given to the facility, if any, which had been seriously considered for implementation by the local jurisdictions or the state — particularly if the facility was included in or was consistent with local comprehensive plans. In many instances, the additional facilities simply represented the completion of a “missing link” between projects included in current construction programs. Such missing links exist since very often not all of an extensive facility can be financed and completed within a short-term building program, which was the basis for delineating Highway Study System 2.

The major facilities of such a missing link character included in Highway Study System 3 (to relieve overloaded sections of System 2) were:

- The section of the new Mountain Highway (SR 7) south of Tacoma between the Parkland and Roy-Wye vicinities.
- The extension of the Valley Freeway (SR 167) between Auburn and Sumner.
- The extension of the Burien Freeway (SR 509) from Burien to the Midway area.
- The extension of the Alaskan Way Viaduct (SR 99 Temporary) from the vicinity of Spokane Street to the First Avenue South Bridge.
- The extension of the R. H. Thomson Freeway southward to Interstate 5 and northward to Bothell.
- The extension of the Snohomish highway (SR 9) southward to the Bothell-to-Monroe highway (SR 202).

Other major facilities were added to System 2 to eliminate intolerable congestion which tests showed would otherwise exist. Included were:

- A new route from downtown Tacoma through the industrial area to the Federal Way vicinity, in conjunction with an upgrading of the present Echo Lake Highway (SR 18) to Auburn and beyond — and a freeway improvement of the Port of Tacoma Road connecting the Interstate 5 Freeway with this new route through the industrial area.
- A new north-south freeway route in the suburban area of King County from east of Auburn northerly to east of Kirkland.
- A new east-west expressway in the Kent vicinity connecting the Interstate 5 Freeway with the previously described new north-south freeway route.
- The extension of the R. H. Thomson Freeway from Seattle to a connection with the Valley Freeway (SR 167) in Renton.
- A cross-town freeway-expressway in Seattle in the general vicinity of South Michigan Street and 19th Avenue South, connecting the Alaskan Way Viaduct route extension at the First Avenue South Bridge with the Interstate 5 Freeway and the R. H. Thomson Freeway.
- An expressway connection from the R. H. Thomson Freeway toward the Seattle central business district generally along the Madison Street corridor.
- An additional Lake Washington bridge in the general vicinity of Sand Point and Kirkland, together with its Seattle and east side approaches.
- A north-south freeway connecting the Interstate 5 Freeway in the Lynnwood area with the northerly extension of the R. H. Thomson Freeway in the general vicinity of Kenmore.
- Several short expressway sections in Seattle serving as distributional facilities.
- The Northwest Expressway route in Seattle, with an extension northerly to the Snohomish-King County line.79

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78. Five were on interstate facilities, one on the Evergreen Point Bridge, one on Spokane Street and three in Bremerton.
79. This route is included in Seattle's comprehensive plan. Although the route was not required to meet a corridor-capacity deficiency for 1990 Plan A travel demands, it was added to evaluate the traffic service it would provide.
In addition, several generally short sections of surface arterials were included in System 3. One of these was the Keyport-Lemolo bridge route in Kitsap County, added to test its ability to alleviate the capacity deficiency on SR 3 north of Keyport.

In summary, Highway Study System 3 incorporated 120 miles of freeways and expressways, in addition to the 215 included in current construction programs and the 110 existing in 1961, for a total of 445 miles and 1,740 miles of surface arterials without access control, which is 25 miles more than the System 2 arterial mileage.

Since Highway Study System 2 is an interim network—limited by present capital improvement programs—System 3 represents the first step toward developing a plan of transportation facilities to meet the travel demands of Plan A for 1990.

TRANSIT FACILITIES

Transit Study System 3 was based on use of buses and utilized a maximum amount of express bus operation on freeways and expressways, in conjunction with local feeder and collector buses. It was almost identical to Transit Study System 2, with only minor revisions in bus headways and slight adjustments in the suburban ends of bus routes.

As Highway Study System 3 was delineated, the transit study system was appraised simultaneously to determine whether some further adjustments in the transit system might be possible and desirable, using the highway facilities added to Highway Study System 2 to form System 3. In most instances, however, the highway additions were in suburban areas so they were of limited value for transit routings—or were in corridors where transit routes were already provided in Transit Study System 2.

CROSS-SOUND FACILITIES

The cross-Sound facilities assumed in operation with System 2 were found to be adequate for continuance as a part of System 3.

Study System 3 Test Results

TRANSIT FACILITIES

The effect of the bus network revisions on the transit and street and highway usage were evaluated and judged to be sufficiently minor that it would be unnecessary to carry out the extensive modal split computer runs required to define the effect precisely.

CROSS-SOUND FACILITIES

The test of System 2 showed that no adjustment to the system of cross-Sound facilities was necessary to serve the 1990 travel demand. The Tacoma Narrows Bridge, while predicted to experience a substantial growth in traffic by 1990, will still have reserve capacity in accommodating the travel demand. Some of the ferry routes will require additional, and possibly larger, vessels in order to meet the future travel demand, but the volumes of traffic which are forecasted are not such that ferries could not feasibly carry them.

HIGHWAY FACILITIES

Procedures identical to those used for Highway Study System 2 led to the determination of the volume of traffic which would use each link of the Highway Study System 3 network.

Highway Study System 3 simply was a stepping stone in the quest for an efficient system adequate to meet the needs of the future travel demand. Therefore, only a summary presentation of the results is given in Table IV-59. Additional facilities in Highway Study System 3 served to reduce substantially the over-all capacity deficiency of inter­state freeways and expressways in comparison to System 2 (see Table IV-57, Page 78).

<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Facility Mileage</th>
<th>Daily Vehicle Miles of Travel</th>
<th>Daily Vehicle Miles of Travel Demand</th>
<th>Ratio of Travel Demand To Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeways</td>
<td>1,164</td>
<td>9,089</td>
<td>9,021</td>
<td>0.99</td>
</tr>
<tr>
<td>Other Freeways</td>
<td>947</td>
<td>11,083</td>
<td>9,021</td>
<td>0.81</td>
</tr>
<tr>
<td>Expressways</td>
<td>67</td>
<td>2,208</td>
<td>1,007</td>
<td>0.46</td>
</tr>
<tr>
<td>Ramps</td>
<td>52</td>
<td>354</td>
<td>394</td>
<td>0.71</td>
</tr>
<tr>
<td>SUBTOTAL—Controlled Access Facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td>530</td>
<td>22,935</td>
<td>19,445</td>
<td>0.85</td>
</tr>
<tr>
<td>Surface Arterials</td>
<td>1,739</td>
<td>17,351</td>
<td>9,021</td>
<td>0.81</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,269</td>
<td>40,285</td>
<td>27,904</td>
<td>0.69</td>
</tr>
</tbody>
</table>

1. This is the facility mileage coded for computer processing. It differs from actual physical route mileage because many major facilities with complex interchanges are coded as two one-way facilities, which, in effect, causes the mileage to be double the actual route miles in such instances. On the other hand, in instances where the road facilities are parallel and in close proximity, with both serving the same function and area, they are frequently consolidated in the facility coding. This causes the mileage as coded to be less than actual route miles. Thus, these two conditions affecting the mileage tend to offset one another. Ramp mileage shown is that coded for computer processing. Only in those instances where interchanges are complex, and the designs of least tentative set, were ramps coded as separate facilities. Thus, this figure is not meant to be all-inclusive for ramps in the Study System.

2. The vehicle hours of travel are for trips assigned to the highway network. It does not include (a) travel times for travel on the so-called local links, the local streets which connect each analysis zone to the arterial network, (b) time consumed at the beginning and ending of each trip in parking and waiting to the trip terminus, or (c) the travel time involved in trips remaining entirely within the analysis zone of trip origin (so-called intrazonal trips).

Special Link Analysis

Since System 3 had resolved most of the capacity problems observed in the test of System 2, just one selected link analysis—between Tukwila and Renton on the Interstate 405 Freeway loop around Lake Washington—was required. Even though the traffic overload on this link was reduced substan-
tially in System 3 from the System 2 level, it was necessary to analyze the origins and destinations of the trips still using this section before a means to relieve the overload could be determined.

**Study System 3 Modification 1**

Although Study System 3 had resolved most of the capacity shortcomings of System 2, some critical areas still remained. Consequently, several additional facilities were delineated which analyses indicated were needed to meet the 1990 Plan A travel demand. These facilities were integrated into System 3 to create Study System 3 Modification 1.

**HIGHWAY FACILITIES**

Figure IV-68 shows Highway Study System 3 Modification 1. Besides the additions and modifications required to resolve capacity shortcomings in Study System 3, several facilities were included simply to test their impact, since these had been considered by various agencies. (A proposed Canyon Road extension across the Puyallup River east of Tacoma in Pierce County is an example.)

The major additions required for capacity need included a new cross-county freeway route south of Tukwila and Renton in King County. Heavy traffic flow demands are generated through this general area because of the Plan A employment concentrations in Seattle, high employment in the Renton and Tukwila areas, and a forecasted population growth in the entire area south of Seattle and east of Renton, Kent, and Auburn. Topography, the river, and relatively sparse development in the past have resulted in extremely limited road and street facilities in an east-west orientation in this area. Interstate 405 and its extension westerly to Burien (Sign Route 518) — the only major route serving cross-county travel between Kent and Seattle — will not be able to cope with the total travel demand without supplemental facilities. Analysis of the travel demand established that a route was needed as near as possible to the Interstate 405 alignment.

As finally delineated, the route makes use of the presently 4-laned South 188th Street and its interchange with Interstate 5. It then crosses the Green River valley generally in the vicinity of South 180th Street to a junction with the north-south freeway route previously made a part of Study System 3.

In addition, to relieve Interstate 405 of heavy traffic overloads north of Renton, an expressway connection from the North Renton Interchange to the north-south freeway east of Renton would permit traffic to and from Renton — and particularly the employment concentration in the Renton industrial area — to make use of the additional north-south freeway. This route will also provide added capacity to serve the heavy east-west travel in the area east of Renton where high population growth is anticipated.

While tests of the previous systems revealed that Interstate 5 through Tacoma would reach its carrying capacity by approximately 1990 (if it were to be widened to its ultimate design of eight lanes throughout its length), growth beyond 1990 would, of course, create capacity deficiencies. Moreover, the Lakes District southwest of Tacoma is forecasted to grow significantly — but it is not directly served by the Interstate freeway. A reasonable — and in the long run preferable — solution might be to construct a route prior to 1990 through the...
Lakes District, generally along the alignment of the proposed Hannah-Pierce Expressway, and to defer construction of the two additional lanes to the Interstate route. This would provide for growth in that area beyond 1990.

Additionally, a modification to the present one-way street system in downtown Tacoma was incorporated in Study System 3 Modification 1 to test whether this might provide improved traffic distribution. Elsewhere in the region, adjustments were made in level of service speeds on individual facilities where it was evident they would attract greater volumes of traffic than could be accommodated at the originally assigned speed levels. In a few other instances provisions of current designs which modified previous assumptions were incorporated also.

In summary, Highway Study System 3 Modification 1 comprised 440 miles of controlled access facilities, 20 more than in System 3. Ten miles of surface arterials were also added, bringing the total to 1,750.

TRANSIT AND CROSS-SOUND FACILITIES

No revisions or additions to the bus transit network nor to the cross-Sound facilities of Study System 3 were necessary.

Study System 3 Modification 1
Test Results

TRANSIT AND CROSS-SOUND FACILITIES

Because there were no significant highway facility changes nor revisions in the transit system of Study System 3, no recomputation of the expected future transit usage was made. It should be pointed out that this has the effect of slightly overstating future transit use since it does not give recognition to the impact of the street and highway facilities added to Study System 2, which was the basis for computing the expected transit use.

Likewise, since there were no changes in the facilities for cross-Sound travel, the travel forecasts described on Page 75 also applied to Study System 3 Modification 1.

HIGHWAY FACILITIES

Figure IV-69 shows the traffic demand flow map for the freeways and expressways of Study System 3 Modification 1. The major difference from the System 3 flow pattern is with respect to the section of the Interstate 405 Freeway from Tukwila, through Renton, to Bellevue.

The cross-county freeway south of Tukwila and Renton effectively relieved Interstate 405 of its traffic overload in the Tukwila area, while the North Renton connection distributed part of the overload on Interstate 405 to the additional north-south freeway. In addition, adjustments to the level of service speeds on Interstate 405, which were necessitated by the heavy traffic demands, caused other traffic shifts.

Travel Demands Compared To Capacity

Figure IV-70 shows comparisons of travel demand with total facility capacity in broad travel corridors. The few corridor capacity deficiencies which still remain are quite small and in many cases are balanced by surpluses in adjoining corridors. However, there is one corridor—from Spokane Street to 16th Avenue South across the Duwamish River in Seattle—with an apparent large capacity deficiency. The First Avenue South Bridge, in particular, experienced a significant overload in this system test, despite the assumption of full eight lanes upon the completion of the proposed parallel span.

To resolve this indicated overload, a selected link analysis was made of the First Avenue South
Bridge, which revealed that much of the travel on the bridge could be diverted to alternate routes with available capacity which could provide almost equal service. However, more than an eight-lane demand would still remain at the bridge. This might be resolved with an additional crossing of the Duwamish or a reversible lane operation, when travel demands reach levels in excess of the normal eight-lane capacity of the bridge.

Regionwide System and Travel Comparisons

Table IV-60 shows the summary results of the test of Study System 3 Modification 1 (see Table IV-59, Page 80 for comparable System 3 figures). It is evident that the modifications made to System 3 have brought about a slight lessening in the regionwide ratio of travel demand to travel capacity.

System 3 Modification 1 can be considered a complete regional network serving 1990 Plan A travel demands adequately and displaying reasonable balance between travel demand and capacity. The analysis of the test results indicate that System 3 Modification 1 will serve the 1990 Plan A travel demands more efficiently and effectively than the 1961 transportation system served 1961 travel demands.

The highway component of Study System 3 Modification 1 has 651 more miles of facilities than the 1961 system (an increase of almost 40 percent), of which 440 miles were controlled access routes. Therefore, while the facility mileage will increase by 40 percent, the system capacity is increased by almost 130 percent. The travel demand increases by 160 percent over the 1961 daily vehicle miles of travel of 10,664,000. However, the total vehicle hours consumed in travel daily would increase only by 52 percent. This relatively modest rise in vehicle hours of travel—compared to the 160 percent increase in vehicle miles of travel and the forecasted growth of almost 100 percent in the total number of vehicle trips—indicates of the substantial improvement over 1961 operating conditions which System 3 Modification 1 would provide.
Study System 4

The study systems thus far described were predicated on the use of buses to provide transit service through the region to serve the 1990 Plan A travel demands. These systems incorporated an extensive and integrated network of express bus routes, supported by local and feeder bus facilities. The highway facilities assumed to be operating in conjunction with the bus transit system were primarily made up of those currently programmed and budgeted. In Study System 4, the addition of a rapid transit line together with its feeder buses was analyzed to evaluate the potential for this mode of transportation in the Puget Sound Region.

BUS AND RAPID TRANSIT FACILITIES

In establishing a transit study system incorporating rapid transit, it was first necessary to delineate the rapid transit lines which would form the backbone of the system. The bus transit segments could then be oriented to serve the rapid transit stations wherever possible.

A thorough examination of future residential and employment density patterns, topographic features and major travel demand corridors preceded the determination of possible locations for rapid transit facilities. These appraisals—carried out in conjunction with the transit consultant to the Puget Sound Governmental Conference—established that the future potential transit demand outside the immediate metropolitan area of Seattle was insufficient to require rapid transit facilities. This conclusion was reached because the other cities in the region and the suburban areas are of lower development density and lower in the number of trips to be served. The future travel demands will continue to be relatively dispersed in such areas, so that it would be difficult to serve adequately large and concentrated blocks of trip origins or destinations within walking distance of the possible rapid transit stations.

Within the Seattle area, the following possible corridor locations emanating from the central business district were studied for the potential application of rapid transit:

—South-easterly in Rainier Valley, possibly as far as Renton.
—To the industrial area and the Seattle Boeing complex, possibly extending as far as the Seattle-Tacoma International Airport.
—To the Harbor Island area and thence through West Seattle.
—To the Queen Anne Hill, Magnolia, Ballard and Greenwood areas of Seattle, with possible extensions north-erly to the Haller Lake, Ronald, Mountlake Terrace and Lynnwood areas.
—To the Capitol Hill, University, Ravenna and Roosevelt districts in Seattle.
—To the First Hill, East Madison, Montlake and Ravenna districts.
—To Mercer Island and Bellevue across Lake Washington.

Possible combinations of such routes were also considered.

Examined for each possible location were: (1) the general density of present and forecasted future development, (2) the topography, (3) possible station locations, (4) the general travel density in each corridor, (5) the orientation of the trips now made and expected to be made by residents of the corridor, (6) the width of the corridor which could be served by the rapid transit line, and (7) the general level of competition which would be offered the rapid transit line by the highway system.

After all these pertinent factors were considered, two corridors emanating from downtown Seattle were selected for testing the potential value and usage of rapid transit. Figure IV-71 shows the general location of the assumed rapid transit system and the tentative station sites. The system is 19.7 miles long and has a total of 18 stations.80

With high construction standards for the roadbed and modern, lightweight equipment capable of rapid acceleration and deceleration (with a maximum speed potential of 80 miles per hour), it would be possible to achieve an overall operating speed of 37 miles per hour, including station stops. The line across Lake Washington would have an overall operating speed of up to 45 miles per hour, depending upon the structural characteristics of the Lake Bridge. The line in the northwest corridor of Seattle, with its closer station spacing, would operate at approximately 31 miles per hour. Based on initial estimates of peak-hourly patronage, headways of four minutes were assumed during peak periods.

It was further assumed for the system test that rapid transit fares would be 25 cents, with free transfer privileges to the bus system, and that at each of the rapid transit stations outside the central business district, a free parking lot would be provided. The bus system was oriented to the rapid transit line, rather than operating in competition. (Bus and rapid transit headways were assumed to be integrated to hold transfer times to a minimum.) Thus, express bus routes included in Systems 2 and 3 north of the Seattle central business district and east across Lake Washington were deleted from Transit Study System 4. Figure IV-72 shows the routes included in Transit Study System 4.

80. Gendell, op. cit., Staff Report No. 10, (See Page 13).
The guiding principle in delineating Highway Study System 4 was to make the facilities complementary to the rapid transit line rather than competitive to it. In those parts of the region outside the influence of the rapid transit line Highway Study System 3 was used as a base network. In the areas where rapid transit was providing service, only the street and highway facilities currently committed and programmed were assumed to be constructed in addition to existing facilities. This limitation on highway facilities served to develop the maximum possible usage of the rapid transit system.

The routes specifically deleted from System 3, amounting to 30 miles, included the so-called Northwest Expressway in Seattle, the Sand Point-Kirkland bridge across Lake Washington and its approaches, and the north-south freeway east of Interstate 405 from Interstate 90 northerly.

Cross-Sound facilities in Study System 4 were identical to those in Study System 3.

Study System 4 Test Results

In making transit patronage estimates based on Study System 4 it was assumed that: (1) a limited highway network would be operating in conjunction with the rapid transit system, (2) a reoriented bus transit system would feed the rapid transit line rather than compete with it, (3) there would be provision for free parking lots for rapid transit users at all of the stations outside of the central business district, (4) the fare would be a flat rate of 25 cents per ride, and (5) free transfer privileges between the rapid transit and bus systems would be granted.

It was also assumed that parking costs in downtown Seattle would increase substantially by 1990 (doubling by that time) and that street and highway facilities during the peak hours would operate at speeds 30 percent below average conditions for a
24-hour period, while the rapid transit line would, of course, operate at the same speed during peak and off-peak hours. All of these assumptions had the effect of increasing the relative attractiveness of the transit network to travelers in contrast to the use of highways, particularly for travel to the central business district of Seattle. Furthermore, data from other areas where rapid transit is available or planned was taken into consideration to give recognition to the effect on transit usage of the improved quality of service 81 provided by rapid transit.

BUS AND RAPID TRANSIT FACILITIES

Figure IV-73 shows the passenger flow for the rapid transit route, both for work trips and total trips. These volumes are generated by the Plan A pattern of development with a large employment concentration allotted to downtown Seattle (which explains the high proportion of total travel made up of work trips).

Figure IV-74 shows the transit passenger flow for work trips for the entire regional transit system. The much heavier usage attracted to the rapid transit line compared to bus transit is clearly evident. Also apparent is the much greater usage of transit in the Seattle area compared to the rest of the region. This is in continuance of existing patterns of usage and is due to the lesser densities of development outside of Seattle.

The test results showed that the rapid transit system developed a usage of almost 40 percent higher (nearly 24,000 trips) than was developed from the same areas by bus transit. This meant a reduction of approximately 18,500 passenger car trips. Table IV-61 shows the rapid transit patronage attracted at specific locations.

81. Characteristics such as comfort, convenience, reliability, assuring each rider of a seat, etc.
TABLE IV-41
RAPID TRANSIT PASSENGER VOLUMES AT SELECTED LOCATIONS

<table>
<thead>
<tr>
<th>Location</th>
<th>Passengers Per Weekday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Work Trips</td>
</tr>
<tr>
<td>Across Lake Washington</td>
<td>19,400</td>
</tr>
<tr>
<td>South of the Seattle Central</td>
<td>22,400</td>
</tr>
<tr>
<td>Business District</td>
<td></td>
</tr>
<tr>
<td>Across the Ship Canal,</td>
<td>20,100</td>
</tr>
<tr>
<td>in Seattle</td>
<td></td>
</tr>
<tr>
<td>Between Letona Street,</td>
<td>26,300</td>
</tr>
<tr>
<td>and the Civic Center</td>
<td></td>
</tr>
</tbody>
</table>

1. Public transportation across Lake Washington is by rapid transit only. No competing bus service is provided.

during the freeway and expressway span and the assumed preemption by the rapid transit line of the two reversible lanes on the southside of the Civic Center.

HIGHWAY FACILITIES

The deletion from Study System 4 of some of the System 3 routes resulted in several over-loading problems. This occurred because the increased transit usage did not reduce the highway travel demand to an extent equal to the decrease in system capacity resulting from the freeway and expressway deletions.

Some of the major capacity deficiencies were found to be on the Lake Washington bridges because of the deletion of the Sand Point-Kirkland span and the assumed preemption by the rapid transit line of the two reversible lanes on the proposed-third Lake Washington bridge at Mercer Island. There were also capacity deficiencies on the Interstate 405 Freeway north of Interstate 90 and in the travel corridors east of the Lake due to the deletion of the north-south freeway east of Bellevue.

TABLE IV-42
TRAFFIC ASSIGNMENT SUMMARY
HIGHWAY STUDY SYSTEM 4 — 1990 PLAN A

<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Facility Milesa</th>
<th>Daily Vehicle Miles of Travel Assigned (000's)</th>
<th>Daily Vehicle Miles of Capacity (000's)</th>
<th>Daily Vehicle Miles of Capacity (% of Demand)</th>
<th>Ratio of Travel to Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeways</td>
<td>144</td>
<td>184</td>
<td>9,874</td>
<td>9,549</td>
<td>1.08</td>
</tr>
<tr>
<td>Other Freeways</td>
<td>220</td>
<td>166</td>
<td>9,439</td>
<td>8,326</td>
<td>0.90</td>
</tr>
<tr>
<td>Expressways</td>
<td>62</td>
<td>21</td>
<td>2,673</td>
<td>997</td>
<td>0.48</td>
</tr>
<tr>
<td>Ramps</td>
<td>50</td>
<td>12</td>
<td>511</td>
<td>441</td>
<td>0.82</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
<td><strong>456</strong></td>
<td><strong>384</strong></td>
<td><strong>20,499</strong></td>
<td><strong>19,501</strong></td>
<td><strong>0.93</strong></td>
</tr>
<tr>
<td><strong>Surface Arterials</strong></td>
<td>1,737</td>
<td>293</td>
<td>17,359</td>
<td>8,224</td>
<td>0.51</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2,233</strong></td>
<td><strong>677</strong></td>
<td><strong>38,158</strong></td>
<td><strong>28,725</strong></td>
<td><strong>0.74</strong></td>
</tr>
</tbody>
</table>

1. This is the facility mileage coded for computer processing. It differs from actual physical route mileage because many of the major facilities with complex interchanges are coded as two one-way facilities, which, in effect, causes the mileage as coded to be double the actual route miles in such instances. On the other hand, in instances where two facilities are parallel and in close proximity, both serving the same function and area, they are frequently consolidated in the facility coding. This causes the mileage as coded to be less than actual route miles. Thus two conditions affecting the mileage tend to offset one another. Ramp mileage shown is that coded for computer processing.

2. The vehicle hours of travel are for trips assigned to the highway network. It does not include (a) travel time for travel on the so-called local links, the local streets which connect each analysis zone to the arterial network; (b) time consumed at the beginning and ending of each trip in parking and walking to the trip terminus, or (c) the travel times involved in trips remaining entirely within the analysis zone of origin (so-called intrazonal trips).

Table IV-62 shows the results of the assignment of 1990 Plan A travel to Highway Study System 4. While the interstate freeways of System 3 had a demand-to-capacity ratio of 0.99, this ratio rose to 1.08 for System 4. Considering all the limited access facilities as a whole, the demand-to-capacity ratio rose from 0.85 in System 3 to 0.93 in System 4.

From the various comparisons, it is evident that Study System 4 lacks sufficient street-and-highway capacity to meet future travel demands. Consequently, further adjustments were necessary.

Study System 4 Modification 1

Because of the capacity shortcomings indicated in the test of Study System 4, it was found necessary to supplement the highway network to bring it into balance with the 1990 Plan A travel demand. (No significant adjustments to the transit system or cross-Sound facilities were required.)

HIGHWAY FACILITIES

The results of the test of Study System 4 revealed shortcomings very similar to those found in tests of System 3. This was not entirely unexpected, since as explained previously, the impact of the rapid transit facility on the highway travel demand is relatively small.

Figure IV-75 portrays Highway Study System 4 Modification 1 delineated to resolve the capacity shortcoming of System 4. It is identical to System 3 Modification 1 with two exceptions. The Northwest Expressway in Seattle was not included because it would be in direct competition with the rapid transit line; also, there was no finding of a significant capacity deficiency in the corridor north of the Seattle central business district which would call for such a route to accommodate 1990 Plan A volumes. The other deviation from System 3 Modification 1 was the assumption that rapid transit facilities would preempt the two reversible lanes for vehicular traffic on the proposed Third Lake Washington bridge.

Study System 4 Modification 1 Test Results

Analyses were made of the effect on the transit usage estimated for System 4 which could be
expected from the highway facilities added to the system. It was found that the effect would be minimal, primarily because the additional highway facilities were not directed toward serving the downtown of Seattle and, therefore, were not in direct competition with the transit facilities. No separate computer runs were made to establish the specific effect. Since the results would have been nearly identical to those for Transit Study System 4.

HIGHWAY FACILITIES

The traffic demand flow map for the controlled access facilities of System 4 Modification 1 is shown in Figure IV-76. The flow is essentially the same as for System 3 Modification 1, (see Figure IV-69, Page 82), except for north of the Seattle central business district where the volume on Interstate 5 is higher in System 4 Modification 1. This results from the absence of the Northwest Expressway which causes additional traffic to be attracted to the interstate route.

Corridor comparisons of capacity versus travel demand are shown in Figure IV-77; again the results are similar to those for System 3 Modification 1. The major exceptions are across the Ship Canal in Seattle and across Lake Washington. The capacity deficiency across the Ship Canal is 24,000 passenger vehicle equivalents daily, substantially less than the 1961 deficiency of 74,000. A more serious problem prevails across Lake Washington where the capacity deficiency of 31,000 passenger vehicle equivalents daily amounts to almost 14 percent of the total capacity across the lake (assuming that two lanes of the proposed third Lake Washington bridge would be preempted by rapid transit). Therefore, careful scrutiny is necessary to insure that vehicular travel demands across Lake Washington are adequately accommodated when the two lanes are allocated to rapid transit.
Regionwide System and Travel Comparisons

Table IV-63 summarizes the results of the assignment of 1990 Plan A travel to Highway Study System 4 Modification 1. They are similar to those for System 3 Modification 1, except for a slightly heavier system-wide travel load on the interstate and other freeways.

Study System 5

Study System 5 was the initial system tested with Land Use Plan B, the pattern of development following the cities-and-corridors concept. System 5 is identical to System 2 in every respect, except that it incorporates a cross-Sound bridge. Inclusion of the cross-Sound bridge in System 5 is not meant to imply that the cities-and-corridors idea hinged upon provision of a cross-Sound bridge, but simply that the test and evaluation of such a span was a necessary part of the Study's regional transportation planning responsibility. The bridge could have been tested in conjunction with the Land Use Plan A pattern yielding essentially the same results. Conversely, had a ferry system been tested for Plan B, the results would have been identical to those of the Plan A tests.

CROSS-SOUND FACILITIES

A cross-Sound bridge, as part of Study System 5, was assumed to be operating in conjunction with a toll-free Tacoma Narrows Bridge, plus those ferry routes necessary to provide reasonable levels of service. It was further assumed, consistently with the indications of previous studies, that a cross-Sound bridge would be a toll facility, and that tolls on the bridge would not be materially different from those presently in existence on the ferry routes.

An appraisal of the possible construction schedule indicates that it would take approximately ten years from legislative authorization to completion of a bridge. Consequently, the operation of a bridge cannot be inaugurated long before 1980. Therefore, its effect on development by 1990 will tend to be minimal.

For purposes of testing the traffic usage which
could be expected of a cross-Sound bridge—and thus obtaining a measure of its desirability and feasibility—a bridge was assumed at the Fauntleroy to Vashon Island to Southworth vicinity, together with connecting highways and bridges on both sides of Puget Sound (See Figure IV-7B). This particular bridge location was selected for the test since previous studies and investigations had established it as the only one possible from an engineering standpoint, the other possible bridge locations being judged unfeasible because of extreme depths of water. 82

In addition, prior studies indicated the feasibility of financing a bridge at the Fauntleroy-Vashon location and that its cost would be less than the other two bridges considered between Seattle and the Kitsap Peninsula. The Seattle approach to the bridge would be consistent with the city’s comprehensive plan and provide good traffic distribution in the city. Moreover, its impact on Seattle’s internal traffic flow, particularly through the central business district, would be the least of any of the possible central bridge locations. A bridge at the Vashon Island location also would have the least effect on navigation of any of the potential sites.

It was also recognized, however, that the results obtained from testing a cross-Sound bridge at the Vashon Island site would be somewhat representative of the effects and the traffic attraction which could be expected from the other possible bridges from Seattle to Kitsap County. Exhaustive engineering and traffic investigations of all other possible bridge locations have been made by the State Highway Commission in cooperation with the Washington Toll Bridge Authority and the Joint Committee of Highways of the Washington State Legislature in response to a legislative directive.

With a bridge at the Vashon Island site, it was assumed that the Fauntleroy-Vashon, Vashon-Southworth, Fauntleroy-Southworth, Seattle-Bremerton and Seattle-Winslow ferries would be discontinued. However, a foot-passenger boat service was assumed to operate between Seattle and Winslow in order to provide a reasonable service to present foot-passenger commuters on the vehicular ferries. The Edmonds-Kingston, Point Defiance-Tahlequah, and Mukilteo-Columbia Beach ferries would continue in operation unchanged.

HIGHWAY FACILITIES

Highway Study System 5 represents the existing street-and-highway system, supplemented by committed and programmed projects as well as the cross-Sound bridge with its approach facilities. (See Figure IV-78.)

TRANSIT FACILITIES

The transit system tested as part of Study System 5 was based on the assumption that transit service would be provided by buses. The network was similar to Transit Study System 2, except for slight modifications in the Bellevue-Lake Hills areas where the Plan B population forecast was substantially higher than in Plan A, thus justifying additional transit service. Figure IV-79 shows the System 5 network assumed to be in operation during peak hours.

Study System 5 Test Results

TRANSIT FACILITIES

Figures IV-80 and IV-81 show the transit passenger flow diagram for System 5. A comparison with the flow maps for Plan A (Figures IV-64 and IV-65, Pages 74 and 75) reveals the lesser transit usage associated with Plan B.

82 Recent studies have indicated that the water-depth is no longer a prohibitive factor at the other possible bridge sites.
The reason for the lower transit trip making associated with Plan B compared to Plan A is the lesser degree of centralization in Plan B. Transit is oriented toward serving the concentrated employment and shopping trip demands of the central business districts. Outlying employment centers cannot be served by transit as adequately as central business districts because of their low density of development. Furthermore outlying centers generally provide free parking which encourages automobile usage.

Table IV-64 shows a comparison of the number of express buses needed to accommodate the peak-hour transit usage for Plans A and B at a number of specific locations.

In appraising the bus headway needed to accommodate the transit demand during the peak hour—compared to the initially assumed headways—it was evident that a somewhat more frequent service than called for by the predicted usage had been assumed.

To rectify this, it would be possible to use smaller buses than the 50-passenger vehicles which were assumed, and thus not rely solely on reduced frequency of service to bring about a balance between usage and the transit capacity being furnished.

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of Buses Plan A</th>
<th>Plan B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evagreen Point Bridge</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Mercer Island Bridge</td>
<td>27</td>
<td>13</td>
</tr>
<tr>
<td>East Channel Bridge</td>
<td>23</td>
<td>10</td>
</tr>
<tr>
<td>A Street Viaduct in Tacoma</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Interstate Freeway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North of Seattle Central Business District</td>
<td>64</td>
<td>41</td>
</tr>
<tr>
<td>South of Seattle Central Business District</td>
<td>47</td>
<td>26</td>
</tr>
<tr>
<td>At Snohomish-King County Line</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>North of Tukwila</td>
<td>15</td>
<td>7</td>
</tr>
</tbody>
</table>
CROSS-SOUND FACILITIES

Table IV-65 shows the forecasted use (for Plan B) of the cross-Sound bridge in Study System 5. These volumes can be compared to the Plan A figures in Table IV-55, Page 75. The total cross-

TABLE IV-65
CROSS-SOUND TRAVEL — 1990 PLAN B
BASED ON A CROSS-SOUND BRIDGE AT THE VASHON ISLAND SITE

<table>
<thead>
<tr>
<th>Cross-Sound Facility</th>
<th>Total Person Trips</th>
<th>Vehicle Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferries</td>
<td>2,994</td>
<td>1,770</td>
</tr>
<tr>
<td>Mukilteo-Columbia Beach</td>
<td>4,347</td>
<td>2,095</td>
</tr>
<tr>
<td>Seattle-Winslow (Foot Passenger Vessel)</td>
<td>4,099</td>
<td></td>
</tr>
<tr>
<td>Cross-Sound Bridge</td>
<td>29,505</td>
<td>14,593</td>
</tr>
<tr>
<td>Fauntleroy to Vashon Island</td>
<td>28,516</td>
<td>11,921</td>
</tr>
<tr>
<td>Vashon Island to Southworth</td>
<td>31,302</td>
<td>22,180</td>
</tr>
</tbody>
</table>

1. Average weekday total person trip and vehicular traffic volumes.
2. Approximately 3,000 trips are to and from Bainbridge Island.

Sound travel is higher in Plan B than in Plan A because of the greater amount of development west of Puget Sound which the cross-Sound bridge can be expected to attract.

HIGHWAY FACILITIES

The traffic flow map for Highway System 5 is shown in Figure IV-82. Compared to the 1990 Plan A traffic flow map for Highway System 2 — Figure IV-66, Page 76 — the overall lesser amount of travel associated with Plan B is observed. Various analyses of System 5 revealed that the network of present plus committed facilities was inadequate to meet the 1990 Plan B travel demands, even

88. The lesser amount of travel in Plan B as compared to Plan A is primarily due to the shorter trip lengths inherent in the distribution of population and employment which was used in the Plan B test. The fact that job, shopping and other trip opportunities are in closer proximity to places of residence in Plan B brings about the somewhat shorter trip lengths. The average trip length for all trip purposes combined in Plan A was 18.1 minutes and 16.9 minutes for Plan B. The respective average trip distances were 8.1 and 7.3 miles. This combined with a greater proportion of the total travel in Plan B which has both trip origin and destination in the same analysis zone, serves to reduce overall vehicle miles of travel in the region by 15 percent.
though travel demands were significantly lower than those forecasted in Plan A.

As examples of specific travel demands on individual facilities, the Evergreen Point Bridge across Lake Washington is estimated at 103,000 passenger car equivalents daily, compared to the 130,000 in Plan A System 2 — both well above the design capacity of approximately 40,000. On the section of the Interstate 405 Freeway between Tukwila and Renton, the System 5 Plan B loading was 137,000 compared to over 150,000 in Plan A System 2 — again both loadings well above the 40,000 per day design capacity.

Regionwide System and Travel Comparisons

Table IV-66 summarizes the results of the assignment of 1990 Plan B travel to Highway Study System 5. The figures can be compared directly to those for the Plan A System 2 test in Table IV-57, Page 78.

It can be seen that System 5 with an overall demand-to-capacity ratio of 0.74 would operate better than System 2 with a ratio of 0.88. This is attributable to the reduction in travel which results from Plan B compared to Plan A. It is also readily apparent that the interstate routes as a whole are significantly overloaded in System 5, pointing the need for additional facilities in order to insure the adequate functioning of the network.

Study System 6

The analyses and evaluations of the test of Study System 5 revealed its shortcomings in meeting the 1990 Plan B travel needs. Consequently, Study System 6 was delineated to serve Plan B travel demands adequately.

HIGHWAY FACILITIES

The delineation of the highway system to resolve the capacity shortcomings of Highway System 5 was guided by two major planning principles: (1) relationship of highway facilities to industrial areas, and (2) relationship of highway facilities to open space. Since the Plan B concept was significantly different from Plan A—particularly insofar as the organized system of open space and the concept of individual communities oriented around community centers are concerned—necessary additions to Highway Study System 5 were examined from the standpoint of serving the designated communities without detracting from the effectiveness of the open space system (see Figure IV-58, Page 62).

Initially an investigation was made of the locational characteristics of existing and committed controlled access facilities with regard to employment centers of more than 1,500 employees. This was to see whether there is a consistent pattern which could be followed insofar as additions to Highway Study System 5 and their relationship to Plan B employment centers are concerned. A map of the present employment centers, compared to existing and committed freeways and expressways, showed a remarkably consistent pattern. Almost without exception, such facilities tend to skirt employment centers, generally passing in close proximity. This seems to be a reasonable relationship since employment centers generally do not make good locations for major highway facilities because of high right-of-way cost and the disruption of the economic base of communities. Locating facilities near employment centers appears to be a good planning principle since the high traffic generating potential of such areas is thus effectively and directly served, while taking advantage of the often blighted areas in the vicinity of employment centers for the necessary right-of-way. Not only is such right-of-way generally reasonable in cost, but the facility can also become an effective buffer between mixed land uses.

A similar examination was made of the relationship of existing and committed controlled access
facilities to the open space bands delineated as a part of the Plan B concept. Once more there appeared to be a remarkable consistency in the locational patterns. The controlled access routes generally were parallel to and along the open space belts. This, again, seems to be a reasonable pattern of location since the open space bands generally utilize areas of steep slopes or flood plains along major streams. Thus, major highway facilities are constrained by such topographic features and tend to parallel them rather than cross them. From a Plan B concept standpoint, there is the added advantage of the transportation facility helping to shape and define the community boundaries and in effectuating the open space system through possible parkway type developments.

If the major transportation routes were to cross the open space bands, they would tend to break down the effectiveness of the open space bands in delineating the community form. This locational relationship was also accepted as a guiding planning principle in considering additions to Highway Study System 5 in order to create an adequate system of highway facilities to meet the Plan B travel demands.

There is a great similarity between Highway Study Systems 6 (shown in Figure IV-83) and 3 Modification 1 (shown in Figure IV-68, Page 81), although this was not by intent. Obviously, the existing, committed and programmed freeways and expressways are a major determinant of travel patterns for both Plan A and Plan B. Many of the additions to Highway Study System 5 are in the nature of “missing links” and were found needed for both Plan A and Plan B systems. The additional corridors in which highway capacity was still found deficient were almost identical in Plans A and B. Thus, it was only with respect to specific location within these corridors that there was any freedom. However, it was generally found that to-
pography in these corridors was so restrictive that little flexibility remained as to location so as to achieve other possible goals.

The additional major facilities in System 6 included all of the routes in System 3 Modification 1 except: (1) the Northwest Expressway in Seattle, (2) the proposed east-west expressway in the Kent vicinity easterly of Interstate 5, and (3) the southernmost portion of the north-south freeway route lying east of Interstate 405 and Renton. A test was also made of an east-west route connecting the Interstate 5 and 405 Freeways in southern Snohomish County to determine if such a route would be preferable to the north-south route from the vicinity of Kenmore to Interstate 5 included in System 3 Modification 1.

A total of 480 miles of limited access facilities were included in System 6—110 more than System 5. Total surface arterial mileage was 1750—30 miles more than System 5.

### TRANSIT AND CROSS-SOUND FACILITIES

No significant modifications to Transit Study System 5 were found necessary, other than slight adjustments in assumed headways and bus sizes and in some of the suburban area routes where usage near the route ends was insufficient to warrant service. Cross-Sound facilities in Study System 6 were identical to those in System 5.

#### Study System 6 Test Results

**TRANSIT AND CROSS-SOUND FACILITIES**

Since no significant changes were involved, the results of the test of Study System 5 can also be considered applicable to System 6.

#### HIGHWAY FACILITIES

Figure IV-84 is the traffic flow map showing 1990 Plan B travel demands on Highway Study System 6. It can be compared to Figure IV-69, Page 82, representing System 3 Modification 1. In general, System 6 volumes tend to be somewhat lower.

The results of capacity-and-demand comparisons for travel corridors in System 6 are shown in Figure IV-85. Only isolated instances of corridor capacity deficiencies are evident, even though lesser numbers of lanes were assumed for most facilities which are identical in System 6 and System 3 Modification 1.

#### TABLE IV-47 TRAFFIC ASSIGNMENT SUMMARY

<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Capacity</th>
<th>Capacity</th>
<th>Capacity</th>
<th>Capacity</th>
<th>Ratio of Travel Demand to Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mileage</td>
<td>Facility</td>
<td>Daily</td>
<td>Daily</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vehicle</td>
<td>Vehicle</td>
<td>Vehicle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hours of Travel</td>
<td>Miles of Travel</td>
<td>Capacity</td>
</tr>
<tr>
<td>Interstate</td>
<td></td>
<td></td>
<td>10,000</td>
<td>1,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Freeways</td>
<td>164</td>
<td>154</td>
<td>6,490</td>
<td>3,780</td>
<td>6,490</td>
</tr>
<tr>
<td>Other Freeways</td>
<td>235</td>
<td>220</td>
<td>9,625</td>
<td>8,190</td>
<td>9,625</td>
</tr>
<tr>
<td>Expressways</td>
<td>73</td>
<td>37</td>
<td>3,780</td>
<td>1,010</td>
<td>3,780</td>
</tr>
<tr>
<td>Ramps</td>
<td>50</td>
<td>9</td>
<td>416</td>
<td>39</td>
<td>416</td>
</tr>
<tr>
<td>SUBTOTAL—Controlled Access Facilities</td>
<td>542</td>
<td>327</td>
<td>22,059</td>
<td>14,514</td>
<td>22,059</td>
</tr>
<tr>
<td>Surface</td>
<td>1,746</td>
<td>1,010</td>
<td>7,969</td>
<td>7,002</td>
<td>7,969</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,288</td>
<td>1,044</td>
<td>18,025</td>
<td>15,516</td>
<td>18,025</td>
</tr>
</tbody>
</table>

1. The figures do not include the mileage, the vehicle miles of capacity involved in the Cross-Sound bridge itself, nor the vehicle hours of travel or the vehicle miles of travel demand involved on the bridge itself. The figures are thus as nearly comparable to those for an all-ierry system as possible.

2. This is the facility mileage coded for computer processing. It differs from actual physical route mileage because many major facilities with complex interchanges are coded as two one-way facilities, which, in effect, double the actual route miles in such instances. On the other hand, in instances where two facilities are parallel and in close proximity, both serving the same function and area, they are frequently consolidated in the facility coding. This causes the mileage as coded to be less than actual route miles. Thus, these two conditions affecting the mileage tend to offset one another. Ramp mileage shown is that coded for computer processing. Only in those instances where interchanges are complex, and the designs at least tentatively set, were ramps coded as separate facilities. Thus, this figure is not meant to be all-inclusive for ramps in the Study System.

3. The vehicle hours of travel are for trips assigned to the highway network. It does not include (a) travel time for travel on so-called local streets, the local streets which connect each analysis zone to the arterial network, (b) time consumed at the beginning and ending of each trip in parking and walking to the trip terminals, or (c) travel time involved in trips remaining entirely within the analysis zone of trip origin (so-called intrazonal trips).
The travel-to-capacity comparisons indicate that Highway Study System 6—with no further modification—could adequately accommodate 1990 Plan B travel, with the exception of the Bellevue to Lake Hills area where an extremely large population and employment growth is forecasted.

Table IV-67 shows the regionwide results of the Highway Study System 6 tests. Comparison to the results for System 5 (see Table IV-66, Page 93) indicates closer balance between system capacity and the travel demand, with the System 5 demand-to-capacity ratio for the interstate freeways reduced from 1.26 to 0.94.

In summary, Highway Study System 6 is a network with adequate capacity to accommodate the 1990 vehicular travel demands generated by Plan B. Moreover, it was created with a specific concern for the proper development of the region within the framework of the cities-and-corridors concept.

**Part IV Section 9**

**EVALUATIONS OF LAND USE AND TRANSPORTATION SYSTEM ALTERNATIVES**

As a basis for developing the Study's recommendations, the alternative land use plans and transportation systems were evaluated to determine the particular combination which would most closely meet regional goals and objectives. While the land use patterns could be compared only qualitatively, the evaluation of alternative transportation systems was in part quantitative.

**Regional Land Use Objectives**

Regional objectives, particularly as they relate to the land use elements of the overall plan, are briefly summarized below.84

Open Space Goals:
1. Generous amounts of open space should be interspersed between development so that it is accessible to large numbers of people.
2. Open space should be utilized to give identity to urban development patterns.
3. Areas for agriculture should be preserved in close proximity to urban development.

Efficiency and Accessibility Goals:
1. National and state parks, forests and other major recreational facilities should be conveniently accessible to the region's residents.
2. Future travel between major destinations should be minimized.
3. Congestion of circulation facilities serving major employment areas should be reduced.
4. Circulation facilities should be utilized to guide development.
5. Development patterns which might make rapid transit feasible should be created.

The alternative land use development plans which had been detailed, analyzed, and tested were evaluated in terms of the regional goals as well as from the standpoint of goals relating to the feasibility of achievement. The latter included examination of the possible legislation and governmental structure which might be needed to implement the particular alternative, as well as the implications as to the effect on governmental structure which the development pattern might bring about.85

**Evaluation of Alternative Land Use Patterns**

From the standpoint of the aforementioned regional goals, it is clear that a land use development pattern which attempts to guide and direct growth—particularly in the burgeoning suburbs—will more likely approach the objectives than an unplanned or unguided pattern.

It should be emphasized that only matters of regional scope and impact are of concern in the evaluation of areawide land use patterns. Neighborhood design details—including schools, parks, playgrounds, stores, etc.—are of purely local interest and they are not the unique attributes of any particular regional pattern.

Because of the many separate governmental jurisdictions in the region, fragmented planning with no regionwide goals has resulted. The regional growth pattern, consequently, has followed an unplanned, unguided direction. In planning for the future of the overall area, then, it is obviously necessary to look beyond the needs and desires of the individual local jurisdictions, while still attempting to achieve a compatibility of local and regional viewpoints.

Since Plan A was predicated upon the current plans and zoning of the individual jurisdictions in the region and did not assume the inauguration of new regional programs, it obviously will not well satisfy the established objectives.

85. Utevsky, op. cit., Staff Report No. 21, (See Page 22).
The cities-and-corridors concept of Plan B, on the other hand, proposes to preserve desirable features of the region by interspersing a system of open space throughout the developing suburban areas, making the maximum use of lands which have been by-passed in the process of urban development (flood plains, steep slopes, agricultural lands, slide areas, etc.). In addition, these open spaces are designed to delineate individual communities as functional areas, which should encourage more compact growth. Finally, by organizing the development on a broad regional basis, not only can the living environment be improved, but travel patterns can also be more meaningfully planned.

In summary, it is clear that the Plan B pattern of planned and guided development is preferable to that of Plan A which represents a continuation into the future of present trends.

**Evaluation of Alternative Assumptions of Development Locations**

Not only is the general pattern of location of the various types of land uses important, but the degree of development or density of development is also significant. As described previously, the alternative land use patterns were evaluated initially only from the standpoint of the degree to which they qualitatively met the regional goals. In addition, however, two different hypothesized distributions of the specific amounts of development forecasted for the future in each portion of the region were analyzed as part of the analysis of Plan A and Plan B. These two levels of development were converted into person trips and then into transit, passenger car and truck trips. The plan test procedure determined the resulting travel load which would be created on each segment of the transportation system by this development and thus formed the basis for measuring the adequacy of the system to accommodate the travel load.

**Population**

As was pointed out earlier, the two hypothesized distributions of the amount of population forecasted for the future in each analysis zone in the region were generally quite similar. The use of two different forecasts provided a range of values within which there could be a greater assurance the future population might fall than if a single forecast were to be made. Thus, the travel demand and transportation system differences—which might occur because of the possible differences in the amount of population at any specific location—could readily be evaluated.

The differences between the population forecasts for each analysis zone used in the analysis of Plan A and Plan B are due largely to the effect of the assumed open space system in the Plan B pattern and the assumed departure in Plan B from present land use zoning where it was expected that higher densities of residential development might actually be permitted in the future.

**Employment**

In contrast to the availability of historic information as to the location of population concentrations, there is a complete lack of previous (or even current) information as to the location of places of employment and the specific number of employees in each portion of the region. Thus, there is no way of developing information on the trends in the location of employment.

With only the information available which the Study developed as to the amount of employment in each analysis zone in 1961, it seemed particularly pertinent to develop alternative forecasts of the future employment to be assumed for analysis purposes in each analysis zone. This gave a greater assurance that the amount of employment which might actually be experienced in the future would be approximated or bracketed than if only a single forecast were to be made. It also permitted a determination of the relative amount of impact on transportation facilities which would be created by either of the hypothesized employment distributions. This was especially important to undertake because of apparent trends which have been developing that seem to be somewhat counterbalancing. This was particularly the case with respect to the central business districts, which are the single largest and most concentrated areas of trip generation.

The trend of a slight continuing decline in retail sales in the central business districts (see Figure IV-15, Page 36)—accompanied by a trend of decline in retail employment and an even more dramatic drop in the number of retail establishments in the central business districts—has been experienced in the Puget Sound Region as well as throughout the nation. Likewise, in varying degrees, there has been an exodus from central business districts of manufacturing activities, wholesale produce and meat distributors, insurance offices, many of the medical and dental services and numerous automobile showrooms and dealerships. In addition, there has been a general and dramatic merging of banks and a dispersal of branch banks, even though the bank headquarters offices are remaining in the central areas.

However, there is an evident growth of new office buildings in downtown areas. Yet, no data is available to establish whether new office building construction is indicative of an increase in employment or whether the new office space is simply resulting in an elimination or a vacation of older space. Another possibility is that an increasing amount of space is being allotted to each employee.
Thus, it is not clear as to what amount of employment may be expected in the central business districts in the future. As a result, it appears most prudent to analyze the effect of a range of employment values for the downtowns. The analyses of Plan A and Plan B considered alternative values for the amount of employment in all other areas of the region, also. Plan B, for instance, assumed that the Green River Valley would be developed into industrial uses (even though much of the valley was not zoned for industry at the time Plan B was detailed), while Plan A assumed that industrial employment would tend to be located largely within existing industrial areas and thus be centralized.

In evaluating the alternative population and employment forecasts, it should not be implied that the specific amounts assumed in each portion of the region for the purposes of analysis are inherent to either Plan A or Plan B. The amounts of employment and population assumed in the analyses of Plan A and Plan B were simply a means to evaluate the transportation impact of differing levels of development, in recognition of the inability to forecast with perfect assurance the location and amounts of population—and especially employment—that can be expected in the future.

Likely Development Patterns, Locations and Amounts

While specific alternative values were used for the forecasts of the location and the amounts of employment and population in each analysis zone in the region—and these values formed the basis for the forecasts of future travel—they have been subjected to continuing review and evaluation based on subsequent data and developmental trends.

Mounting official and public interest in the planning process portends a growing desire to improve the regional environment and form. Open space programs, for instance, have been developing gradually at federal, state and local levels. Project Open Space of the Puget Sound Governmental Conference66 contains significant portions of the Plan B concept.

While it would be naive to expect that the Plan B pattern will come into being exactly as formulated, it is evident that revisions in the form of suburban development are occurring. These revisions appear to be clearly in the direction of the cities-and-corridors philosophy.

With respect to the specific locations and amounts of population to be expected in the future, there appears to be no reason to question the general values forecasted for the analysis of either Plan A or Plan B. As was pointed out, the forecasted future distribution of population was quite similar in the two alternatives. Conditions which have developed since the forecasts were made in 1964 do not indicate that significant revisions in the distribution of population are called for.

There appears to be some basis for expecting that many of the lands assumed to be kept in open space uses in Plan B will indeed be kept from residential development. Likewise, there has been some tendency to permit higher densities of residential development in certain locations than had been the case under the zoning ordinances in effect in 1961. This trend is also in keeping with the assumptions made in developing the population forecasts used in the analysis of Plan B. However, it is too early to conclude that the Plan B forecasts of population will prove more accurate than the Plan A forecasts. This is not of critical concern, though, inasmuch as the difference between the two alternative forecasts of population are not of material significance.

With respect to the two alternative forecasts for the location, amounts and types of employment, it is clear that neither of the specific forecasts used in the analysis of Plans A and B truly can be said to represent a continuation of present trends. This is primarily because there is no data available (except for retail trade employment, sales and establishments) from which trend information can be established. However, recent developments indicate that the Plan B analysis assumption that the Green River Valley would be developed for industrial uses will in fact come about, and possibly even to a greater extent than was forecasted. It obviously follows that, if certain manufacturing and other types of employment choose to locate in the Green River Valley, this amount of such employment will not be located elsewhere in the region. With respect to the Green River Valley, the forecasts of employment used for the Plan B analysis appear to be more valid than the employment forecasts used for the Plan A analysis.

Regarding other types of employment—particularly those which might locate in central business districts—it is not possible to reach a clear judgment as to which of the two forecasted employment distributions can be considered more valid. A comparison of the 1961 data to a study of Seattle made in 1946 shows that over the 15-year period the number of people coming downtown by all means of travel declined by 20 percent.67 With a relatively nominal reduction having taken place in retail sales during this period—and a very apparent reduction in manufacturing, wholesaling and medical and dental activities during this time—it is not possible to pinpoint the trend in office employment, the largest single category of downtown employment.

67. Walker and Cowan, op. cit., Staff Report No. 3, Revised (See Page 57).
With all of these considerations in mind, it does appear that the Seattle downtown forecast value used for the Plan A analysis is overly optimistic, while even the Plan B forecast value appears to represent optimism with respect to the total downtown Seattle employment. This seems to be borne out by comparison to forecasts made for other cities in North America for which comparative data is available. Therefore, in appraising the transportation system test results, it must be kept in mind that the particular employment forecasts for each analysis zone, which were the basis for the travel forecasts, are not being suggested as amounts which will actually be achieved by 1990 in the particular locations shown, but as values to be used for analysis purposes. For example, there is reason to believe that the employment values—and thus the travel estimates—developed for Plan A are overly optimistic, particularly in the cases of downtown Tacoma, downtown Seattle and the Seattle industrial district. Being high, it can be considered that the forecasts are therefore on the "safe" side insofar as planning for these critical areas is concerned.

**Effect of Transportation Facilities**

**On Locations and Amounts of Growth**

It is generally recognized that transportation facilities have an influence on the location and type of development which takes place. Historically, in the largest metropolitan areas, development occurred in quite narrow corridors along the street car and other rail lines, generally limited to easy walking distances to the lines or stations. Then came the motor vehicle with its dramatic influence on urban development patterns.

No longer was it necessary to live within walking distance of the rail facility. The spread of growth outward in the form of narrow fingers along the rail lines changed to a process of filling in the areas between the fingers. As the filling-in process continued and the close-in lands became more fully developed, urban growth tended to spread outward, freed from the earlier restraints which tended to channel growth into narrow corridors extending outward from the central city core.

In the foreseeable future, the residential growth patterns in urban areas can be anticipated to continue to show the relatively weakened effect of transportation facilities as an influence on the locations of urban growth. With extensive street and road networks, access to potential areas of development is not a real problem. The influence on the particular location of residential development has become more a matter of the amount of land under single ownership or control, the availability of utility services, the view or other amenities of the area, plus reasonable access to places of employment, shopping, etc. 

Only in the case of a new facility's opening up a new area for the first time—or providing it with a dramatic improvement in accessibility—does the transportation facility become the major influence on development. The effect of the first Lake Washington Bridge is a case in point. The second bridge (and possible other bridges) across Lake Washington are no longer predominant influences in channeling the location of development on the east side of the lake. The ubiquity of urban transportation facilities today considerably weakens and de-emphasizes the influence of any one additional facility which may be provided.

Nonetheless, it is recognized that any new transportation facility, or a significant improvement in existing transportation facilities, will exert some influence on growth patterns. The technique created by the Transportation Study to develop the forecasts of population for each analysis zone (the so-called population distribution model) was based on a statistical evaluation of the factors which determined the growth which occurred in the region between 1950 and 1960. One of the five factors which was isolated as attracting and influencing locations of growth was the accessibility of each area to places of employment.

With respect to the factors which influence the location of places of employment, analyses were made of the attributes of the present sites where each particular category of employment activity is located as a way of isolating the relevant factors. The lack of trend data, however, severely restricted the ability to identify such factors with confidence and to detect or project the possible changing importance being placed on each locational factor. In general, it can be said that many considerations—other than the quality of service provided by the street, highway or transit systems—are major controlling factors as to the location selected by an employer. On the other hand, certain types of developments consider the quality of access a major influence (shopping centers and motels, for instance).

The technique developed to distribute each of the various categories of employment (employment distribution models) included the influence of the relative quality of access provided by the transportation system. Thus, the Study's forecasts of population and employment were responsive to the influences that new or improved transportation facilities can be expected to bring about. However, it should be re-emphasized that transportation
facilities are not the major influences they once were in inducing or shaping development, except in those circumstances where the facility opens up new lands not previously accessible or very poorly so.

The central business districts are areas that cannot readily be forecasted with any degree of assurance, nor can it readily be established to what specific extent development in the downtowns is being influenced by transportation considerations. The virtual transportation monopoly which downtowns once had no longer exists. Thus, the attraction of downtown is not predominantly based on its transportation advantages. Nor does examination of the data which is available for other cities clearly establish that a positive influence can be attributed to the existence of rapid transit in a city. Some cities with rapid transit have experienced declines and others have experienced growth, while cities without rapid transit in the same population ranges have had similar mixed experiences of growth or decline. It can safely be said that there are such a multitude of influences that affect locational decisions (particularly in this day of increased freedom and flexibility in operations) that it is simply not possible to attribute with any degree of assurance a particular trend or occurrence to any single factor.

In summary, therefore, transportation influences on development appear to be considerably weaker than was once the case. The almost universal accessibility provided in urban areas by the transportation system results in very little difference between alternative locations from a transportation standpoint. It can be expected that the injection of a new or improved transportation facility over and beyond that considered by the Study will naturally introduce an additional or changed influence, but this should not be expected to distort significantly the Study’s forecasts.

**Regional Transportation Objectives**

Just as in the case of the land use pattern alternatives, the regional transportation objectives were guides in developing the alternative systems which were tested. In brief, the goals established by the Study Prospectus are:

1. To develop an optimum transportation system to meet regional needs.
2. To encourage and serve desirable patterns of land use and promote desirable development.
3. To determine the transportation system which is best for a given regional land use plan.

Certain secondary goals must be considered implicit in the definitions of “optimum” and “best.” Among them are: (1) safety, (2) attractiveness to users, (3) economy (both in first as well as total costs), and (4) flexibility to adapt to unanticipated changes.

Even planning for as far as 20 to 25 years in the future is hazardous; beyond that it is simply not possible or practical. Therefore, as much flexibility as possible is desirable in planning and undertaking programs for the future to assure the highest degree of adaptability to changes and developments which cannot reasonably be anticipated or predicted at this time. This is particularly important because of rapid technological development and dynamic changes in our communities. At the same time, society is experiencing changes in tastes, desires and the ability to achieve those desires because of a growing affluence, productivity and amount of leisure time.

Conceivably, it may not be possible to achieve all of the individual regional goals simultaneously. In other words, the safest transportation system may not be the most economical, the most flexible, the most attractive to users or the one which could be said to encourage, serve and promote “desirable” land use patterns. Thus achieving goals which might be mutually exclusive—or at least not subject to simultaneous optimization—bears essentially a matter of attempting to reach a reasonable middle ground which gives recognition to each of the goals, and to some extent achieves each of them, but which may not necessarily maximize any single one. If each goal can be converted into common value units, achieving an optimum solution is simplified.

A frequently used common base value unit is dollars-and-cents. Most transportation studies have applied such a measure. The resulting optimum in terms of “least cost” or “most economic” must be recognized as encompassing factors other than simple transportation facility costs. It includes a weighing of many factors, placing them on a common base to the extent that it is possible and thus attempting to achieve an overall maximizing of a number of differing goals and objectives.

It is to be expected, however, that the goal of total economy will always be an important concern. The recently coined term “cost effectiveness” and the stress placed on it both in business and government, is evidence that maximizing economy within certain overall restraints and controls is a major goal. Achieving such a goal, in an urban area not only means an improved competitive position for business and industry, since the costs of doing business will thus be minimized, but also a better way of life for the residents of the community since it means getting the most for their tax and operating dollars. In economic comparisons, however, it is important to include in the tabulation of costs all

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92. For an excellent example and thorough discussion see Chicago Area Transportation Study, Volume III, Chapter II, pgs. 6-20, Chicago, 1962.
factors to assure that economy is really being achieved.

Certain concerns as to the general public welfare must also be considered as implicit goals. While it can be said that the general welfare is best served by maximizing the economy and efficiency of transportation, certain services must be provided simply as a matter of public policy, with only moderate concern as to the economics of the matter. A good example is public transit.

A reasonable level of transit service must be provided simply as a matter of public policy. While not as vital to the general health and welfare as publicly-provided water, sanitary services and fire-and-police protection, public transit is nonetheless a necessary service for significant numbers of urban area residents.

In 1961 almost one-fifth of the households in the region did not own an automobile. Almost two-fifths of the population was either too young to be able to drive or over 65 years of age. For these age groups especially, and for the non-vehicle owner, some form of adequate public transportation is absolutely essential. While it is expected that by 1990 the percentage of the households which own no autos will decline to less than half of the 1961 value, there will still be a sizeable number involved.

The proportion of the total population which is in the non-driving age brackets is not expected to change materially by 1990. Nevertheless, this will represent an 80 percent increase in the number of people in such age groups. Thus, the planning of transportation systems must be predicated upon the provision of a basic system of transit service, without establishing the requirement for such service simply from the standpoint of economics.

As to the means of evaluating alternative transportation systems with respect to the goals of encouraging and promoting desirable patterns of land use, obviously a translation into dollars and cents is not possible. Subjective judgments only can be applied. However, even this is difficult, if not impossible, in view of the lack of consensus as to what specifically represents a "desirable pattern," as well as the problem of determining the specific ability of a particular transportation system or facility to promote a particular pattern.

After establishing the regional transportation objectives and means applying them, it was possible to evaluate the alternative transportation systems to determine which would most nearly meet the goals.

**Evaluation of Alternative Transportation Systems**

As described in Section 8, the transportation system development followed a logical step-by-step process. There remained, then, a final evaluation in terms of: (1) the relative quality of service (the ability of the system to meet future travel demands), and (2) a comparison of costs.

Relative to the latter, transportation costs include: (1) capital expenditures, (2) maintenance costs, (3) costs represented by accident losses, (4) operating expenses of autos, trucks, buses, ferries, parking facilities and rapid transit (if provided), and (5) costs represented by the travel time of individuals and commercial vehicles. All costs in the evaluations have been expressed in terms of 1964 prices to provide a consistent and reasonably equal basis for comparison.

**QUALITY OF SERVICE**

Each of the highway study systems was appraised by comparing the over-all travel demands to the total transportation system capacity. The test results were individually described in Section 8 and are summarized below in Table IV-68.

**TABLE IV-68**

**CAPABILITY OF ALTERNATIVE HIGHWAY SYSTEMS TO ACCOMMODATE FUTURE TRAVEL DEMAND**

<table>
<thead>
<tr>
<th>Highway Study System</th>
<th>Land Use Plan</th>
<th>Interstate Freeways</th>
<th>Other Freeways</th>
<th>Arterials</th>
<th>Systemwide Ratio of Travel Demand to Design Capacity</th>
<th>Milage Above Design Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>A</td>
<td>1.53</td>
<td>0.81</td>
<td>0.59</td>
<td>0.86</td>
<td>92</td>
</tr>
<tr>
<td>3 Modification 1</td>
<td>A</td>
<td>0.94</td>
<td>0.76</td>
<td>0.47</td>
<td>0.67</td>
<td>12</td>
</tr>
<tr>
<td>4 Modification 1</td>
<td>A</td>
<td>0.77</td>
<td>0.79</td>
<td>0.47</td>
<td>0.78</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>1.36</td>
<td>0.64</td>
<td>0.53</td>
<td>0.74</td>
<td>46</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>0.94</td>
<td>0.64</td>
<td>0.45</td>
<td>0.62</td>
<td>9</td>
</tr>
</tbody>
</table>

1. Assuming no improvements beyond those included in 1962 six-year capital improvement programs.
2. Based on so-called demand traffic loads, assuming traffic uses the shortest time path and that sufficient capacity is provided to accommodate the load.

Only Study Systems 3 Modification 1, 4 Modification 1, and 6 provide a reasonable balance between capacity and demand from an overall system-wide standpoint. Of these three systems, 4 Modification 1 (which includes rapid transit in the Seattle area) has the most mileage of facilities which experience traffic overloads. While not large in terms of miles, it is significant in that it is a one-third increase over 3 Modification 1 in the number of miles of interstate freeway which are overloaded. This is due primarily to the proposal that the rapid transit facility utilizes the two reversible lanes on the new Lake Washington bridge.

While rapid transit across Lake Washington attracts a somewhat higher number of transit riders than the alternative bus lines, the increased ridership is not sufficient to offset the loss of the vehicular capacity if the reversible lanes are prompted. Serious question must, therefore, be raised as to whether this is a practical way in which to carry rapid transit across the lake.
There can be no question that the capital costs involved in providing transportation facilities constitute an important consideration in evaluating alternative transportation systems. While capital is expended for construction of new facilities, this is conventionally done for the purpose of developing an economic benefit or return at least as great as the amount invested in the facility. As a matter of fact, a capital expenditure cannot be justified from an economic standpoint unless the return to be derived is at least as great as the return which might be achieved if the capital funds were invested in some other productive use.

For this reason economic analyses assume a cost for capital which is expressed by applying an interest rate. Only if the investment in the transportation facility creates a measurable economic return greater than an equal investment for some other productive purpose is the transportation facility investment justified.

Generally private industry expects a return on capital invested of no less than 6 percent. Many firms will not invest capital unless a return of more than 10 percent can be expected. Since the funds used by governmental agencies to finance transportation facilities are derived in the first instance from individuals and businesses, public agencies should be expected to expend the public’s funds such that the citizenry will derive a rate of return from the expenditure which is in keeping with the return that individuals or businesses could derive from a private investment. In comparing alternative investments, the equivalent rate of return from each can be computed—so a particular expenditure can be compared to the other alternative choices for investment so that the one offering the greatest return can be selected.

By evaluating public expenditures against such an economic yardstick, business and industry can be assured that governmental programs will create the most advantageously competitive business climate in comparison to other areas. Applying such a measure in the economic analysis of transportation systems also assures that undue emphasis will not be placed on expenditures for transportation facilities to the detriment of other worthwhile programs.

In the ensuing estimates, all costs are expressed in terms of constant 1964 dollars and are based on 1964 prices.

### Streets and Highways

A cost estimate—including engineering, right-of-way, landscaping and contingencies in addition to the construction costs—was prepared for each of the facilities included in the various alternative transportation systems. The cost estimates for the freeway and expressway facilities in each study system were prepared by the Department of Highways at the request and expense of the Transportation Study. In many cases, particular facilities were included in long-range plans of the state, cities or counties, and cost estimates had previously been made. When necessary, these prior estimates were updated.

In some instances, however, the PSRTS test systems included freeways and expressways which had never before been considered by others, since the need for them was revealed only in the course of the Study's analyses. The Department of Highways developed cost estimates for these facilities also, on the basis of generalized locations and design configurations provided by the Study.

The costs involved in constructing arterials included the expenditures already budgeted by the state, cities and counties for construction of specific projects. However, the Transportation Study's analyses established a considerable amount of additional work which will be required on the existing arterial system. In addition, since much of the region is only partially developed, there is no existing arterial network in such areas which is adequate or extensive enough to accommodate the future growth.

The mileage of such needed new arterials and the costs to provide them were estimated on the projected densities of development and reasonable standards for arterial spacings. Arterial costs were based upon an examination of the actual costs incurred on a large number of recent arterial construction projects in the region, together with reference to research studies for the legislature on the costs of building arterials.

It should be pointed out that Study Systems 5 and 6 included a cross-Sound bridge. The bridge route which was assumed was one crossing Puget Sound via Vashon Island, including a Rich Passage bridge to Bainbridge Island and a fill and bridge across Sinclair Inlet to shorten the present distance around the end of the inlet.

The total street-and-highway capital costs for the alternative transportation systems included in the economic evaluation are shown in Table IV-69.

Funds budgeted for new freeways and expressways by the early 1970s (Study System 2) amount to over one-half billion dollars—more than a third of the total funds needed in the next 25 years to construct all required streets and highways (even for the most costly alternative transportation systems). This would imply that financing the regional development.

---

The number of additional parking spaces required in downtown 

Construction costs for the parking facilities needed to meet future demands should be included as a part of the cost of providing a transportation system. It was assumed that all future additional parking in downtown Tacoma and Seattle would be provided in garages rather than in parking lots since downtown space is at a premium.\textsuperscript{06} In Everett and Bremerton—where reasonably close-in downtown space is still available—it was assumed that future needs would be provided predominantly by parking lots.

The total additional parking spaces needed to meet future demands in the downtowns of the four cities are summarized in Table IV-71, and the total capital costs for providing these additional spaces are shown in Table IV-72. The rapid transit system reduces parking needs in downtown Seattle by 6,400 spaces, for a net parking capital cost saving of $12,200,000 compared to that needed for System 3 Modification 1.

### TABLE IV-71

<table>
<thead>
<tr>
<th>Location</th>
<th>Parking Spaces Needed by 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seattle Downtown</td>
<td>29,000</td>
</tr>
<tr>
<td>Rapid Transit Stations</td>
<td>26,600</td>
</tr>
<tr>
<td>Tacoma Downtown</td>
<td>4,700</td>
</tr>
<tr>
<td>Everett Downtown</td>
<td>4,700</td>
</tr>
<tr>
<td>Bremerton Downtown</td>
<td>2,200</td>
</tr>
</tbody>
</table>

### TABLE IV-72

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>80,300</td>
<td>14,000</td>
<td>3,300</td>
<td>1,000</td>
<td>850</td>
<td>97,600</td>
</tr>
<tr>
<td>3 Modification 1</td>
<td>80,300</td>
<td>14,000</td>
<td>3,300</td>
<td>1,000</td>
<td>850</td>
<td>97,600</td>
</tr>
<tr>
<td>4 Modification 1</td>
<td>61,100</td>
<td>7,500</td>
<td>1,600</td>
<td>1,000</td>
<td>850</td>
<td>84,300</td>
</tr>
<tr>
<td>5</td>
<td>42,400</td>
<td>8,500</td>
<td>800</td>
<td>1,000</td>
<td>850</td>
<td>53,500</td>
</tr>
<tr>
<td>6</td>
<td>42,400</td>
<td>8,500</td>
<td>800</td>
<td>1,000</td>
<td>850</td>
<td>53,500</td>
</tr>
</tbody>
</table>

The costs for providing parking in areas other than the central business districts were not estimated since there is little reason to expect that the differences in this regard among the alternative transportation systems will be significant, particularly since providing parking spaces in non-central systems are shown in Table IV-70. (No costs for new or expanded bus garages or maintenance facilities are included.)

### Parking Facilities

The estimated capital costs for public transit buses were based on the forecasts of transit usage. It was assumed that all of the present bus fleets will have exceeded their remaining service lives before 1990 and will have to be replaced.

System 4 Modification 1 includes a rapid transit system. The cost of the latter was estimated by the transit consultants to the Puget Sound Governmental Conference.\textsuperscript{06} Rapid transit reduces the number of buses required and, thus, total bus costs.

Systems 5 and 6 are based on Plan B forecasts which generated a lesser transit usage than the other systems and, therefore, have reduced bus needs.

The total transit capital costs for the various

### TABLE IV-70

<table>
<thead>
<tr>
<th>Study System</th>
<th>Number of New Buses Required</th>
<th>Capital Cost for Rapid Transit System Construction and Equipment</th>
<th>Capital Cost for Rapid Transit System and Equipment (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>800</td>
<td>$22,900,000</td>
<td>$22,900,000</td>
</tr>
<tr>
<td>3 Modification 1</td>
<td>800</td>
<td>22,900,000</td>
<td>22,900,000</td>
</tr>
<tr>
<td>4 Modification 1</td>
<td>800</td>
<td>20,700,000 + $168,000,000 + 197,000,000</td>
<td>197,000,000</td>
</tr>
<tr>
<td>5</td>
<td>610</td>
<td>15,900,000</td>
<td>15,900,000</td>
</tr>
<tr>
<td>6</td>
<td>610</td>
<td>15,900,000</td>
<td>15,900,000</td>
</tr>
</tbody>
</table>

1. Capital cost for rapid transit system construction and unit cost for rolling stock estimated by the transit consultant to the Puget Sound Governmental Conference. Does not include costs for bridges across Lake Washington or the highway right-of-way taken by the line and its stations.

\textsuperscript{06} Interim Report to the Puget Sound Governmental Conference on Feasibility of Rapid Transit Operation Within the Seattle Area (San Francisco: Delano Culver and Company, 1968).
business district areas is quite inexpensive compared to downtown parking costs. In addition, there was no practical way to define readily the costs that might be incurred in providing parking outside of the downtown areas of the region's four central cities.

Ferry Facilities

To accommodate travel across Puget Sound, ferry service will be necessary even with a cross-Sound bridge. The number and size of vessels needed—with and without a bridge—were estimated on the basis of the forecasted traffic volumes for ferry routes operating within the region only. Study Systems 5 and 6 (with a cross-Sound bridge) include the capital cost for a passenger ferry operating between Winslow and Seattle. Resulting capital costs for ferry vessels for each of the alternative systems are shown in Table IV-73.

Total Capital Costs

Total capital costs for the alternative transportation systems are summarized in Table IV-74.

It is obvious that Study System 4 Modification 1 is the most costly from a capital expenditure standpoint, since the expense of rapid transit is not balanced by a commensurate reduction in the street-and-highway cost in Plan A, System 3 Modification 1, which is the most comparable system for the Plan A analysis. System 6—based on the Plan B analysis and with a cross-Sound bridge—is less costly than the comparable Plan A alternative (System 3 Modification 1). This results from the lesser over-all travel demand associated with the cities-and-corridors pattern of development.

ANNUAL COSTS

Before a truly meaningful comparison of the various systems can be made, it is necessary to include the day-to-day costs of operating and using them. These costs are generally figured on an annual basis and include maintenance expenses; the costs of operating such facilities as parking lots, garages and ferries; the expense involved in using the system (operating costs); the value of the users' time; and the costs of accidents. All of these costs can be combined with the capital costs—also expressed on an annual basis—to place each system on an equal footing in the evaluation procedure.

The conversion of total capital costs to an equivalent annual cost is a function of the service life of the individual facilities and the "cost of money," or interest rate.

Capital Costs

In placing capital costs on an annual basis, certain assumptions were made relative to service lives for the various capital cost components; e.g., buses were estimated to have a service life of 15 years, and rapid transit (on an overall basis) 40 years. Differences in the service lives of various capital cost items are thus reflected in the annual capital cost figures. The annual capital cost, however, is also a function of the interest rate (cost of money). Table IV-75 shows the annual capital cost for each of the study systems based on a number of assumed interest rates.

Annual Operating Costs—Maintenance of Freeways, Expressways and Arterials

Actual maintenance costs for various facility types were obtained from records of the Washington and Oregon Departments of Highways and from a number of cities in the state. By applying the typical values thus gathered, the estimated total annual maintenance cost for the street and highway portion of each of the alternative systems was established (see Table IV-76).
Annual Operating Costs—Ferries

The costs of operating the ferry portion of each of the alternative transportation systems were based on actual 1964 costs applied to the estimated numbers and types of vessels needed to accommodate the predicted future cross-Sound traffic volumes. Because almost half of the direct ferry operating costs are chargeable to labor—which are rising at a faster rate than general price indexes—applying 1964 cost levels results in a more favorable picture with respect to the ferry portions of the system than would otherwise be the case.

Operating costs may also be expected to rise more rapidly once the new, faster and more powerful (8,000 to 10,000 horsepower) vessels are in operation, since their fuel consumption on a per mile basis will undoubtedly be higher than the present ferries (the most powerful of which has 2,500 horsepower). In addition, the greater speed of the new vessels will enable them to improve the service by making more trips per day, but this will also mean more miles of operation daily. However, if the ferry scheduling is adjusted to the levels of patronage, rather than to the capability of the vessels to make runs, the operating costs can be tailored to the increases in patronage (and revenue). This may mean holding down the number of miles which the new vessels will be permitted to operate per day. The 1964 actual operating costs were adjusted slightly upward to reflect the probable increase in fuel consumption of the new vessels.

After the first few years of operation, it is not expected that the maintenance costs for the new vessels will necessarily be materially different from those for some of the other vessels in the fleet. Furthermore, maintenance expenses are a relatively small portion of the total annual costs. So, even if the new vessels offer possible maintenance savings, the economic evaluation will not be significantly altered.

### Table IV-76

<table>
<thead>
<tr>
<th>Study System</th>
<th>Annual Maintenance Cost (000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>$6,410</td>
</tr>
<tr>
<td>3 Modification 1</td>
<td>6,810</td>
</tr>
<tr>
<td>4 Modification 1</td>
<td>6,760</td>
</tr>
<tr>
<td>5</td>
<td>6,440</td>
</tr>
<tr>
<td>6</td>
<td>7,020</td>
</tr>
</tbody>
</table>

### Annual Operating Costs—Ferries

The resulting annual ferry operating expenses estimated for each of the alternative transportation systems are shown in Table IV-77.

### Annual Operating Costs—Transit

The annual operating costs for the bus transit facilities included in the alternative transportation systems were computed on the basis of the bus miles needed to serve the estimated number of riders for each study system. The operating cost per bus mile was based on the Seattle Transit System's 1961 cost experience.

To the extent that transit operating costs increase at a faster rate than general price levels (because of the high labor input and inability to increase the labor productivity), use of the 1961 costs in the economic evaluation favors the transit facilities. However, any elaborate attempt to predict the differential rate of transit operating cost increases compared to increases to be expected in other costs included in the economic analysis is not warranted in view of the relatively small magnitudes involved in relation to the other cost elements included in the economic evaluation.

The annual operating cost for the rapid transit system was likewise based on the forecasts of patronage. The number of car miles required to serve the predicted usage was computed by the transit consultant to the Puget Sound Governmental Conference and an estimated operating cost per car mile was applied. The car mile cost which was used in the analysis includes the cost of accidents and maintenance and is representative of the costs of operating a modern rapid transit system with modern equipment.

Total annual bus and rapid transit operating costs are summarized in Table IV-78.

### Table IV-78

<table>
<thead>
<tr>
<th>Study System</th>
<th>Annual Rapid Transit Operating Costs (000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>$16,400</td>
</tr>
<tr>
<td>3 Modification 1</td>
<td>14,700</td>
</tr>
<tr>
<td>4 Modification 1</td>
<td>11,700</td>
</tr>
<tr>
<td>5</td>
<td>11,200</td>
</tr>
<tr>
<td>6</td>
<td>11,200</td>
</tr>
</tbody>
</table>

Table IV-78 reveals that in terms of total transit operating expense, Study System 4 Modification 1 is more costly than any of the other alternatives. This should be expected since the inclusion of rapid transit does not result in a commensurate reduction in bus miles and bus operating costs.

### Annual Operating Costs—Parking

Included in the computation of the capital cost for each alternative transportation system was the
provision of parking facilities. Likewise, the cost of their operation is part of the operating costs of the entire transportation system.

Actual operating cost data for parking lots and parking garages (both attendant and self-parking) were applied to the estimated additional number of parking spaces which would be required for each of the alternative systems in the central business districts of Seattle, Tacoma, Everett and Bremerton—and at the rapid transit stations. A conservative assumption was made as to the proportion of the future parking facilities which would be self-parking. In view of rising labor costs, the trend is almost entirely toward self-parking facilities. Table IV-79 summarizes the total annual operating costs for the parking facilities which will be in operation in 1990 in the four central business districts and—where applicable—at the outlying rapid transit stations.

### TABLE IV-79

**ANNUAL OPERATING COSTS FOR PARKING FACILITIES**

<table>
<thead>
<tr>
<th>Study System</th>
<th>Annual Operating Cost (000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>$11,350</td>
</tr>
<tr>
<td>3 Modification 1</td>
<td>11,350</td>
</tr>
<tr>
<td>4 Modification 1</td>
<td>10,360</td>
</tr>
<tr>
<td>5</td>
<td>9,040</td>
</tr>
<tr>
<td>6</td>
<td>9,040</td>
</tr>
</tbody>
</table>

**Annual Operating Costs—Accidents**

The accident costs included in this computation are for the street-and-highway facilities only, since it is customary in the transit industry to figure such costs as part of operating expenses. The accident rates applied were based on national averages for typical street-and-highway facilities, since local accident information was not available in the necessary detail. The value used to represent the average cost per accident was one suggested by the National Safety Council.97

The resulting annual accident costs are shown in Table IV-80.

### TABLE IV-80

**ANNUAL ACCIDENT COSTS FOR PASSENGER CARS AND TRUCKS ON STREETS AND HIGHWAYS**

<table>
<thead>
<tr>
<th>Study System</th>
<th>Annual Accident Cost (000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>$102,770</td>
</tr>
<tr>
<td>3 Modification 1</td>
<td>95,780</td>
</tr>
<tr>
<td>4 Modification 1</td>
<td>96,822</td>
</tr>
<tr>
<td>5</td>
<td>90,650</td>
</tr>
<tr>
<td>6</td>
<td>85,730</td>
</tr>
</tbody>
</table>

The highest cost system from an accident standpoint is the one which represents a minimum program—doing nothing in the way of constructing additional major facilities after completion of the currently budgeted program. It is also interesting to note that the provision of rapid transit (System 4 Modification 1) does not result in a lower annual accident cost than in System 3 Modification 1. The reduced accident rate attributable to the rapid transit facility is more than offset by the increases caused by the elimination of freeway capacity.

**Annual Operating Costs—Passenger Cars And Trucks**

The number of vehicle miles which would be experienced in 1990 on each facility type of the alternative transportation systems was established from the system tests. Then, using standard cost-per-mile operating figures—such as fuel, tires, oil, maintenance and depreciation—the total annual vehicular operating cost on each of the alternatives was computed (see Table IV-81).

### TABLE IV-81

**ANNUAL OPERATING COSTS FOR PASSENGER CARS AND TRUCKS**

<table>
<thead>
<tr>
<th>Study System</th>
<th>For Travel on Freeways and Expressways</th>
<th>For Travel on Arterials</th>
<th>Total (000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>$361,800</td>
<td>$177,900</td>
<td>$539,700</td>
</tr>
<tr>
<td>3 Modification 1</td>
<td>394,700</td>
<td>142,600</td>
<td>537,300</td>
</tr>
<tr>
<td>4 Modification 1</td>
<td>406,300</td>
<td>145,100</td>
<td>551,400</td>
</tr>
<tr>
<td>5</td>
<td>326,400</td>
<td>146,700</td>
<td>473,100</td>
</tr>
<tr>
<td>6</td>
<td>323,700</td>
<td>138,700</td>
<td>462,400</td>
</tr>
</tbody>
</table>

**Annual Operating Costs—Travel Time**

In most people's thinking, time is considered valuable, and this applies to the time spent in travel as well. The faster a person can make a trip, the more time he has to spend in a productive activity or a pleasing pastime.

There can be no question that time savings to trucks are valuable and can be expressed in specific dollars-and-cents terms. The same is true for salesmen or others who travel in the course of their work. However, it is more difficult to attach a specific value to a housewife's time in driving to or from a shopping center, or the man of the house in driving his car or riding a bus to work. That such time is considered valuable is evident since motorists will use a toll facility to save minutes, will pay a premium fare to take an express bus, will drive at speeds which are highly uneconomic for the purpose of saving time and incurring a cost to do so.

It is obviously impossible to place a specific value on time for each individual, each vehicle or each individual circumstance. Economic analyses of transportation facilities are normally made assuming a reasonable value for time which is applied as an average for all conditions and vehicle types. There is no consensus as to this value, however. But $1.00 per person per hour appears to be a reason-
able compromise in view of values ranging from somewhat less than $1.00 to over $2.00 which have
been recommended for use by various authorities.98

While individuals place a value on time, if it is
accorded an excessive value in an economic analysis,
it may create a distorted picture. This is true
because many of the time savings provided for indi-
vidual trips by alternative transportation systems
may be in small fractions of minutes and thus diffi-
cult to attribute with a value proportionate to the
value of a full hour. By using a conservative time
value, however, the results of the analysis can also
be considered as conservative, favoring the systems
whose primary values are not savings in time.

For each alternative transportation system which
was tested, the total travel time involved in travel-
ing from portal-to-portal between each and every
trip origin and destination was accumulated. The
portal-to-portal travel time for auto trips includes
not only the driving time, but also the time spent
in parking and in walking to the ultimate desti-
nation. For trips on transit the portal-to-portal time
includes the time to walk (or drive) to the transit
stop, a wait for the transit vehicle, the riding time,
and the time to walk to the ultimate destination.
A waiting time was also included for ferry trips.

The value of $1.00 per person per hour was
applied to the accumulated travel time for each
of the alternative transportation systems to deter-
mine for each the total annual cost of the time
involved in travel. The results are shown in Table
IV-82.

<table>
<thead>
<tr>
<th>Study System</th>
<th>Annual Travel Time Costs (000's)</th>
<th>On Transit Facilities</th>
<th>On Streets, Highways and Perries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>$260,000</td>
<td>$833,000</td>
<td>$1,093,000</td>
<td></td>
</tr>
<tr>
<td>3 Modification 1</td>
<td>28,000</td>
<td>735,000</td>
<td>763,000</td>
<td></td>
</tr>
<tr>
<td>4 Modification 1</td>
<td>31,060</td>
<td>778,000</td>
<td>799,060</td>
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</tr>
<tr>
<td>5</td>
<td>39,000</td>
<td>777,950</td>
<td>817,950</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>39,000</td>
<td>798,000</td>
<td>837,000</td>
<td></td>
</tr>
</tbody>
</table>

The transportation system which incurs the
highest travel time cost is Study System 2, the
minimum program of transportation facilities, which
represents completing only the freeways and
expressways which are now underway or budgeted.
As has already been pointed out, this results in a
congested system, high in accident costs and also
high in the amount of time involved in daily travel.
Systems 5 and 6, which were based on the popu-
lation and employment forecasts used for the
analysis of Plan B, are the lowest in travel time
costs. It can be seen that there are significant travel
time savings derived from a less centralized location
of employment.

Study System 4 Modification 1, which included
rapid transit, had the highest travel time cost of
any of the alternative systems which included new
facilities in an attempt to meet the future travel
needs. The high travel time cost for this system
was primarily because the rapid transit line was
assumed to substitute for a freeway in the north-
west area of Seattle and to take over the two
reversible vehicular lanes on the proposed Third
Lake Washington Bridge. This resulted in a lower
quality of service or congestion in these corridors
with consequent travel time penalties to motorists.
These travel time penalties in comparison to Study
System 3 Modification 1 outweighed the improve-
ment in travel time for the rapid transit users who
formerly rode in buses.

**Total Annual Costs—Summary**

By summarizing the annual operating cost figures
derived for each of the alternative transportation
systems, the total annual operating cost of each
alternative was determined. This total operating
cost figure included the maintenance costs; ferry,
transit and parking facility operating costs; acci-
dent costs; the operating costs of vehicles using
the transportation system; and the travel time
costs. The annual capital cost is included separately
since it is subject to the particular choice of interest
rate which is made. For purposes of showing a
comparison of the total annual costs for the alter-
native transportation systems, a 6 percent cost of
money was assumed to convert total capital costs
to an annual equivalent. The results are summarized
in Table IV-83. The differences for the various
alternative systems are so great that their relative
positions with respect to total annual cost would not
change, regardless of what interest rate (between
zero percent and 15 percent) might be used.

It can be seen from the table that Study System 2
is the most expensive from a total annual cost
standpoint. Such a system, with the traffic conges-
tion it would experience, has high accident, high
vehicle operating and high travel time costs which
more than counterbalance the smaller annual capi-
tal costs.

The next most costly system from the total
annual cost point of view is Study System 4 Modifi-
cation 1, which is based on a rapid transit system
in the Seattle area. Besides having a moderately
higher transit operating cost than the other alter-
native transportation systems, this system suffers
in the economic evaluation in comparison to System
3 Modification 1 because of the penalty to motor-
ists which comes from substituting rapid transit for
a freeway in the northwest part of Seattle. It also
shows a greater cost because a vehicular congestion
problem is created across Lake Washington since

98 Other values for time were also assumed for purposes of analysis to
99 The values assumed. Time values per person per hour of $2.00, $1.50,
$1.00, $0.50, and $0 were used in these alternate analyses.
rapid transit was assumed to take over the two-lane reversible vehicular roadway on the proposed Third Lake Washington Bridge.

The least costly of the alternative transportation systems are the two which are based on the population and employment forecasts which were used in the analysis of the Plan B land use pattern. This lower level of centralization results in a reduced amount of travel, and thus lower travel costs, as well as lower annual capital costs because of a lesser need for transportation facilities.

It is important to note the relative magnitudes of the various factors included in the economic analysis. The passenger auto and truck operating costs make up approximately one-third of the total annual costs of each of the alternative systems, while the travel time costs make up approximately one-half the total. The accident costs and annual capital costs make up the lion’s share of the remaining 15 to 20 percent, with less than 5 percent of the total annual costs consisting of maintenance costs and the operating costs for the ferry and transit systems and parking facilities.

If travel time is considered of no value whatsoever, the economic evaluation still results in Study Systems 5 and 6 showing the lowest total annual costs, but Study System 4 Modification 1 then becomes the most costly of any of the alternative transportation systems tested.

If time were considered to be worth $2.00 per person per hour instead of the $1.00 used in the economic analysis, the relative positioning of the various alternative transportation systems from a total annual cost standpoint does not change from that shown in Table IV-83. System 2 remains the most costly and System 4 Modification 1 the next most costly. Systems 5 and 6 continue to be the least costly.

OTHER CONSIDERATIONS

There are numerous other considerations which can and should enter into the evaluation of transportation systems. Many of these, however, are not of a regional scale since they are subject to the details of location and design of individual facilities in local areas.

As an example, an accepted objective is to provide the urban area with its needed transportation facilities with a minimum of adverse impact on the smooth, pleasant, stable and economic functioning of the total urban area and each of its sub-units. With respect to residential neighborhoods, transportation facilities should not be disruptive of already established internal social and economic relationships, nor should such facilities isolate individual local units from the other functional elements of the total urban community. The transportation facilities, to the extent possible, should serve to maximize linkages among the various functional areas in the total region, without impinging on the well being of the individual areas themselves.

This is, of course, an ideal not possible of complete accomplishment, but it should be the goal in developing a functioning system of transportation facilities and integrating it into the existing urban scene. However, in developing an overall plan at the regional scale, matters of detailed location and design cannot be definitively established. Transportation system planning is but one step in a total effort to provide adequately for the services needed by an urban community.

The translation of the plan to a functioning reality is a continuing process involving more detailed planning and engineering studies extending to actual construction. It is necessary that the basic objectives which have guided the transportation system planning also guide the undertaking of individual projects. As a matter of fact, the local values and objectives must be given specific emphasis as the regional plan is translated into specific locations and designs at the local level.

Besides the essentially negative nature of the objective of minimizing the adverse impact of transportation facilities on local areas, it should be recognized that a properly planned transportation facility can be used as a positive force to improve the social and economic well being of individual neighborhoods and communities. But this is essentially a matter of properly integrating the individual facility into the local scene at the location and design stages so as to improve the local areas to the extent this can be done over and beyond performing the transportation function as part of an overall system.

Table IV-83

<table>
<thead>
<tr>
<th>Study System</th>
<th>Maintenance</th>
<th>Ferries</th>
<th>Transit</th>
<th>Parking</th>
<th>Accidents</th>
<th>Auto &amp; Truck</th>
<th>Travel Time</th>
<th>Total Operating Cost</th>
<th>Annual Capital Cost @ 5% Interest</th>
<th>Total Annual Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>$5,410</td>
<td>$6,825</td>
<td>$16,400</td>
<td>$11,350</td>
<td>$102,770</td>
<td>$539,700</td>
<td>$861,083</td>
<td>$1,544,535</td>
<td>$84,660</td>
<td>$1,629,195</td>
</tr>
<tr>
<td>3 Modification I</td>
<td>6,810</td>
<td>6,825</td>
<td>16,400</td>
<td>11,350</td>
<td>95,280</td>
<td>537,900</td>
<td>753,000</td>
<td>1,427,265</td>
<td>124,730</td>
<td>1,561,995</td>
</tr>
<tr>
<td>4 Modification I</td>
<td>4,760</td>
<td>6,825</td>
<td>18,900</td>
<td>10,340</td>
<td>96,850</td>
<td>545,800</td>
<td>769,090</td>
<td>1,416,585</td>
<td>128,880</td>
<td>1,543,465</td>
</tr>
<tr>
<td>5</td>
<td>6,460</td>
<td>3,400</td>
<td>11,700</td>
<td>9,040</td>
<td>90,690</td>
<td>497,300</td>
<td>746,510</td>
<td>1,364,840</td>
<td>85,840</td>
<td>1,449,680</td>
</tr>
<tr>
<td>6</td>
<td>7,020</td>
<td>3,400</td>
<td>11,700</td>
<td>9,040</td>
<td>85,730</td>
<td>470,600</td>
<td>706,920</td>
<td>1,293,810</td>
<td>118,660</td>
<td>1,412,470</td>
</tr>
</tbody>
</table>
The local integration of the facility is a level of detail, of course, which cannot be undertaken at the regionwide planning stage. Because of local needs or problems, the detailed final planning and design studies may require variations of facility locations from those shown in the Transportation Study's map of as much as one-half mile in one direction or another, without significantly affecting the utility of the facility from a regional standpoint.

A frequently cited objective of reducing air pollution, while of a regional scale and appropriate to consider in a transportation planning project, appears to be in the process of resolution by technological means rather than through a transportation planning approach. Consequently, it was not included as a consideration in the evaluation process. It should be pointed out, however, that the amount of pollution from travel by vehicles powered by internal combustion engines can be considered to be somewhat in proportion to the vehicle operating cost estimates. Table IV-81 shows that the greatest reduction relative to air pollution by vehicles (other than by modification of the power plants themselves) can be expected to be developed by arrangements of places of population and employment which reduce the amount of travel, such as was forecasted in connection with the Plan B analysis (Study Systems 5 and 6), rather than through the application of an alternate mode of travel, such as the rapid transit system in Study System 4 Modification 1.

Other objectives of a broad area scale which have not been incorporated in the economic evaluation may pertain to giving an economic advantage to one particular area compared to others. This, however, is not pertinent to the planner's function since this is a policy determination. However, as stated earlier, it should be recognized that under present conditions and technology, the influence of transportation facilities on the development which can be attracted to a particular portion of a local area is not as great nor as direct as it once was. Thus, policy decisions of this type must be weighed from the standpoint of the problematical effects which might be generated rather than on the basis of a cause-and-effect relationship, with assured results which might be derived from expenditures for such facilities.

In summary, the economic analysis incorporated all of the factors which are considered appropriate and applicable at the regional scale for transportation planning purposes. The result of the overall evaluation process places the alternative transportation systems in the relative order shown by the figures in the last column to the right in Table IV-83, Page 108.

Possible Effect of Technological And Socio-Economic Changes

As previously indicated, certain assumptions regarding future transportation technology had to be made in planning alternative transportation study systems to serve the region's future travel. Similarly, other assumptions relating to the future social and economic conditions were made in developing the population and employment forecasts for the region and the possible patterns of location of places of residence and employment. In addition, assumptions as to future social and economic conditions were made in developing forecasts of such factors as personal income and family size, which formed the basis for the forecasts of vehicle ownership and travel characteristics.

Since all of the forecasts are contingent upon the validity of the various assumptions, it is appropriate to consider the effect of possible changes in these factors on the forecasts of development patterns, travel and transportation system requirements.

TRANSPORTATION TECHNOLOGY

Possible developments in transportation technology can change: (1) the dimensional characteristic of vehicles used for transportation, (2) their safety, speed, comfort and convenience, (3) their control characteristics, (4) their initial capital costs, (5) their operating and maintenance expenses, and (6) the types of power plants used.

Such development can affect private cars, trucks, mass transit equipment and the various types of vessels used to transport people and vehicles over water. The possible developments will be appraised separately in light of their effect on transportation planning and the types of facilities now in existence or being planned for the future.

Passenger Cars and Trucks

There is today an immense investment in streets and highways and in the vehicles which use them. Moreover, our entire way of life and form of community development has been and continues to be oriented around the street-and-highway system. As a result, it appears obvious that it will be an economic as well as a practical necessity in attempting to apply improvements in transportation technology to follow a course of adaptation rather than an attempt to replace the entire transportation system overnight.

Even if a radically new form of transportation needing neither streets, highways nor rails were to be developed—and if it offered exceptional advantages over anything known today—it would take significant time to develop the new technique
for practical application, to place it into production and to substitute it gradually for the current transportation system. If it could simply be added as an overlay to what is now in existence — without eliminating or changing present conditions — there would be the economic burden of supporting two independent systems during the transitional period which might take generations to accomplish.

The magnitude of the problem staggered the imagination. All who have attempted an appraisal of the problem have concluded that insofar as the street-and-highway system is concerned, any revision in technology must permit a gradual changeover, adapting the new to the existing and the old to the new.

With a concept of adaptation rather than total change, then, appraisals were made of the possible physical developments of future trucks and passenger cars. One of the most important features of a vehicle is its power plant. The internal combustion engine—in almost universal use—is basically the same today as when it was invented. Studies by the Rand Corporation101 imply that it probably will be superseded by either of two possible engine types by the middle or late 1970s. One is the fuel cell and the other a new development in storage batteries. Both offer high efficiencies and almost complete elimination of air pollution. However, neither of these types of power plants will call for new power plant influence basic changes in the use being made of vehicles, other than reducing operating costs and thus inducing even greater vehicular usage.

Extensive applications of the techniques of automation and control to the operation of cars and trucks appear to be forthcoming. Such efforts seem to be concentrated on systems which are adaptable to current facilities and vehicles. For instance, a system of automatically controlled lanes would increase the capacity of present facilities by several times, as well as offering essentially accident-free operation. The potential advantages of such a development are tremendous and appear to be physically and economically achievable within a generation. A primary effect would be a significant reduction in the need for additional highways and highway lanes.

If automation and control are coupled with a higher vehicular speed — which is a likely possibility — it would undoubtedly make private car use even more attractive than at present. It may also induce an even more expanded urban form. It is unlikely, however, that any increase in speed over the present capabilities of the human operator can be safely attained without applying automatic vehicular controls consistent with the geometrics of the particular highway facility.

Mass Transit Vehicles

Possible technological developments affecting mass transit vehicles were assessed by reviewing all the recent studies and research available. Included were Rand Corporation studies in urban transportation,102 as well as the planning and research in modern rapid transit technology undertaken in San Francisco and Washington, D.C. Foreign developments and capabilities were also extensively reviewed in an attempt to assess the possible effect of technological development, not only on the mass transit facilities, but also on the role which mass transit might play in urban areas in the future and its effect on the urban pattern of development.

It has been well established that current rapid transit equipment can attain the maximum acceleration and deceleration rates within which the human body can safely sustain a free standing position. This means that no improvements can be made in the speed capabilities of rapid transit equipment for urban area applications since it must be assumed that patrons will at some point in their journey be standing. The time penalty which would result from waiting for all riders to be seated before starting and not permitting them to rise until the vehicle is at a full stop exceeds the time advantages which higher acceleration and deceleration rates could possibly offer. Neither can the control of riders be so exacting as to assure that everyone is seated at all times when the vehicle is moving. But without such rigid control, it is impossible to exceed the acceleration and deceleration rates currently available on rapid transit equipment.

Thus, if the speed characteristics of rapid transit are to be improved, they can only come from increasing top speed capabilities and/or by reducing the number and shortening the time of stops to pick up or discharge riders. With respect to the top speed capability, currently available equipment can attain the highest speed possible between stations sufficiently close together to provide adequate urban area service. The farther apart the stations, the fewer the stops, the lesser the time consumed for station stops and the faster the top speed can be attained after leaving one station before having to brake for the next. However, it is obvious that the stations must be spaced a reasonable distance apart if the rapid transit facility is to perform an urban transit service. Generally, no more than a mile between stations is considered reasonable in fully developed areas and as much as two miles in partially developed areas.

The average speed attainable between stations which are one mile apart—with an acceleration and

101. A large number of individual reports on various aspects of urban areas and urban transportation were prepared by the Rand Corporation. Many of these formed the basis for J. R. Meyer, J. F. Kain, M. Wohl, The Urban Transportation Problem (Cambridge, Massachusetts: Harvard University Press, 1966).
102. Meyer, Kain and Wohl, op. cit (This page).
modern rapid transit equipment appears to offer
deceleration rate the standing human can absorb—is approximately 32 miles per hour (if the top
speed capability of the equipment is 55 mph). It is approximately 40 mph if the top speed capa-
bility is 100 mph. Thus, there is little improvement attainable in the average speed even with such a
significant improvement in top speeds. The higher top speed, of course, is accompanied by a higher
cost for equipment, a higher operating cost and a less comfortable ride.

Consequently, the average speed which an urban rapid transit facility can attain is regulated
by inherent limitations of the human body and the stop-and-start characteristics of the facility. Rapid
transit operators in New York and Chicago, where transit demand is high, have been able to apply
skip-stop operations to increase overall speed. However, this can only be done where patronage is
exceedingly high since it raises the cost of operation and increases the headway between trains destined
to particular points.

In summary, therefore, no technological developments appear possible in the urban rapid transit
field to better the currently existing performance characteristics. Thus, it is not possible to look
forward to an improvement in the relative travel time between use of a private auto and of rapid transit.
As a matter of fact, since it appears possible that private auto travel times can be increased through
application of new technology, rapid transit may not be able to retain its present competitive posi-
tion.

With respect to bus transit equipment, it is possible to improve significantly its acceleration capa-
bility—and thus its overall average speed—by increasing the installed horsepower. This has not
been done in the past simply because of the sub-
stantially increased fuel consumption and operating costs which result. However, with increased support
from public funds being directed toward transit, it appears logical to expect that transit operators will
act to increase the installed horsepower or possibly to apply gas turbines in buses to improve operating
characteristics. This should make bus riding faster and more attractive to riders than is currently the
case.

The attractiveness and comfort features of transit equipment have been improved substantially in
recent years. Further improvement appears possible through better springing, acoustical control, air-
conditioning and more powerful engines. Transit operators realize the increased attractiveness to
riders from such improvements, but the increased costs have prevented most of them from taking
action. As indicated earlier, increased public support may permit such improvements. Present
modern rapid transit equipment appears to offer
little room for upgrading in these factors since it
already offers a comfortable ride, air-conditioning
and as high a speed as the riders can absorb.

Mass transit has always been at a disadvantage
from the standpoint of flexibility to adapt to per-
sonal desires. Schedules must be kept; certain
routings followed; and stops are allowed at only
certain places. The individual is not provided with
a direct service from origin to destination at the
particular time he desires it. Nor have rapid or
other transit modes which involve a considerable
investment in fixed facilities been able to adapt to
changing development patterns.

As our society has become more affluent and as
the physical arrangement of our urban areas has
changed, fixed transit operations have not been
able to adjust readily: The bus, on the other hand,
had the flexibility to adapt as circumstances
have warranted. Urban areas today are passing
through a period of substantial change; consequent-
ly, it has been suggested that investment in high
cost, inflexible mass transit facilities at this time
might be ill-advised until the future can be better
appraised.108

Automation and automatic control appear to be
applicable to rapid transit in particular and should
offer advantages in reliability, simplified toll-
collection and, possibly, reducing labor require-
ments and costs. However, the new San Francisco
rapid transit system, which will be automated in
many respects, will not do away with the motor-
man-engineer, although he will function more as an
attendant than as a train controller. The possible
effect on the operation of the system and its costs
will have to await some actual operating experi-
ence.

The possibility of applying automation and
automatic control to bus equipment appears to
depend upon the application of such technology to
vehicular roadways. In any event, it does not
appear to lend itself to local, surface street pick-up
and delivery use. However, if automatic control is
instituted on major highways and urban freeways
and expressways, it would appear that buses could
easily perform a rapid transit function on such
facilities. They would retain the full flexibility of
routing and local pick-up and delivery which rail
facilities lack and be capable of operating at sus-
tained high speeds without traffic delays.

Furthermore, the development of fuel cells or
new electric storage batteries to power buses would
eliminate the engine exhaust problem which pres-
ently is a limiting factor in distributing high
volumes of buses in congested downtown areas. It
would even be possible to build bus transit subways

Transportation (A report to the President's Panel on Civilian Tech-
nology, 1965).
in downtown areas without requiring expensive ventilation equipment. Thus, automation and control, coupled with new power plants, appear to offer great promise insofar as bus transit vehicles are concerned.

In summary, the possible effect of applying modern technological developments to rapid transit facilities appears to offer a slight cost reduction, possibly a greater reliability and more convenient toll collection. However, it does not seem as if a significant change in the service characteristics of rapid transit can be expected from foreseeable developments. The many exotic types of rapid transit equipment which have been offered in the past have the same inherent limitations as conventional rail equipment, often with no cost advantage. Still, the quality of service provided by all existing and proposed rapid transit systems appears to be essentially equivalent; thus, the application of new equipment should not materially alter the relative competitive positions of travel by rapid transit and by private auto. In short, only through the development of a radically new concept—which does not have the inherent limitations of today's equipment — can the situation be expected to change.

Technological improvements, however, appear to offer fruitful possibilities for bus transit which might enhance or at least permit retention of the present relative competitive position of bus transit compared to the passenger car—as well as the relative competitive position of bus transit compared to rail transit. This matter should be continually reviewed so the planning for the future can take advantage of and adjust to possible developments.

**Water Transportation of People and Vehicles**

While the Puget Sound ferries provide a necessary transportation service and constitute an operation of sizeable proportions, they accommodate relatively small amounts of travel (less than one-half of one percent of the total person trips in the region). It is unlikely that this proportion will increase significantly in the future. Moreover, it should be recognized that transporting people and vehicles by boat on short trips is an extremely expensive operation. For this very basic economic reason, ferry operations are replaced by bridges wherever possible.

The application of exotic water transportation equipment—such as hovercraft and hydrofoils—has been considered. However, these vessels have the same inherent cost limitations as conventional ferry boats, further aggravated by the greater power requirements to sustain the new vessels and to achieve high speeds. They are also not well adapted to carrying vehicles. A study of the potential use of hydrofoils on Puget Sound concluded that a run as long as from Seattle to Bremerton would be required to reach the threshold of practical application from the standpoint of significant speed advantage.104

Overall, it was judged that transportation planning in the region should be predicated upon continuance of existing ferry facilities, possibly augmented by a cross-Sound bridge. Presently known types of equipment do not seem to offer significant improvement potential for application in the region. In any event, the possible impact of such equipment—or of new and unanticipated technological break-throughs in water transportation—are unlikely to have a notable impact on the regional development and travel patterns.

**POSSIBLE SOCIO-ECONOMIC CHANGES AND THEIR EFFECT ON TRAVEL**

The twentieth century has brought substantial changes in the social and economic structure of the United States. These changes have been particularly rapid since the end of World War II and have a direct and significant effect on the forms of our urban areas and on the amounts and patterns of travel. It can be expected that similar social and economic changes will continue into the future.

One of the most prominent changes has been the great economic growth of the nation which has been translated into increased personal incomes and affluence. This apparently has tended to make people less cost-conscious and has affected the proportion of total personal income which is directed toward certain purposes. Thus, not only have the per capita expenditures for transportation increased significantly, but they have also increased as a percentage of the total personal income. Moreover, the reduced cost-consciousness and increased affluence of the nation has been accompanied by a much greater passenger car ownership and a much reduced use of public transit.

The Study's projections are based on the expectation that these general trends will continue, but at a declining rate.105 However, it is important that matters such as these be periodically appraised because of their impact on the functioning of the urban area, the travel demands and the need for transportation facilities.

Besides a reduced usage of mass transit facilities, another result of greater personal income and increased vehicle ownership is an upswing in the total number of trips being made on a per capita or per household basis.106 Moreover, while the number of trips per household for work purposes remains relatively constant regardless of the personal income,

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106. Schmidt, op. cit., Staff Report No. 11 (See Page 62).
the number of trips for social-recreation, shopping and similar purposes goes up substantially as income increases.\textsuperscript{107} Trips made for the latter types of trip purposes tend to be non-transit oriented and generally in quite dispersed directional patterns. The Study's forecasts are based on the expectation of continuation of these tendencies.

Similarly, greater affluence has tended to direct residential development toward areas of lower densities, with such growth possible only in the outlying sectors where there is ample room. Low density developments generate fewer trips per acre or per mile of transportation facility and, as a consequence, are less feasible to serve with transit facilities than the older and higher density areas. As a result, not only does the quality of transit service to such areas of new development suffer, but fewer of the trips made by such households are by transit. Moreover, such households generate more trips per day than do households in higher density areas.\textsuperscript{108} The Study's forecasts assumed that new residential developments would be at densities similar to those presently prevailing.

A characteristic of current development patterns is the spread outward of places of employment, schools, stores, theaters, etc., as the residential areas also spread into the suburbs. This has created a different and more diffused travel pattern than formerly existed or was possible. Much of this has come about because of the increased locational freedom which the motor vehicle has provided. Since mass transit facilities are best suited to serving concentrations of travel demands in specific corridors, a diffusion of travel patterns does not lend itself to being served by mass transit facilities. The Study's projections are based upon a continuance to alternate degrees of the diffusion of employment and other activities which attract trips.

Not only does the diffusion of types of development tend to create diffused travel patterns, but it may also be leading to a shortening of the individual trips which are being made. Of necessity, trip lengths will tend to be the longest if the places of employment and other trip attracters are specialized. A diffusion of trip attracters closer to places of residence will result in a shortening of the individual trips. Unfortunately there is a complete lack of historic data on trip lengths, so the possible change and the rate of change in trip lengths cannot be established. This is another matter for periodic reappraisal since the average trip length has a direct impact on the amount of transportation facility which must be provided.

It can readily be seen from the foregoing that the trends of the twentieth century—and particularly since the late 1940s—have had very pronounced impacts on the type, amount, purpose and directional orientation of travel. Each of these has in turn had an effect on the travel mode—such as transit versus the private car—with the trend of each bringing about a lessening in transit usage. Any pronounced reversal of these trends may have the effect of changing the trends in mass transit usage. However, no such reversal is yet apparent nor has it occurred in other American cities, whether larger or smaller than those in the Puget Sound Region. As a matter of fact, some cities have experienced even more pronounced trends than have occurred here.

Another factor which also has had a pronounced effect on travel, and particularly on the usage of mass transit facilities, is the length of the work week. Since the primary usage of transit is for work trips, the change from the historical six-day week to a five-day week has had a direct and material effect on transit—a reduction of almost 20 percent in the number of work trips being made.

The Study has not attempted to incorporate into its forecasts any possible further shortening of the work week, though it appears this can be expected. If such a reduction takes the form of less hours of work per day, rather than less work days per week, the effect on the use of transit may be minimal. A shortened work day will provide improved opportunities for staggering the hours of work. Thus the peak-hour problems could be lessened, which might have an adverse effect on transit ridership.

A decrease in the number of work days per week will reduce the number of transit riders traveling to and from work per week, whether this takes the form of a standard four-day week (such as Monday through Thursday) or whether business continues to operate on a Monday through Friday basis, with employees being rotated as to their additional day off. However, under the latter basis, the peak-hour problem will be lessened (being reduced by 20 percent) with a consequent improvement of travel conditions (and possibly some adverse effect on transit use), while under the former condition the peak-hour problem will not be affected, only being experienced four days out of the week rather than five. The potential benefits from a transportation standpoint alone of either a shortened work day with staggered hours or of a rotating third day off for employees are substantial.

The effect of an increase in the application of automation on the social and economic functioning of the urban community is difficult to assess in full. Recent experience appears to bear out that automation will not reduce employment but, rather, it will increase worker productivity and will result in a change in the composition of employment and

\textsuperscript{107} Gary R. Cowan and John R. Walker, Rationales for Trip Production-Generation Analysis. Staff Report No. 6: Forecasts of Future Trip Ends by Trip Purpose. Staff Report No. 16 (Seattle: PSRTS, 1964).
\textsuperscript{108} Schmidt, op. cit., Staff Report No. 11 (See Page 52).
the skills required. If this does occur, it can be anticipated to have transportation implications (such as possible higher incomes, resulting higher auto ownership and thus a lesser tendency to use transit), but these will probably be nominal.

One implication of automation with respect to headquarters office functions which has been suggested\(^\text{109}\) is a possible shift from what has traditionally been a day-shift female clerical function to a predominantly male data processing function operating on a two or more shifts per-day basis. The heavy investment in data processing equipment—the capacity (and thus the cost) of which can be minimized by operation on an around-the-clock basis—has already had this effect to a limited extent, but it is expected to be felt even to a greater extent in the future with increasing use of computers (and with higher-cost computers of greater capacity).

To the extent the application of computers and other automated equipment makes significant inroads into the overall composition of employment—and to the extent that business continues to expand extra shift operations to minimize the investment and costs of obtaining and using such equipment—there will be transportation implications. The changes may be subtle, such as the reduction in the relative proportion of the total day’s travel taking place during the peak hour because of the spreading of employment throughout the 24-hour period. The tendency is for second and third shift trips to be made predominantly by private car rather than by transit, for a number of obvious reasons—unwillingness to wait at the corner or walk to or from the transit stop at night, the poorer service provided by transit at that time because of low usage potentials, etc.

Another possible effect of automation and developing technology relates to the location of industry and other places of employment. Data transmission devices and improved transportation facilities permit the location of data processing functions away from the data generating sites and the location of management. New bank data processing centers outside of the downtown areas in both Seattle and Tacoma are examples of such an effect. Computer inventory control, coupled with fast air travel, reduces or completely eliminates the need for stock inventories by wholesalers and distributors of many products, shifting the stock function to possibly only one central location in the nation. This reduces the employment in regional offices such as might be located in the Puget Sound area.

The reduced dependence on rail and water transportation because of improved and more extensive ground transportation facilities has allowed much greater freedom in industrial locations than previously was possible. Current and changing industrial technology and materials-handling techniques have affected the types of plants which are suitable for modern industry. The need for single level plants so designed to permit use of modern equipment, with a maximum of flexibility in equipment layout, is well known. In many instances this has triggered a move to new buildings on completely new sites.

Firms manufacturing electronic and other similar products have found outlying locations necessary because of the need for clean air which will not contaminate the products during assembly. Such locations are usually readily accessible without congestion and are considered as desirable places to work. They are especially attractive to suburban housewives who favor the pleasant surroundings and the close-to-home convenience of such employment.

In summary, it can be said that technological changes and automation are exerting a substantial effect on industrial and other employment activities, both as to location and type. In many ways the effect is one of lowering the employment density, a dispersal of locations and an increased freedom of locational choice.

In developing the alternate forecasts of the locations of future employment, it was not possible to reflect explicitly the effect of automation and technological advances on the future sites of industry and other work activities. It may be implied, therefore, that the alternative employment forecasts may reflect a higher degree of centralization (aggregation at current sites of employment) than may actually be experienced if these influences of technology and automation on location continue or even accelerate. Therefore, periodic reappraisals of such matters should be made so developing trends may be detected. In that way the forecasts can be adjusted, if found necessary, to reflect such influences and the trends which they generate.

**Summary**

The alternative land use patterns and the various alternative transportation systems were evaluated against regional goals and objectives to determine which combination might best meet the regional goals.

A land use pattern which represents a conscious attempt to guide and shape future urban growth in response to regional goals obviously better meets regional objectives than any alternative course of action. Only by a regional approach in planning for development on a broader area basis than individual governmental jurisdictions can there be assurance that the environment will be improved. A regional approach can provide such further by-product possibilities and advantages as a lessening of the need

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for travel and travel patterns which will reduce total regional travel.

The Plan B pattern, which is a regional goal-oriented development pattern, is obviously preferable to Plan A, which represents a continuation of present trends in residential development following the current planning and land use zoning of the separate governmental jurisdictions in the region.

Alternative forecasts of the amount of development which might be expected to locate in specific areas of the region were analyzed to determine the transportation impact. The forecasts which were used in the analysis of Plan A represent a high degree of centralization of employment, while the forecasts used in analyzing Plan B represent a lesser degree of centralization. Both, however, are based on forecasts for the central business districts which appear to be optimistic. There was a significant (15 percent) penalty in total regional travel (expressed in vehicle miles) which comes from the more highly centralized pattern of employment location. Recent developments seem to imply that the forecasts of the amounts and locations of employment used in the analysis of Plan B are more in keeping with what can actually be expected to occur in view of current trends, than the assumption for employment locations used in the analysis of Plan A.

Because transportation facilities are almost universally available, new facilities seem to have a much lesser influence on the locational patterns of development than was once the case. It is not anticipated, as a result, that the construction of any new transportation facilities not included in the Transportation Study's planning will materially affect the forecasts of development.

The various alternative regional transportation systems were evaluated against the regional goals. A number of factors were included in the evaluation, with each factor converted into terms of cost.

Many aspects of planning a regional transportation system are matters of detailed location and design rather than of regional planning. Thus, aesthetic considerations as to facility design and location and the integration of specific facilities into the pattern of neighborhoods, are not germane to the establishment of a regional framework, since in the detailed planning, the regional facilities can be adjusted to fit local requirements without sacrificing their regional effectiveness.

It was concluded that a reasonable level of transit service must be provided in any alternative system as a matter of public policy simply to provide for the travel needs of a significant portion of the region's population and to serve the central business districts of the region's major cities.

Detailed evaluations of the alternative transportation system established that the worst course of action for the future would be to construct no new freeway, expressway or other major street and highway facilities beyond those currently being constructed or already budgeted. The next most costly alternative to meet regional objectives was found to be the one which includes a rapid transit system in the Seattle area.

The best direction to follow with respect to transportation systems are those based on the Plan B pattern of development. The lesser centralization which this represents compared to the forecast used for the Plan A analyses creates significant transportation planning advantages, as well as being preferable from a land use planning standpoint.

Though radically new forms of transportation are not envisioned, possible technological developments offer hope of considerable improvements in the carrying capacity of street-and-highway facilities. New types of power plants for passenger cars and trucks may increase their speed of operation and eliminate automotive air pollution as well. Automated control of motor vehicles must also be considered.

The rapid transit equipment available today has reached the performance limits possible for urban service; technological developments cannot improve the competitive relationship of rapid transit to the private car. Only a radically new concept can alter this picture, and such development — practical of application — cannot now be foreseen. Bus transit, however, offers a promising field for technological changes which might improve its competitive relationship to the private auto.

The use of ferries or other more exotic types of vessels cannot be expected to have a significant impact on the regional transportation problem. Less than one-half of one percent of the total person travel in the region is now accommodated on the ferry system. The transporting of people and vehicles on short trips by water is inherently expensive, and cost factors cannot be expected to improve by the application of such vessels as hydrofoils or hovercraft.

Possible technological developments in the field of transportation seem to reinforce rather than weaken the basic premises upon which the Transportation Study's planning for the future was based. The same is true of possible socio-economic changes which can be expected to affect the patterns, types and locations of development, as well as the patterns of travel and the ways in which trips will be made in the future.

For recommendations based upon the findings and conclusions of the Puget Sound Regional Transportation Study, please refer to Part III of this report.
Present Staff Members of the
PUGET SOUND REGIONAL TRANSPORTATION PLANNING PROGRAM

Herman Basmaciyan, Acting Director
James W. MacIsaac, Senior Transportation Planning Engineer
Donald R. Pethick, Urban Planner
Kenneth E. Berg, Graphics Supervisor
Russel E. Griggs, Computer Systems Analyst
Robert C. Jenkins, Transportation Planning Engineer
Labh Singh Sachdev, Transportation Planning Engineer
Gerald D. Dinndorf, Transportation Planning Engineer
Dorothy Ann Sires, Graphics Aide
Ruby N. Elliott, Transportation Planning Technician
Leona M. Utt, Analysis and Research Technician
Margaret L. Adams, Analysis and Research Technician
Rachel R. Baum, Analysis and Research Technician
Opal M. Gunderson, Planning Technician
Ernest H. Trim, Jr., Transportation Planning Technician
Virginia L. Easley, Accounting Assistant
Dorothy H. Lemmon, Magnetic Tape Librarian
Patricia K. M. Cole, Typist-Stenographer

Key Staff Members of the
PUGET SOUND REGIONAL TRANSPORTATION STUDY

John K. Mladinov, Director
Stephen George, Jr., Deputy Director
Fred Utevsky, Assistant Director for Regional Planning
James W. Schmidt, Assistant Director for Traffic and
  Transportation Planning
Gary R. Cowan, Assistant Director for Analysis and Research
Charles H. Graves
Bruce E. Howlett
Rajanikant N. Joshi
Gene A. Letendre

Herman Basmaciyan
Mart Kask
John R. Walker