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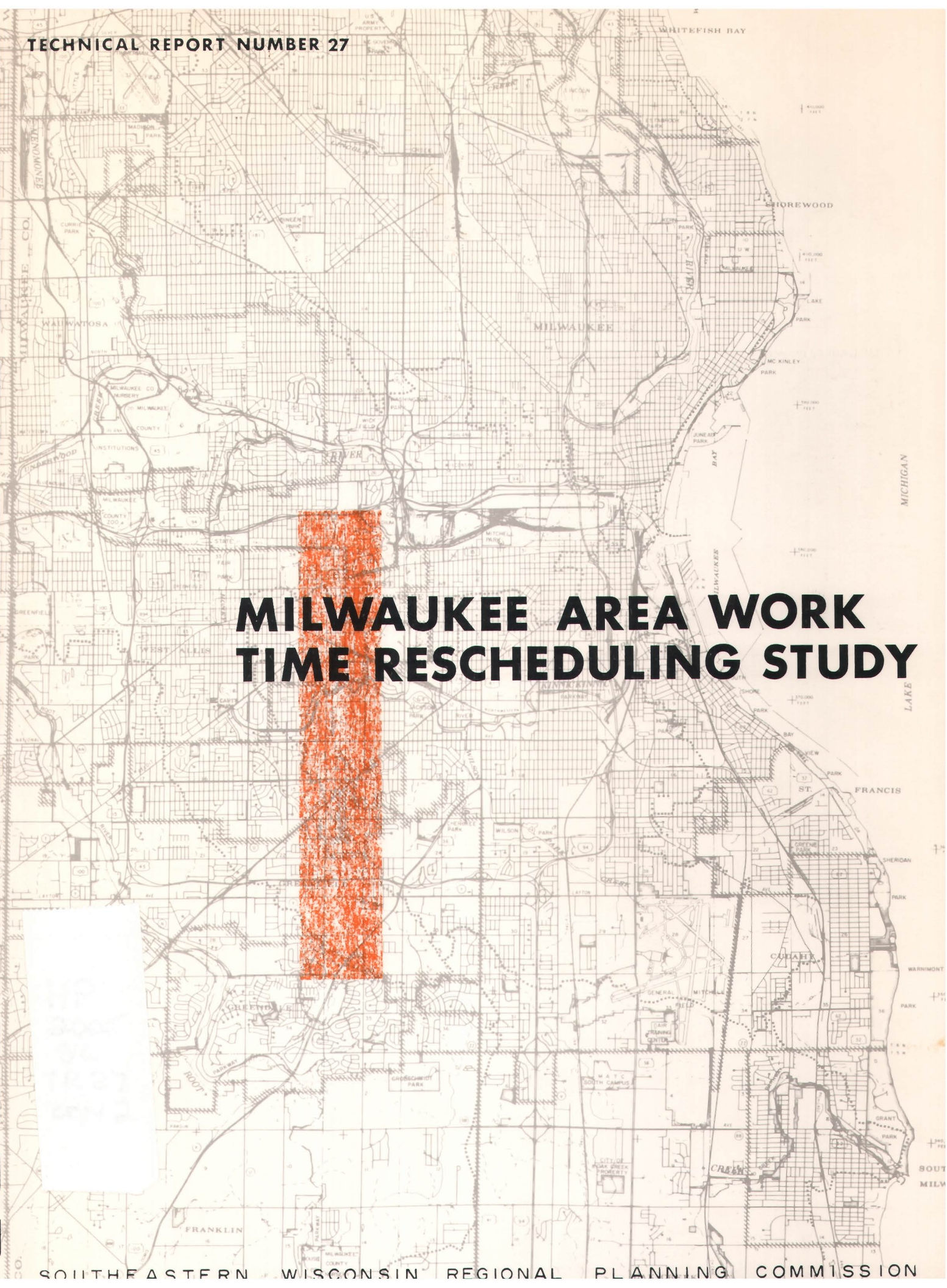

MILWAUKEE AREA WORK TIME RESCHEDULING STUDY

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Special acknowledgement is due Mr. Craig A. Murawski, SEWRPC Principal Planner, and Mr. Louis E. Keefer, SEWRPC Transportation Planning Specialist, for their contribution to the preparation of this report.

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TECHNICAL REPORT
NUMBER 27

MILWAUKEE AREA WORK TIME RESCHEDULING STUDY

Prepared by the

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The preparation of this report was financed in part through a joint planning grant from the U. S. Environmental Protection Agency, the U. S. Department of Transportation, Urban Mass Transportation Administration and Federal Highway Administration, and the Wisconsin Department of Transportation.

August 1981

Inside Region $ 5.00
Outside Region $10.00

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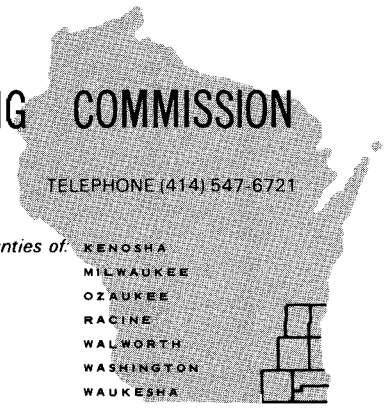

August 25, 1981

STATEMENT OF THE EXECUTIVE DIRECTOR

On December 19, 1977, the Southeastern Wisconsin Regional Planning Commission adopted its first transportation system management plan. That plan examined the current operations and management of the highway and mass transit systems of the Region and recommended ways to enhance the efficiency of those systems. The plan recommended implementation of a variety of low-cost transportation system management measures, including a study of the potential of work time rescheduling to reduce traffic congestion and improve the operations of the existing transportation system.

Accordingly, the Commission directed that a prospectus be prepared, with the assistance of an advisory committee comprised of knowledgeable local, state, and federal public officials and representatives of industry and organized labor, for a study of work time rescheduling. The prospectus, as adopted on December 7, 1978 at the specific direction of the Advisory Committee, recommended that the study be initially carried only through the analysis phase, based upon which a determination would be made as to whether the study should be terminated or continued through the plan preparation stage. The determination was to consider the feasibility, as well as the potential, of work time rescheduling to modify transportation demand significantly and thereby directly contribute to the more effective use of the area's transportation system capacity, thus alleviating the need for additional capital investment and new or reconstructed transportation facilities.

In accordance with the prospectus, the Commission in 1980 undertook the recommended study of work time rescheduling. This report sets forth the findings and recommendations of that study.

The study involved inventories of the existing degree of highway and transit congestion by hour in the three-hour morning and afternoon Milwaukee area peak travel periods; of Milwaukee area employers' current work schedules and of the existing extent of the use of work time rescheduling; and of managerial attitudes toward, and of other constraints on, the implementation of additional work time rescheduling. Analyses of the inventory data indicated that the potential of work time rescheduling to relieve peak-period traffic congestion and reduce peak-period transit vehicle fleet needs was significant if a substantial proportion of work-related travel could be shifted from the peak morning and afternoon travel hours to the hours surrounding the two peak travel hours. Analyses of the inventory data, however, also indicated that the feasibility and practicability of achieving the shift in work-related travel necessary to affect peak-hour congestion significantly—thereby achieving a substantial proportion of the potential benefits—was questionnable.

It was accordingly concluded that the benefits which could be achieved practically through further work time rescheduling in the Milwaukee area were limited, and it was recommended that no areawide plan for an expanded work time rescheduling program be prepared at this time. However, because of the significant potential benefits of such rescheduling, it was further recommended that the Commission and concerned state and local units and agencies of government in the Milwaukee area continue to promote the concept and implementation of work time rescheduling in traffic management planning efforts directed at small subareas of the Region and at increasing the efficiency of transit service.

Respectfully submitted,

Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

The Milwaukee area work time rescheduling study represents an examination by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) of the extent to which work time rescheduling can reduce existing highway and transit system congestion problems in the Milwaukee area. These congestion problems, caused by travel demands which are greater than the transportation system capacity, generally are severe only during one early morning and one early evening hour of the weekday when travel is at its peak in the Milwaukee area. The objective of work time rescheduling is to reduce this severe congestion by spreading these peak-hour demands as much as possible over surrounding travel hours.

Work time rescheduling basically embraces four different concepts: flexible work hour programs, staggered work hour programs, shifted work hours, and shortened work weeks. Each concept affects the employer, the employee, and peak travel demand in different ways. Flexible work hour programs allow workers to determine their daily work hours according to personal preference, as long as their work hours total a specified number daily and/or weekly. In many applications of flexible work hours, workers are also required to work during a specified "core" period, for example, between 10:00 a.m. and 3:00 p.m. In staggered work hour programs, worker starting and quitting times are scheduled at short intervals such as 15 minutes over selected morning starting and evening quitting periods, rather than at a single common starting and quitting time. Shifted work hour programs reschedule the starting and quitting times of an entire firm or plant rather than rescheduling different portions of the work force as in staggered work hour programs. The reduced work week most commonly requires employees to work a total of 40 hours each week, while reducing the number of days worked each week.

This study estimates the maximum potential reduction in transportation system congestion that may be expected through work time rescheduling in the Milwaukee area, and determines the extent to which such potential reduction can, as a practical matter, be achieved given the probable extent of employer participation in work time rescheduling. The study found that work time rescheduling in the Milwaukee area has the potential to significantly reduce existing arterial street and highway congestion and transit vehicle needs by shifting peak-hour work-related travel demand. The study also found, however, that the degree to which Milwaukee area employers may be expected to participate in such rescheduling, over and above the existing participation, would be insufficient to achieve any substantial measure of the potential benefits. Based on these findings, the study recommends that no further areawide planning for work time rescheduling in the Milwaukee area be undertaken at this time. Because of the potentially large benefits of work time rescheduling, and because implementation of such rescheduling would constitute a step toward achieving those benefits, the study does, however, recommend the promotion of work time rescheduling on case-by-case basis in travel corridors and geographic subareas of the Region.

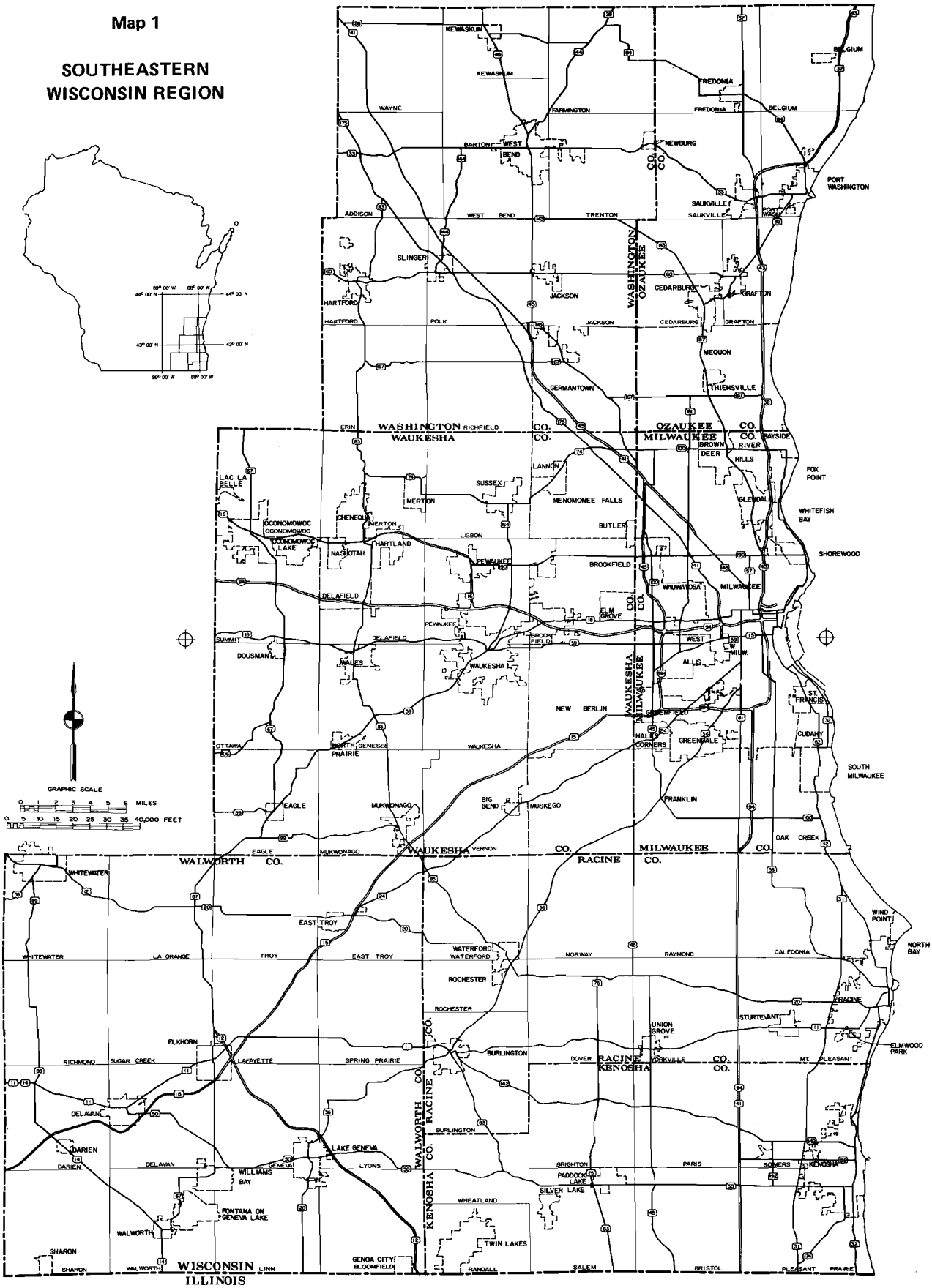
THE REGIONAL PLANNING COMMISSION

The Southeastern Wisconsin Regional Planning Commission provides the necessary areawide planning services for the seven-county Southeastern Wisconsin Region. The Commission was created upon the unanimous petition of the seven county boards concerned in August 1960, under the provisions of Section 66.945 of the Wisconsin Statutes. It exists to serve and assist the local, state, and federal levels, units, and agencies of government in planning for the orderly physical and economic development and redevelopment of the seven-county Southeastern Wisconsin Region comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties (see Map 1). The Commission's role is entirely advisory, and participation by local units of government is on a voluntary, cooperative basis. The Commission is composed of 21 citizen members, three from each county in the Region, who serve without pay.

The powers, duties, and functions of the Commission are set forth in state enabling legislation. The Commission is authorized to employ experts and staff as necessary to execute its responsibilities. Basic funds necessary to support Commission operations are provided by the member counties, with the budget apportioned among the seven counties on the basis of relative equalized assessed property valuation. The Commission is authorized to request and accept aid from all levels and agencies of government to accomplish its objectives and is authorized to deal directly with the state and federal governments for this purpose. The Commission, its committee structure, its staff organization, and its relationship to the constituent counties are shown in Figure 1.

Map 1

SOUTHEASTERN WISCONSIN REGION

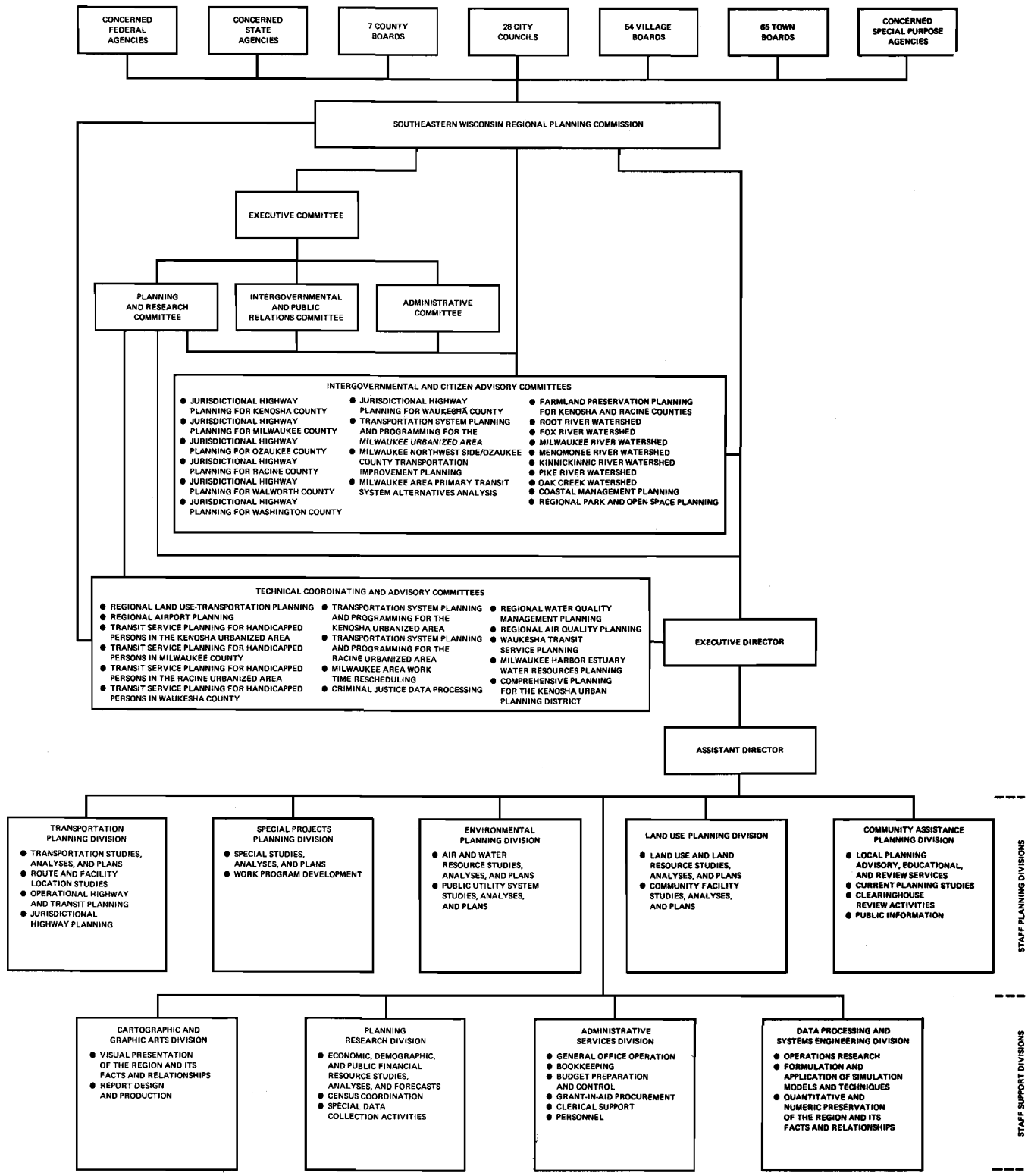


The seven-county Southeastern Wisconsin Region encompasses an area of about 2,689 square miles, or about 5 percent of the total area of the State of Wisconsin. About 40 percent of the State's population, however, resides in these seven southeastern counties. The Region employs about 40 percent of the State's labor force and contains about 42 percent of all the tangible wealth in the State as measured by equalized assessed property valuation. The Region has been subject to rapid population growth and urbanization, and from 1960 to 1975 accounted for about 40 percent of the total population increase of the State.

Source: SEWRPC.

Figure 1

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION ORGANIZATIONAL STRUCTURE



Source: SEWRPC.

COMMISSION FUNCTIONS

As conceived by the Commission, regional planning is not a substitute for, but a supplement to, local, state, and federal planning efforts. Its objective is to assist the various levels, units, and agencies of government in finding solutions to areawide developmental and environmental problems which cannot be properly resolved within the framework of a single municipality or county. As such, regional planning has three principal functions:

1. Inventory—the collection, analysis, and dissemination of basic planning and engineering data on a uniform, areawide basis so that, in light of such data, the various levels and agencies of government and private investors operating within the Region can better make decisions concerning community development.

2. Plan Design—the preparation of a framework of long-range and short-range plans for the physical development of the Region, these plans being limited to functional elements having areawide significance. To this end, the Commission is charged by law with the function and duty of "making and adopting a master plan for the physical development of the Region." The permissible scope and content of this plan, as outlined in the enabling legislation, extend to all phases of regional development, implicitly emphasizing preparation of alternative spatial designs for land use and for supporting transportation and utility facilities.

3. Plan Implementation—the promotion of plan implementation through the provision of a center to coordinate the planning and plan implementation activities of the various levels and agencies of government in the Region and to enter solutions to areawide problems, and alternatives thereto, into the existing decision-making process.

The Commission maintains a continuing planning process providing outputs of value to the making of development decisions by public and private agencies, and to the preparation of plans and plan implementation programs at the local, state, and federal levels. It emphasizes close cooperation among the governmental agencies and private enterprise responsible for the development and maintenance of land uses in the Region, and for the design, construction, operation, and maintenance of the supporting public works facilities. All Commission work programs are intended to be carried out within the context of a continuing planning program which provides for periodic reevaluation of the plans produced, and for the extension of planning information and advice necessary to convert the plans into action programs at the local, state, and federal levels.

THE REGION

The seven counties that comprise the Southeastern Wisconsin Planning Region, exclusive of Lake Michigan, have a total area of 2,689 square miles and a resident population of about 1.8 million persons.

As shown on Map 1, the Region can be divided into those areas which are urbanized and those areas which are not urbanized. There are three urbanized areas, as defined by the U. S. Bureau of the Census, within the Southeastern Wisconsin Region: Kenosha, Milwaukee, and Racine. Each of the urbanized areas is comprised of a large central city with a population of at least 50,000 and a surrounding area contiguous to the city which is devoted to intensive urban use. The intent of defining urbanized areas is to identify those areas which function as a single urban entity, and as such comprise a true physical city.

COMMISSION TRANSPORTATION PLANNING AND CONSIDERATION OF A MILWAUKEE AREA WORK TIME RESCHEDULING STUDY

The first major work program of the Commission actually directed toward the preparation of long-range development plans was a regional land use-transportation study, initiated in January 1963 and completed on December 1, 1966. This study produced two key elements of a comprehensive plan for the physical development of the Region: a land use plan and a surface transportation plan, including highway and transit elements. The findings and recommendations of the study, which served for over a decade to guide land use and transportation system development in the Region, were published in the three-volume Commission Planning Report No. 7, The Regional Land Use-Transportation Study.

Subsequent to the adoption of the initial long-range land use and transportation system plans, the Commission participated in the refinement of the adopted regional transportation plan as required for its eventual implementation. In cooperation

with the constituent county boards of supervisors, the Commission prepared jurisdictional highway system plans for all seven counties in the Region.[1] These jurisdictional highway system plans, adopted by the respective seven county boards as well as by the Regional Planning Commission and the Wisconsin Department of Transportation, recommended jurisdictional responsibilities for the various segments of the arterial street and highway system proposed in the adopted regional plan, including the realignment of the federal aid routes underlying that system. The planning effort provided an important frame of reference for the extensive corridor refinement and right-of-way reservation, acquisition, and construction activities undertaken by the state, county, and local units of government in implementation of the arterial street and highway system recommendations of the regional plan. The Commission also assisted in the preparation of the Milwaukee Area Transit Plan, which served to refine, detail, and stage the recommendations of the regional transportation plan concerning long-range transit development in the Milwaukee urbanized area.[2] The Commission has also annually monitored and reported on land use and transportation system plan implementation. Through such monitoring, the Commission has been able to assess the continued validity of the forecasts on which the plans were in part based.

A complete reevaluation of the initial regional land use and transportation plans began in 1972 with extensive reinventories of the factors affecting land use and transportation development in the Region, and an assessment of the extent of land use and transportation system plan implementation since 1966. The inventories indicated that substantial changes in population, economic activity, land use development, public finance, community plans and zoning, and travel characteristics had occurred over the 10 years since the original land use and transportation inventories were conducted. Although anticipated in the original regional planning effort, some of these changes, particularly the distribution of population and employment and land use development within the Region, had not been incorporated into the normative land use plan adopted in that effort.

The assessment of regional transportation plan implementation indicated long delays in planned freeway construction in Milwaukee County since the early 1970's, with the rights-of-way for a number of facilities—the Park Freeway-East and -West and portions of the Stadium Freeway-South—remaining almost entirely cleared for seven or more years, with construction blocked by public resistance. The assessment indicated that a sharp division of public opinion had developed as to freeway construction recommendations in Milwaukee County. This division of public opinion was reflected at public hearings, meetings of public officials, and meetings of technical and citizen advisory committees to the Regional Planning Commission.

In recognition of some of the changes in the factors influencing land use and transportation development, and in an attempt to help resolve this division of public opinion and the resulting impasse in transportation system development in the Region created by this division, the Commission prepared and adopted a new regional transportation system plan[3] which, with respect to freeway

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[1] *See SEWRPC Planning Report No. 11, A Jurisdictional Highway System Plan for Milwaukee County, formally adopted by the Commission on June 4, 1970; SEWRPC Planning Report No. 15, A Jurisdictional Highway System Plan for Walworth County, formally adopted by the Commission on March 1, 1974; SEWRPC Planning Report No. 17, A Jurisdictional Highway System Plan for Ozaukee County, formally adopted by the Commission on March 7, 1974; SEWRPC Planning Report No. 18, A Jurisdictional Highway System Plan for Waukesha County, formally adopted by the Commission on June 5, 1975; SEWRPC Planning Report No. 22, A Jurisdictional Highway System Plan for Racine County, formally adopted by the Commission on December 4, 1975; SEWRPC Planning Report No. 23, A Jurisdictional Highway System Plan for Washington County, formally adopted by the Commission on September 11, 1975; and SEWRPC Planning Report No. 24, A Jurisdictional Highway System Plan for Kenosha County, formally adopted by the Commission on September 11, 1975.*

[2] *See Milwaukee Area Transit Plan, prepared by the Milwaukee County Expressway and Transportation Commission in cooperation with the Southeastern Wisconsin Regional Planning Commission, and formally adopted by the Commission on March 2, 1972.*

[3] *See SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, and Volume Two, Alternative and Recommended Plans, formally adopted by the Commission on May 30, 1978.*

development, consisted of two tiers, an "upper tier" and a "lower tier." Facilities placed in the upper tier—about 37 miles of freeway in the Region and 13 miles in Milwaukee County—would remain on the long-range plan, but no further work would be undertaken toward their construction for at least a decade. During that decade, a combination of "transportation systems management" [4] actions, intended to reduce the anticipated peak-hour travel demand in Milwaukee County while obtaining the highest possible efficiency from existing transportation facilities and services, would be implemented. The proposed transportation systems management actions included an extensive freeway operational control system, increased promotion of carpooling and vanpooling, and significantly improved mass transit service.

The two-tier plan envisioned that if at some future time it was determined that these actions to modify travel demand and achieve maximum facility and service efficiency had been effective and that surface arterials and transit services were adequately accommodating travel demand, then steps could be taken at that time to formally remove the upper-tier freeway proposals from the long-range plan. On the other hand, if the consensus at such future time was that travel demand modification and improved transportation efficiency efforts had not worked well and that arterial street and transit improvements had not adequately provided the needed transportation service, work could again proceed toward the construction of the upper-tier freeways. In the meantime, the plan recommended that all right-of-way currently cleared for the remaining freeway segments be held in a transportation land bank, with appropriate consideration given to the use of the land for park and open space uses.

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[4] *Transportation systems management refers to a variety of transit facility and service, traffic engineering, and travel demand modification actions which are primarily of a low capital investment nature, and have a general objective of enhancing the efficiency of existing transportation facilities and services. These actions can be divided into four categories: those actions directed toward the more efficient use of existing road space; those actions directed toward the reduction of vehicle use in congested areas; those actions which would improve transit service; and those actions which would increase internal transit management efficiency.*

The plan also recommended that any currently undeveloped lands needed to accommodate construction of freeways in the upper tier of the plan continue to be held in open use. If this undeveloped land were not set aside, the construction of the recommended upper-tier facilities, if determined necessary at a later date, may very well be impossible. The interim conversion of undeveloped right-of-way to intensive land uses would significantly increase the costs and impacts of the development of the upper-tier transportation facilities, requiring the substantial reconsideration of the upper-tier recommendations. In this respect, it should be noted that although the Commission staff and the Commission advisory committees concerned recommended preservation in open space use of all lands acquired and cleared for freeway construction, including such lands for the Park Freeway-West, the Commission, as a result of information presented at the extensive public hearings held on the new plan, acted to delete the Park Freeway-West and related Stadium Freeway-North "gap closure" from the regional system plan. Consequently, land acquired and cleared for these facilities will be disposed of and probably developed for urban use, thus precluding, as a practical matter, the construction of these two facilities. The lower tier of the plan included 60 miles of freeway in the Region, 3.9 miles in Milwaukee County, which were recommended to be constructed as soon as possible.

The Commission at the same time prepared and adopted a transportation systems management plan [5] which expanded upon the long-range plan's recommendations to maximize the efficiency of the existing transportation system within southeastern Wisconsin. This plan proposed a coordinated areawide program of 24 actions to ensure full and efficient use of existing arterial street and highway facilities, to reduce vehicle use in congested areas, to improve transit service, and to increase internal transit management efficiency.

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[5] *See SEWRPC Community Assistance Planning Report No. 21, A Transportation Systems Management Plan for the Kenosha, Milwaukee, and Racine Urbanized Areas in Southeastern Wisconsin: 1978, and its update, SEWRPC Community Assistance Planning Report No. 26, A Transportation Systems Management Plan for the Kenosha, Milwaukee, and Racine Urbanized Areas in Southeastern Wisconsin: 1979.*

Among the actions proposed were studies for treatments at the "stub ends" of freeways, a study of arterial corridors, a taxi fare and regulation study, a study of downtown parking rate structures, and continued implementation and improvement of transit service and carpool and vanpool promotion programs.

To achieve more efficient use of existing transportation facilities through peak-hour travel demand reduction, the transportation systems management plan recommended the preparation by the Commission of a prospectus for a study of the impacts of work time rescheduling in the Southeastern Wisconsin Region. The proposed study was to explore the potential of flexible work hours, staggered work hours, and the four-day work week to reduce peak-hour travel demand and thereby reduce transportation system congestion and improve air quality within southeastern Wisconsin. In determining of the effectiveness of work time rescheduling, the proposed study was to consider the feasibility of implementing work time rescheduling in southeastern Wisconsin, because such implementation would have to be based upon the voluntary participation of private and public sector employers and employees.

The transportation systems management plan adopted by the Regional Planning Commission on December 19, 1977, called for the Commission staff to undertake the work necessary to prepare the prospectus. The Commission staff was directed to investigate the need for such a study; determine the desirable scope and content of the study; and prepare a recommended time schedule, cost estimate, and budget for the study.

In order to actively involve the units and agencies of government most concerned with transportation systems management and development in the Region in the preparation of the prospectus, as well as to bring the knowledge of individuals possessing broad experience in the planning, design, construction, operation, maintenance, and use of highway and mass transit facilities and services to bear on the question, the Executive Committee of the Commission acted on July 10, 1978, to create a Work Time Rescheduling Study Prospectus Steering Committee. Membership on this Committee is set forth in Table 1. The Steering Committee reviewed and unanimously approved a prospectus and on September 26, 1978, recommended that the Regional Planning Commission undertake the conduct of a work time rescheduling study as described therein.

THE MILWAUKEE AREA WORK TIME RESCHEDULING STUDY PROSPECTUS

The prospectus investigated the need for the proposed study and, finding a need to exist, defined the desirable scope and content of the study and prepared a recommended time schedule, cost estimate, and budget for the study.[6]

Need for the Study

The prospectus determined that four principal factors contributed to the need for a study of work time rescheduling in the Milwaukee area:

1. The existing problems of peak-period transportation system congestion within the Milwaukee area which require resolution, but for which new facilities cannot be constructed for a variety of reasons;

2. The potential of work time rescheduling to reduce peak-period transportation system congestion through the spreading of peak-period travel demand over other hours of the day, thus making better use of existing transportation system capacity and decreasing the need for capital investment to expand system capacity;

3. The potential of work time rescheduling to improve air quality and reduce motor fuel consumption by reducing present and future peak-period transportation system congestion; and

4. The possibility that implementation of an untested work time rescheduling scheme may disrupt the existing complex urban travel pattern in the Milwaukee area and actually interfere with the work and other trip purpose staggering that is already occurring, increasing rather than decreasing congestion levels on some parts of the transportation system.

Scope and Content of the Study

Based on this finding of need, the prospectus recommended that a study be undertaken based on the following assumptions which, in effect, define the scope and content of the study:

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[6] *See Milwaukee Area Work Time Rescheduling Study Prospectus, SEWRPC, December 1978.*

Table 1

WORK TIME RESCHEDULING STUDY PROSPECTUS STEERING COMMITTEE

Kurt W. Bauer	Executive Director, Southeastern Wisconsin Regional Planning Commission
Robert W. Brannan	Deputy Director, Milwaukee County, Department of Public Works
William P. Chapman	Vice-President, Johnson Controls, Inc., Milwaukee
Thomas L. Frank	Planning and Research Engineer, U. S. Department of Transportation, Federal Highway Administration
Michael S. Treitman	Community Planner, Air Planning and Development Section, Region V, U. S. Environmental Protection Agency
Thomas J. Parker	President, Milwaukee County Labor Council
Allan P. Pleyte	Traffic Engineer and Superintendent, Bureau of Traffic Engineering and Electrical Services, City of Milwaukee
Samuel R. Seward	Senior Planner, Department of City Development, City of Milwaukee
Dennis C. Vierra	Planning Representative, U. S. Department of Transportation, Urban Mass Transportation Administration
Thomas A. Winkel	District Chief Planning Engineer, District 2, Wisconsin Department of Transportation

Source: SEWRPC.

1. That the study will focus on areawide work time rescheduling and its impacts on the transportation system serving the Milwaukee urbanized area. In response to specific requests, the study may include the examination of localized traffic congestion problems to determine whether site- or area-specific work time rescheduling is a possible solution to localized traffic congestion.

2. That one purpose of a work time rescheduling study is to determine and document all significant potential costs and benefits associated with such rescheduling, answering all substantive questions concerning the desirability of such rescheduling that can be raised by both proponents and opponents.

3. That because the task of implementing a major work time rescheduling program is dependent upon the voluntary participation of the private sector of the economy, a work time rescheduling study should determine the feasibility of its implementation and attempt to identify the means of overcoming any obstacles to implementation.

4. That a work time rescheduling study should provide a basis for appropriate actions based upon study results. That is, if work time rescheduling is shown to be both feasible and desirable, and a rescheduling program is formulated and adopted following evaluation of alternatives, then the study should identify all further work necessary to refine

any selected rescheduling program and should specify the actions necessary to implement that program, along with an implementation schedule.

5. That full use will be made of all existing and available surveys, studies, reports, and other data which may influence or affect the proposed work, and that additional data collection activities will be considered only as necessary to provide original data essential to establish the desirability and feasibility of a work time rescheduling program and to make recommendations regarding its implementation.

6. That developing the capability to simulate peak-period travel demand is essential to the evaluation of impacts of the alternative work time rescheduling plans to be proposed in the study, and furthermore will be useful to the Commission staff in future testing of other transportation system management measures. This peak-period travel simulation capability can be developed from data gathered in the Commission's 1963 and 1972 origin and destination surveys through modification of the Commission's existing average weekday travel demand simulation capabilities.

7. That the study will determine and report the potential impacts of work time rescheduling on regional air quality and coordinate its findings with the regional air quality maintenance planning efforts.

The prospectus further recommended that following the completion of analyses of the potential and feasibility of work time rescheduling in the Milwaukee area—that is, of the potential benefits of spreading morning and evening peaks in travel demand and of the feasibility of private sector implementation of work time rescheduling—the study advisory committee consider the merits of completing the study. If it was determined to fully complete the study, alternative work time rescheduling plans would then be designed, and these plans would be evaluated with respect to transportation costs and benefits, impacts on regional air quality, and feasibility of implementation.

THE MILWAUKEE AREA WORK TIME RESCHEDULING STUDY PLANNING PROCESS

The Milwaukee area work time rescheduling study as proposed in the study prospectus was to utilize a seven-step planning process to develop a recommended program for the implementation of additional work time rescheduling in the Milwaukee area. The seven steps of the process were: 1) study design, 2) formulation of objectives, principles, and standards, 3) inventory, 4) analyses and forecasts, 5) plan preparation, testing, and evaluation, 6) plan selection and adoption, and 7) plan implementation. Following the completion of the fourth step, the merits of continuing the study through the remaining steps were to be reconsidered.

Study Design

The first step in the study was the preparation of a study design setting forth the methods and procedures to be used and the time and resources required in each particular study work element, subject to the need for flexibility to accommodate any unforeseen changes once the work was underway. The major elements of the Milwaukee area work time rescheduling study as set forth in the study design are outlined in Figure 2. In addition, in the study design phase of the study, the Prospectus Steering Committee which guided the preparation of the study prospectus was expanded as recommended in the prospectus to the Milwaukee Area Work Time Rescheduling Study Advisory Committee, as shown in Table 2, to guide the conduct of the study itself.

Formulation of Objectives, Principles, and Standards

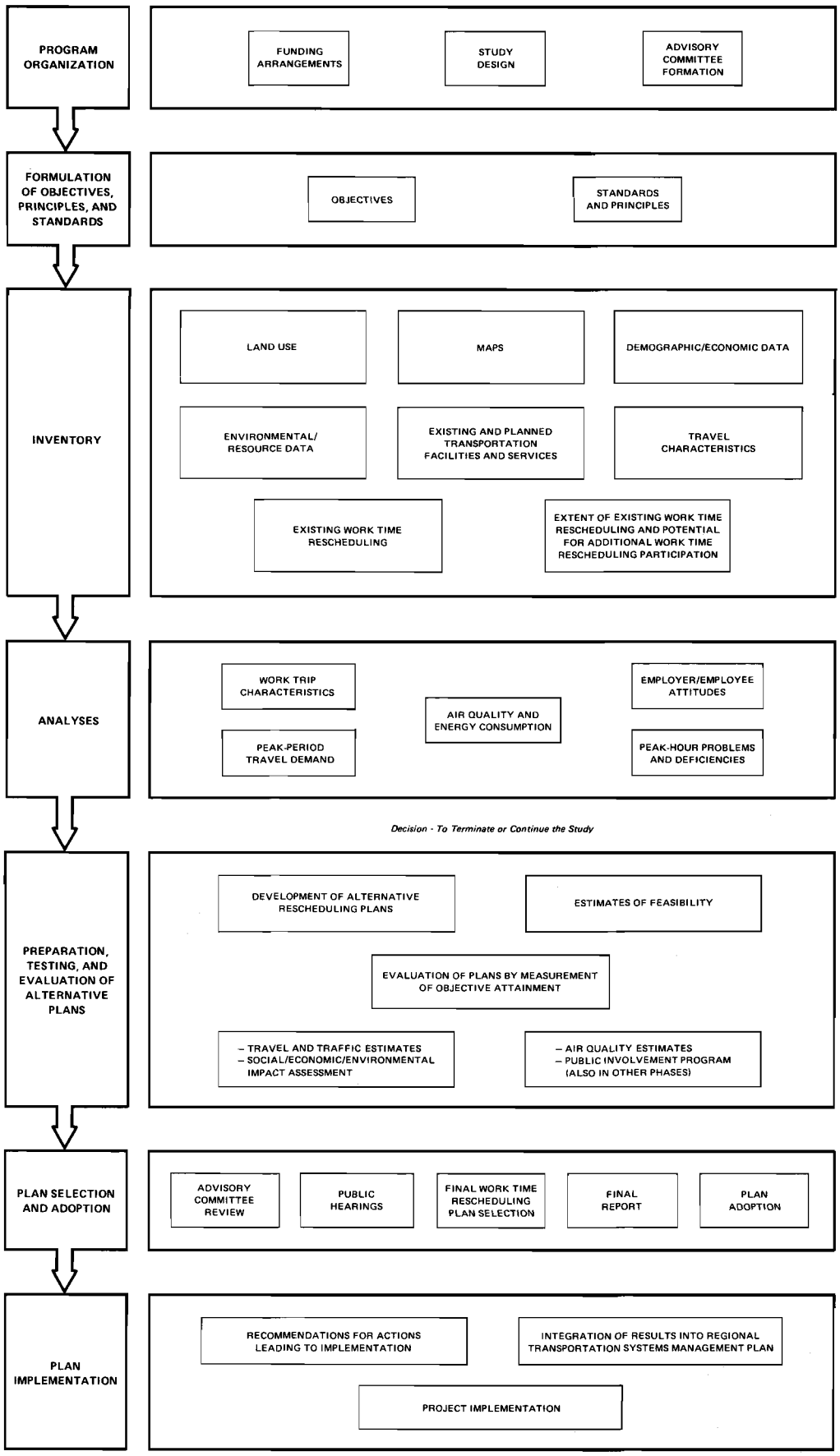
The formulation of objectives for the planning process constituted a formal definition of the desired characteristics of the Milwaukee area transportation system, identifying the broad needs which that system should aim to satisfy. The formulation of objectives for the Milwaukee area work time rescheduling study was an essential task in the study. Objectives had to be established before the peak-period congestion problems of the study area could be identified, and the benefits of work time rescheduling in the Milwaukee area considered. The objectives not only had to be clearly stated and logically sound, but had to be related in a demonstrable way to alternative work time rescheduling programs so as to permit the evaluation of their desirability. To accomplish this in the study, logically conceived and clearly expressed objectives were translated into quantifiable standards to provide the basis for problem identification and work time rescheduling program consideration.

Inventory

Since basic planning and engineering data were required for the sound conduct of the planning analyses in the study as well as for plan prepara-

Figure 2

MAJOR PHASES OF THE MILWAUKEE AREA WORK TIME RESCHEDULING STUDY



Source: SEWRPC.

Table 2

MILWAUKEE AREA WORK TIME RESCHEDULING STUDY ADVISORY COMMITTEE

William P. Chapman Chairman	Vice-President, Johnson Controls, Inc., Milwaukee
Thomas J. Parker Vice-Chairman	President, Milwaukee County Labor Council
Kurt W. Bauer Secretary	Executive Director, Southeastern Wisconsin Regional Planning Commission
Terrence J. Baudhuin	Materials Manager, Automotive Division, A. O. Smith Company
Robert W. Brannan	Deputy Director, Milwaukee County Department of Public Works
Vencil F. Demshar	Highway Commissioner, Waukesha County
William Ryan Drew	Commissioner, Department of City Development, City of Milwaukee
Thomas L. Frank	Planning and Research Engineer, Federal Highway Administration, U. S. Department of Transportation
Arne L. Gausmann	Director, Bureau of System Planning, Wisconsin Department of Transportation
P. Douglas Gerleman	Director, Bureau of System Planning, Wisconsin Department of Transportation
Sam H. Hay	Director of Labor Relations and Public Affairs, Allen-Bradley Company, Milwaukee
Paul Juhnke	Vice-President, Urban Affairs, Milwaukee Metropolitan Association of Commerce
Henry M. Mayer	Managing Director, Milwaukee County Transit System
Allan P. Pleyte	Traffic Engineer and Superintendent, Bureau of Traffic Engineering and Electrical Services, City of Milwaukee
James Rickun	Transportation/Air Quality Planner, Wisconsin Department of Natural Resources
John E. Schumacher	City Engineer, City of West Allis
Michael S. Treitman	Chief of Transportation and Planning, U. S. Environmental Protection Agency
Thomas A. Winkel	District Chief Planning Engineer, District 2, Wisconsin Department of Transportation

Source: SEWRPC.

tion and evaluation, an inventory of such data was the first operational step in the study planning process. Except for surveys of large Milwaukee area employers, who identified their work time rescheduling practices and their attitudes toward work time rescheduling, the necessary data were collated from information already acquired, rather than collected through direct measurement as a part of the study planning program. The basic types of inventory data gathered for the study included base maps, land use data, demographic characteristics, economic activity, arterial street and highway and public transit system physical and operational characteristics, travel characteristics, traffic counts, and air quality data.

Analyses

Extensive analyses of Milwaukee area work trip characteristics, peak-period travel demand, existing transportation system peak travel hour and period

congestion and related problems, and employer attitudes and practices with respect to alternative work schedules were conducted. Such analyses were essential in order to determine the potential benefits of peak-travel-demand shifts, and the feasibility of peak travel shifts and congestion problem reduction through work time rescheduling. These analyses involved an assessment of the extent of existing work time rescheduling in the Milwaukee area and of the additional Milwaukee area employers and employees that would adopt work time rescheduling. It was determined in this step of the study that, while the potential arterial congestion and transit vehicle fleet reduction possible through peak-travel-demand shifts was large, the degree to which Milwaukee area employers may be expected to participate in work time rescheduling programs, over and above existing participation, would be insufficient to achieve any significant reduction in areawide arterial street and highway congestion or transit vehicle needs. It was therefore concluded that the remaining three steps of the study proposed in the study prospectus should not be conducted, as the likely benefits of any work time rescheduling which would be implemented as a result of further study would not justify the costs, time, or efforts of further detailed planning.

STUDY ORGANIZATION

The Milwaukee area work time rescheduling study was carried out through the cooperative participation of the Regional Planning Commission, the Wisconsin Departments of Transportation and Natural Resources, the U. S. Department of Transportation, the U. S. Environmental Protection Agency, and concerned and affected local governmental agencies. The Commission assumed lead agency responsibility for the entire study, and completed all phases of the study with its own staff. The staff organization for the study is shown in Figure 3, along with the broader organizational structure for the study including participating governmental agencies, the Commission and its committee structure, and the study Advisory Committee. Public involvement was recognized as an important element of the study and, while several public involvement mechanisms were utilized, including public informational meetings and public hearings, the study relied primarily on the study Advisory Committee for public involvement. This Committee included major employer and employee representatives, as well as technicians.

SCHEME OF PRESENTATION

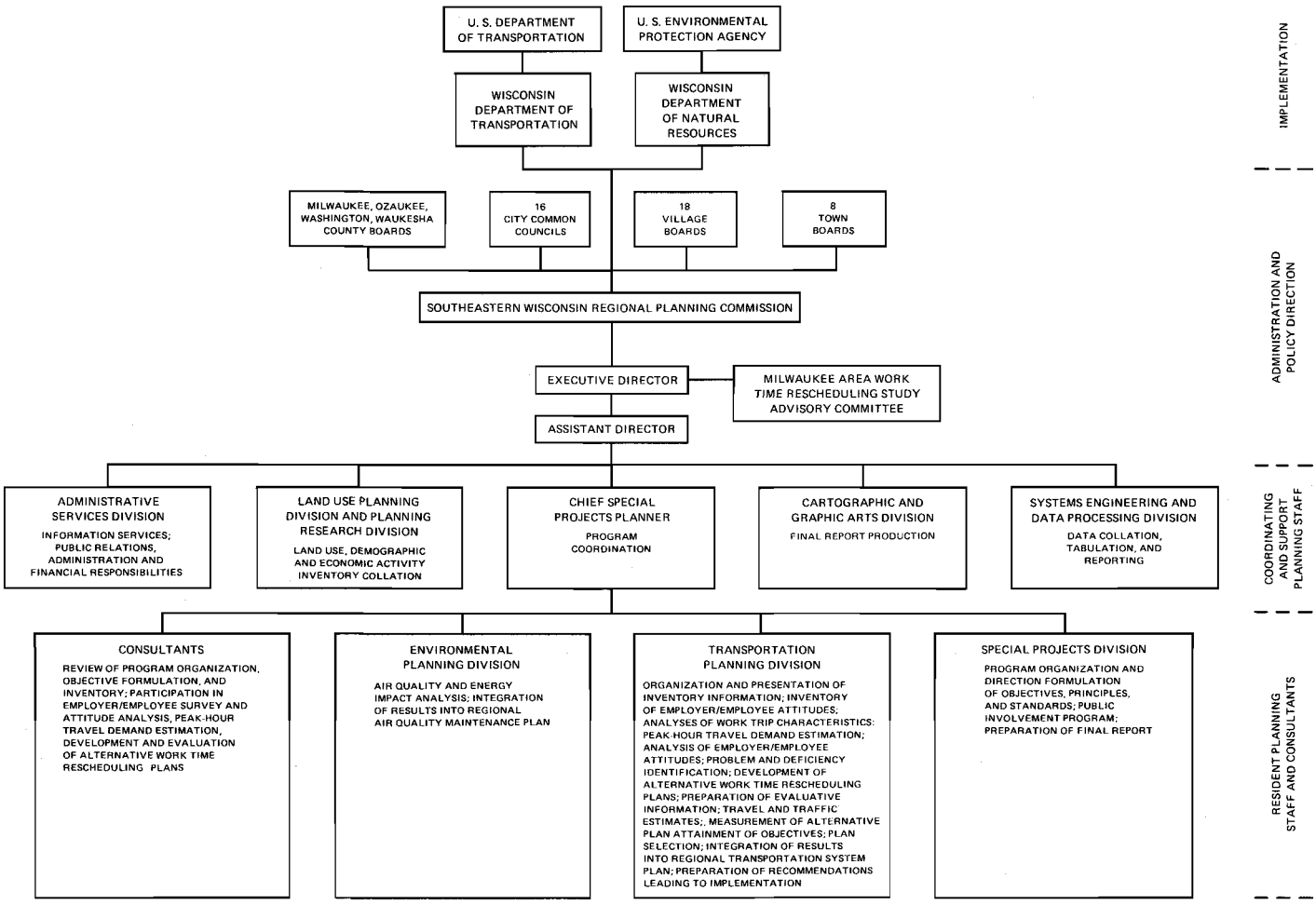
The major findings and conclusions of the Milwaukee area work time rescheduling study are presented in this technical report. This report consists of seven chapters in addition to the first introductory chapter. Chapter II sets forth the study objectives, and supporting principles and standards. Chapter III summarizes the demographic and economic structure of the Milwaukee area which in part establishes and shapes the travel patterns of the area. Chapter IV examines the travel habits and patterns of the Milwaukee area, particularly those of work-related travel and of the peak travel hours of the weekday. Chapter V presents a summary of the current supply and use of arterial streets and highways and mass transit facilities and services in the Milwaukee area. Chapter VI identifies existing Milwaukee area transportation system problems and deficiencies, including transportation-related air quality problems, arterial highway and public transit congestion, and excessive fuel consumption. Chapter VII provides an assessment of the feasibility of work time rescheduling and of the potential of work time rescheduling to reduce the deficiencies discussed in Chapter VI. And Chapter VIII presents a summary of the technical report along with the conclusions of the report.

SUMMARY

The Milwaukee area work time rescheduling study is one of a number of transportation systems management studies recommended by the Regional Planning Commission to examine ways to obtain the maximum efficiency from existing transportation facilities and services. It is important that the actions recommended in these studies be undertaken, because the two-tier concept of the long-range regional transportation system plan calls for delaying further major freeway construction within the Milwaukee area for at least a decade, until the ability of transportation systems management actions—in combination with standard surface arterial and transit service improvements—to adequately accommodate travel demand in the Region has been determined. Work time rescheduling is one of the systems management measures believed by some citizens and elected officials in Milwaukee County to have the potential to minimize areawide transportation system problems without the high cost and adverse social and

Figure 3

ORGANIZATIONAL STRUCTURE FOR THE MILWAUKEE AREA WORK TIME RESCHEDULING STUDY



Source: SEWRPC.

environmental impacts attendant to the improvement and expansion of the capacity of the transportation system. Without a careful evaluation of the ability of work time rescheduling to minimize traffic congestion and a determination of the feasibility of voluntary participation in such a program, and without similar assessments and, in some cases, demonstrations of other transportation systems management measures, it is reasonable to expect that the impasse with respect to resolution of the Milwaukee area's transportation problems by any means will continue.

The need for, desirable scope and content of, and necessary organizational framework, time schedule, and budget for a study of work time rescheduling in the Milwaukee area was investigated by a Steering Committee created by the Regional Planning Commission for that purpose, and the findings and recommendations of that Committee have been set forth in the Milwaukee Area Work Time Rescheduling Study Prospectus. This report summarizes the findings and recommendations of a work time rescheduling study undertaken in accordance with the prospectus.

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Chapter II

OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

In any transportation planning process, the formulation of objectives constitutes a formal definition of the desired characteristics of the transportation system being planned. The formulation of objectives for transportation systems management in the Milwaukee area work time rescheduling study was therefore an essential task which had to be undertaken before peak-period transportation problems could be systematically identified, and the potential and feasible benefits of work time rescheduling considered.

The formulation of objectives essentially involves a formal recognition and definition of needs. As a consequence, the defined objectives explicitly reflect an underlying value system for the residents of the area for which the planning is conducted. The diverse and often conflicting nature of personal values concerning transportation in any large urban community complicates this problem of objective formulation and makes it one of the most difficult tasks in the transportation planning process.

As a result of the recognition of the value system implications inherent in any set of planning objectives, the Commission, since its inception, has provided for the involvement of interested and knowledgeable public officials, technicians, and private citizens in the transportation planning process. This participation by elected or appointed public officials and by citizen leaders in the planning process, including the formulation of objectives, is implicit in the structure and organization of the Southeastern Wisconsin Regional Planning Commission. Moreover, through its establishment of advisory committees to assist the Commission and its staff in the conduct of its planning programs, the Commission has provided an even broader opportunity for the active participation of public officials and private interest groups in the regional planning process.

The use of advisory committees has been, and still appears to be, the most practical and effective way available to involve public officials, technicians, and citizen leaders in the transportation planning process and to openly arrive at decisions and action programs which can shape the future development and present management of the Region's transportation system. Only by combining the accumulated knowledge, experience, views, and values of the various advisory committee members concerning the transportation system can a meaningful expression of the desired direction, magnitude, and quality of the future development and current management of that system be obtained.

The Advisory Committee established by the Commission for the preparation of a work time rescheduling plan for the Milwaukee area was identified earlier in this report. One of the major tasks of this Committee in this effort was to assist in the formulation of transportation system objectives and supporting planning principles and standards.

The transportation system management objectives formulated for the study are similar, but not identical, to the long-range transportation system development objectives and the Milwaukee urbanized area short-range transportation systems management objectives previously adopted by the Commission. The parallels among these three sets of objectives result from the fact that transportation system management and development objectives, as already indicated, serve to define formally the basic needs which transportation facilities and services should satisfy, such as land use accessibility, personal mobility, economic efficiency, environmental quality, and public safety. These transportation system development and management objectives, which are essentially a list of basic transportation needs, should not be expected to differ greatly over time, nor with different levels and types of transportation system planning. The transportation systems management objectives for the work time rescheduling study differ from the previously adopted transportation system development objectives only in their ability to adopt a narrower focus for this work time rescheduling study. The study deals with a single transportation action, work time rescheduling, for which no alternative plans can directly or substantially influence the attainment of previously adopted objectives.

BASIC CONCEPTS AND DEFINITIONS

The term "objective" is subject to a wide range of interpretation and application and is closely linked to other terms often used in planning work which are equally subject to a wide range of interpretation and application. The following definitions have been adopted in previous Commission planning efforts in order to provide a common frame of reference:

1. Objective: a goal or end toward the attainment of which plans and policies are directed.

2. Principle: a fundamental, primary, or generally accepted tenet used to support objectives and prepare standards and plans.

3. Standard: a criterion used as a basis of comparison to determine the adequacy of plan proposals to attain objectives.

4. Plan: a design which seeks to achieve agreed-upon objectives.

5. Policy: a rule or course of action used to ensure plan implementation.

6. Program: a coordinated series of policies and actions to carry out a plan.

Although this chapter deals with only the terms "objective," "principle," and "standard," an understanding of the interrelationship among the foregoing definitions and the basic concepts which they represent is essential to the following discussion of objectives, principles, and standards.

OBJECTIVES

In order to be useful in the Milwaukee area work time rescheduling study, objectives had to be logically sound, clearly stated, and derived from local values. Moreover, objectives had to be related in a demonstrable and measurable way to alternative work time rescheduling programs to facilitate consideration of their benefits. The quantification of objectives for problem definition and work time rescheduling program consideration was facilitated by complementing each specific objective with a set of standards. These standards were, in turn, directly relatable to a planning principle which supports the chosen objective.

The objectives adopted for transportation systems management under the work time rescheduling study are concerned with utilizing work time rescheduling to provide to the Milwaukee area a transportation system which will facilitate quick and convenient travel, while minimizing motor fuel consumption and improving air quality. The following objectives were adopted by the Commission after careful review and recommendations from the Advisory Committee:

1. A transportation system which facilitates quick, convenient, and comfortable travel among component parts of the Milwaukee area and between that area and other component parts of the Region.

2. A transportation system which is efficient with respect to energy consumption, satisfying all other objectives with a minimum use of energy—in particular, of petroleum-based motor fuels.

3. A transportation system which contributes to the provision of a healthful air quality environment in the Milwaukee area, aiding in the achievement of national air quality standards.

SUPPORTING PRINCIPLES AND STANDARDS

Complementing each of the foregoing previously adopted transportation systems management and development objectives are a planning principle and a set of standards, set forth in Table 3. A planning principle supports each specific objective by asserting its validity. Each set of standards is directly related to the planning principle, as well as to the objective, and serves to facilitate quantitative application of the objectives. The planning standards provide either comparative or absolute measurements. The comparative standards provide a measure or criterion for comparison among alternative plans. The absolute standards provide absolute measures of alternative plan objective attainment, specifying minimum, maximum, or desirable values of objective attainment. The standards identified for each planning objective are intended to include all relevant and important measures which would indicate the attainment of the objective, while limiting the measures included to those which can be quantified with reasonable effort, thus keeping the entire set of measures to a level which can be worked with and compre-

hended. These planning principles and standards were also adopted by the Advisory Committee to the Milwaukee area work time rescheduling study.

SUMMARY

This chapter has presented a set of objectives, principles, and standards for work time rescheduling. These objectives, principles, and standards were prepared and adopted by the study Advisory Committee and the Commission. The purpose of the objectives is to guide the definition of existing Milwaukee area transportation system problems and the consideration of work time rescheduling under the Milwaukee area work time rescheduling study, and to thereby aid in the selection of a recommended course of action. The objectives adopted were developed within the context of the regional transportation system development and management objectives and the Milwaukee urbanized area transportation systems management objectives, both previously adopted by the Regional Planning Commission. The standards supporting the objectives provide important guidelines for measuring the attainment of the objectives.

Table 3

MILWAUKEE AREA WORK TIME RESCHEDULING STUDY TRANSPORTATION SYSTEMS MANAGEMENT OBJECTIVES, PRINCIPLES, AND STANDARDS

OBJECTIVE NO. 1

A transportation system which facilitates quick, convenient, and comfortable travel among component parts of the Milwaukee area, and between that area and other component parts of the Region.

PRINCIPLE

To support the everyday activities of business, shopping, and social intercourse, a transportation system which provides for reasonably fast, convenient travel is essential. Congestion increases the cost of transportation, including the cost of the journey to work, and adversely affects travel safety, motor fuel consumption, and air pollution emissions. Congestion is also reflected in higher production costs, thereby adversely affecting the relative market advantages of businesses and industries in the planning area.

STANDARDS

1. The proportion of the arterial street and highway system subject to congestion during peak travel periods of the weekday, and thus operating at design capacity and over design capacity, should be minimized.[a]

2. The public transit system should be operated so as to provide adequate transit vehicle capacity to meet travel demand during peak travel periods. The proportion of the public transit system operating during peak travel periods over the average maximum load factors of 1.00 in primary transit service, 1.25 in secondary transit service, and 1.33 in tertiary public transit service should be minimized.[b]

OBJECTIVE NO. 2

A transportation system which is efficient with respect to energy consumption, satisfying all other objectives with a minimum use of energy—in particular, of petroleum-based motor fuels.

PRINCIPLE

Minimization of the amount of energy devoted to the transportation system is important, because transportation is heavily dependent upon petroleum-based fuels and unexpected short-term motor fuel shortages could occur at any time, long-term supplies of petroleum-based motor fuel will become limited and are needed for other purposes, and conservation of petroleum-based motor fuels is a national objective.

STANDARDS

1. The amount of energy utilized, particularly petroleum-based motor fuels, in the operation of the transportation system during peak travel periods of the weekday should be minimized.

OBJECTIVE NO. 3

A transportation system which contributes to the provision of a healthful air quality environment in the Milwaukee area, aiding in the achievement of national air quality standards.

PRINCIPLE

The location, design, and management of transportation facilities and services can adversely affect air quality, in some cases substantially. Consideration of the implications of the transportation system on air quality is therefore necessary to assure the provision of a healthful environment and protection of the natural resource base, as well as to aid in meeting national air quality standards.

STANDARDS

1. The amount of carbon monoxide emitted by the transportation system during peak travel periods of the weekday should be minimized.

2. The amount of hydrocarbons emitted by the transportation system during peak travel periods of the weekday should be minimized.

3. The amount of nitrogen oxides emitted by the transportation system during peak travel periods of the weekday should be minimized.

4. The amount of particulates emitted by transportation vehicles during peak travel periods of the weekday should be minimized.

5. The amount of sulfur dioxide emitted by the transportation system during peak travel periods of the weekday should be minimized.

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[a] *An arterial facility operating at design capacity experiences some restrictions on speed and lane changing and, as a consequence, reductions in average speed and some delays behind turning vehicles at controlled intersections. An arterial facility operating over design capacity experiences greater speed and maneuvering restrictions, and thereby reductions in speeds, momentary stoppages, necessary speed changes, and backups and delays behind turning vehicles at intersections for more than one traffic signal cycle. An arterial facility operating over design capacity experiences some unstable flow or traffic breakdown conditions, with traffic delays for more than one signal cycle at signalized intersections, frequent traffic stoppages, and substantially lowered speeds.*

[b] *The average maximum load factor is defined as the ratio of the number of passengers carried on public transit vehicles past the maximum load point of any route to the seating capacity of those vehicles past that point in the peak flow direction during the operating period.*

Source: SEWRPC.

Chapter III

MILWAUKEE AREA POPULATION, EMPLOYMENT, AND LAND USE

INTRODUCTION

This chapter presents basic population, employment, and land use data necessary for the consideration of work time rescheduling in the Milwaukee area.[1] Data are presented on existing trends in population and economic activity characteristics and levels, and land use development patterns in the Milwaukee area (see Map 2). Data are additionally presented for the entire seven-county Southeastern Wisconsin Region, of which the Milwaukee area is an integral part.

These data have been collated largely from the data bank assembled under the Regional Planning Commission's continuing, comprehensive, areawide planning program, and have been updated as necessary and possible for the purposes of this study. Considerable information about the Region's population and economy was published by the Commission following the U. S. Census in 1970. [2] To the extent possible, this chapter presents more recent data not previously available, especially with regard to employment.

Information on where people work and live, and on the types of businesses and industries in which they work, is basic to any study of work time rescheduling. It is the concentration of population and employment and common work starting and quitting times which gives rise to large numbers of work trips converging on common routes during the morning and evening peak travel hours of an average weekday, causing transportation system congestion. The objective of work time rescheduling is to alleviate this congestion by spreading over time the existing temporal distribution of work trips. An understanding of the level and characteristics of Milwaukee area population, employment, and land use development is basic to this consideration of the potential of work time rescheduling in the Milwaukee area.

POPULATION

The 1978 resident population of the Region was approximately 1,770,500 people, only 14,400 people, or about 1 percent, more than the 1970 population. More importantly, the available data suggest that the Region may actually have lost population since 1975. Milwaukee County and the Milwaukee area are estimated to have lost about 93,300 and 47,500 people, or about 8.8 and 3.8 percent, of their population, respectively, since 1970.

As shown in Table 4, until now the population of the Region has increased steadily, recording gains every decade since 1850, when the federal census first included southeastern Wisconsin. In the late nineteenth and early twentieth centuries, the resident population grew at rates of up to 222,000 persons per decade. After a relatively small increase from 1930 to 1940, the population grew by about 173,000 from 1940 to 1950, by about 333,000 from 1950 to 1960—the historic peak growth decade, and by another 182,000 from 1960 to 1970, to reach 1,756,100 people. From 1970 to 1975, the population is estimated to have grown to 1,788,000, up about 2 percent from 1970. Between 1975 and 1978, the resident population of the Region is estimated to have declined slightly to 1,770,500 people, a decrease of about 1 percent. If confirmed by the 1980 national census, this would be the first time in its history that the Region, as a whole, has actually lost population.

Of greater concern for the work time rescheduling study, however, are the population trends within the Milwaukee area. As shown in Table 5, the resident population within the area in 1950 was an estimated 935,800 people, or about 75 percent of

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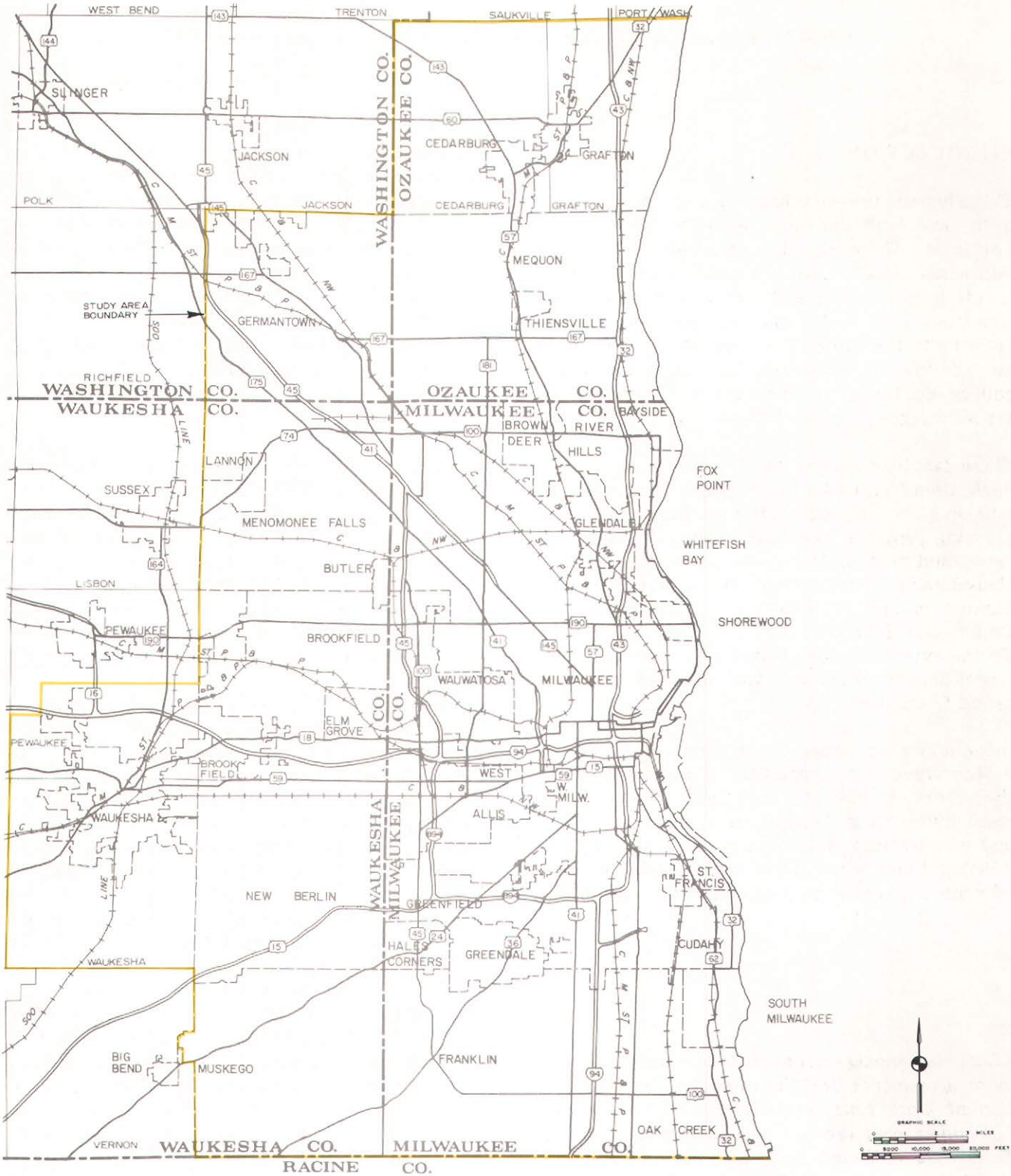
[1] *Data on management attitudes and decisions, labor agreements, and the character and extent of current work time rescheduling programs in the Milwaukee area are not included in the chapter. Such data collected in special inventories under the study are presented in Chapter VII.*

[2] *See SEWRPC Technical Report No. 10, The Economy of Southeastern Wisconsin, and SEWRPC Technical Report No. 11, The Population of Southeastern Wisconsin.*

Map 2

THE MILWAUKEE AREA AS DEFINED FOR THE WORK TIME RESCHEDULING STUDY



The Milwaukee area as defined for the purpose of the work time rescheduling study consists of all or part of 38 civil divisions, as shown by the yellow boundary on this map. This area has a resident population of 1.2 million, or about 68 percent of the population of the seven-county Region of which the Milwaukee area is an integral part. This area is the most intensively developed part of the Region, and may be thought of as the "true physical city" set within the "true socioeconomic city" that is the Region.

Source: SEWRPC.

Table 4

POPULATION OF THE UNITED STATES, WISCONSIN, AND THE REGION: SELECTED YEARS 1850-1970

Geographic Area	Population						
	1850	1860	1870	1880	1890	1900	1910
United States	23,191,876	31,443,321	38,448,371	50,155,783	62,947,714	75,994,575	91,972,266
Wisconsin	305,391	775,881	1,054,670	1,315,497	1,693,330	2,069,042	2,333,860
Southeastern Wisconsin Region	113,389	190,409	223,546	277,119	386,774	501,808	631,161

Geographic Area	Population						
	1920	1930	1940	1950	1960	1970	Change 1850-1970
United States	105,710,620	122,775,046	131,669,275	151,325,798	179,323,175	203,184,772	179,992,896
Wisconsin	2,632,067	2,939,006	3,137,587	3,434,575	3,952,771	4,417,933	4,112,542
Southeastern Wisconsin Region	783,681	1,006,118	1,067,699	1,240,618	1,573,620	1,756,086	1,642,697

Geographic Area	Percent Change						
	1850-1860	1860-1870	1870-1880	1880-1890	1890-1900	1900-1910	1910-1920
United States	35.6	22.6	30.1	25.5	20.7	21.0	14.9
Wisconsin	154.1	35.9	24.4	28.7	22.2	12.8	12.8
Southeastern Wisconsin Region	67.9	17.4	24.0	39.6	29.7	25.8	24.2

Geographic Area	Percent Change					
	1920-1930	1930-1940	1940-1950	1950-1960	1960-1970	1850-1970
United States	16.1	7.2	14.9	18.5	13.3	776.1
Wisconsin	11.7	6.8	9.5	15.1	11.8	1,346.6
Southeastern Wisconsin Region	28.4	6.1	16.2	26.8	11.6	1,448.7

Source: SEWRPC.

Table 5

POPULATION OF THE MILWAUKEE AREA BY THE CITY OF MILWAUKEE AND COUNTY PORTIONS: 1950-1978

Portion of Milwaukee Area	1950	1960	1970	1975	1978
City of Milwaukee	637,392	741,324	717,372	670,663	620,160
Remainder of County	233,655	294,717	336,877	341,873	340,833
Ozaukee County Portion	12,054	24,439	36,051	44,280	48,775
Washington County Portion	2,457	4,606	7,390	9,011	10,171
Waukesha County Portion	50,197	108,965	163,307	182,746	193,551
Total	935,755	1,174,051	1,260,997	1,248,573	1,213,490

Source: U. S. Bureau of the Census, Wisconsin Department of Administration, and SEWRPC.

the Region's resident population. From 1950 to 1960, the population of the Milwaukee area increased to 1,174,100, still about 75 percent of the Region's population, and an increase of 25 percent since 1950. From 1960 to 1970 the population of the Milwaukee area increased again to 1,261,000 people. However, since 1970 the population level of the Milwaukee area is estimated to have declined. The estimated population of the Milwaukee area in 1975 was 1,248,600 people, or 70 percent of the regional population, and a decline of 1 percent since 1970. Since 1975 it would appear that the resident population of the Milwaukee area has continued to decline, both in absolute numbers and as a percent of the regional population, as shown in Table 6, which compares 1975 and 1978 population estimates by civil division for the Milwaukee area and the Region.

Population Distribution

Population change in the Milwaukee area since 1960 has not been uniform, with that portion of the area not within Milwaukee County steadily experiencing substantial population increase since 1960, and Milwaukee County as a whole experiencing a substantial population decrease since 1970, as shown in Table 7. Prior to 1960 both the City of Milwaukee and Milwaukee County experienced rapid increases in population, and between 1960 and 1970 the City of Milwaukee experienced a decrease in population while the County continued to increase in population. It is estimated that between 1970 and 1978 the population of both City and the County of Milwaukee decreased. During that same period, substantial population increases are estimated to have occurred in the portions of the area outside Milwaukee County, as shown on Map 3.

These shifts in the Milwaukee area resident population have several implications for work time rescheduling. To the extent that recent population growth has occurred in outlying parts of the Milwaukee area not served by public transit, travel within the Milwaukee area, including work trips, has become increasingly dependent upon the automobile. The recent population growth has occurred outside Milwaukee County, which historically has been the major center of employment. Milwaukee County remains the major center of employment in the Milwaukee area and the Region, although outlying parts of the Milwaukee area and of the Region have experienced more rapid rates of employment increase in recent years. To the extent that the recent population growth has resulted in movement farther from employment locations, work trip lengths will have increased, possibly both in time and distance, creating the potential for more overlapping of travel to work during peak travel periods, particularly on major routes.

Population Characteristics

Also important in the consideration of work time rescheduling are such characteristics of the population as age structure, marital status, and household size, since these may affect the willingness of employees to adopt different work time rescheduling programs.[3] Other population characteristics, such as employment status, automobile ownership, and personal income, have important implications for peak-travel-period transportation demand, particularly in terms of choice of travel mode to work.

Information on population characteristics, however, is difficult to obtain between decennial censuses, even for geographic areas the size of the Milwaukee area or the Region. Differential and changing age-specific rates of fertility, mortality, and migration make the estimation of population characteristics within small areas especially difficult and error-prone. Special censuses conducted in the Milwaukee area and the Region since 1970 do, however, provide some basis for updating those characteristics.

Special censuses have been conducted since 1970 by the U. S. Bureau of the Census at the request of individual civil divisions within the Region,

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[3] *Some evidence indicates that there is a correlation between certain population characteristics and preferences for alternative work schedules. Age and marital status are population characteristics which have been determined to be particularly important, but household size and residential location have also been found to be related to work schedule preferences. A survey of employees of a large employer in Albany, New York, found that preferences for various work time rescheduling programs were related to the age of the employees and size of their households. In California, a survey of employees of a large firm having flexible working hours found that choice of arrival time was related to the marital status and residential location of the employees.*

Table 6

POPULATION OF THE MILWAUKEE AREA BY CIVIL DIVISION: 1975 AND 1978

Civil Division	Population		Population Change	
	1975	1978	Number	Percent
Milwaukee County				
City of Cudahy	21,653	21,144	- 509	- 2.35
City of Franklin	13,950	16,856	2,906	20.83
City of Glendale	13,480	13,722	242	1.80
City of Greenfield	31,651	30,250	- 1,401	- 4.43
City of Milwaukee	670,663	620,160	- 50,503	- 7.53
City of Oak Creek	15,748	16,070	322	2.04
City of St. Francis	9,925	10,269	344	3.47
City of South Milwaukee	23,390	22,673	- 717	- 3.07
City of Wauwatosa	55,712	54,416	- 1,296	- 2.33
City of West Allis	68,966	66,791	- 2,175	- 3.15
Village of Bayside	4,430	4,550	120	2.71
Village of Brown Deer	13,570	14,250	680	5.01
Village of Fox Point	7,911	7,895	- 16	- 0.20
Village of Greendale	16,844	17,975	1,131	6.71
Village of Hales Corners	8,773	8,890	117	1.33
Village of River Hills	1,547	1,590	43	2.78
Village of Shorewood	14,336	14,163	- 173	- 1.21
Village of West Milwaukee	3,787	3,529	- 258	- 6.81
Village of Whitefish Bay	16,200	15,800	- 400	- 2.47
Subtotal	1,012,536	960,993	- 51,543	- 5.09
Ozaukee County				
City of Cedarburg	9,766	10,536	770	7.88
City of Mequon	14,820	16,654	1,834	12.38
Village of Bayside	108	120	12	11.11
Village of Grafton	7,983	8,880	897	11.24
Village of Thiensville	3,819	4,015	196	5.13
Town of Cedarburg	4,619	5,476	857	18.55
Town of Grafton	3,165	3,094	- 71	- 2.24
Subtotal	44,280	48,775	4,495	10.15
Washington County				
Village of Germantown	8,539	9,713	1,174	13.75
Town of Germantown	472	458	- 14	- 2.97
Subtotal	9,011	10,171	1,160	12.87
Waukesha County				
City of Brookfield	33,371	35,638	2,267	6.79
City of Muskego	13,410	15,241	1,831	13.65
City of New Berlin	31,333	33,260	1,927	6.15
City of Waukesha	47,744	50,572	2,828	5.92
Village of Butler	2,230	2,105	- 125	- 5.61
Village of Elm Grove	7,692	8,038	346	4.50
Village of Lannon	1,161	1,114	- 47	- 4.05
Village of Menomonee Falls	33,429	32,842	- 587	- 1.76
Town of Brookfield	4,117	4,173	56	1.36
Town of Pewaukee (part)	3,427	3,655	228	6.70
Town of Waukesha	4,832	6,913	2,081	43.07
Subtotal	182,746	193,551	11,359	6.12
Total	1,248,573	1,213,490	- 35,083	- 2.81
Region	1,788,000	1,770,500	17,500	0.98

Source: Wisconsin Department of Administration and SEWRPC.

Table 7

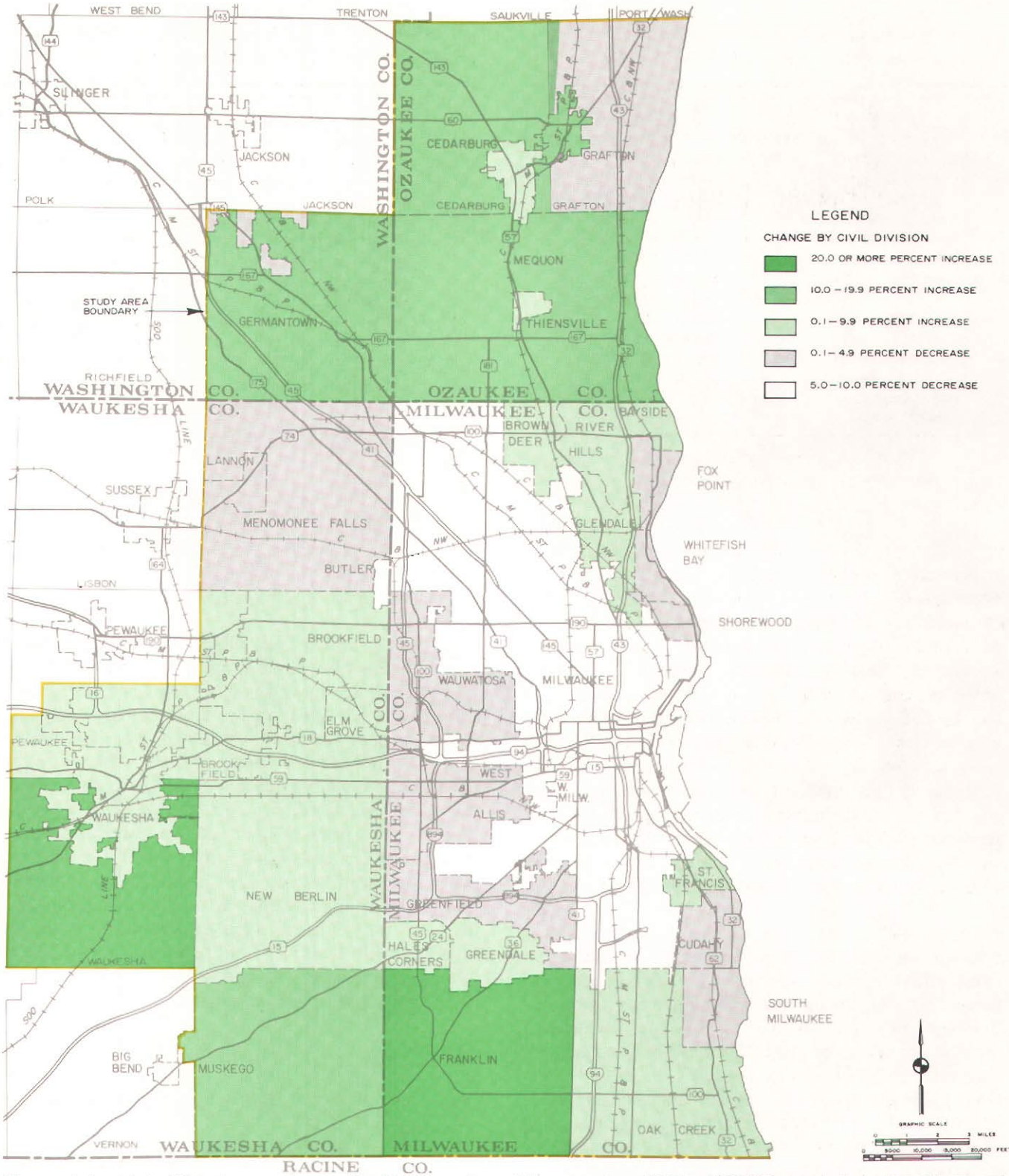
MILWAUKEE AREA POPULATION AND PERCENT OF TOTAL LAND AREA BY CIVIL DIVISION: 1950-1978

Civil Division	Population				Percent of 1978 Area Total
	1950	1960	1970	1978	
Milwaukee County					
City of Cudahy	12,182	17,975	22,078	21,144	0.8
City of Franklin	--	10,000	12,247	16,856	5.6
City of Glendale	--	9,537	13,426	13,722	1.0
City of Greenfield	--	17,636	24,424	30,250	1.9
City of Milwaukee	637,392	741,324	717,372	620,160	15.6
City of Oak Creek	--	9,372	13,928	16,070	4.6
City of St. Francis	--	10,065	10,489	10,269	0.4
City of South Milwaukee	12,855	20,307	23,297	22,673	0.8
City of Wauwatosa	33,324	56,923	58,676	54,416	2.1
City of West Allis	42,959	68,157	71,649	66,791	1.8
Village of Bayside (part)	--	3,078	4,338	4,550	0.4
Village of Brown Deer	--	11,280	12,582	14,250	0.7
Village of Fox Point	2,585	7,315	7,939	7,895	0.5
Village of Greendale	2,752	6,843	15,089	17,975	0.9
Village of Hales Corners	--	5,549	7,771	8,890	0.5
Village of River Hills	567	1,257	1,561	1,590	0.9
Village of Shorewood	16,199	15,990	15,576	14,163	0.3
Village of West Milwaukee	5,429	5,043	4,405	3,529	0.2
Village of Whitefish Bay	14,665	18,390	17,402	15,800	0.3
Town of Franklin	3,886	--	--	--	--
Town of Granville	11,784	--	--	--	--
Town of Greenfield	20,907	--	--	--	--
Town of Lake	18,956	--	--	--	--
Town of Milwaukee	5,857	--	--	--	--
Town of Oak Creek	4,807	--	--	--	--
Town of Wauwatosa	23,941	--	--	--	--
Subtotal	871,047	1,036,041	1,054,249	960,993	39.1
Ozaukee County					
City of Cedarburg	2,810	5,191	7,697	10,536	0.5
City of Mequon	--	8,543	12,150	16,654	7.6
Village of Bayside (part)	--	103	123	120	--
Village of Grafton	1,489	3,748	5,998	8,880	0.4
Village of Thiensville	897	2,507	3,182	4,015	0.2
Town of Cedarburg	1,568	2,248	3,774	5,476	4.4
Town of Grafton	1,225	2,099	3,250	3,094	3.5
Town of Mequon	4,065	--	--	--	--
Subtotal	12,054	24,439	36,051	48,775	16.4
Washington County					
Village of Germantown	357	622	6,974	9,713	5.6
Town of Germantown	2,100	3,984	416	458	0.3
Subtotal	2,457	4,606	7,390	10,171	5.8
Waukesha County					
City of Brookfield	--	19,812	31,761	35,638	4.2
City of Muskego	--	--	11,573	15,241	5.8
City of New Berlin	--	15,788	26,910	33,260	5.9
City of Waukesha	21,233	30,004	39,695	50,572	2.2
Village of Butler	1,047	2,274	2,261	2,105	0.1
Village of Elm Grove	--	4,994	7,201	8,038	0.5
Village of Lannon	438	1,084	1,056	1,114	0.4
Village of Menomonee Falls	2,469	18,276	31,697	32,842	5.4
Town of Brookfield	7,425	1,990	4,303	4,173	1.1
Town of Menomonee Falls	3,793	--	--	--	--
Town of Muskego	4,157	8,888	--	--	--
Town of New Berlin	5,334	--	--	--	--
Town of Pewaukee (part)	2,193	2,315	3,018	3,655	2.7
Town of Waukesha	2,108	3,540	3,832	6,913	4.4
Subtotal	50,197	108,965	163,307	193,551	31.2
Total	1,240,618	1,573,620	1,756,086	1,770,500	--

Source: U. S. Bureau of the Census, Wisconsin Department of Administration, and SEWRPC.

Map 3

POPULATION CHANGE IN THE MILWAUKEE AREA CIVIL DIVISIONS: 1975-1978



The population of the Milwaukee area decreased by 35,000 people, or 2.8 percent, from 1975 to 1978. This map indicates that this decrease was not uniform throughout the area. The most central portions of the area generally decreased in population, while the outlying portions generally increased in population. The City of Milwaukee showed the largest absolute and percentage decrease—50,500 people, or almost 8 percent—while the City of Franklin showed the largest absolute increase—almost 3,000 people, or 21 percent—and the Town of Waukesha showed the largest percentage increase—43 percent, or 2,100 people.

Source: SEWRPC.

Table 8

SPECIAL CENSUSES CONDUCTED WITHIN THE MILWAUKEE AREA: 1970-1978

Civil Division	Date of Special Census
Village of Grafton	June 7, 1973
Village of Germantown	January 3, 1974 and January 18, 1978
City of St. Francis	May 6, 1974
City of Brookfield	June 4, 1974
Town of Pewaukee	June 20, 1974
Village of West Milwaukee	December 2, 1974 and April 6, 1978
City of Milwaukee	March 3, 1975
City of Oak Creek	December 14, 1976
Town of Cedarburg	February 8, 1977
Town of Waukesha	March 11, 1977
City of Greenfield	July 19, 1978
Town of Grafton	September 19, 1978

Source: U. S. Bureau of the Census, Wisconsin Department of Administration, and SEWRPC.

Table 9

CHANGE IN MEDIAN AGE IN SELECTED CIVIL DIVISIONS IN THE MILWAUKEE AREA SINCE 1970

Civil Division	Median Age		Change
	1970 Census	Special Census	
City of Greenfield	27.2	30.4	3.2
City of Milwaukee	28.2	28.1	-0.1
City of Oak Creek	22.9	25.9	3.0
Village of Germantown	22.4	26.8	4.4
Village of West Milwaukee	38.9	40.4	1.5
Town of Cedarburg	24.1	27.3	3.2
Town of Grafton	25.5	30.2	4.7
Town of Waukesha	27.3	28.3	1.0

Source: U. S. Bureau of the Census and SEWRPC.

as shown in Table 8. Some civil divisions have requested a census in order to challenge annual population estimates made by the Wisconsin Department of Administration for the purpose of distributing state-shared taxes on the basis of population size. In addition, some civil divisions have contracted with the U. S. Bureau of the Census for a special census to obtain more current information about their population. The special censuses provide a basis for evaluating probable changes in the age and sex composition of the population, and in total and occupied housing units by civil division within the study area. They also permit an evaluation of changes in the number of households and in average household size.

Prior to 1974, the U. S. Bureau of the Census released only total population figures obtained from these special censuses of civil divisions of under 10,000 population, and tabulated population age, race, and sex distribution and household counts for areas of 10,000 or more population. Beginning in 1974, special censuses for all civil divisions provided age, race, and sex distribution tabulations; and, beginning in 1975, household and housing unit counts were also provided for all censuses of civil divisions, regardless of population size. Accordingly, the special censuses conducted in 12 civil divisions (see Table 8) within the Milwaukee area beginning in 1975 provide valuable data on changes in the Milwaukee area population characteristics. Of particular importance are the data obtained for the City of Milwaukee in 1975, because the City represented 51 percent of the Milwaukee area population in 1978.

Age: Analysis of the results of the special censuses indicate that the population of the Milwaukee area is aging. A comparison of median ages computed for the year 1970 and for the date of the special censuses (see Table 9) indicates that the median age has increased in seven of the civil divisions examined. In five of these civil divisions, an increase of three or more years in the median age was observed. Only the City of Milwaukee experienced a decrease in median age since 1970. General fertility declines account for some of the observed increases in median age, as evidenced by the fact that all eight civil divisions experienced a decrease in the proportion of their total population under five years of age between 1970 and the date of their respective special censuses.

Household Size: The special censuses indicate a decrease in the average household size[4] in all eight civil divisions, with the City of Milwaukee

[4] *A household is defined as all persons, either unrelated individuals or family members, occupying a separate dwelling unit, as opposed to persons who are inmates of institutions or who reside in group quarters such as boarding homes or dormitories.*

Table 10

CHANGE IN HOUSEHOLD SIZE IN SELECTED CIVIL DIVISIONS IN THE MILWAUKEE AREA SINCE 1970

Civil Division	Household Size		Change	
	1970 Census	Special Census	Number	Percent
City of Greenfield	3.48	2.62	-0.86	-24.71
City of Milwaukee	2.96	2.72	-0.24	- 8.14
City of Oak Creek	3.88	3.39	-0.49	-12.63
Village of Germantown	4.00	3.27	-0.73	-18.25
Village of West Milwaukee	2.35	1.91	-0.44	-18.72
Town of Cedarburg	3.95	3.72	-0.23	- 5.82
Town of Grafton	3.67	3.27	-0.40	-10.90
Town of Waukesha	3.66	3.55	-0.11	- 3.01

Source: U. S. Bureau of the Census and SEWRPC.

Table 11

CHANGE IN NUMBER OF HOUSEHOLDS IN POPULATION IN SELECTED CIVIL DIVISIONS IN THE MILWAUKEE AREA SINCE 1970

Civil Division	Households		Change	
	1970 Census	Special Census	Number	Percent
City of Greenfield	6,897	11,486	4,589	66.54
City of Milwaukee	236,981	240,608	3,627	1.53
City of Oak Creek	3,585	4,569	984	27.45
Village of Germantown	1,744	2,974	1,230	70.53
Village of West Milwaukee	1,845	1,809	- 36	- 1.95
Town of Cedarburg	956	1,384	428	44.77
Town of Grafton	851	1,032	181	21.27
Town of Waukesha	1,206	1,756	559	46.35

Civil Division	Population		Change	
	1970 Census	Special Census	Number	Percent
City of Greenfield	24,424	30,651	6,227	25.5
City of Milwaukee	717,372	669,022	-48,350	- 6.7
City of Oak Creek	13,928	15,510	1,582	11.4
Village of Germantown	6,974	9,729	2,755	39.5
Village of West Milwaukee	4,405	3,506	- 899	- 20.4
Town of Cedarburg	3,774	5,152	1,378	36.5
Town of Grafton	3,250	3,377	127	3.9
Town of Waukesha	3,832	6,268	2,436	64.6

Source: U. S. Bureau of the Census and SEWRPC.

showing a substantially smaller reduction in household size than most of the suburban communities (see Table 10). Only the Towns of Cedarburg and Waukesha showed a smaller reduction in household size than the City of Milwaukee. It should be noted that since the late 1940's, average household sizes throughout the Region, the State, and the United States have been declining. Recent decreases are primarily attributable to declining birthrates and rapid increases in households of only one or two persons.

It is important to note that the total number of households in all eight civil divisions for which special censuses were conducted increased faster, or declined slower, than did population, as shown in Table 11. With the exception of the Village of West Milwaukee which showed a decrease in both total number of households and population, the rate of increase in households in outlying and suburban portions of the Milwaukee area was greater than the rate of population increase, as shown in Table 11.

Automobile Ownership: Because workers from carless households cannot commute to work by automobile except as passengers, and because two workers from one-car households cannot each commute to work by automobile unless one household member is a passenger in the same automobile or is a passenger in a carpool, automobile ownership is an important consideration in peak-travel-period travel demand and work time rescheduling. Available data indicate that automobile ownership in Milwaukee County has risen faster between 1970 and 1975 than has either the total population or the number of households (see Table 12). In five years, the number of cars registered in Milwaukee County increased from 424,100 to 455,551. From 1975 to 1978, automobile registration in the County decreased by 4,300 vehicles, or about 1 percent, while the population decreased by 51,500 or about 5 percent. As a result, even though the absolute number of both people and automobiles has decreased in Milwaukee County since 1975, the number of persons per automobile has continued to decline in the County.

Income: Personal income within Milwaukee County in 1970 was about $3,491 and $3,006 per capita, and about $10,473 and $9,018 per household, expressed in 1970 and 1967 dollars, respectively. These figures are somewhat higher than those for the Region as a whole or the nation (see Table 13).

Table 12

AUTOMOBILE OWNERSHIP IN MILWAUKEE COUNTY: 1960-1978

Characteristic	1960	1970	1975	1978
Number of Automobiles	325,400	424,100	455,551	451,251
Percent Change	--	30.3	7.4	- 0.9
Population	1,036,041	1,054,249	1,012,536	960,993
Persons per Automobile	3.2	2.5	2.2	2.1

Source: U. S. Bureau of the Census; Wisconsin Department of Transportation, Motor Vehicle Division; and SEWRPC.

Table 13

INCOME TRENDS IN THE UNITED STATES, WISCONSIN, AND MILWAUKEE COUNTY: SELECTED YEARS 1950-1970

Geographic Area	Income			Change 1950-1960		Change 1960-1970	
	1950	1960	1970	Number	Percent	Number	Percent
United States							
Total Income (in millions)							
Actual	$165,063	$331,700	$635,563	$166,637	101.0	$303,863	91.6
Constant[a]	228,612	374,390	546,966	145,788	63.8	172,576	46.1
Per Capita Income							
Actual	1,070	1,849	3,128	779	72.8	1,279	69.2
Constant[a]	1,481	2,087	2,692	606	40.9	605	29.0
Wisconsin							
Total Income (in millions)							
Actual	$ 3,581	$ 7,287	$ 13,457	$ 3,706	103.5	$ 6,170	84.7
Constant[a]	4,960	8,225	11,581	3,265	65.8	3,356	40.8
Per Capita Income							
Actual	1,043	1,844	3,046	801	76.8	1,202	65.2
Constant[a]	1,445	2,081	2,621	636	44.0	540	25.9
Milwaukee County							
Total Income (in millions)							
Actual	$ 1,209	$ 2,371	$ 3,680	$ 1,162	96.1	$ 1,309	55.2
Constant[a]	1,674	2,677	3,168	1,003	59.9	491	18.3
Per Capita Income							
Actual	1,338	2,289	3,491	901	64.9	1,202	52.5
Constant[a]	1,922	2,584	3,006	662	34.4	422	16.3

[a] *Adjusted for price change; base year 1967 equals 100.0.*

Source: U. S. Bureau of the Census, U. S. Department of Labor, Wisconsin Department of Administration, and SEWRPC.

From 1960 to 1970, per capita income levels in Milwaukee County increased from $2,289 to $3,491 in actual dollars, an increase of about 53 percent, and from $2,584 to $3,006 in constant 1967 dollars, an increase of about 16 percent. These increases are slightly lower than the national and state rates of increase over this same period.

ECONOMIC ACTIVITY

Employment in both the Milwaukee area and the seven-county Southeastern Wisconsin Region has steadily increased since 1960. Total regional employment from 1960 to 1970 increased by 93,700 jobs—from 647,900 to 741,600—or by about 14 percent. Between 1970 and 1975, regional employment increased by another 37,400 jobs.

Between 1960 and 1970, total employment in Milwaukee County increased by 24,100 jobs, or 5 percent, to a level of 510,900. Total employment in Milwaukee County in 1975 was 521,300 jobs, an increase over 1970 of 10,400 jobs, or 2 percent. Thus, while Milwaukee County has experienced a population decrease since 1970, employment in the County has continued to grow. However, the rate of employment growth has been much slower than in the outlying counties of the Region. From 1960 to 1975, the rate of employment growth for the Region, excluding Milwaukee County, was 63 percent, compared with a 7 percent increase for Milwaukee County over the same period. Nevertheless, Milwaukee County remains by far the most important concentration of employment in the Region, containing about two-thirds of all regional employment in 1975. The Milwaukee area contained about 603,200 jobs in 1975, or 77 percent of all regional employment.

Distribution of Economic Activity

The distribution of employment in 1975 within the Milwaukee area is shown on Map 4. In 1975 the majority of the jobs in the area were located within Milwaukee County, which contained approximately 86 percent of the area's total employment, as shown in Table 14.

A large share of the Milwaukee area employment is concentrated in relatively few locations. This concentration has particular meaning for work time rescheduling, as it is both the spatial and temporal concentration of work travel which gives rise to transportation system congestion. Map 5 displays the total employment per square mile for the Milwaukee area. The density of employment ranges from a high of about 35,000 jobs per square mile in the Milwaukee central business district to a low of fewer than 10 per square mile in the less developed portions of the urbanized area. It can be seen that jobs are concentrated largely in the City of Milwaukee central business district and the developed portions of Milwaukee County.

Employment in the Milwaukee area is concentrated not only within a small proportion of the total land area, but also within a relatively small number of employers. In 1975, 393,000 jobs, representing almost 65 percent of all jobs in the Milwaukee area, were provided by the 758 area firms which employed 100 or more persons. These firms represented about 3 percent of all employers in the area in 1975. Map 6 shows the distribution of these major employers within the Milwaukee area. Concentrations of these firms are particularly evident in the Milwaukee central business district and along the major transportation corridors of the Milwaukee area. The largest proportion of these major employers is concentrated in the manufacturing sector, as shown in Table 15, which summarizes the employers within the Milwaukee area in 1975 by sector of the economy and number of employees. The private services group provides the next highest number of major employers.

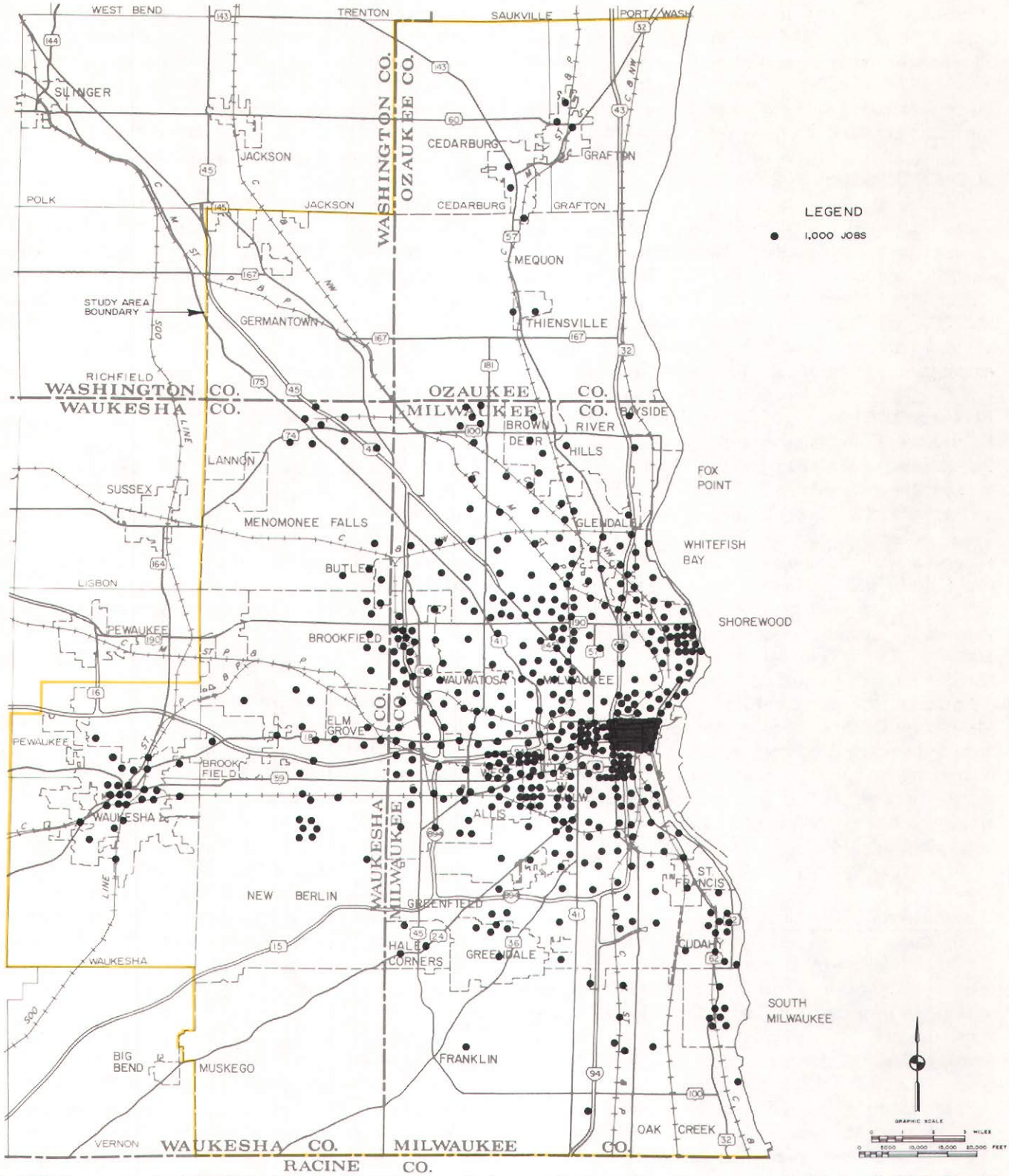
Structure of Economy

The characteristics of the employment and economic activity of the area and Region can be best described in terms of its economic structure. The number and types of economic activities within the Milwaukee area will affect the feasibility of introducing changes in existing work schedules. Employment can be classified into nine economic sectors: 1) agriculture, 2) mining and construction, 3) manufacturing, 4) wholesale trade, 5) retail trade, 6) transportation, communication, and utilities, 7) finance, insurance, and real estate, 8) private services, and 9) government services and education.

The distribution of jobs among economic sectors for the Region, the Milwaukee area, and the City of Milwaukee was quite similar in 1975, as shown in Table 16 and Figure 4. Employment within the City of Milwaukee, the area, and Region is heavily concentrated in manufacturing. In 1975, 31 percent of the total jobs in the area were in manufacturing, compared with 26 percent of total jobs in the City of Milwaukee and 32 percent of total jobs in the Region.

Map 4

DISTRIBUTION OF EMPLOYMENT IN THE MILWAUKEE AREA: 1975



In 1975 there were about 603,200 jobs in the Milwaukee area. As shown on this map, these jobs are located largely in Milwaukee County, 86 percent. The City of Waukesha, and the area immediately surrounding it, has a smaller proportion of the Milwaukee area jobs, about 5 percent, but the number of jobs in this area increased by about 5 percent between 1970 and 1975, while the number in Milwaukee County increased by 2 percent.

Source: SEWRPC.

Table 14

EMPLOYMENT TRENDS IN THE REGION, MILWAUKEE AREA, AND MILWAUKEE COUNTY: 1960-1975

Area	Employment			Change 1960-1970		Change 1970-1975	
	1960	1970	1975	Absolute	Percent	Absolute	Percent
Region	647,900	741,600	779,000	93,700	14.5	37,400	5.0
Milwaukee Area	N/A	N/A	603,200	--	--	--	--
Milwaukee County . .	486,200	510,900	521,300	24,700	5.1	10,400	2.0

NOTE: N/A indicates data not available.

Source: Wisconsin Department of Administration and SEWRPC.

LAND USE

One of the central concepts underlying urban transportation planning is that land use and transportation are closely interrelated. The type, intensity, and spatial distribution of land uses determine the number and variety of trips generated by an area and by each of its subareas. A complete inventory of existing land use is, therefore, essential to any transportation planning effort so that quantitative relationships existing between land use and travel can be established and used to test alternative transportation plans. Such a complete inventory of regional land use was first conducted by the Commission in 1963, and has since been updated to the year 1970. A further update to the year 1975 is now nearly complete. This section summarizes selected land use information from these inventories relevant to this study of work time rescheduling in the Milwaukee area.

Historic Urban Growth Patterns

The historic urban development patterns of the study area and of the Southeastern Wisconsin Region from 1850 to 1970 are shown on Map 7. Until 1950 urban development[5] in the Region occurred in a fairly regular pattern, forming concentric rings of relatively high-density urban development contiguous to, and outward from, the existing urban areas—principally, Milwaukee, Racine, Kenosha, and Waukesha—and long-established mass transit, utility, and communication facility systems. Since 1950, the character of urban growth in the Region has begun to change to a more diffused pattern of development, with relatively low densities predominating and a proliferation of clusters of noncontiguous development. The implication of this "urban sprawl" pattern of development since mid-century has been a rapid decline in urban population densities. While the population of the Region increased only 42 percent from 1950 to 1970, land devoted to urban uses increased by 188 percent.

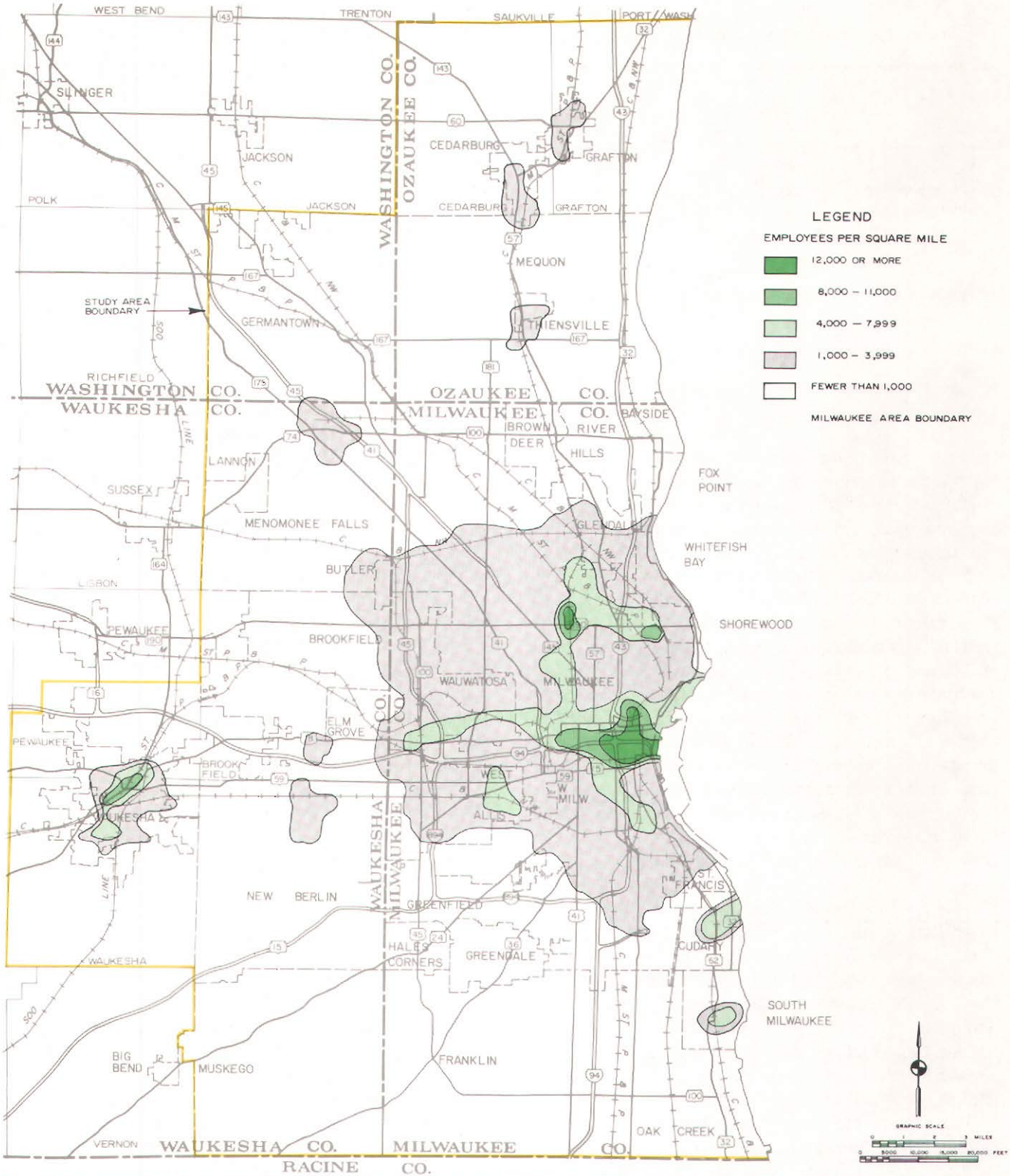
Residential Land Use

About 68 percent of the total land area of Milwaukee County and about 20 percent of the total area of the Region was considered to be urban in 1970. Of the urban land uses, residential land uses comprised the greatest proportion, as shown in Table 17 and on Map 8. Residential lands accounted for 45,632 acres in Milwaukee County, or about 29 percent of the total land area, and 156,266 acres in the Region, or about 9 percent of the total area. Such uses, however, comprised 43 percent and 48 percent, respectively, of the developed urban portions of Milwaukee County and the Region.

[5] *Urban development includes those areas wherein houses or other buildings have been constructed in relatively compact groups or where a closely spaced network of minor streets has been constructed, thereby indicating a concentration of residential, commercial, industrial, governmental, or institutional land uses. The continuity of such development was considered interrupted if a quarter-mile or more of nonurban land uses, such as agriculture, woodlands, or wetlands, prevailed, and the above conditions were generally absent.*

Map 5

EMPLOYMENT DENSITY IN THE MILWAUKEE AREA: 1975

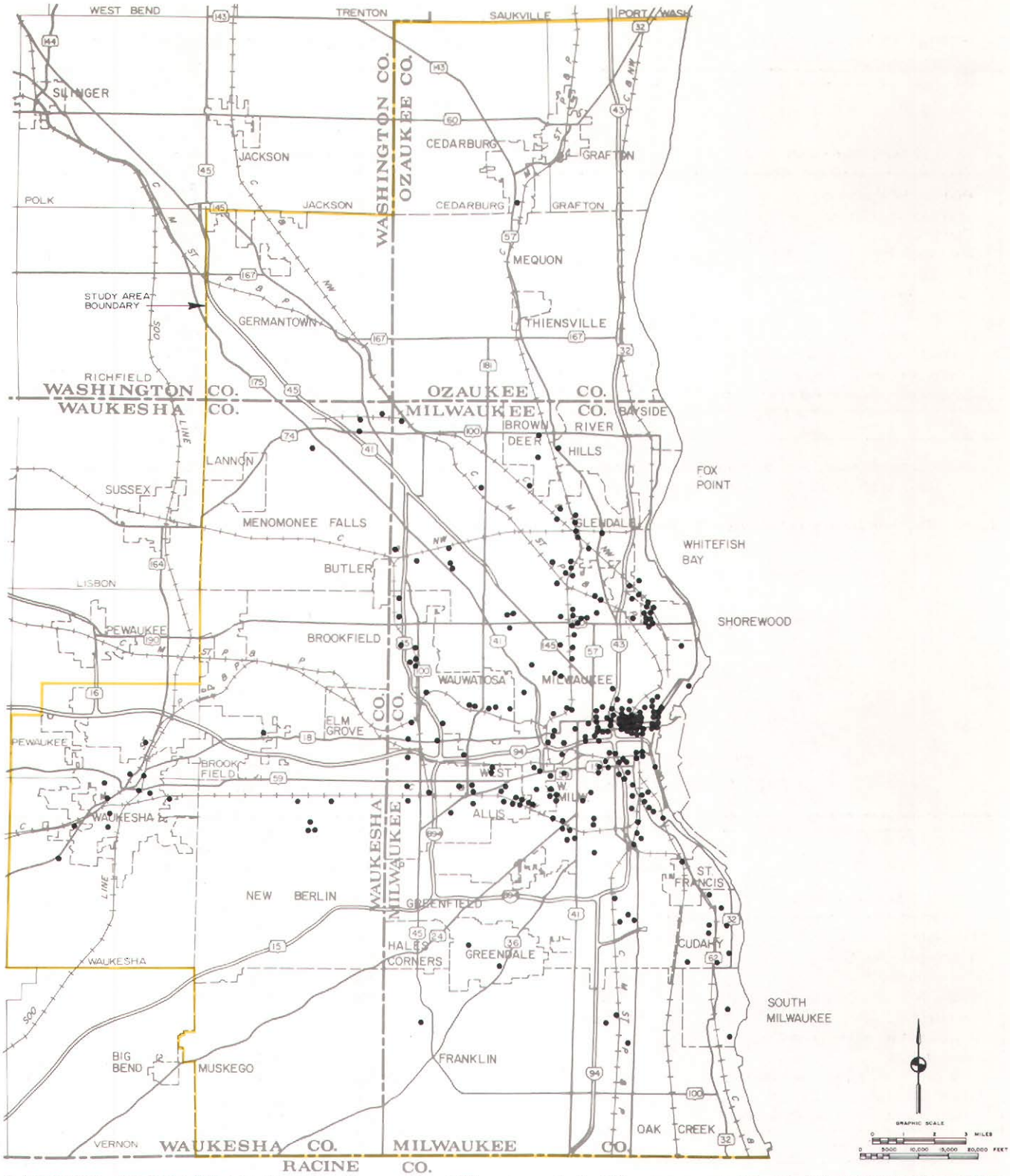


The greatest concentration of employment in Milwaukee lies in and around the central business district and in the industrial area between N. Teutonia Avenue and N. Hopkins Street from W. Nash Street to Hampton Avenue. Both these areas have employment densities in excess of 12,000 employees per square mile. Employment densities are in excess of 1,000 employees per square mile throughout the central portions of the Cities of Milwaukee and Waukesha. However, only small portions of the suburban areas have high employment densities.

Source: SEWRPC.

Map 6

DISTRIBUTION OF EMPLOYERS WITH MORE THAN 100 EMPLOYEES IN THE MILWAUKEE AREA: 1975



In 1975 there were about 758 establishments with more than 100 employees in the Milwaukee area. In the map, each dot represents one firm, with most of these firms, almost 85 percent, located in Milwaukee County.

Source: SEWRPC.

Table 15

DISTRIBUTION OF THE EMPLOYERS IN THE MILWAUKEE AREA BY INDUSTRY AND EMPLOYMENT SIZE: 1975

Employment Sector	Size of Employment			Total	
	0-99 Employers	100-249 Employers	250+ Employers	Employers	Employees[a]
Agriculture, Forestry, Fishing, and Mining	257	--	--	257	801
Construction	2,680	13	4	2,697	17,703
Manufacturing	2,259	129	111	2,499	186,358
Transportation, Communication, and Utilities	792	25	12	829	29,072
Wholesale Trade	2,368	35	5	2,408	31,096
Retail Trade	6,890	55	28	6,973	98,154
Finance, Insurance, and Real Estate	2,651	31	16	2,698	30,725
Private Services	7,485	131	90	7,706	136,290
Government Services and Education	159	29	44	232	73,011
Total	25,541	448	310	26,299	603,210

[a] *If a firm reported employment by more than one Standard Industrial Classification (SIC) group, the number of employees was summed and counted only in the firm's SIC Group which had the largest number of employees.*

Source: Wisconsin Department of Industry, Labor and Human Relations, and SEWRPC.

Table 16

ESTIMATED EMPLOYMENT BY MAJOR ECONOMIC SECTOR IN THE REGION, MILWAUKEE AREA, AND CITY OF MILWAUKEE: 1975

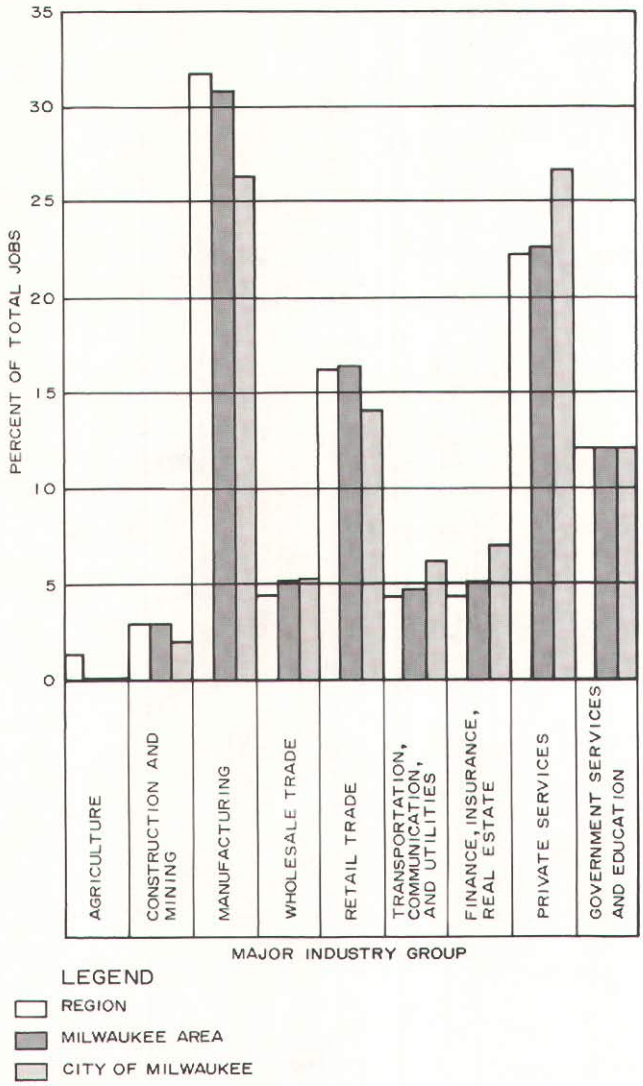
Economic Sector	Employment			Percent of Total		
	Region	Milwaukee Area	City of Milwaukee	Region	Milwaukee Area	City of Milwaukee
Agriculture	10,300	600	200	1.3	0.1	0.1
Construction and Mining	23,200	17,900	6,800	3.0	3.0	2.0
Manufacturing	248,000	186,400	89,100	31.8	30.9	26.3
Wholesale Trade	35,000	31,100	18,100	4.5	5.1	5.3
Retail Trade	125,600	98,100	48,300	16.1	16.3	14.2
Transportation, Communication, and Utilities	35,100	29,100	21,500	4.5	4.8	6.3
Finance, Insurance, and Real Estate	35,200	30,700	23,600	4.5	5.1	7.0
Private Services[a]	172,400	136,300	90,700	22.2	22.6	26.7
Government Services and Education	94,200	73,000	41,200	12.1	12.1	12.1
Total Employment	779,000	603,200	339,500	100.0	100.0	100.0

[a] *Includes the self-employed and domestic household workers.*

Source: Wisconsin Department of Industry, Labor and Human Relations, and SEWRPC.

Figure 4

PERCENTAGE DISTRIBUTION OF JOBS BY MAJOR ECONOMIC SECTOR IN THE REGION, MILWAUKEE AREA, AND CITY OF MILWAUKEE



Source: SEWRPC.

Transportation, Communication, and Utility Land Uses

Transportation, communication, and utility land uses consist of the large areas of land devoted to airports, parking lots, and rights-of-way for streets and highways, railroads, and utility lines. Next to the residential land use category, this category represents the most extensive amount of urban development. In 1970 these types of land use accounted for 35,431 acres in the County, or about 23 percent of the total county land area, and 109,407 acres in the Region, or about 6 percent of the total area of the Region (see Table 17 and Map 8). In addition, such uses constituted approximately 33 percent of the developed urban portions of both the County and the Region.

Commercial and Industrial Land Use

Commercial land use consists of all retail and service uses, including both local and regional shopping centers, highway-oriented commercial uses, and professional and executive offices, but excluding off-street parking of more than 10 spaces. Industrial land use includes all manufacturing activities, wholesaling offices, and warehouse and storage areas, but excludes related off-street parking of more than 10 spaces. Within Milwaukee County in 1970, 2,785 acres of land, or 1.9 percent of the total land area, were devoted to commercial land uses, and 4,899 acres of land, or 3.2 percent of the total area, were devoted to industrial land uses (see Table 17 and Map 8). At the same time in the Region, 6,517 acres of land, or 0.4 percent of the total area, were devoted to commercial land uses, and 10,039 acres of land, or 0.6 percent of the total area, were devoted to industrial land uses.

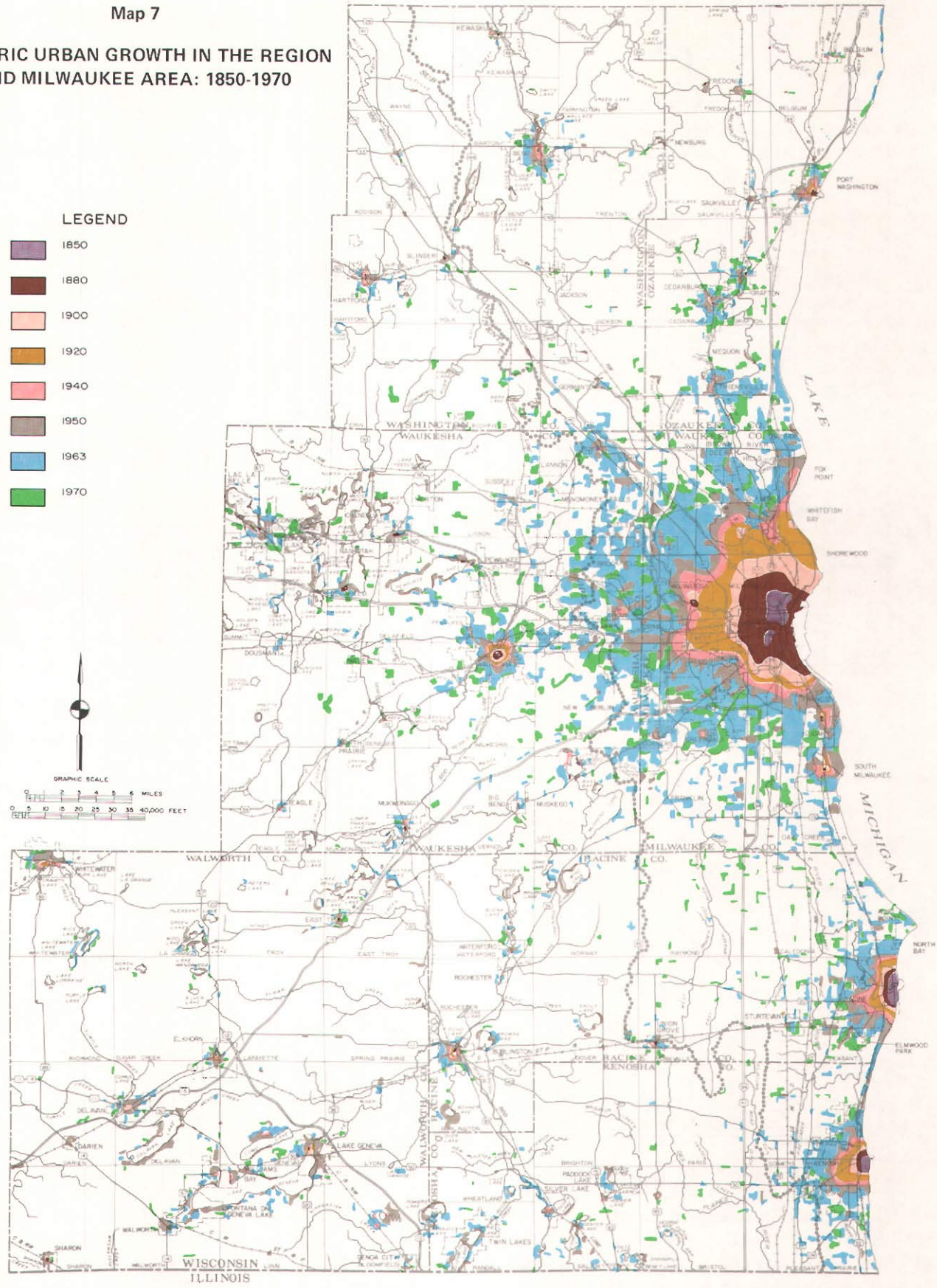
Furthermore, commercial and industrial land uses represented 13 percent of the developed portion of Milwaukee County in 1970, and 5 percent of the developed portion of the Region. Importantly, although these land uses occupied relatively small areas of the County and Region, they provided the basis for 77 percent of the county employment and 81 percent of the regional employment in 1970. In fact, about 32 percent of the total employment in Milwaukee County is located in industrial land uses (see Map 8). Map 8 indicates that most commercial development was dependent upon accessibility as well as population concentration, as the axial pattern of commercial land use approximated the pattern of major highways, as well as of major concentrations of residential land.

Governmental and Institutional Land Use

Governmental and institutional land use includes all land devoted to local, regional, or federal administrative, safety, or assembly functions, as well as to educational, health, and cemetery uses. The rather widespread dispersion of governmental and institutional land uses throughout the County is apparent on Map 8. In 1970, Milwaukee County contained 7,490 acres of such land, or 5 percent of the total land area within the County, compared with 16,618 acres of such land in the Region, or 1 percent of the total land area within

Map 7

HISTORIC URBAN GROWTH IN THE REGION AND MILWAUKEE AREA: 1850-1970



Urban development within the Region occurred in a fairly regular pattern until about 1950, forming concentric rings of relatively high-density urban development contiguous to, and outward from, the existing urban areas and long-established mass transit, utility, and community facility systems. Soon after World War II, however, the character of urban growth in the Region began to change to a much more diffused pattern of development, with relatively low densities and a high proliferation of clusters of noncontiguous development. Between 1963 and 1970 this sprawl pattern of development continued, with an additional 57 square miles of land committed to urban use within the Region over that period, representing a rate of approximately 8 square miles per year. The continuation of this sprawl pattern of land use development threatens further destruction of prime agricultural lands and of the underlying and sustaining natural resource base, and the creation of urban enclaves in essentially rural areas that will be difficult to serve economically, if at all, with necessary public utilities and services.

Source: SEWRPC.

the Region (see Table 17). Of the developed portions of the County and Region, 7 and 5 percent, respectively, were devoted to governmental and institutional land uses. The governmental and institutional land uses provided the basis for about 9 percent of the employment in Milwaukee County and 11 percent of the employment in the Region in 1970. Together, the employment in commercial and industrial and governmental and institutional land uses represented about 86 percent of total Milwaukee County employment in 1970, and thus these types of land use must be an important focus of work time rescheduling.

Recreational Land Use

Recreational land uses considered to be urban lands include only those portions of recreational sites which are intensively used for recreational purposes, and include playgrounds, parks, golf courses, zoos, campgrounds and picnic areas, and marinas.

In Milwaukee County about 9,900 acres, or 6.4 percent of the total land area, were devoted to such recreational land uses in 1970. In the Region only about 29,000 acres, or 1.7 percent of the total land area, were devoted to these types of recreational land use (see Table 17). In terms of total site area, there were 54,556 acres of recreational and related land in the Region in 1970, or 3.2 percent of the total land area. In Milwaukee County the recreational site area totaled 16,397 acres, or 10.6 percent of the total land area. Concentrations of these recreational lands are evident around many lakes and streams (see Map 8).

SUMMARY AND CONCLUSIONS

The primary purpose of the Milwaukee area work time rescheduling study is to find the best means of reducing the severe peak-hour Milwaukee area highway and transit congestion by spreading peak work travel demands as much as possible over surrounding hours. The first operational step in the study was the assembly of pertinent information on existing levels of, and historic trends in, population and economic activity levels and characteristics and land use development in the Milwaukee area. Similar information was assembled for the Southeastern Wisconsin Region, because sound transportation system planning must consider the larger socioeconomic unit of which the Milwaukee area is a part. The inventory data presented in this chapter have been collated largely from the comprehensive planning data bank assembled under the Regional Planning Commission's continuing, comprehensive areawide planning program, and have been updated as necessary and possible.

The most important and basic findings of the inventory are the following:

1. The population of the Milwaukee area has been declining during the 1970's. The population of the area in 1970 was 1,260,997 people and in 1978 was estimated to be 1,213,490 people. In spite of this decline in population, the Milwaukee area still represents a substantial portion of the resident population of the Region, accounting in 1978 for about 68 percent of the population of the entire seven-county Region. This Milwaukee area comprised 620 square miles, or 22 percent of the total area of the Region.

2. The spatial distribution of population in the Milwaukee area and the Region has been changing since the 1960's, with more rapid increases in population into the outlying portions of the study area and the Region. The portion of the Milwaukee area outside Milwaukee County experienced population increases of almost 50 percent from 1960 to 1970, and of over 20 percent from 1970 to 1978. The population of the Milwaukee County portion of the area increased by less than 2 percent from 1960 to 1970, and decreased by almost 9 percent from 1970 to 1978. Nevertheless, the Milwaukee County portion of the area represented about 80 percent of the total resident population of the area in 1978. Not all of the Milwaukee County portion of the area has been experiencing population decline; rather, portions of the City of Milwaukee and most of its inner suburbs have generally decreased in population, while the outlying portions of the County, including outlying parts of the City of Milwaukee itself, have generally increased in population.

3. The characteristics of the population of the area vary between the outlying portion and the City of Milwaukee portion. In 1970, the population of the City of Milwaukee was older than the population of Milwaukee County, 28.2 years of median age, compared with 28.0 years of age in Milwaukee County.

Table 17

DISTRIBUTION OF LAND USE IN THE REGION AND MILWAUKEE COUNTY: 1970

Land Use Category	Milwaukee County		Region	
	Acres	Percent	Acres	Percent
Urban				
Residential[a]	45,632	29.4	156,266	9.1
Commercial	2,875	1.9	6,517	0.4
Industrial[b]	4,899	3.2	10,039	0.6
Transportation, Communication, and Utilities[c]	35,431	22.9	109,407	6.3
Governmental and Institutional[d]	7,490	4.8	16,618	1.0
Recreational	9,924	6.4	28,996	1.7
Subtotal	106,251	68.6	327,843	19.0
Rural				
Agriculture	28,607	18.4	1,040,121	60.4
Open Lands[e]	20,206	13.0	353,136	20.5
Total	155,064	100.0	1,721,100	100.0

[a] *Includes all residential areas, developed and under development.*

[b] *Includes all manufacturing, wholesaling, and storage.*

[c] *Includes off-street parking areas of more than 10 spaces.*

[d] *Includes institutional land uses.*

[e] *Includes woodlands, quarries, water, and wetlands, as well as unused and other open lands.*

Source: SEWRPC.

In addition, family sizes were smaller in the City of Milwaukee, 2.96 persons per household, compared with 3.04 persons per household in Milwaukee County, and household incomes were lower, $9,612, compared with $10,473 in Milwaukee County. Between 1970 and 1975 both the age of the population and family size declined as a whole in the City of Milwaukee.

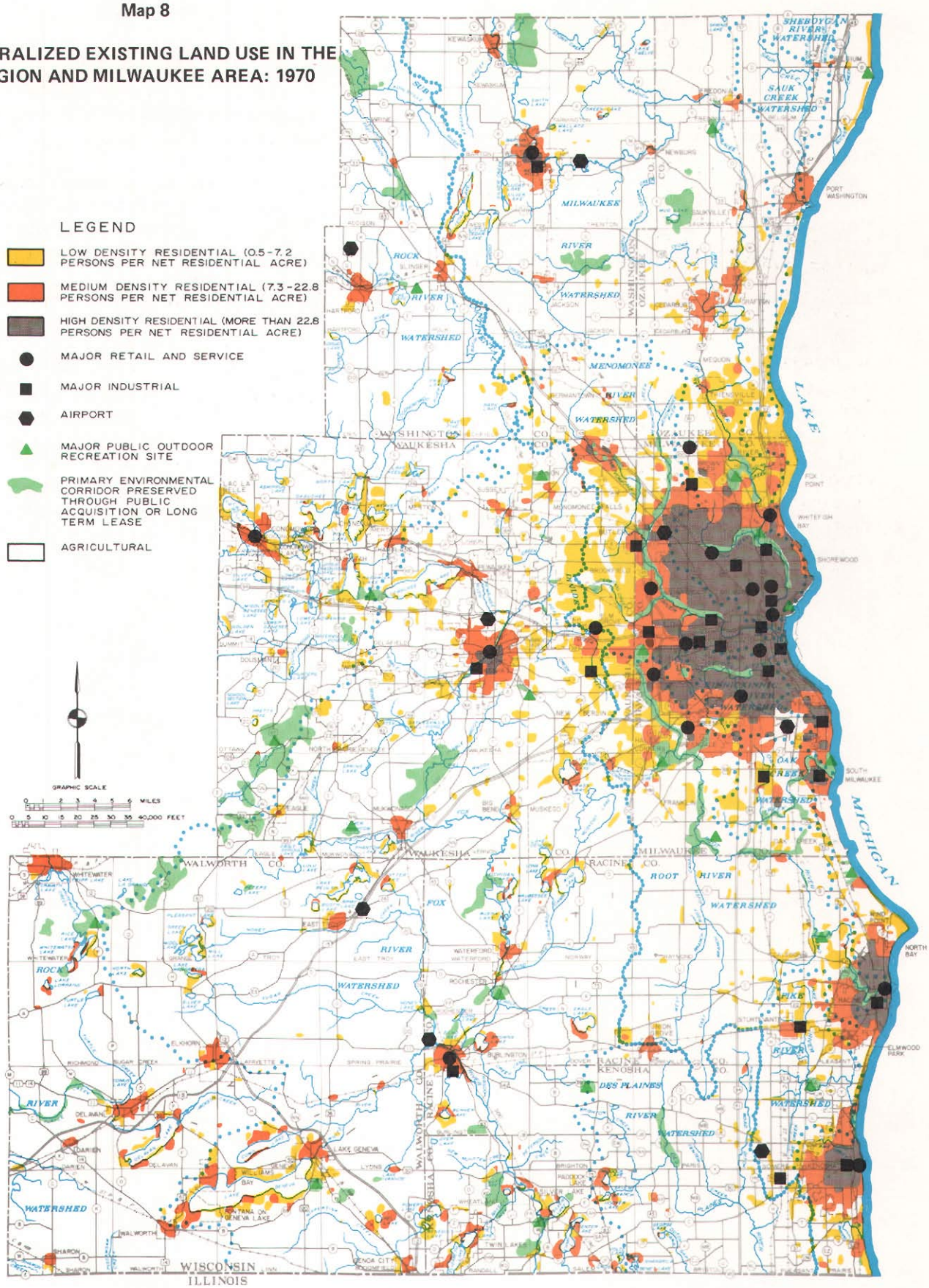
4. Employment in the Milwaukee area in 1975 was estimated at 603,200 jobs, or about 77 percent of the total jobs available in the Region. Nearly 86 percent of these area jobs were located in its Milwaukee County portion. The distribution of jobs in the study area among major industry groups was similar to that in the Region and the City of Milwaukee, with about 30 percent of the total area jobs being in manufacturing, approximately 12 percent being in government services and education, and about 23 percent being in private services.

5. Relatively few employers provide the majority of the jobs in the Milwaukee area. In 1975, 393,000 jobs, representing almost 65 percent of all jobs in the Milwaukee area, were provided by firms having 100 or more employees. These firms, however, constituted only about 3 percent of the total number of employers in the Milwaukee area in 1975. These major employers tended to be concentrated within the Milwaukee central business district and along the major transportation corridors of the Milwaukee area, and to be in the manufacturing sector of the economy.

6. From 1850 to 1950, urban growth within the Region occurred in a fairly compact

Map 8

GENERALIZED EXISTING LAND USE IN THE REGION AND MILWAUKEE AREA: 1970



This map summarizes the spatial distribution of the various land uses existing within the Region as of April 1970. Although southeastern Wisconsin is a highly urbanized region, less than 20 percent of its total area is presently devoted to urban-type land uses. Agriculture, while declining in economic importance within the Region, still occupies 60 percent of the total land use in the Region, with the remaining 20 percent being occupied by water, woodlands, and wetlands.

Source: SEWRPC.

pattern of concentric rings of relatively high-density urban development located contiguous to, and outward from, existing urban development. Since 1950, the character of urban growth in the Region has changed to a much more diffused pattern of development, with predominantly low population densities and a proliferation of clusters of noncontiguous urban development. The implication of this "urban sprawl" pattern of development since 1950 has been a rapid decline in the population density of the Milwaukee area.

7. Less than 20 percent of the total area of the Southeastern Wisconsin Region was devoted to urban land uses in 1970, while almost 68 percent of Milwaukee County was devoted to such uses in that year. Of the urban land uses in Milwaukee County, residential land constituted the largest proportion, 29.4 percent of the total, followed by transportation land uses, 22.9 percent. Commercial and industrial land uses consituted only 5 percent of the total county lands.

Thus, the Milwaukee area represents a substantial and highly developed part of the Southeastern Wisconsin Region. Although it includes only 22 percent of the regional land area, the Milwaukee area accounted for at least half of the Region's population, households, and employment opportunities in 1975. Parts of the Milwaukee area have been losing population since 1970 and in some cases, the 1960's; however, the area still remains the most highly developed and populated portion of the Region. In spite of the significant decreases in population in the City of Milwaukee since 1960 and in Milwaukee County since 1970, both the City and County, and the Milwaukee area as a whole, have experienced an increase in the number of households and jobs over this same time period.

Chapter IV

MILWAUKEE AREA TRAVEL DEMAND, HABITS, AND PATTERNS

INTRODUCTION

This chapter summarizes the important characteristics of personal travel in the Southeastern Wisconsin Region and in the Milwaukee area both on an average weekday and in the morning and evening peak-travel periods. Such characteristics include not only the trip purposes and their origins and destinations, but also attributes of the tripmakers that bear on the potential for and feasibility of work time rescheduling. Particular emphasis is placed on the characteristics of work trips, since they are the basis of work time rescheduling plans.

One of the central concepts underlying any urban transportation planning effort is that personal travel is an orderly, regular, and measurable occurrence, evidenced by recognizable patterns. An inventory of existing personal travel is necessary to reveal these patterns, and to indicate which patterns demonstrate a high degree of repetitiveness. In this respect, the travel inventory must provide a clear representation of total personal travel, while taking stock of and describing in detail each of its component parts.

Another central concept underlying urban transportation planning is that land use and transportation are closely interrelated. An inventory of existing personal travel will also determine the quantitative relationships existing between land use and travel, thereby providing a basis for determining the travel demand to be generated from proposed land use patterns, along with the socio-economic characteristics of that demand, and for determining the distribution of that demand over the transportation network assumed to be in place.

Comprehensive travel inventories were conducted by the Commission in 1963 for use in the preparation of its initial regional transportation system plan, and again in 1972 for use in the reevaluation and revision of that plan. The principal findings of these travel inventories are presented in SEWRPC Planning Report No. 7, Land Use-Transportation Study, Volume One, Inventory Findings, and SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, respectively. Travel origin-destination surveys conducted in both years consisted of home interview, truck and taxi fleet, and external cordon surveys. In 1972 five other origin-destination surveys were also conducted: a public transit user survey; a public transit nonuser survey; a major traffic generator survey; an interregional motorbus, rail, and carferry survey; and a weekend travel survey.

AVERAGE WEEKDAY TRAVEL DEMAND

Important characteristics of total daily travel in the Milwaukee area and the Region include the quantity of total person and vehicular travel, the purposes of such travel, the modes of travel used, and the timing and location of the travel.

Quantity of Total Travel

In 1972 approximately 4.68 million person trips[1] were made within the Region on an average weekday. Of these person trips, about 4.50 million, or about 96 percent, were internal person trips—that is, trips having both their origin and destination within the Region. In addition, about 177,000 external person trips were made into, out of, or through the Region in 1972. The Milwaukee area accounted for 72 percent of all regional internal tripmaking in 1972, as shown in Table 18. The Milwaukee County portion of the area accounted for almost 2.5 million of these trips, or 77 percent of the total tripmaking in the Milwaukee area, while the other contiguous portions of the area accounted for 722,600 trips, or the remaining 23 percent.

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[1] *A person trip is defined herein as a one-way journey between a point of origin and a point of destination by a person five years of age or older traveling as driver or as a passenger in an auto, taxi, truck, motorcycle, or school bus or other mass transit carrier. To be considered, the trip must have been at least the equivalent of one full city block in length.*

Table 18

AVERAGE WEEKDAY INTERNAL PERSON TRIPS GENERATED IN THE MILWAUKEE AREA AND THE REGION: 1972

Area	Population	Person Trips	Person Trips per Capita	Number of Households	Person Trips per Household
Region	1,810,700	4,504,900	2.5	567,700	7.9
Milwaukee Area	1,284,300	3,238,000	2.5	408,600	7.9
Milwaukee County . . .	1,060,500	2,462,400	2.3	348,500	7.1
City of Milwaukee . . .	712,000	1,506,300	2.1	239,300	6.3

Source: SEWRPC.

On an average weekday in 1972, 2.5 internal person trips per capita were made in the Region, and 7.9 internal person trips were made per household. At the same time in the Milwaukee area, the average internal person trip generation rates were also 2.5 trips per capita and 7.9 trips per household. However, trip generation rates were lower in both the Milwaukee County portion of the area and the City of Milwaukee—2.3 and 2.1 person trips per capita and 7.1 and 6.3 trips per household, respectively.

Map 9 indicates the variation in the household trip generation rate on an average weekday in the Milwaukee area. Particularly evident is the low tripmaking rate in the central area of the City of Milwaukee and the higher than average tripmaking rates in the suburban and rural-urban fringe areas of the study area. Differences in automobile availability, household size, and household income explain some of these differences in tripmaking, as shown in Tables 19 through 21.

Larger households were found to produce more trips per household than smaller households and, outside of households with five or more persons, they had a higher per-person-trip production rate than single-person households. In 1972, single-person households constituted 17.4 percent of all households, but produced only 5.2 percent of all person trips in the Region. The number of trips per person made by members of two-, three-, and four-person households on an average weekday was very similar—2.8, 2.7, and 2.6 trips per person, respectively. Although the largest households, households with five or more members, constituted only about 22 percent of all households, they accounted for more person trips than did households of any other size, 37.7 percent of total person trips. The rate of trip production for such households, however, was only 2.2 trips per person, less than the rate for any other household size.

Person trip production is also strongly related to the number of automobiles available to households. The larger the number of automobiles available to a household, the larger the number of person trips produced by the household on an average weekday in 1972. Households without an automobile available produced only 1.9 trips per household, compared with a minimum of 7.0 trips per household by households with one or more automobiles available.

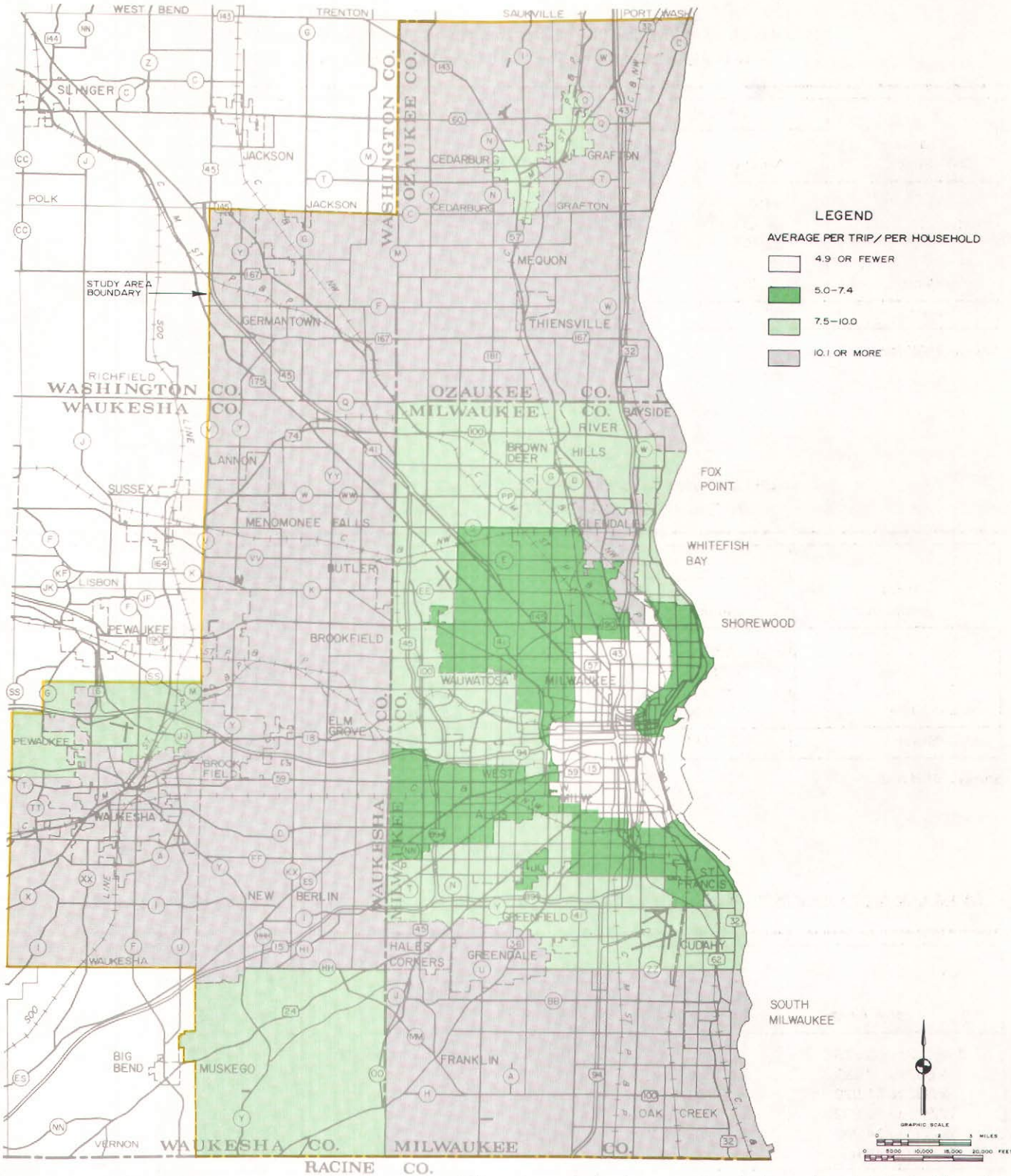
Table 21, shows the relationship between the number of trips per household and household income in 1972. The number of trips per household increases as household income increases, reaching a maximum production of 13.9 trips per household for households with 1972 incomes of $25,000 or more. This rate is almost five times the 2.8 trips per household reported by households with incomes of less than $4,000.

Vehicle Travel

The 2.3 million person trips attributed to Milwaukee County in 1972 represented 1.9 million vehicle trips by automobile, truck, and taxi. About 5.8 percent of the trips were by light trucks and taxis, and about 5.4 percent were by medium and heavy trucks, as shown in Table 22. These percentages are very similar to the percentages of total vehicle trips made by each of these modes within the City of Milwaukee and the Region in 1972.

Map 9

AVERAGE WEEKDAY INTERNAL PERSON TRIPS PER HOUSEHOLD IN THE MILWAUKEE AREA: 1972



In 1972, households in the most central portions of the City of Milwaukee made the fewest number of trips per household in the Milwaukee area on an average weekday, and households in the most suburban portions of the Milwaukee area made the largest number of trips. Generally, the number of trips made per household tended to increase with distance away from the Milwaukee central business district.

Source: SEWRPC.

Table 19

AVERAGE WEEKDAY INTERNAL PERSON TRIPS PER HOUSEHOLD AND PER PERSON IN THE REGION BY FAMILY SIZE: 1972

Family Size	Households		Person Trips		Person Trips per Household	Person Trips per Person
	Number	Percent of Total	Number	Percent of Total		
1	98,700	17.4	234,800	5.2	2.4	2.4
2	164,200	28.9	903,200	20.1	5.5	2.8
3	92,400	16.3	762,100	16.9	8.2	2.7
4	86,600	15.3	904,700	20.1	10.4	2.6
5 or More . . .	125,800	22.1	1,700,100	37.7	13.5	2.2
Region	567,700	100.0	4,504,900	100.0	7.9	2.5

Source: SEWRPC.

Table 20

AVERAGE WEEKDAY INTERNAL PERSON TRIPS PER HOUSEHOLD IN THE REGION BY AUTOMOBILE AVAILABILITY: 1972

Autos Available	Households		Person Trips		Person Trips per Household
	Number	Percent of Total	Number	Percent of Total	
0	95,600	4.1	182,500	4.1	1.9
1	279,200	49.2	1,964,900	43.6	7.0
2	161,300	28.4	1,851,000	41.1	11.5
3 or More	31,600	5.6	506,500	11.2	16.0
Region	567,700	100.0	4,504,900	100.0	7.9

Source: SEWRPC.

Table 21

AVERAGE WEEKDAY INTERNAL PERSON TRIPS PER HOUSEHOLD IN THE REGION BY INCOME GROUP: 1972

Income Range	Households[a]		Person Trips		Person Trips per Household
	Number	Percent of Total	Number	Percent of Total	
$ 0 to 3,999	51,600	13.2	145,300	4.2	2.8
4,000 to 7,999	67,100	17.2	384,400	11.2	5.7
8,000 to 11,999	117,300	30.1	1,043,200	30.5	8.9
12,000 to 15,999	75,600	19.4	854,700	25.0	11.3
16,000 to 24,999	60,200	15.4	741,800	21.7	12.3
25,000 or More	18,200	4.7	252,300	7.4	13.9
Total Reporting Households	390,000	100.0	3,421,700	100.0	8.8

[a] *Approximately 31 percent of total households did not provide household annual income data.*

Source: SEWRPC.

Table 22

AVERAGE WEEKDAY INTERNAL VEHICLE TRIPS IN THE MILWAUKEE AREA AND THE REGION BY MODE: 1972

Mode	Milwaukee County		City of Milwaukee		Region	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total
Automobile	1,649,900	88.8	994,300	87.8	2,897,000	88.3
Light Truck	107,100	5.8	71,600	6.3	200,100	6.1
Medium or Heavy Truck	101,400	5.4	66,400	5.9	185,200	5.6
Total Vehicle Trips	1,858,400	100.0	1,132,300	100.0	3,282,300	100.0

Source: SEWRPC.

Table 23

AVERAGE WEEKDAY INTERNAL PERSON TRIPS IN THE MILWAUKEE AREA AND THE REGION BY TRIP PURPOSE AT DESTINATION: 1972

Trip Purpose at Destination	Study Area		Region	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total
Home	1,294,000	40.0	1,836,200	40.8
Work	564,800	17.4	740,800	16.4
Personal Business	468,200	14.5	654,900	14.5
School	160,100	4.9	220,000	4.9
Social-Recreational	354,500	11.0	508,100	11.3
Shopping	396,000	12.2	544,900	12.1
Total	3,237,600	100.0	4,504,900	100.0

Source: SEWRPC.

Regionwide in 1972, 88.3 percent of all vehicle trips were made by automobiles, 6.1 percent were made by light trucks and taxis, and 5.6 percent were made by medium and heavy trucks. Within the City of Milwaukee a slightly higher percentage of trips was made by trucks and taxis than in the County or the Region; light truck and taxi trips constituted 6.3 percent of the vehicle trips in the City, and medium and heavy truck trips constituted 5.9 percent of all vehicle trips.

Trip Purpose

Home-oriented travel within the Milwaukee area accounted for the largest proportion of total internal person travel on an average weekday, 40.0 percent of all person trip destinations in 1972 (see Table 23). Next in importance were trips to work, which accounted for 17.4 percent of total person trip destinations in the Milwaukee area, or a total of 564,800 trips on an average weekday. Of the remaining trip purpose categories, personal business trips accounted for 14.5 percent of total area tripmaking on an average weekday, shopping trips for 12.2 percent, social and recreational trips for 11.0 percent, and trips to attend school the remaining 5 percent. The distribution of regional tripmaking by trip purpose was about the same as that for the study area, as shown in Table 23.

Mode of Travel

The opportunity to select a particular mode of travel, principally automobile or public transit, is not available to all residents of the study area or the Region. Many households are located in areas not served by public transit, and are thus dependent on the automobile. Many other households

Table 24

AVERAGE WEEKDAY INTERNAL PERSON TRIPS IN THE MILWAUKEE AREA AND THE REGION BY MODE: 1972

Area	Mode of Travel										Total Number of Trips
	Auto Driver		Auto Passenger		Transit Passenger		School Bus Passenger		Other		
	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total	
Milwaukee Area	2,068,000	63.9	859,000	26.5	179,500	5.6	117,900	3.6	13,200	0.4	3,237,600
Milwaukee County	1,648,900	64.3	681,000	26.5	178,000	6.9	49,600	1.9	9,300	0.4	2,566,800
Remaining Contiguous Portions	419,100	62.5	178,000	26.5	1,500	0.2	68,300	10.2	3,900	0.6	670,800
Region	2,885,000	64.0	1,217,300	27.0	184,700	4.1	170,000	3.8	47,900	1.1	4,504,900

Source: SEWRPC.

do not have automobiles available because of age, income, personal disability, or choice, and are thus dependent almost entirely on public transit.

In 1972 automobile travel accounted for the large majority of person trips attributed to the Milwaukee area on an average weekday. Automobile driver trips accounted for more than 2 million person trips in the area, or 64 percent of all trips, and automobile passenger trips accounted for 859,000 person trips, or 26.5 percent of all such trips. The percentages of total regional travel attributed to each of these modes of travel were very similar to those for the Milwaukee area, as shown in Table 24. Within the Milwaukee County portion of the Milwaukee area, auto driver trips accounted for 64.3 percent of total person trips and auto passenger trips accounted for 26.5 percent of such trips.

Public transit passenger trips accounted for 5.6 percent of total travel within the Milwaukee area, as compared with about 4 percent of total travel in the Region. Within the Milwaukee County portion of the study area, in which nearly all transit service in the study area was provided, 6.9 percent of total travel on an average weekday was made by public transit. Within the other contiguous portions of the Milwaukee area, less than 0.2 percent of all travel was made by public transit. Map 10 indicates the amount of public transit utilized throughout the Milwaukee area in 1972. The greatest concentrations of transit use in 1972 occurred in the central portions of the Milwaukee area, which accounted for 10 to 20 percent of all transit tripmaking. Transit use declined rapidly with distance from this central area.

School bus passenger trips accounted for almost 4 percent of total trips within the Milwaukee area in 1972, and for about the same percent of total regional trips. School bus passenger trips in the Milwaukee County portion of the Milwaukee area accounted for only 1.9 percent of total county trips, as compared with 10.2 percent of all tripmaking in the other contiguous portions of the Milwaukee area. However, almost 25,000 school-purpose trips were made on public transit in the Milwaukee area on an average weekday in 1972—about 14 percent of total Milwaukee area public transit trips. It should be noted that these statistics do not reflect the increased school busing program for racial integration initiated in the City of Milwaukee in 1977.

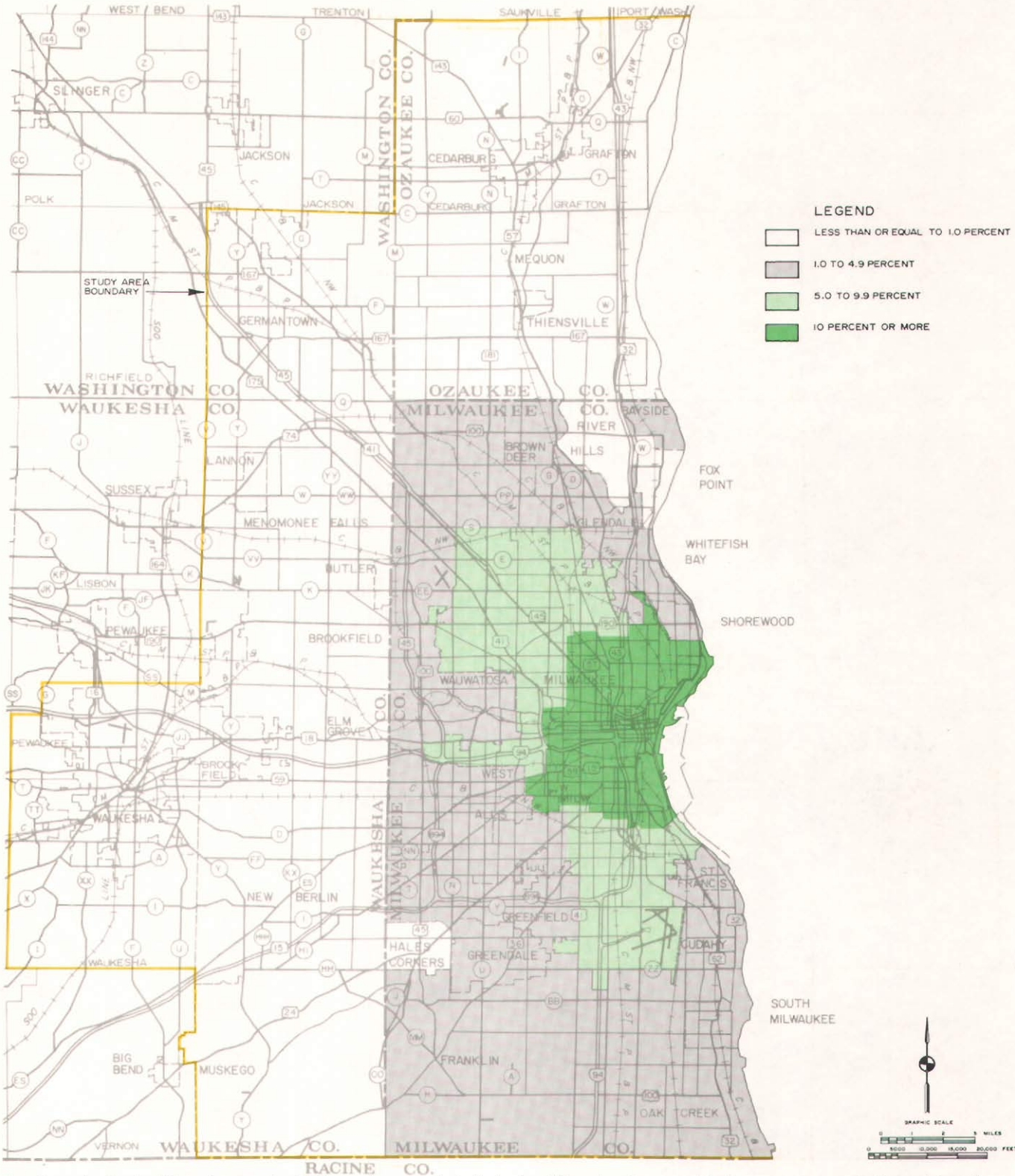
Location of Travel

The amount of travel generated by, and attracted to, a given area is largely determined by the amount, type, and intensity of development in that area. Map 11 shows the spatial distribution of travel, both trip origins and trip destinations, within the Milwaukee area on an average weekday in 1972. The highest concentration of tripmaking in 1972 occurred in the major commercial and industrial parts of the Milwaukee area, and to a lesser extent in its highly developed residential areas. Significant concentrations of tripmaking, however, are also found in many smaller communities throughout the Milwaukee area.

In 1972, prior to the opening of the two major Milwaukee area shopping centers—Northridge in northwestern Milwaukee and Southridge in Greendale—five major trip attractors accounted for 21 percent of all person trips in the Milwaukee

Map 10

PUBLIC TRANSIT UTILIZATION IN THE MILWAUKEE AREA: 1972

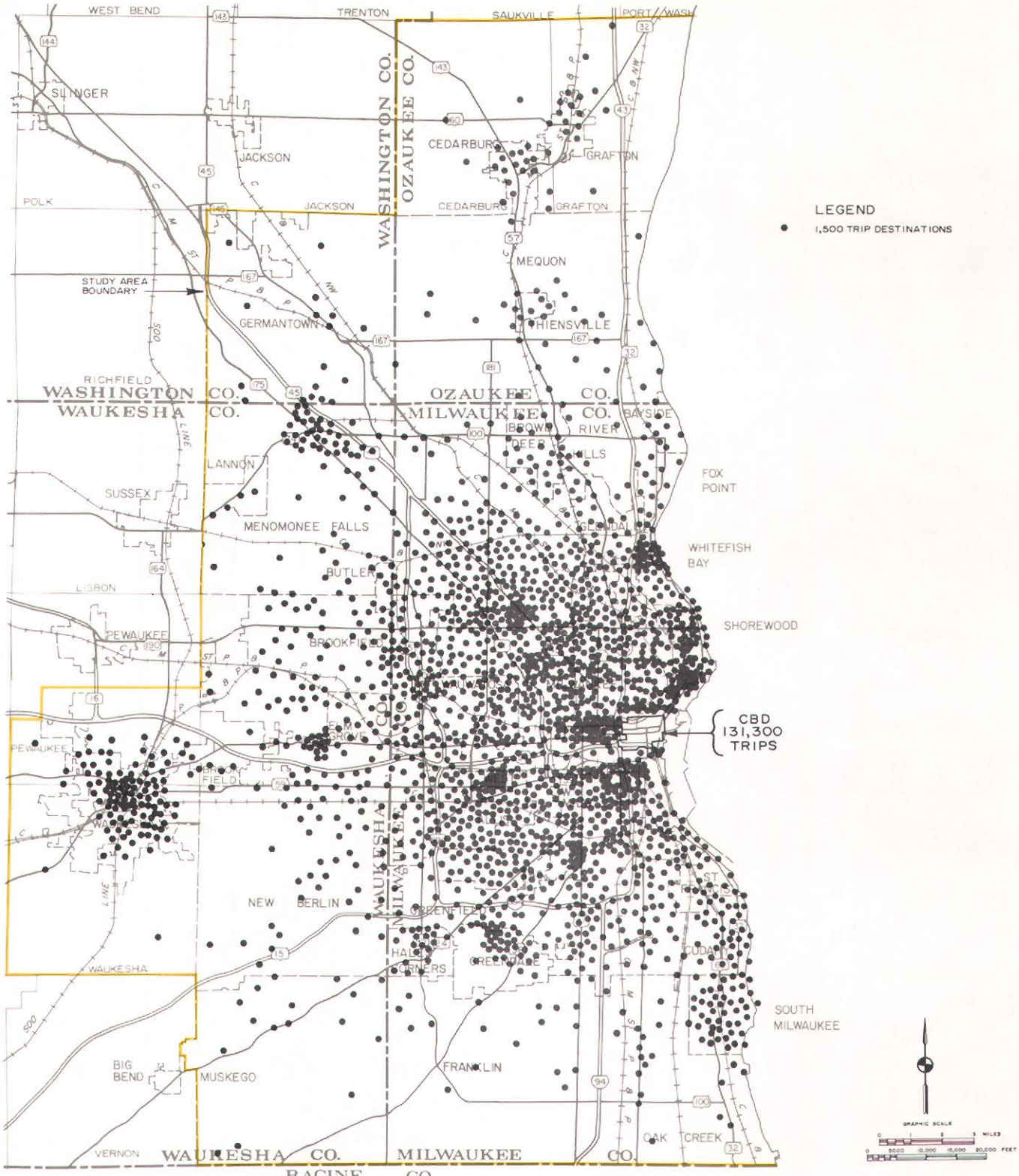


Transit service in the Milwaukee area in 1972 was almost entirely limited to Milwaukee County, with the greatest concentrations of transit use occurring in the City of Milwaukee. Suburbs within Milwaukee County accounted for no more than 5 percent of total trips made on public transit, while over 20 percent of all trips to the most central portions of the City of Milwaukee were made on public transit.

Source: SEWRPC.

Map 11

AVERAGE WEEKDAY INTERNAL PERSON TRIP DESTINATIONS IN THE MILWAUKEE AREA: 1972



The amount of travel attracted to a given area is determined by the amount, kinds, and intensity of land use development present in that area. In 1972 the highest concentrations of internal person trip destinations in the Milwaukee area were found in the Milwaukee central business district and in the central business districts of several suburban communities, particularly the City of Waukesha. The overall pattern produced by plotting the location of internal person trip destinations closely resembles the existing urban development pattern.

Source: SEWRPC.

area: the Milwaukee central business district (CBD), the Capitol Court area, the University of Wisconsin-Milwaukee (UWM)/Lower East Side area, the Marquette University/Wisconsin Avenue area, and the Near South Side area (see Map 12 and Table 25). Of these trip attractors, the Milwaukee central business district attracted the greatest number of person trips on an average weekday, 251,000, or 8 percent of the total person trips entering, leaving, and made within the Milwaukee area on an average weekday in 1972. The next largest trip attractor areas on an average weekday in the Milwaukee area in 1972 were the UWM/Lower East Side area, (123,000 trips), the Marquette University/Wisconsin Avenue area (107,000 trips), the Capitol Court area (102,000 trips), and the Near South Side area (93,000 trips). Table 25 illustrates dependence on the automobile as the primary mode of travel to all of these major trip attractors of the Milwaukee area. The percentage of auto driver and auto passenger travel to these areas ranged from a low of 78 percent of all trips to the Milwaukee central business district to 95 percent of all trips attracted to the Capitol Court area. Thus, the greatest amount of transit travel was made to the Milwaukee CBD, to which 22 percent of all trips were made on public transit. On the other hand, only 4 percent of all trips attracted to the Capitol Court area were made using transit. Collectively, the five major trip attractor areas in the Milwaukee area accounted for 20 percent of the total 3.2 million internal person trips that were made on an average weekday in 1972 within the Milwaukee area.

In addition to being the largest single trip attractor in 1972, the Milwaukee central business district attracted the largest percentage of work trips, 50 percent—an important consideration for work time rescheduling. Table 26 shows the number of trips to the Milwaukee central business district by trip purpose and mode. Work trips to the Milwaukee central business district in 1972 were made primarily by automobile, but 22 percent of these trips were made by transit.

Hourly Patterns of Internal Person Travel

The hourly distribution of 1972 person trips in the Region by trip purpose at destination shown in Figure 5 depicts a familiar pattern of morning and evening peaking characteristics. The pattern shows the relative inactivity of the early morning hours, followed by a sharp peak between 7:00 a.m. and 8:00 a.m. as trips to work and school begin. Trips for shopping, personal business, and social-recreational purposes begin during the early morning hours and continue fairly evenly until mid-afternoon. The afternoon peak period, beginning at 3:00 p.m., is larger in trip volume and more sustained than the morning peak period, and is characterized predominantly by trips to return home. Person trip activity declines sharply following the afternoon peak, but the decline tapers off in the early evening hours as trips for shopping and social-recreational purposes reach their maximum hourly volumes for the day. The hourly distribution of person travel in the Milwaukee area is very similar to that in the Region (see Figure 6).

Trips having a destination of home constitute a large proportion of the afternoon peak-period travel in both the Region and the Milwaukee area, although such trips constitute a relatively small proportion of morning peak-period travel. However, in the Milwaukee area in 1972, 87 percent of all trips originated at home during the morning peak period, 6:00 a.m. to 9:00 a.m., while during the afternoon peak, 3:00 p.m. to 6:00 p.m., only 21 percent of all person trips originated at home. Figure 7 shows the hourly distribution of person trips in the Milwaukee area by trip purpose at origin. This distribution contrasts with the distribution of trips by destination, shown in Figure 6, since 60 percent of all trips during the afternoon peak have a destination of home while, during the same period, 32 percent of all person trips originate at work, and a substantial amount of trips originate at business establishments—15 percent; shopping establishments—12 percent; and school—10 percent.

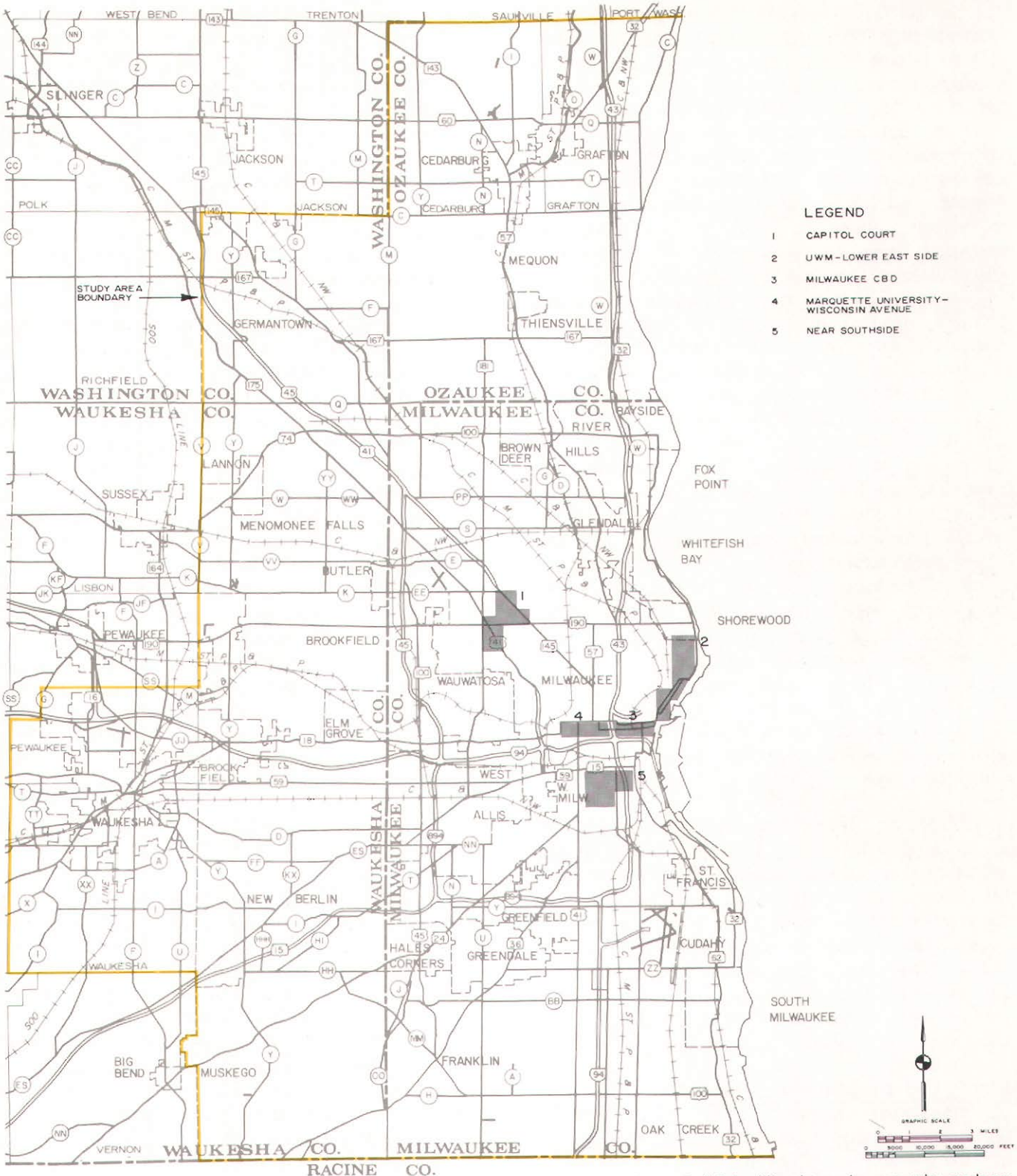
WORK TRAVEL

The following sections look more carefully at some of the principal characteristics of travel to work—when, where, and how such trips are made, and by whom. Much emphasis is placed upon when such trips occur, since the ultimate objective of the Milwaukee area work time rescheduling study is to prepare and test alternative proposals for rearranging these trips so that relatively fewer are made during conventional peak travel periods. The morning peak period is singled out for special emphasis since the majority of trips made during this period are trips to work.

Trips are classified in this section by the trip purpose at either the origin or destination of the trip. The majority of the trips classified as work trips are trips made directly from home to work and

Map 12

1972 MAJOR TRIP ATTRACTOR AREAS



Five major trip attractor areas within the Milwaukee area accounted for 20 percent of the total of 3.2 million internal person trips made on an average weekday in 1972. The Milwaukee central business district attracted by far the greatest number of trips, while four other areas, including Milwaukee's two major universities and two other major retail shopping districts, attracted substantial numbers of trips. All of these areas are located within the City of Milwaukee, and the UWM/Lower East Side and Marquette University-Wisconsin Avenue attractors are contiguous to the Milwaukee central business district.

Source: SEWRPC.

Table 25

INTERNAL MILWAUKEE URBANIZED AREA PERSON TRIPS ENTERING, LEAVING, AND OCCURRING WITHIN THE FIVE LARGEST TRIP ATTRACTORS ON AN AVERAGE WEEKDAY BY MODE OF TRAVEL: 1972

Trip Attractor	Mode of Travel								Total Trips	Percent
	Auto Driver Trips	Percent	Auto Passenger Trips	Percent	Bus Passenger Trips	Percent	Other Trips[a]	Percent		
Milwaukee CBD										
Entering	67,500	56.6	24,790	20.8	26,350	22.1	580	0.5	119,220	100.0
Leaving	68,030	56.9	25,350	21.2	25,410	21.3	670	0.6	119,460	100.0
Within	6,820	56.6	2,470	20.5	2,660	22.1	90	0.8	12,040	100.0
Total	142,350	56.8	52,610	21.0	54,420	21.7	1,340	0.5	250,720	100.0
UWM-Lower East Side										
Entering	33,300	63.1	13,330	25.2	5,770	10.9	400	0.8	52,800	100.0
Leaving	33,350	61.4	14,430	26.6	6,230	11.5	280	0.5	54,290	100.0
Within	9,540	60.2	4,910	31.0	1,140	7.2	260	1.6	15,850	100.0
Total	76,190	62.0	32,670	26.5	13,140	10.7	940	0.8	122,940	100.0
Marquette University-Wisconsin Avenue										
Entering	28,110	58.8	11,210	23.4	7,790	16.3	730	1.5	47,840	100.0
Leaving	28,100	59.4	11,010	23.3	7,470	15.8	740	1.5	47,320	100.0
Within	7,530	65.6	2,680	23.3	1,060	9.2	220	1.9	11,490	100.0
Total	63,740	59.8	24,900	23.3	16,320	15.3	1,690	1.6	106,650	100.0
Capitol Court										
Entering	29,510	62.9	14,610	31.1	2,340	5.0	450	1.0	46,910	100.0
Leaving	29,550	63.5	14,580	31.3	1,980	4.2	450	1.0	46,560	100.0
Within	5,690	65.6	2,870	33.1	110	1.3	--	--	8,670	100.0
Total	64,750	63.4	32,060	31.4	4,430	4.3	900	0.9	102,140	100.0
Near South Side										
Entering	26,280	63.7	9,670	23.5	4,650	11.3	620	1.5	41,220	100.0
Leaving	26,040	63.0	10,280	24.9	4,400	10.6	620	1.5	41,340	100.0
Within	6,180	60.3	2,690	26.3	1,370	13.4	--	--	10,240	100.0
Total	58,500	63.0	22,640	24.4	10,420	11.2	1,240	1.4	92,800	100.0

[a] *Includes passenger travel by school bus, taxi, truck, motorcycle, and charter bus.*

Source: SEWRPC.

Table 26

AVERAGE WEEKDAY INTERNAL PERSON TRIPS IN THE MILWAUKEE CENTRAL BUSINESS DISTRICT BY TRIP PURPOSE AT DESTINATION AND MODE OF TRAVEL: 1972

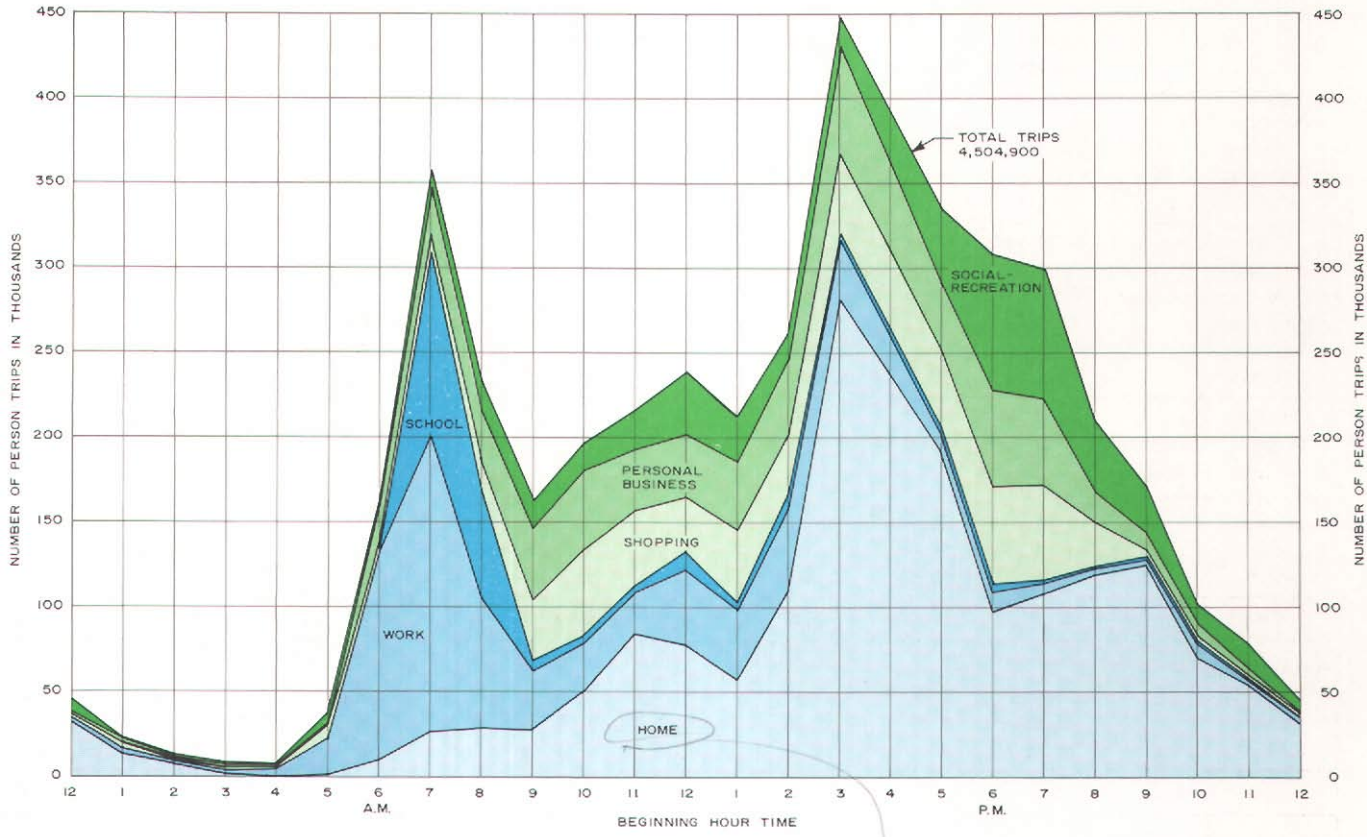
Trip Purpose at Destination	Mode of Travel									
	Auto Driver		Auto Passenger		Transit Passenger		Other		Total	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total
Home	2,400	3.2	1,000	3.7	900	3.1	--[a]	--	4,300	3.3
Work	40,000	53.9	10,800	39.6	14,500	50.0	200	28.6	65,500	49.9
Personal Business	18,100	24.4	7,600	27.8	3,200	11.0	100	14.3	29,000	22.1
School	3,600	4.8	800	2.9	3,300	11.4	100	14.3	7,800	5.9
Social-Recreational	6,500	8.7	4,600	16.8	900	3.1	300	42.8	12,300	9.4
Shopping	3,700	5.0	2,500	9.2	6,200	21.4	--[a]	--	12,400	9.4
Total	74,300	100.0	27,300	100.0	29,000	100.0	700	100.0	131,300	100.0

[a] *Fewer than 50 trips.*

Source: SEWRPC.

Figure 5

HOURLY VARIATION OF AVERAGE WEEKDAY INTERNAL PERSON TRIPS IN THE REGION BY TRIP PURPOSE AT DESTINATION: 1972



Source: SEWRPC.

type size

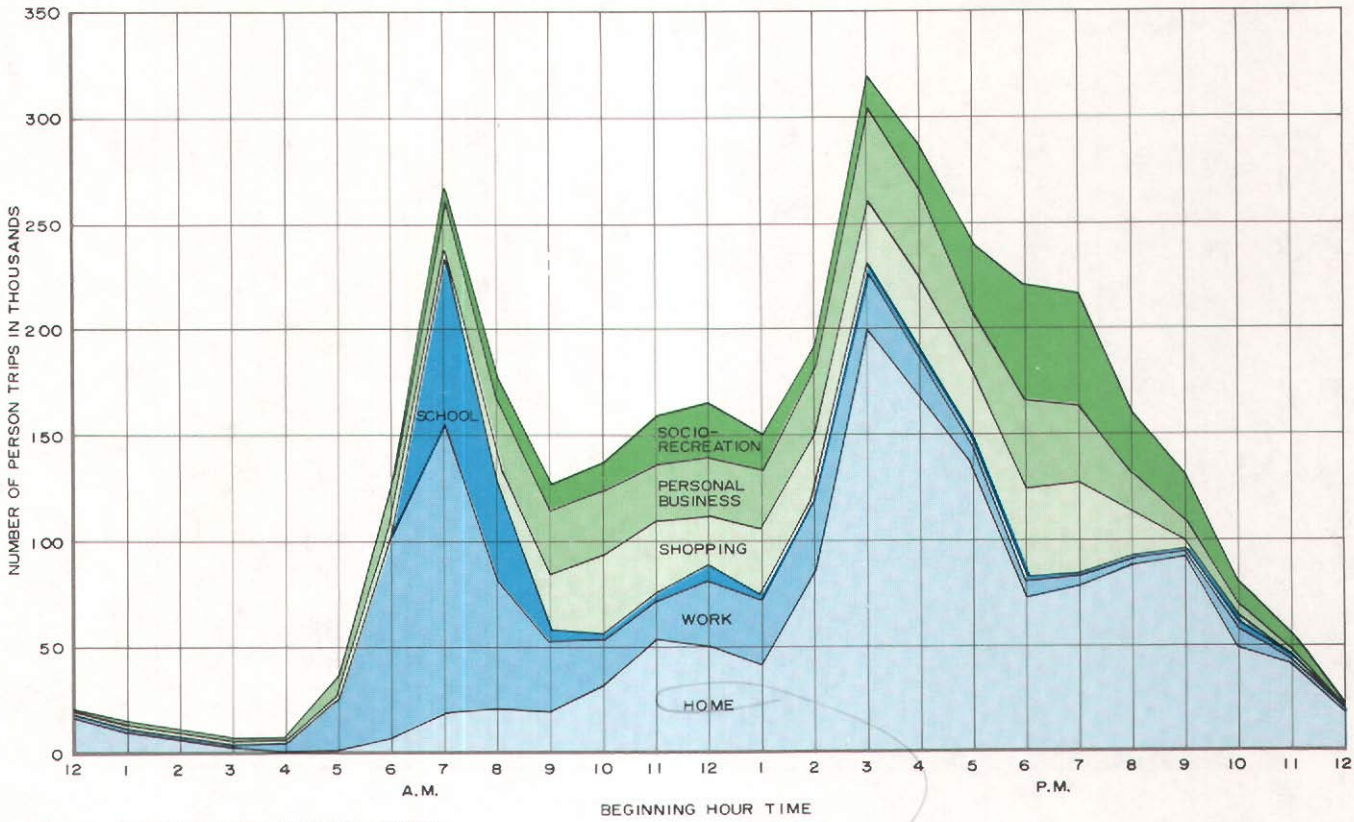
directly from work to home. However, some trips to or from work include intermediate stops, such as at shopping establishments. The magnitude of trips for all trip purposes having intermediate stops can be identified by establishing the proportion of total trips comprised of nonhome-based trips. Nonhome-based trips are trips which do not originate or terminate at home, such as the work-to-shopping portion of a trip which will then proceed home. The proportion of nonhome-based trips made within the Region in 1972 during the peak periods is shown in Table 27. Nonhome-based trips constituted only a small proportion of the trips made during the morning peak period, 6:00 a.m. to 9:00 a.m.—3.6 percent. The afternoon peak period, 3:00 p.m. to 6:00 p.m., comprised a larger proportion of nonhome-based trips than the morning peak period, with a maximum percentage of such trips occurring between 4:00 p.m. and 5:00 p.m. However, these nonhome-based trips accounted for only 18.2 percent of all trips from 4:00 p.m. to 5:00 p.m., and only 15.9 percent of all trips during the three-hour afternoon peak period.

Temporal Patterns

As shown in Figure 8, person trips to work constituted the largest proportion of tripmaking within the Milwaukee area during the morning hours in 1972. Between 4:00 a.m. and 8:00 a.m. work trips constituted over half of all person trips made within the Milwaukee area; however, only 1.7 percent of all person trips were made between midnight and 6:00 a.m., as indicated by the broken line in Figure 8. During the morning peak travel hours of 6:00 a.m. to 9:00 a.m., when 17 percent of all person trips occurred, trips to work within

Figure 6

HOURLY VARIATION OF AVERAGE WEEKDAY INTERNAL PERSON TRIPS IN THE MILWAUKEE AREA BY TRIP PURPOSE AT DESTINATION: 1972



NOTE: ALL TRIPS WHICH BEGIN DURING AN HOUR ARE SHOWN AT START OF THAT HOUR

Source: SEWRPC.

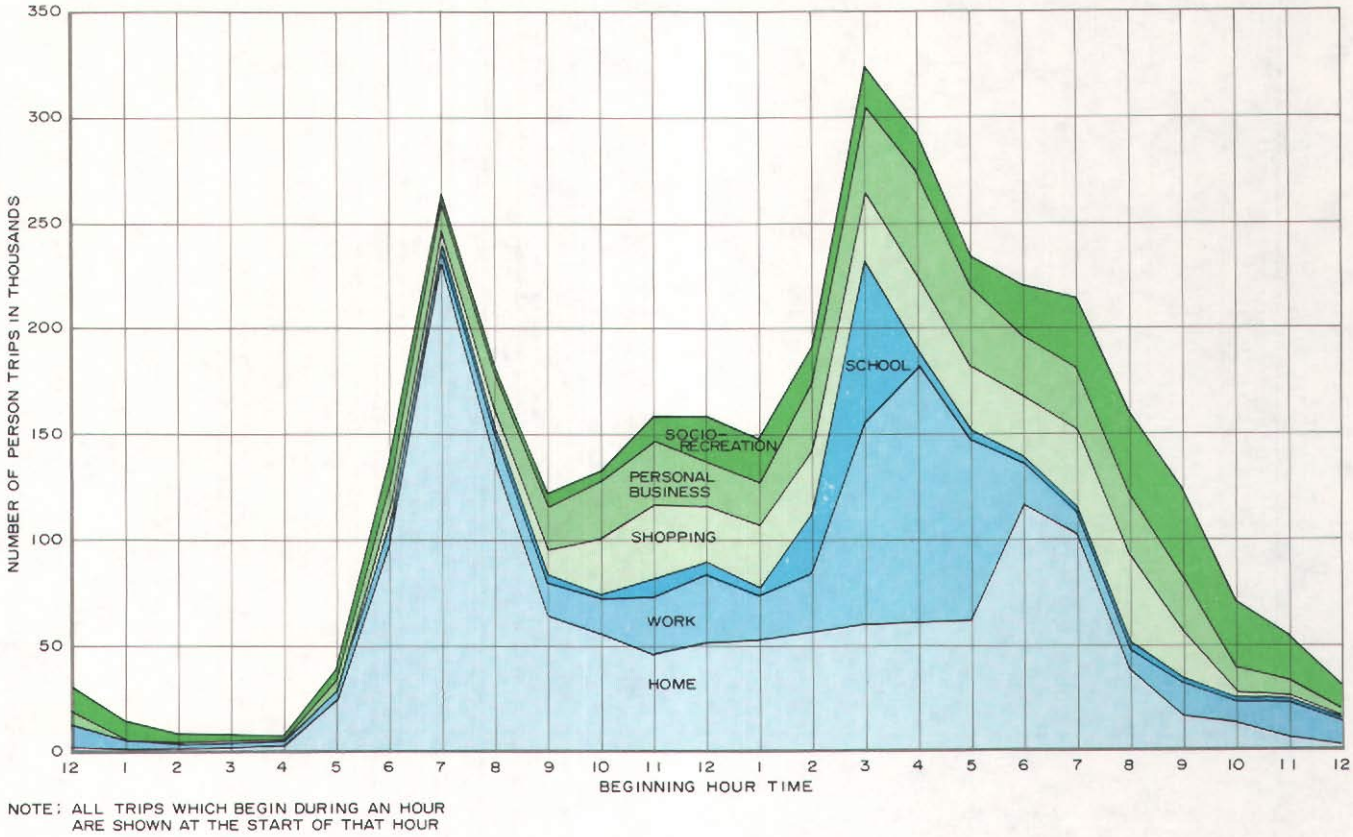
the Milwaukee area accounted for 53 percent of all person trip destinations. Similarly, during the afternoon peak travel hours person trips from work represented the largest proportion of total trip-making by purpose at origin within the Milwaukee area in 1972 (see Figure 9). From 3:00 p.m. to 5:00 p.m., for example, places of work accounted for 35 percent of all person trip origins. Thus, trips to and from work constitute a major part of the total peak-period travel demand to be accommodated by the area transportation system.

Mode of Travel

Of the total 564,800 work trips made in the Milwaukee area on an average weekday in 1972, 80 percent were made as automobile drivers, 12 percent were made as automobile passengers, 7 percent were made as public transit passengers, and less than 1 percent were made by all other modes. As shown in Figure 10 and Table 28, both the number and proportion of transit and automobile work trips vary throughout the day. During the morning peak period, 6:00 a.m. to 9:00 a.m., transit carried 8.7 percent of all trips to work, while the automobile accounted for 90.9 percent. During the remainder of the day, transit carried only 5.5 percent of all work trips, while the private automobile carried 94.0 percent. The three-hour peak period in the morning accounted for almost 30 percent of all transit trips made on an average day in 1972, with work trips accounting for almost 40 percent of these transit trips. The morning and afternoon peak periods combined accounted for 70 percent of all transit trips made on an average weekday in 1972.

Figure 7

HOURLY VARIATION OF AVERAGE WEEKDAY INTERNAL PERSON TRIPS IN THE MILWAUKEE AREA BY TRIP PURPOSE AT ORIGIN: 1972



NOTE: ALL TRIPS WHICH BEGIN DURING AN HOUR ARE SHOWN AT THE START OF THAT HOUR

Source: SEWRPC.

Table 27

NONHOME-BASED PERSON TRIPS IN THE REGION: 1972

Time	Person Trips		
	Total	Nonhome Based	
		Number	Percent
6:00 a.m. to 7:00 a.m.	112,842	2,402	2.1
7:00 a.m. to 8:00 a.m.	264,098	6,663	2.5
8:00 a.m. to 9:00 a.m.	190,738	11,296	5.9
A. M. Peak Period	567,678	20,361	3.6
3:00 p.m. to 4:00 p.m.	327,624	52,393	16.0
4:00 p.m. to 5:00 p.m.	295,936	53,951	18.2
5:00 p.m. to 6:00 p.m.	295,936	40,074	13.5
P. M. Peak Period	919,496	146,418	15.9

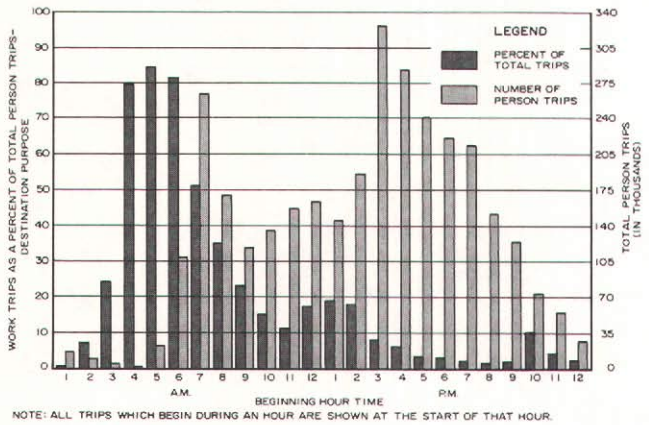
Source: SEWRPC.

Land Use at Trip Destination

Figure 11 shows the arrival time patterns for work trips by the type of land use at the trip destination. Trips to manufacturing land uses peak much earlier than do trips to other land uses, as almost 70 percent of all work trips arriving between 6:30 and 7:00 a.m. are destined to manufacturing establishments, while only 13 percent are destined to institutional establishments, 9 percent are destined to retail establishments, and about 8 percent are destined to all other classes of establishments. The proportion of work trips to manufacturing establishments decreases steadily throughout the rest of the morning—with such trips representing about 45 percent of all work trips between 7:00 and 7:30 a.m., about 30 percent between 7:30 and 8:00 a.m., and about 21 percent between 8:00 and 8:30 a.m. Conversely, only about 11 percent of all work trips are destined for retail and wholesale establishments between 6:30 and 7:00 a.m., but

Figure 8

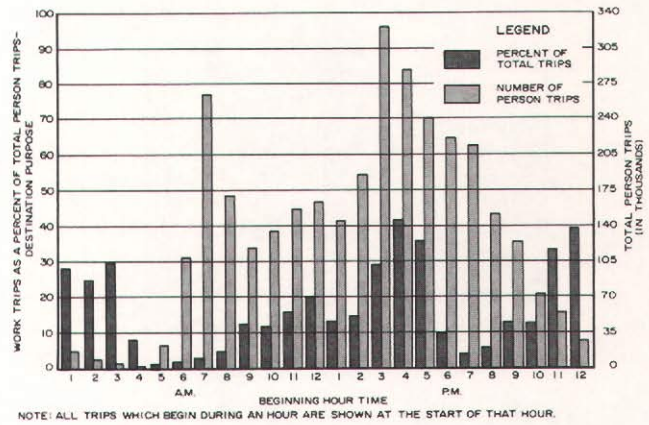
HOURLY DISTRIBUTION OF PERSON TRIPS TO WORK IN THE MILWAUKEE AREA AS A PERCENT OF TOTAL PERSON TRIP DESTINATIONS: 1972



Source: SEWRPC.

Figure 9

HOURLY DISTRIBUTION OF PERSON TRIPS FROM WORK IN THE MILWAUKEE AREA AS A PERCENTAGE OF TOTAL TRIP ORIGINS: 1972



Source: SEWRPC.

this percentage increases throughout the rest of the morning—to about 27 percent between 7:00 and 7:30 a.m., about 37 percent between 7:30 and 8:00 a.m., and about 52 percent between 8:00 and 8:30 a.m.

Characteristics of the Tripmaker

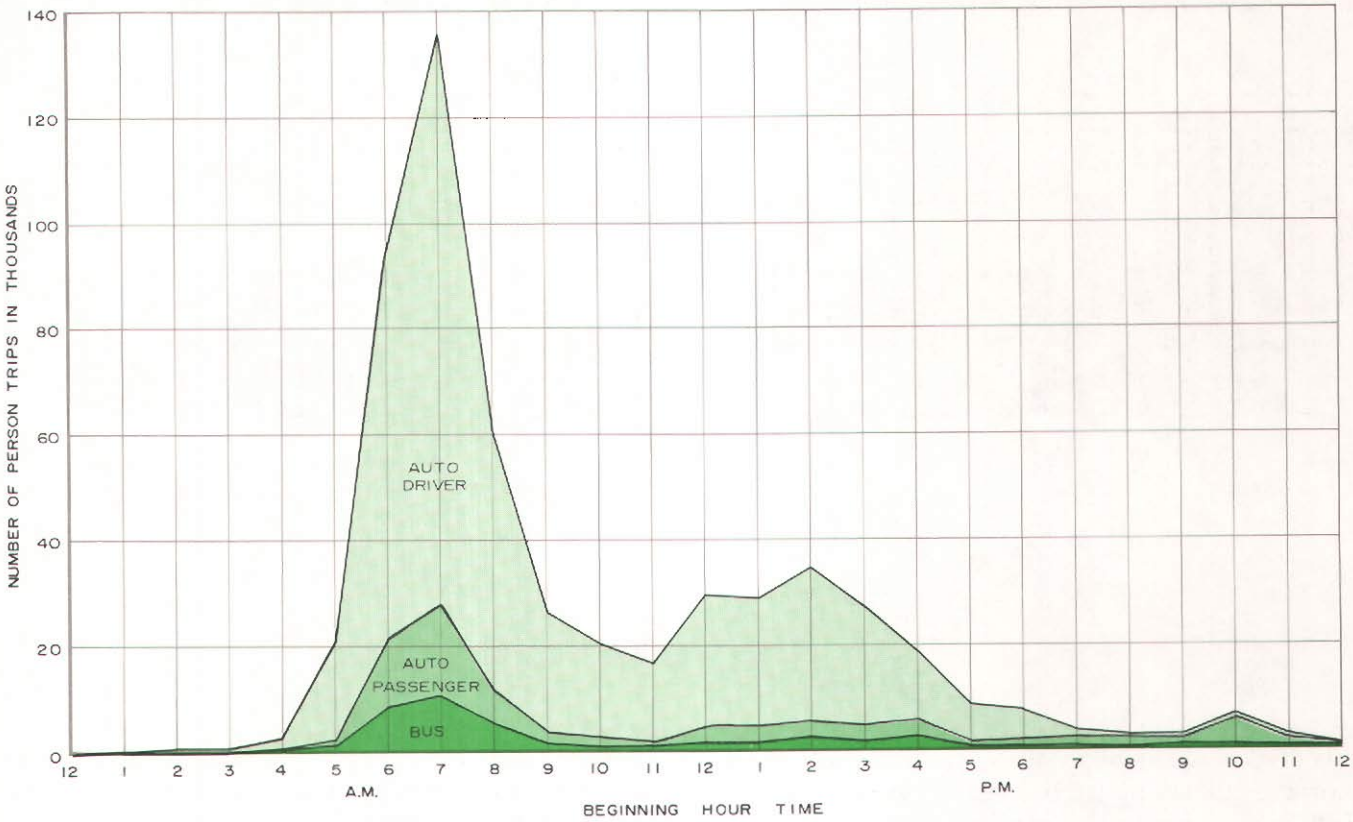
The 1972 home interview survey acquired data not only about the travel behavior of residents of southeastern Wisconsin on an average weekday in 1972, but also about the age, occupation, and industry of employment of each tripmaker. For the purpose of the work time rescheduling study, it is important to know the temporal distribution of work trips of these population groups. The following section presents the temporal distribution of the starting time of work trips in the Milwaukee area by the industry, age, and occupation of the tripmaker. All starting times are discussed in terms of one-hour intervals, with trips occurring between hours reported at the start of the hour.

Industry of Employment: Figure 12 shows the temporal distribution of the starting time of work trips in the Milwaukee area in 1972 by the industry of employment of the tripmakers. The majority of the work trips starting between 5:00 a.m. and 8:00 a.m., as well as of all trips starting in the area during that period, were made by employees of manufacturing firms. After 8:00 a.m., wholesale, retail trade, and private services were the major industries of employment of tripmakers making work trips in the Milwaukee area. The timing of afternoon work trips was similar to that of the morning work trips in that most of the work trips made by employees of manufacturing firms occurred prior to 4:00 p.m., slightly earlier than the major portion of the work trips made by employees of wholesale, retail trade, and private services industries, which peaked between 4:00 p.m. and 6:00 p.m.

Age: The majority of the persons making work trips in the Milwaukee area in 1972 were from 25 to 34, 35 to 44, and 45 to 54 years of age. Trips made by each of these groups constituted about 22 percent of the total work trips in the area. Each of these groups made work trips throughout the day, but the peaks for each age group paralleled those for the total population, with most work trips being made between 7:00 a.m. and 8:00 a.m., followed by a decline in work trips until 11:00 a.m., and then an increase to an afternoon peak between 3:00 p.m. and 4:00 p.m. Two population groups, those 20 to 24 years of age and those 16 to

Figure 10

HOURLY DISTRIBUTION OF PERSON TRIPS TO WORK IN THE MILWAUKEE AREA ON AN AVERAGE WEEKDAY BY MODE OF TRAVEL: 1972



NOTE: ALL TRIPS WHICH BEGIN DURING AN HOUR ARE SHOWN AT THE START OF THAT HOUR

Source: SEWRPC.

Table 28

AVERAGE WEEKDAY INTERNAL WORK TRIPS BY MODE DURING THE MORNING PEAK PERIOD (6:00 A.M. TO 9:00 A.M.) IN THE MILWAUKEE AREA: 1972

Mode of Travel	Morning Peak Period		Remainder of Day	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total
Auto Driver	229,500	78.2	224,400	82.7
Auto Passenger . . .	37,100	12.7	30,800	11.3
Transit Passenger . .	25,500	8.7	14,900	5.5
Other	1,300	0.4	1,400	0.5
Total	293,400	100.0	271,500	100.0

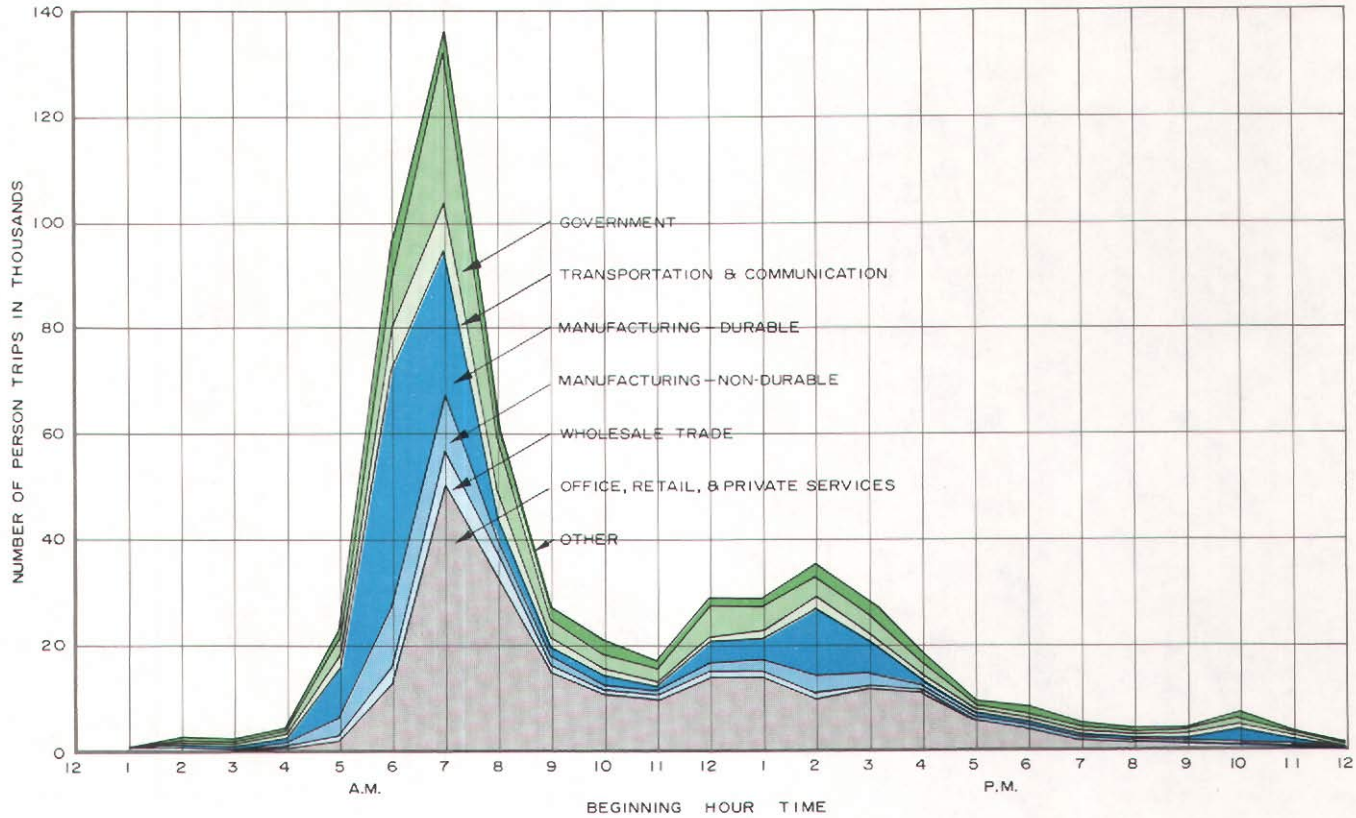
Source: SEWRPC.

19 years of age, varied slightly from this pattern. The 20- to 24-year-old group made more work trips from 6:00 a.m. to 7:00 a.m. than did other age groups. The 16- to 19-year-old group constituted a larger percentage of the work trips from 3:00 p.m. to 5:00 p.m. than of the work trips during other portions of the day, as shown in Figure 13.

Occupation: The temporal distribution of work trips in the Milwaukee area in 1972 by the occupation of the tripmaker is shown in Figure 14. Work trips made by operatives, laborers, and clerical employees tended to begin earlier than did work trips made by managers, office staff, and sales personnel. More than half of all work trips made by operatives, laborers, and clerical employees

Figure 11

HOURLY DISTRIBUTION OF PERSON TRIPS TO WORK IN THE MILWAUKEE AREA BY LAND USE AT DESTINATION: 1972



NOTE: ALL TRIPS WHICH BEGIN DURING AN HOUR ARE SHOWN AT THE START OF THAT HOUR

Source: SEWRPC.

began before 8:00 a.m.—67.5 percent, 67.8 percent, and 56.0 percent, respectively, compared with 32.6 percent of all work trips made by managers and office staff and only 18.3 percent of all work trips made by sales personnel. Operatives and craftsmen composed the largest proportion of all work trips made between 3:00 p.m. and 4:00 p.m., 17.9 percent and 16.6 percent, respectively, followed closely by trips made by managers and office staff, 16.6 percent, professional/technical workers, 12.6 percent, and sales personnel, 11.4 percent.

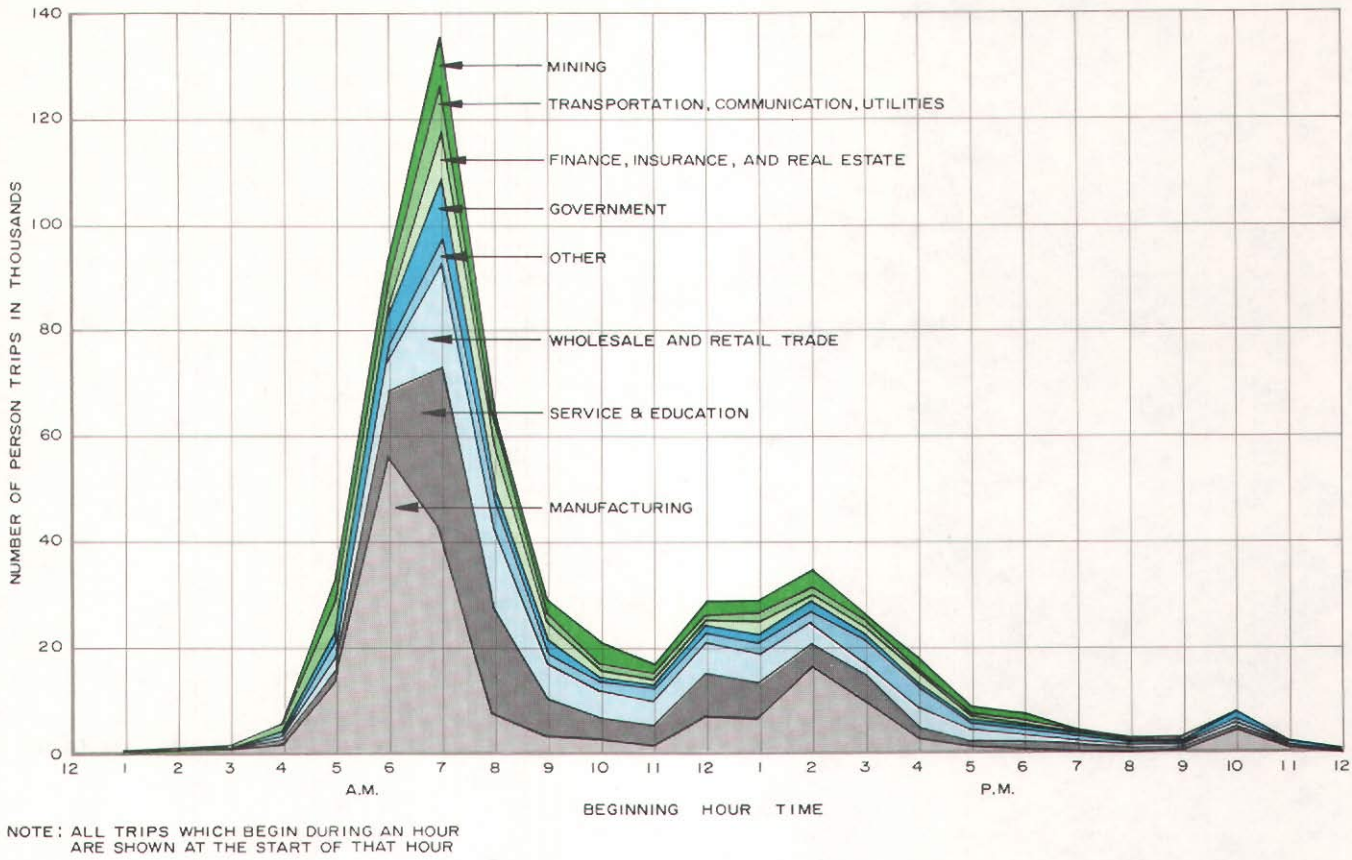
Temporal Stability of Travel Demand, Habits, and Patterns Between 1963 and 1972

Comprehensive travel inventories, as discussed earlier, have been conducted by the Commission in both 1963 and 1972. The data presented in this chapter have been drawn from the 1972 inventories, since these are the most current data available. Eight years have passed since the data were collected and, as discussed in Chapter III, many changes have occurred within the Milwaukee area and the Region over that period of time.

Between 1970 and 1978, the population of the Region increased by about 14,400 people, or about 1 percent, and employment increased by 110,200 jobs, or 15 percent. From 1963 to 1972, the population of the Region increased by 117,900 people, or 19 percent, and employment in the Region increased by 117,900 jobs, or 19 percent. During this nine-year period, total tripmaking within the Region is estimated to have increased by

Figure 12

HOURLY DISTRIBUTION OF PERSON TRIPS TO WORK IN THE MILWAUKEE AREA BY INDUSTRY OF EMPLOYMENT OF TRIPMAKER: 1972



NOTE: ALL TRIPS WHICH BEGIN DURING AN HOUR ARE SHOWN AT THE START OF THAT HOUR

Source: SEWRPC.

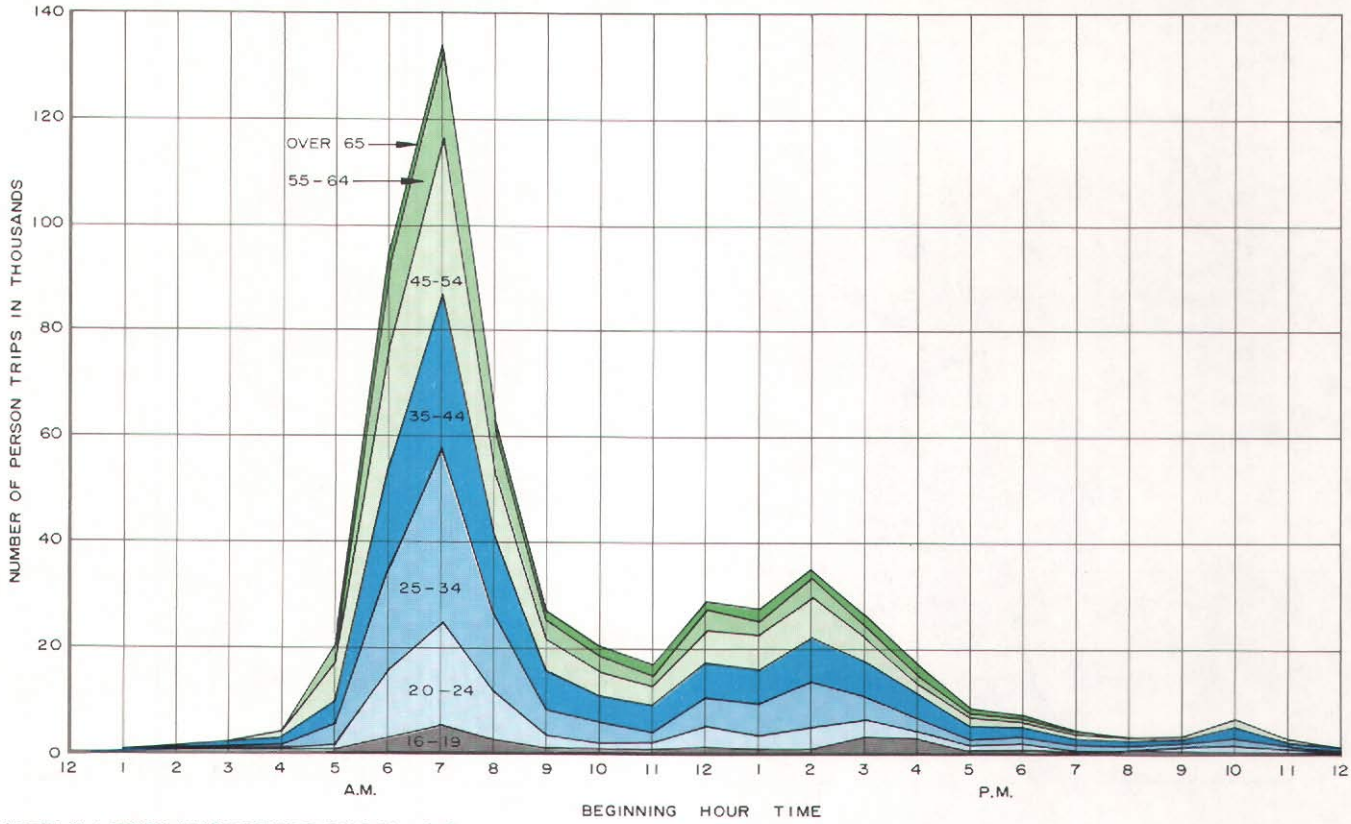
more than 900,000 trips, or 25 percent, while in the Milwaukee area person trip production is estimated to have increased by 538,000 trips, or 20 percent, and work trips by 41,800 trips, or 8 percent, as shown in Table 29. However, personal travel habits and patterns within the Milwaukee area, particularly as they relate to work time rescheduling, were found to have remained stable from 1963 to 1972. Accordingly, it may be assumed that such habits and patterns have remained stable from 1972 to 1978.

Importantly, the temporal distribution of work trips was quite similar in 1963 and 1972, with travel peaks, the times of greatest concern in any study of work time rescheduling, occurring during the same morning and afternoon peak periods. As shown in Figure 15, the hourly distribution of work trips on an average weekday in the years 1963 and 1972 differs primarily between the hours of 6:00 a.m. and 7:00 a.m., with about 18 percent of all work trips in 1963 and 17 percent of all work trips in 1972 starting during that hour.

Work trips also constituted about the same proportion of total daily travel during each hour of an average weekday in 1972 and 1963. This similarity is particularly true for the peak travel periods of the day (see Figure 16). The largest difference in the proportion of hourly work trips is evident during the midday period from 9:00 a.m. to 2:00 p.m. Figure 17 shows a similar correlation for trips

Figure 13

HOURLY DISTRIBUTION OF PERSON TRIPS TO WORK IN THE MILWAUKEE AREA BY AGE OF TRIPMAKER: 1972



NOTE: ALL TRIPS WHICH BEGIN DURING AN HOUR ARE SHOWN AT THE START OF THAT HOUR

Source: SEWRPC.

which originate at work. The difference indicated between the hours of 2:00 a.m. and 4:00 a.m. is large only in terms of the percentage of work trips occurring during these hours, since work trips during these hours represented only 0.2 percent of all trips in 1963 and 0.3 percent of all trips in 1972. Thus, although more trips for purposes other than work were being made in 1972 than in 1963, the proportion of work trips made during the morning and afternoon peak periods remained about the same over that time period.

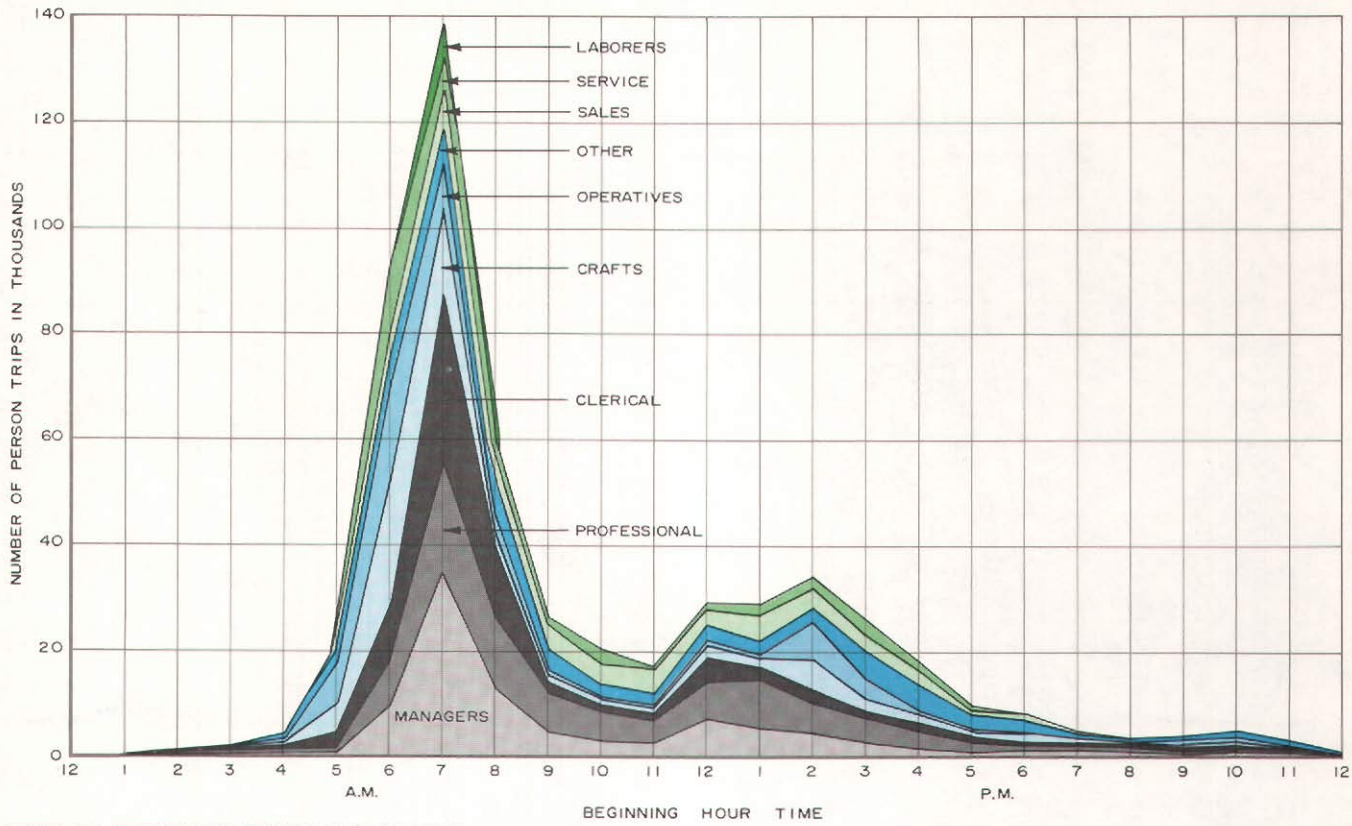
Based upon the stability in the relevant travel characteristics from 1963 to 1972, it is reasonable to assume that, although the magnitude and composition of travel may have continued to change in the Milwaukee area since 1972, the temporal distribution of work trips in the Milwaukee area, as it relates to work time rescheduling, has not changed dramatically.

SUMMARY AND CONCLUSIONS

This chapter has presented some of the salient characteristics of personal travel in southeastern Wisconsin and the Milwaukee area in order to provide a foundation for the formulation and evaluation of work time rescheduling plans. The primary purpose of this study is to find the best means of spreading the peak-hour travel demand over surrounding hours in order to reduce the peak-hour highway and transit congestion in the

Figure 14

HOURLY DISTRIBUTION OF PERSON TRIPS TO WORK IN THE MILWAUKEE AREA BY OCCUPATION OF TRIPMAKER: 1972



NOTE: ALL TRIPS WHICH BEGIN DURING AN HOUR ARE SHOWN AT THE START OF THAT HOUR

Source: SEWRPC.

Table 29

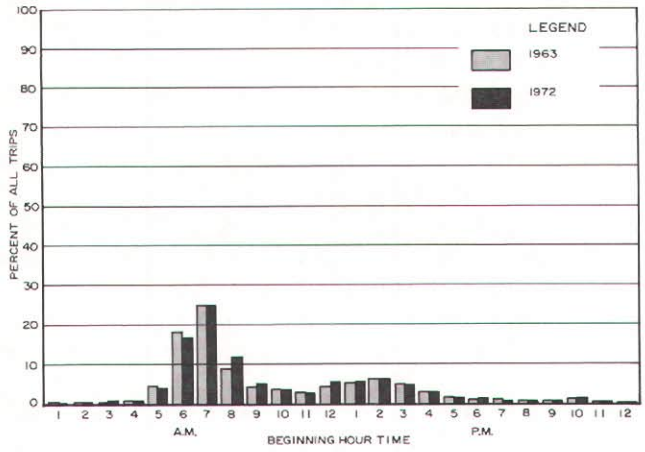
TOTAL PERSON TRIPS AND WORK TRIPS MADE WITHIN THE REGION: 1963 AND 1972

Area	Person Trips				Work Trips			
			Difference				Difference	
	1963	1972	Number	Percent	1963	1972	Number	Percent
Region	3,603,000	4,504,900	901,900	25.0	664,400	740,800	76,400	11.5
Milwaukee Area	2,700,000	3,238,000	538,000	19.9	523,000	564,800	41,800	8.0

Source: SEWRPC.

Figure 15

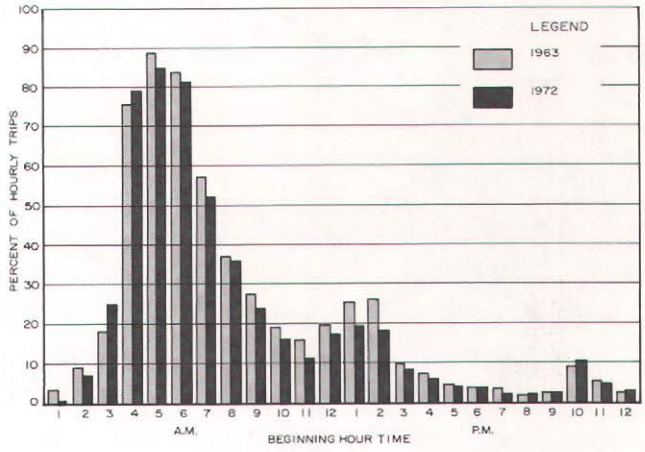
HOURLY DISTRIBUTION OF PERSON TRIPS TO WORK AS A PERCENTAGE OF DAILY WORK TRIPS: 1963 AND 1972



Source: SEWRPC.

Figure 16

HOURLY DISTRIBUTION OF PERSON TRIPS TO WORK AS A PERCENTAGE OF TOTAL HOURLY WORK TRIPS: 1963 AND 1972



Source: SEWRPC.

Milwaukee area. The data presented in this chapter have been drawn from the personal travel data gathered under the Regional Planning Commission's continuing, comprehensive areawide planning program. Particular emphasis has been placed on travel to and from work since this is the basis for alternative work time rescheduling plans.

Below is a summary of the characteristics of personal travel in southeastern Wisconsin important to the preparation of work time rescheduling plans.

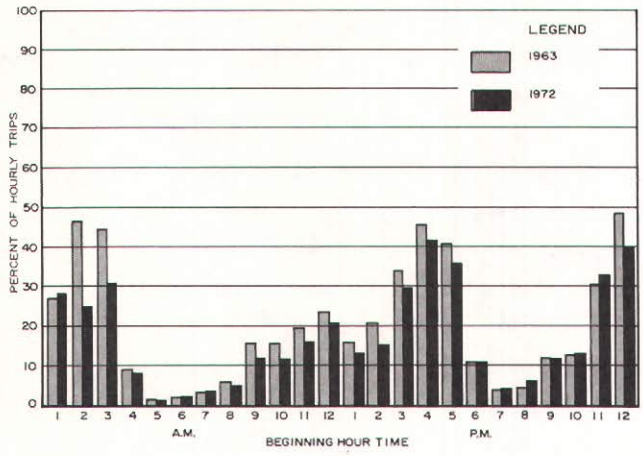
1. A total of 4.68 million person trips were made in the Region on an average weekday in 1972. Of these trips, 3.2 million had destinations within the Milwaukee area. At the same time, the average internal person trip generation rate in the Milwaukee area was 2.5 trips per capita and 7.9 trips per household, with the most central portions of the City of Milwaukee having lower trip generation rates of 2.1 per capita and 6.3 per household. The outlying suburban areas had higher trips generation rates—3.5 per capita and 7.9 per household.

2. Differences in the rate of tripmaking by households are related to differences in automobile availability, household size, and household income. Increases in both the number of automobiles available and household income were shown to be related to increases in the number of trips per household. It was also shown that larger households produce more trips per household and have higher per-person-trip production rates than do single-person households.

3. In 1972 trips to work were second in importance only to trips to home in the Milwaukee area. More than half of all trips made between the hours of 4:00 a.m. and 8:00 a.m. on an average weekday were work trips. Trips to work accounted for 17.4 percent of total trip destinations, while trips to home accounted for 40.0 percent. Travel to and from work, like travel for all other trip purposes, was made primarily by the automobile in 1972. Automobiles provided transportation for 92 percent of all work trips in the Milwaukee area. Although transit trips,

Figure 17

HOURLY DISTRIBUTION OF PERSON TRIPS FROM WORK AS A PERCENTAGE OF TOTAL HOURLY WORK TRIPS: 1963 AND 1972



Source: SEWRPC.

the Region. The morning peak period, 6:00 a.m. to 9:00 a.m., was composed primarily of work trips, with rapid increases in the volume of trips occurring over a short period of time. The afternoon peak period, 3:00 p.m. to 6:00 p.m., was characterized by outside of school bus trips, accounted for only 5.6 percent of total travel in the Milwaukee area on an average weekday in 1972, they accounted for 22 percent of all trips to the Milwaukee central business district on an average weekday.

4. In 1972 the characteristics of travel during the morning and afternoon peak periods in the Milwaukee area were similar to those in higher trip volumes, more sustained volumes, and a larger proportion of trips being made for shopping and personal business purposes.

5. The starting times of work trips made within the peak hours are related to the age, occupation, and industry of employment of the tripmakers. Based on the 1972 home interview survey conducted by the Commission, more trips are made by employees of manufacturing firms during the first half of the morning peak period than by employees of any other industry. Similarly, three occupation groups, laborers, operatives, and clerical employees, tend to start their work trips earlier than do other occupation groups. Later in the morning peak period, from 8:00 a.m. to 9:00 a.m., a larger proportion, 42 percent, of the work trips are made by managers and office personnel and professional/technical employees. Most of the persons making work trips in the Milwaukee area are from 25 to 34, 35 to 44, and 45 to 54 years of age, with each group constituting about 22 percent of total work trips in the area. The peak periods of work trips for these age groups occur between 7:00 a.m. and 8:00 a.m. and between 3:00 p.m. and 4:00 p.m.

Peak-period demand thus accounted for substantial percentages of the total daily automobile and transit demand in the Milwaukee area in 1972. No single age, occupation, or employment group had peak-period travel characteristics which were dramatically different from those of other age, occupation, or employment groups, although within the morning and afternoon peak periods there were differences in the starting times of various groups. Nevertheless, 50 percent of all work trips began between 6:00 a.m. and 9:00 a.m. in 1972. Because of the substantial peak-period demand for work travel, a potential exists to reduce peak-period highway and transit congestion in the Milwaukee area by spreading peak-hour work travel demand over adjacent earlier and later hours, depending upon the spatial distribution of that demand and the capacity of the transportation system.

Chapter V

MILWAUKEE AREA TRANSPORTATION FACILITIES AND SERVICES AND THEIR USAGE

INTRODUCTION

Any transportation system planning effort must consider the supply of as well as the demand for transportation facilities and services. This is particularly true for the Milwaukee area work time rescheduling study because its objective is to use more efficiently the existing supply of transportation facilities and services through the spreading of peak travel demands. For the purposes of this study, the transportation system of the Milwaukee area is defined as the extensive and well-developed network of arterial streets and highways within the area, and the network of public transit motor bus lines operated in the area.

EXISTING TRANSPORTATION FACILITIES AND SERVICES

Existing Supply of Streets and Highways

The total street and highway system of the Milwaukee area in 1978 consisted of 4,451 miles of facilities, of which 1,306 miles, or about 29 percent, were classified by function as arterials; and 3,145 miles, or about 71 percent, were classified as collector and land access streets, as shown on Map 13 and in Table 30. In the Region in 1978, about 32 percent, or 3,294 miles, of a 10,436-mile system was classified as arterials. Thus, although the Milwaukee area comprised about 22 percent of the total area of the Region in 1978, it contained 43 percent of the total regional street and highway mileage and 40 percent of the regional arterial mileage.

Arterials consist of those streets and highways which serve the movement of heavy volumes of through motor vehicle—automobiles, motor trucks, motorcycles, and motor bus—traffic between major subareas of the Region, between such subareas and points outside the Region, and through the Region. The primary function of arterial facilities is the expeditious movement of vehicular traffic. Access to abutting property may be a secondary function of some types of arterial streets and highways, but it should always be subordinate to the primary function of traffic movement. Together, the arterials should form an integrated, areawide system, located and designed to properly carry the imposed traffic loadings. It is this arterial street system which must meet the heaviest travel demands, which experiences the greatest traffic congestion problems, and which potentially can receive the greatest benefit from work time rescheduling.

Freeways, expressways, and certain parkways, as well as standard arterial streets and highways, all are types of facilities which may be included in this arterial system.[1] In 1978 freeways accounted for more than 8 percent of the 1,307 miles of arterial facilities in the Milwaukee area, and 7 percent of the 3,294 miles of arterial facilities in the Region as a whole.

The jurisdictional responsibilities for the existing arterial street and highway system of the study area are shown on Map 14 and summarized in Table 31. This jurisdictional classification establishes which level of government—state, county, or local—has responsibility for the design, construction, maintenance, and operation of each segment of the area's arterial street and highway system. As set forth in Table 31, nearly 32 percent, or 418 miles, of the existing Milwaukee area arterial street mileage is on the state trunk highway

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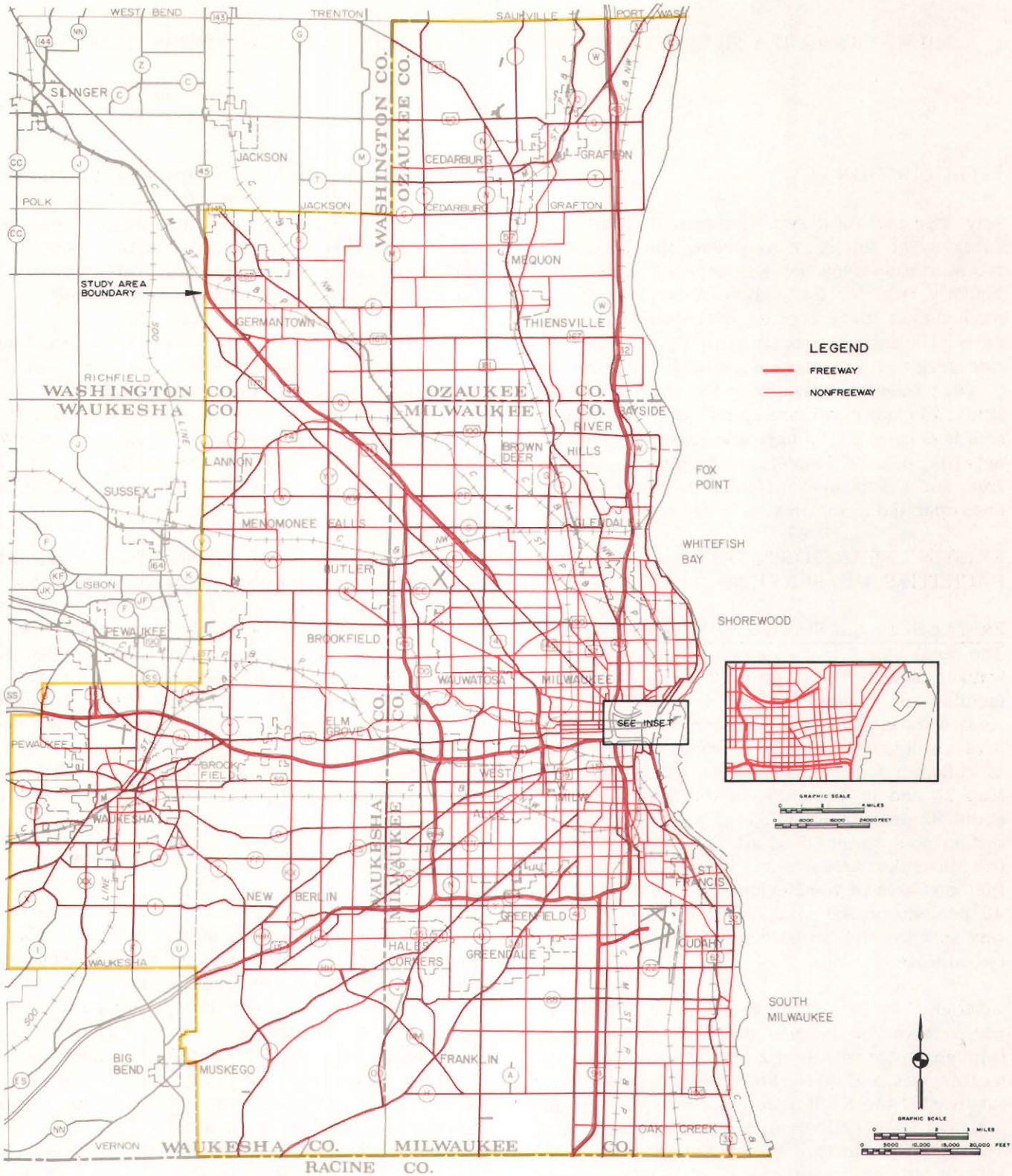
[1] *A freeway is defined as a divided arterial highway with full control of access and grade separations at all intersections. An expressway is defined as a divided arterial highway with full or partial control of access and grade separations at some, but not necessarily all, intersections. A parkway is defined as an arterial highway provided for noncommercial traffic with full or partial control of access and usually located within a ribbon of parklike development. The term parkway as defined herein should not be confused with park roads or drives, which are not intended to serve as arterials. Standard arterial streets and highways may be defined as arterials with at-grade intersections with no control of access—that is, with direct access to abutting property.*

Map 13

ARTERIAL STREETS AND HIGHWAYS IN THE MILWAUKEE AREA: 1978



In 1978 there were a total of 4,500 miles of streets and highways of all kinds—arterials, collectors, and land access—open to traffic within the Milwaukee area, of which 1,300 miles, or about 29 percent, were functioning as arterial streets and highways. Although the responsibility for the financing, construction, operation, and maintenance of these arterial facilities rests with one federal agency, one state agency, four county units of government, and 38 local units of government within the Milwaukee area, these facilities must form a single integrated system able to safely and efficiently serve the existing and probable future travel demand within the area without regard to county and municipal boundary lines.

Source: SEWRPC.

Table 30

DISTRIBUTION OF STREET AND HIGHWAY MILEAGE IN THE REGION AND THE MILWAUKEE AREA BY COUNTY: 1978

Portion of Study Area	Existing Arterials (miles)			Existing Nonarterials (miles)	Total Miles
	Freeway	Standard	Total		
Milwaukee County	69.2	684.8	754.0	2,048.8	2,802.8
Ozaukee County	12.2	148.1	160.3	243.8	404.1
Washington County	6.1	56.5	62.6	60.6	123.2
Waukesha County	23.2	306.4	329.6	791.6	1,121.2
Total					
Milwaukee Area	110.7	1,195.8	1,306.5	3,144.8	4,451.3
Region	237.7	3,056.2	3,293.9	7,141.7	10,435.6

Source: Wisconsin Department of Transportation and SEWRPC.

system, including all 111 miles of freeway in the area. More than 20 percent, or about 263 miles, of the arterial street system in the Milwaukee area is on the county trunk highway system, and is the responsibility of Milwaukee, Waukesha, Washington, or Ozaukee Counties. The remaining 48 percent of the Milwaukee area arterial street and highway system, or nearly 626 miles, is under the jurisdiction of cities, villages, and towns as local trunk highways. In 1978, nearly 39 percent of the Region's arterial street mileage was on the state trunk highway system, 34 percent was on the county trunk highway system, and the remaining 27 percent was the responsibility of cities, villages, and towns. County trunk facilities constitute a smaller proportion of the total system in the Milwaukee area than in the Region because of the historic dissolution of the county trunk highway system in Milwaukee County as unincorporated areas of the County were increasingly incorporated into municipalities.

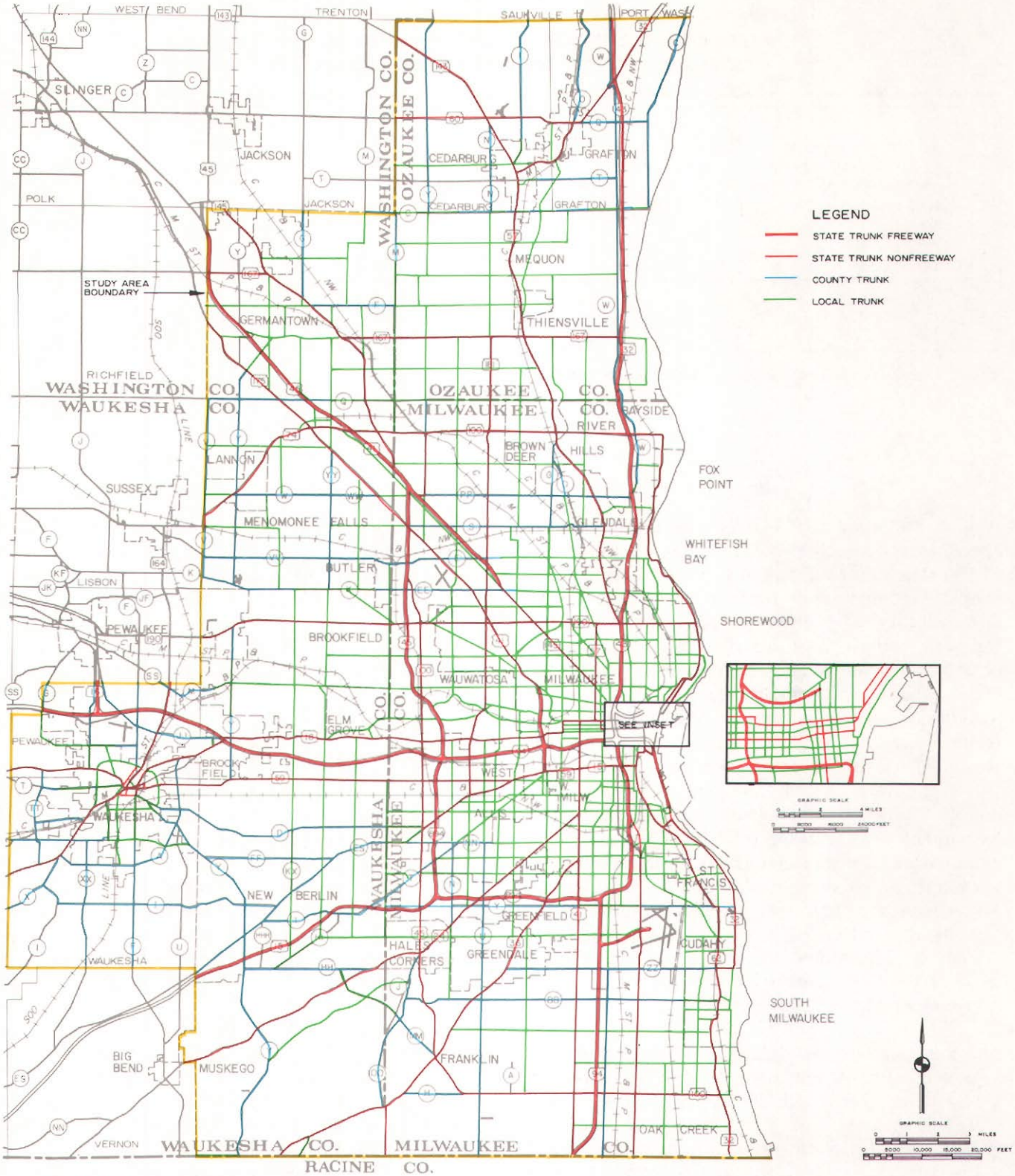
The arterial street and highway system of the study area can be further classified in terms of the federal aid systems which underlie it. The four basic federal aid systems are the federal aid interstate system, the federal aid primary system, the federal aid secondary system, and the federal aid urban system. The classification of the street and highway system by federal aid system as it existed in 1978 is shown on Map 15 and presented in Table 32. About 1,250 miles of the Milwaukee area arterial street system, or about 95 percent of the system, were a part of a federal aid system. More than 70 miles, or 5 percent of the Milwaukee area arterials, were on the federal aid interstate system; 240 miles, or 19 percent, were on the federal aid primary system; 900 miles, or 69 percent, were on the federal aid urban system; and 30 miles, or 2 percent, were on the federal aid secondary system.

Capacity of the Arterial Street and Highway System

The service provided by the existing arterial street system of the Milwaukee area may be described in terms of the maximum capacity of the various segments of the system. The maximum capacity of a segment of street or highway is the maximum number of vehicles which can pass over that facility given the characteristics of the street and the traffic using it during a specified period of time, usually one hour. In order for a facility to operate at maximum capacity, the density of traffic in all lanes of the facility must be increased relative to the density of traffic operating under free-flow conditions. As a result of this increased density, speeds on the facility are necessarily reduced, and lane changing and maneuverability become difficult, if not impossible. Traffic flow on a facility at maximum capacity is unstable, because almost continual speed changes are required of vehicles on the facility as momentary stoppages of traffic flow occur. Moreover, there is the potential for an arterial facility operating at maximum capacity to move into a breakdown, or traffic jam, condition, with frequent traffic stoppages and substantially

Map 14

JURISDICTIONAL STREET AND HIGHWAY SYSTEM IN THE MILWAUKEE AREA: 1978



As shown on this map, the design, construction, operation, and maintenance of the existing arterial street and highway system is the responsibility of three levels of government: state, county, and local. Because of the nature of local streets and highways and the piecemeal additions and deletions which have been made in the county trunk highway system over time, only the state trunk highway system constitutes a truly integrated street and highway system within the Milwaukee area.

Source: SEWRPC.

Table 31

DISTRIBUTION OF STREET AND HIGHWAY MILEAGE IN THE MILWAUKEE AREA AND THE REGION BY JURISDICTION AND COUNTY: 1978

Portion of Study Area	Existing Arterials (miles)						Existing Nonarterials (miles)			Total Miles
	State Trunk Highway		Connecting Streets	County Trunk Highway	Local Trunk Highway	Total	County Trunk Highway	Local Trunk Highway	Total	
	Freeway	Nonfreeway								
Milwaukee County	69.2	95.2	93.1	82.7	413.8	754.0	62.4	1,986.4	2,048.8	2,802.8
Ozaukee County	12.2	31.7	6.0	41.7	68.7	160.3	3.6	240.2	243.8	404.1
Washington County	6.1	15.5	--	10.2	30.8	62.6	5.3	55.3	60.6	123.2
Waukesha County	23.2	51.8	14.4	128.0	112.2	329.6	12.7	778.9	791.6	1,121.2
Total										
Milwaukee Area	110.7	194.2	113.5	262.6	625.5	1,306.5	84.0	3,060.8	3,144.8	4,451.3
Region	237.7	863.1	173.8	1,124.8	894.5	3,293.9	428.8	6,712.9	7,141.7	10,435.6

Source: Wisconsin Department of Transportation and SEWRPC.

lowered speeds. Breakdown conditions can also result from aberrations such as inclement weather, street or utility maintenance that restricts street width, and minor accidents. If arterial facilities were planned and designed to operate at maximum capacity, a very limited number of aberrations in the system could potentially result in breakdown, or traffic jam, conditions over a large area of the system. Therefore, arterial street systems are not designed to operate at maximum capacity. Nevertheless, specific project planning may recommend that at-maximum-capacity conditions occur on certain arterial portions of a facility, particularly during peak travel hours, and therefore on limited portions of the total system.

Arterial systems are usually planned to operate at a design capacity which is about 70 percent of maximum capacity. At design capacity the potential for traffic breakdown, even assuming some aberrations affecting traffic flow, is reasonably limited. However, even on facilities operating at design capacity, operating speed and lane changing are sometimes constrained, and there are backups and delays behind turning vehicles at controlled intersections.

Figure 18 shows an arterial operating approximately at design capacity. As indicated by this figure, vehicle spacing at design capacity conditions is close enough that operating speeds and maneuverability are controlled by the traffic volume. Most drivers are restricted by adjacent vehicles in selecting their own speeds, changing lanes, or passing, although a relatively satisfactory operating speed is still maintained. As traffic volumes increase on a street or highway and the degree of congestion reaches that associated with operation over design capacity, the following traffic conditions will occur:

1. The amount of delay a driver experiences at traffic signals will increase because vehicles attempting to use the intersection will back up, and not all vehicles will be able to proceed through the intersection on a single green light phase;

2. The average speed of vehicles on the roadway segment between intersections will decrease as vehicles reduce speed to maneuver through traffic;

3. The overall travel time required of a motorist to complete a trip will increase;

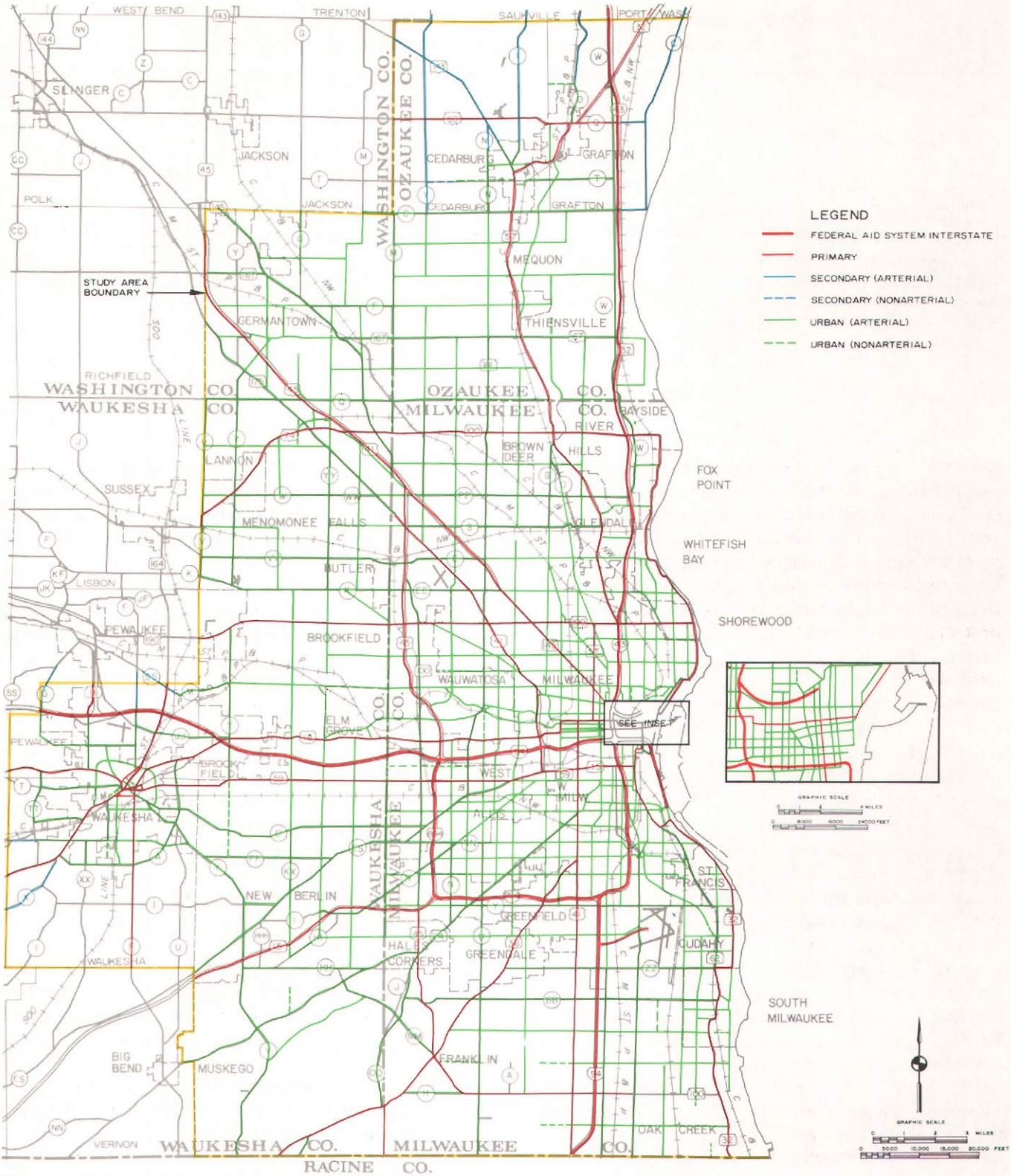
4. The rate of fuel consumption will increase because a vehicle cannot maintain a constant speed, and is required to decelerate, accelerate, and idle during delays; and

5. The air pollutants emitted by vehicles will increase as vehicles operate at lower speeds and idle at intersections.

Figure 19 shows a facility operating "over" design capacity. Vehicle spacing and operating speeds are less than those at design capacity. Traffic flow is unstable and momentary stoppages occur, and drivers are unable to maneuver and change lanes.

Map 15

FEDERAL AID HIGHWAY SYSTEM IN THE MILWAUKEE AREA: 1978



Streets and highways designated as part of the federal aid highway system are eligible for federal aid in partial support of their improvement. Federal participation in highway improvements should be focused on those facilities which constitute the arterial system, since these facilities serve not only intracommunity travel, but also intercommunity, intercounty, interregional, and interstate travel.

Source: SEWRPC.

Table 32

EXISTING FEDERAL AID SYSTEM ROUTE MILES IN THE MILWAUKEE AREA AND THE REGION BY COUNTY AND FEDERAL AID CLASSIFICATION: 1978

Portion of Study Area	Federal Aid System Route Miles				
	Interstate	Primary	Secondary	Urban	Total
Milwaukee County	48.2	149.3	--	524.7	722.2
Ozaukee County	12.2	21.2	26.6	98.4	158.4
Washington County	--	5.8	--	53.4	59.2
Waukesha County	11.4	67.2	5.5	223.5	307.6
Total					
Milwaukee Area	71.8	243.5	32.1	900.0	1,247.4
Region	124.3	952.0	715.3	1,085.7	2,877.3

Source: Wisconsin Department of Transportation and SEWRPC.

Each arterial street and highway segment within the Milwaukee area in 1978 was defined in terms of its peak-hour design capacity. The peak-hour design capacity of arterial segments was defined primarily as a function of the segment's number of traffic lanes and pavement width, modified by factors representing the presence of lateral restrictions and the percentage of trucks in the traffic flow. The peak-hour design capacity of the intersections of standard arterial streets and highways was defined as a function of the intersection's approach pavement width, modified by factors reflecting the location of the intersection with respect to the intensity of urban development, the directional imbalance in the traffic flow, the intersection approach gradient, the percentage of right- and left-turning vehicle movements, the percentage of trucks in the traffic flow, the provision for parking along the street or highway, and the percentage of the traffic signal cycle which was allocated to the green phase. Normally in an urban setting, it is the intersection approach capacities, and not the capacities of the segments between intersections, that limit street capacity.

Map 16 indicates the peak-hour design capacity for each segment of the arterial street and highway system in the Milwaukee area in 1978, based upon the controlling factor—that is, the intersection approach or segment capacity—but generalized and expressed in terms of the number of moving traffic lanes. The hourly design capacity of freeway facilities in the Milwaukee area ranges from approximately 3,000 vehicles per hour to about 6,000 vehicles per hour in each direction, while the hourly design capacity of standard arterials ranges from approximately 500 vehicles per hour to about 1,800 vehicles per hour in each direction. Since the arterial system of the Milwaukee area has been developed over a long period of time in response to actual and perceived travel demands, facilities with the greatest capacity and closest spacing are located in the most highly developed portions of the Milwaukee area, particularly in and around the Milwaukee central business district. Both the capacity and spacing of the arterials decrease in the outlying, less developed portions of the area.

Highway System Utilization and Relationship to Capacity

Total vehicle miles of travel has increased within the Region as a whole since 1963. In that year the Commission's first areawide travel survey indicated that 13,072,000 vehicle miles of travel occurred within the Region on an average weekday. By 1972, the year of the Commission's second areawide travel survey, vehicle miles of travel had increased to about 20,124,000 per average weekday, an increase of 54 percent, or an annual compounded growth rate of 4.9 percent. Between 1972 and 1978 vehicle miles of travel continued to increase, but at a somewhat slower annual rate. In 1978 vehicles miles of travel totaled about 24,520,000 per average weekday, an increase of 22 percent since 1972, or an annual compounded growth rate of 3.3 percent. While there was a temporary setback in the growth of travel during the oil embargo of 1973-1974, the long-term upward trend was

Figure 18

TYPICAL ARTERIAL STREET
OPERATING AT DESIGN CAPACITY

This photograph shows typical at-design-capacity operations on the eastbound approach to the intersection of W. Capitol Drive and N. 27th Street. The volume-to-design capacity ratio is 1.0, indicating that the arterial exhibits traffic volumes equal to design capacity—a condition which is defined as the upper limit of level of service "C" for arterial street and highway operation. A steady traffic flow, with some attendant restrictions on a driver's opportunity to change from one traffic lane to another, slightly reduced vehicle operating speed, and short delays at some intersections, characterize facilities operating at design capacity.

Source: SEWRPC.

Figure 19

TYPICAL ARTERIAL STREET
OPERATING OVER DESIGN CAPACITY

This photograph shows the intersection of W. Capitol Drive and N. 27th Street when operating over design capacity. The volume-to-design capacity ratio is now 1.19, indicating that traffic volumes substantially exceed design capacity. The facility is operating at level of service "E," meaning that traffic volumes approach the maximum capacity and exhibit unstable flow and congested operation. A heavy flow of traffic precluding a driver's opportunity to change from one traffic lane to another, substantially reduced vehicle operating speeds, and extended delays at intersections caused by backups of vehicles characterize facilities operating over design capacity.

Source: SEWRPC.

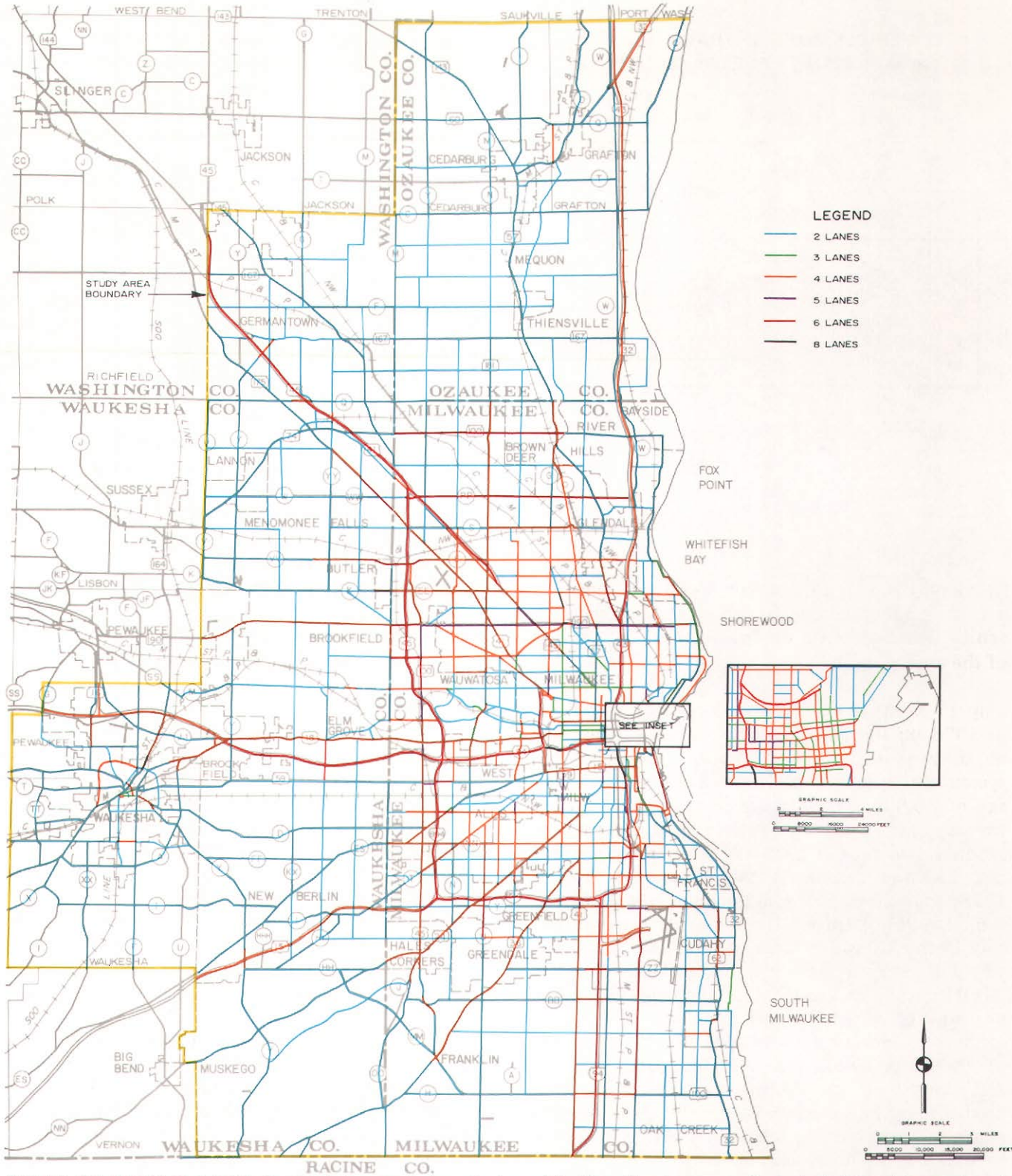
soon reestablished until the gasoline shortage of mid-1979. Figure 20 shows the annual vehicle miles of travel on the Milwaukee County freeway system from 1970 through 1979.

The detailed breakdown of growth in daily vehicle miles of travel in the Milwaukee area and the Region between 1963 and 1978 is shown in Table 33. Average weekday vehicle miles of travel increased by 6 percent annually in both the Milwaukee area and the Region between 1963 and 1972. Vehicle miles of travel showed greater increases in the suburban portions of the Milwaukee area, with annual increases of as large as 10 percent in the Waukesha and Washington County portions of the area, and 17 percent in the Ozaukee County portion. During this time, about 75 miles of freeways and expressways were completed within the Milwaukee area, leading to a four-fold increase in the daily mileage on such facilities—from 1.5 million vehicle miles of travel on an average weekday in 1963 to 6.2 million vehicle miles of travel on an average weekday in 1972. In Milwaukee County, the average weekday vehicle mileage on such facilities increased from 530,000 miles in 1963 to 4 million miles in 1972. Between 1972 and 1978, vehicle miles of travel within the Milwaukee area and the Region continued to increase but at a slower rate—less than 4 percent per year.

Vehicle miles of travel increased twice as much on freeways and expressways as on the other arterials in the Milwaukee area and the Region between 1972 and 1978. In the Milwaukee area vehicle miles of travel increased by 34.3 percent on freeways and expressways and by only 15.8 percent on other arterials. The corresponding increases for the Region were 33.9 percent and 16.5 percent. From 1972 to 1978, the Milwaukee County portion of the Milwaukee area experienced smaller increases than the suburban areas in not only total vehicle miles of travel but also travel on both freeways and other arterials. The completion of the North-South

Map 16

CAPACITY OF ARTERIAL STREETS AND HIGHWAYS IN THE MILWAUKEE AREA: 1978

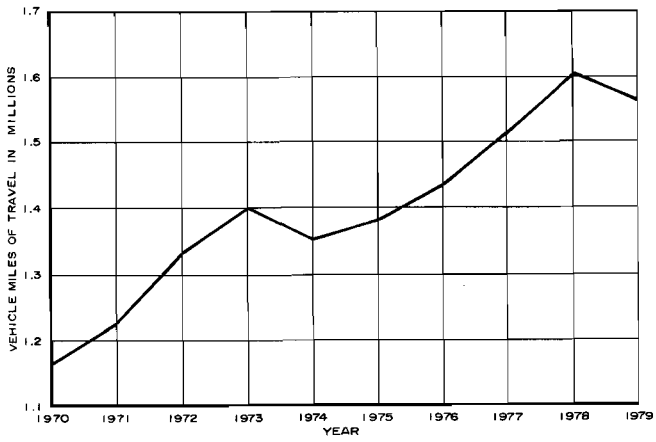


Although the capacity of a facility is related to many factors, the type of facility—either freeway or standard arterial—and the number of moving traffic lanes have the greatest influence. This map shows the number of lanes available for traffic during the morning peak period for freeways and standard arterials. Since this arterial system has been developed over a long period of time in response to actual and perceived travel demands, facilities with the greatest capacity and closest spacing are located in the most highly developed portions of the Milwaukee area, particularly in and around the Milwaukee central business district. Both the capacity and the spacing of the arterials decrease in the outlying, less developed portions of the area.

Source: SEWRPC.

Figure 20

VEHICLE MILES OF TRAVEL ON MILWAUKEE COUNTY FREEWAYS: 1970-1979



Source: SEWRPC.

Freeway (IH 43) in Ozaukee County during this period is reflected in the substantial increase in vehicle miles of travel on freeways in that portion of the area.

Map 17 shows the average weekday traffic volumes in 1978 on the Milwaukee area arterial street and highway system. The Milwaukee area freeway system was heavily used in 1978, carrying an average of 56,800 vehicle miles of travel per mile of freeway per weekday. Although freeways constituted less than 9 percent of the arterial street and highway system in the Milwaukee area in 1978, they carried over 62 percent of the arterial vehicle miles of travel. The most heavily used freeway in the Milwaukee area was the East-West Freeway (IH 94) between the North-South Freeway (IH 94-IH 43) and the Stadium Freeway (USH 41), portions of which carried in excess of 120,000 vehicles on an average weekday in 1978. Portions of the North-South Freeway immediately north and south of the Milwaukee central business district were the next most heavily used freeway segments, with average weekday traffic volumes in excess of 110,000 vehicles in 1978.

Major nonfreeway arterials, particularly in the northwest side of the City of Milwaukee, also carried substantial average weekday traffic volumes in 1978. More than 25,000 vehicles per day were carried on portions of W. Capitol Drive, W. Good Hope Road, and W. Silver Spring Drive between the Zoo Freeway (IH 45) and the North-South Freeway (IH 43); W. Appleton Avenue and W. Fond du Lac Avenue north of W. Capitol Drive; portions of W. Lisbon Avenue between N. 27th Street and W. Appleton Avenue; Sherman Boulevard south of W. Center Street; W. Howard Avenue west of S. Howell Avenue; W. Layton Avenue on portions between S. Loomis Road and S. Howell Avenue; S. Howell Avenue south of E. Layton Avenue; W. National Avenue east of S. 35th Street; portions of S. 27th Street between W. Oklahoma Avenue and W. Harwood Avenue; N. 6th Street south of W. Kilbourn Avenue; S. 35th Street north of W. National Avenue; N. 35th Street at W. Park Hill Avenue; portions of W. 76th Street between W. Bradley Road and W. Silver Spring Drive; STH 100 between Janesville Road and W. Capitol Drive; and W. Blue Mound Road on the portion between N. Sunny Slope Road and N. Barker Road. Traffic volumes on both freeways and standard arterials in the suburban portions of the Milwaukee area were generally lower than the traffic volumes on arterials within Milwaukee County.

EXISTING SUPPLY OF PUBLIC TRANSIT

Public transit is an important element of the transportation system in the Milwaukee area. Some form of public transportation is essential to the provision of a balanced transportation system in any large urbanized area, not only to meet the needs of that segment of the population unable to command direct use of personalized transportation, but also to provide an alternative, more efficient mode of travel for certain types of trips within urbanized areas, particularly in heavily traveled corridors. Public transit can be classified as fixed route or nonfixed route service, according to whether service is provided on regular schedules over prescribed routes or on a demand-responsive basis. Public transit can be further divided into common carrier and special carrier service, according to whether service is provided to the general public or limited to special subgroups of the general public. Thus, public transit can be divided for analysis purposes into four basic types: fixed route common carrier, fixed route special carrier, nonfixed route common carrier, and nonfixed route special carrier service. With the exception of nonfixed route common carrier service, all these types of services were provided in the study area in 1979.

Fixed route common carrier service was by far the largest and most heavily utilized form of public transit service operating in the study area in 1979.

Table 33

ARTERIAL VEHICLE MILES OF TRAVEL IN THE MILWAUKEE AREA AND THE REGION ON AN AVERAGE WEEKDAY BY COUNTY: 1963, 1972, AND 1978

Portion of Study Area	1963 Average Weekday Vehicle Miles of Travel (1,000's)			Annual Increment	
	Freeways and Expressways	Other Arterials	Total	Number (1,000's)	Percent
Milwaukee County	531	6,817	7,348	--	--
Ozaukee County	20	164	184	--	--
Washington County	73	39	112	--	--
Waukesha County	159	939	1,098	--	--
Total					
Milwaukee Area	783	7,959	8,742	--	--
Region	1,462	11,610	13,072	--	--

Portion of Study Area	1972 Average Weekday Vehicle Miles of Travel (1,000's)			Annual Increment 1963 to 1972	
	Freeways and Expressways	Other Arterials	Total	Number (1,000's)	Percent
Milwaukee County	3,977	6,718	10,695	372	5.1
Ozaukee County	74	389	463	31	16.8
Washington County	150	63	213	11	10.0
Waukesha County	484	1,592	2,076	109	9.9
Total					
Milwaukee Area	4,685	8,762	13,447	523	6.0
Region	6,213	13,911	20,124	784	6.0

Portion of Study Area	1978 Average Weekday Vehicle Miles of Travel (1,000's)			Annual Increment 1972 to 1978	
	Freeways and Expressways	Other Arterials	Total	Number (1,000's)	Percent
Milwaukee County	4,883	7,523	12,406	285	2.7
Ozaukee County	303	673	976	86	18.4
Washington County	257	103	360	25	11.5
Waukesha	847	1,846	2,693	103	5.0
Total					
Milwaukee Area	6,290	10,145	16,435	498	3.7
Region	8,320	16,200	24,520	733	3.6

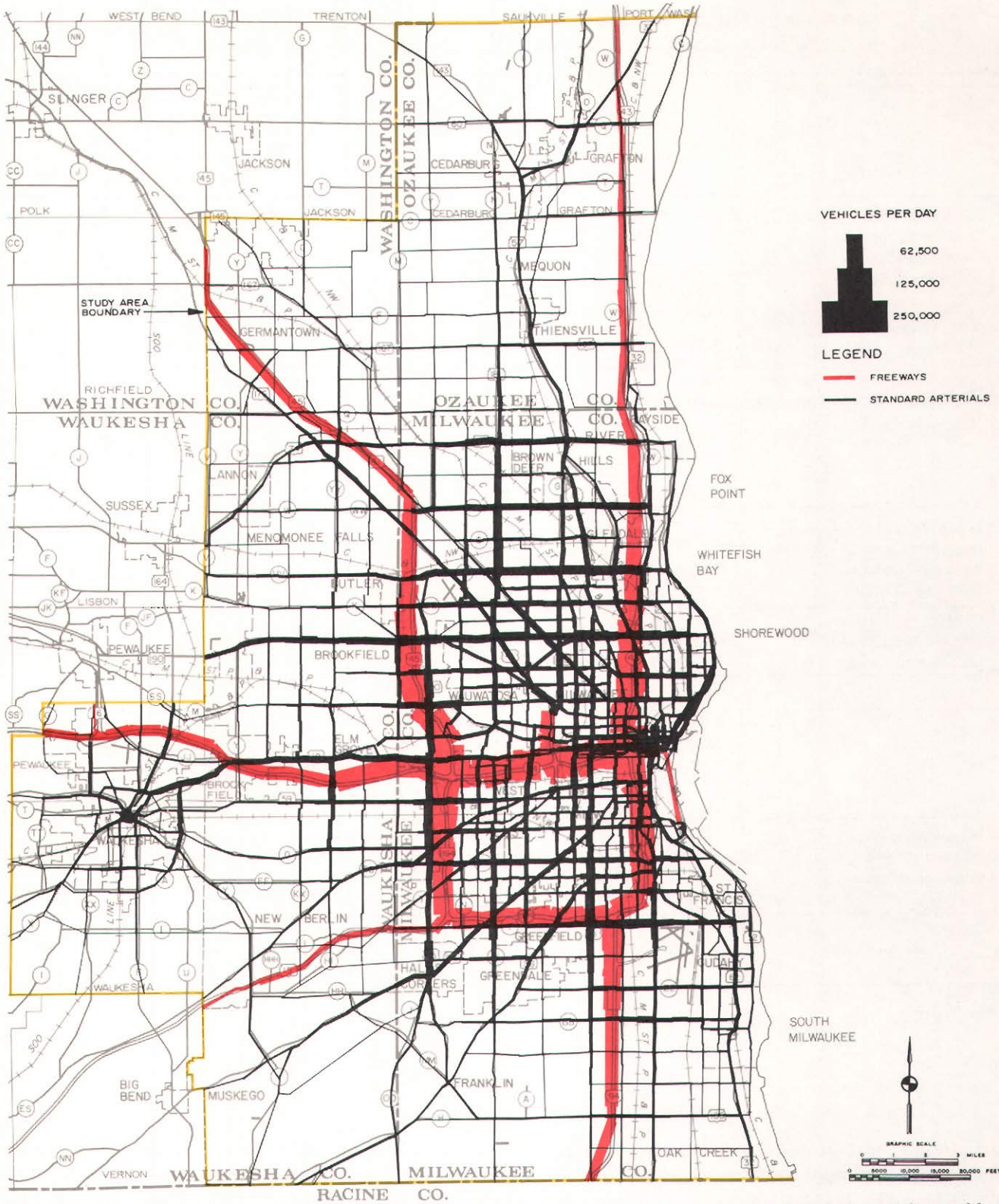
Source: SEWRPC.

Fixed route common carrier service was operated at the primary, or rapid, secondary, or express, and tertiary, or local, levels of service in 1979 in the Milwaukee area, as shown on Map 18. All tertiary and secondary level service and nearly all primary level service was limited to the Milwaukee County portion of the study area.

Primary public transit service is characterized by relatively high operating speeds and relatively low accessibility. Primary transit service can be provided in a rapid transit form by operation of vehicles over exclusive, fully grade-separated rights-of-way; or in a modified rapid transit form by operation of vehicles in mixed traffic over

Map 17

AVERAGE WEEKDAY TRAFFIC VOLUMES ON THE MILWAUKEE AREA ARTERIAL STREET AND HIGHWAY SYSTEM: 1978

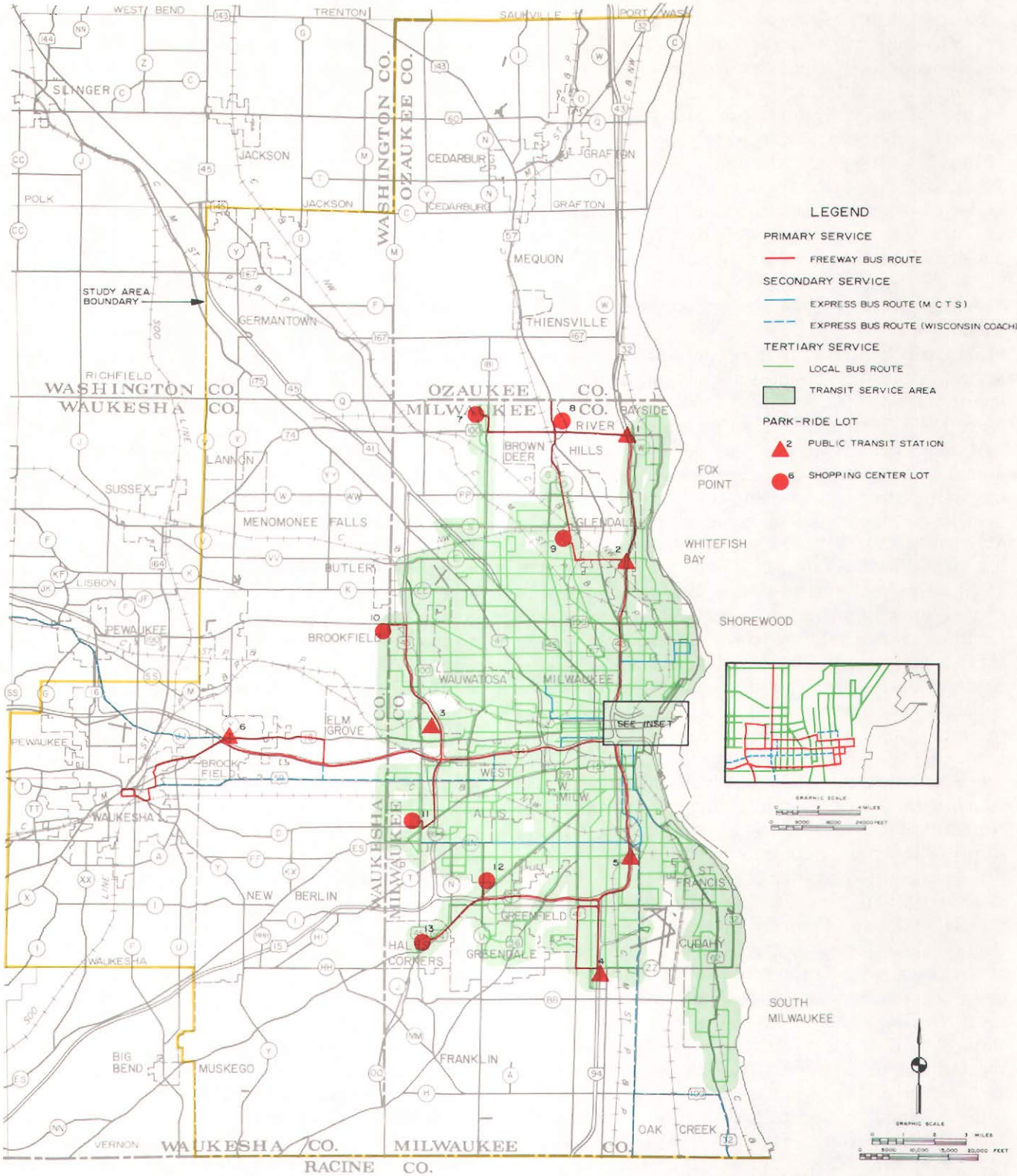


The freeways in the Milwaukee area are highly efficient and immensely popular carriers of travel, as indicated by the heavy volumes of freeway travel shown on this map. The volumes of the standard arterials are well below those of the freeways, but numerous facilities in the northwest portion of the City of Milwaukee carry in excess of 25,000 vehicles per day. Traffic volumes are considerably less in the outlying portions of the area than in more urbanized portions, particularly the City of Milwaukee.

Source: SEWRPC.

Map 18

PRIMARY, SECONDARY, AND TERTIARY PUBLIC TRANSIT SERVICE IN THE MILWAUKEE AREA: FALL 1979



As shown on this map, in 1979 fixed route common carrier service was operated in the Milwaukee urbanized area at primary, secondary, and tertiary levels utilizing motor buses. All tertiary levels of service and nearly all primary and secondary levels of service were limited to Milwaukee County. The existing modified rapid primary transit service utilizing motor buses was initiated in 1964 as a single route providing six vehicle trips during peak travel periods between the Milwaukee central business district and one privately owned outlying shopping center parking lot. This service has been expanded to include 10 freeway bus routes providing 203 weekday vehicle trips, primarily as peak-travel-period service, to 13 outlying park-ride lots.

Source: SEWRPC.

freeways, or on exclusive, but not fully grade-separated, rights-of-way. Primary transit service in the Milwaukee area at the fall of 1979 consisted of 10 modified rapid transit "Freeway Flyer" motor bus routes operated by the Milwaukee County Transit System, the county-owned but privately managed major transit operator in the Milwaukee area. In addition, Wisconsin Coach Lines, Inc., a privately owned transit operator under contract to Waukesha County, operated one primary transit route between the Waukesha area and the Milwaukee central business district.

Freeway Flyer service was initiated in the Milwaukee area in 1964 as a single route providing six vehicle trips during peak travel periods between the Milwaukee central business district and the parking lot of Mayfair Mall Shopping Center at N. Mayfair Road (STH 100) and W. North Avenue. This modified rapid transit service has been expanded to include 10 freeway bus routes providing 226 weekday vehicle trips in the Milwaukee area, primarily in peak-travel-period service, nonstop between the Milwaukee central business district and 13 outlying park-ride facilities, as shown in Table 34. In 1979, seven park-ride lots were located in privately owned shopping center parking lots, while six facilities were publicly owned and maintained transit stations specifically designed for change-of-mode operations. The following routes provided collection-distribution service in the outlying areas prior to entering the freeway system for nonstop service to the central business district: Route 47, the S. 27th Street Freeway Flyer—the only route which served no park-ride facility; Route 49, the Northridge-Treasure Island Freeway Flyer, which stopped at three park-ride facilities; Route 42, the Northshore-Northland Freeway Flyer, which stopped at two park-ride facilities; and Route 43, the Hales Corners Freeway Flyer. All other routes operated only between a park-ride facility and the central business district via the freeway system. Once the motor buses arrived in the central business district, they transversed the area along various routes, all of which, however, included the portion of Wisconsin Avenue between N. 6th and N. Van Buren Streets. Although these routes were designed to transport people between outlying suburban park-ride facilities and the Milwaukee central business district, they all carried revenue passengers both with and against the direction of peak-period travel, thus serving both travel from outlying areas into the central business district and travel from central areas into outlying areas.

With one exception, all Freeway Flyer routes operated only during weekday morning and afternoon peak travel periods. This exception was the route operated between the park-ride facilities at the North-South Freeway and W. Brown Deer Road and the North-South Freeway and W. Silver Spring Drive and the central business district, which provided hourly service between the hours of 9:00 a.m. and 4:00 p.m. The fare for Freeway Flyer service on the Milwaukee County Transit system was $0.60 in 1979.

The only other primary transit service in the Milwaukee area was provided by Wisconsin Coach Lines, Inc., between the Milwaukee central business district and the Goerkes Corners public transit station in the Town of Brookfield. Primary service was provided by five trips during the morning peak period and five trips during the afternoon peak period. The bus fare for this service was distance-related, ranging from $0.75 to $1.15.

In 1979 secondary service in the Milwaukee area was composed of five express bus routes, three operated by the Milwaukee County Transit System and two operated by Wisconsin Coach Lines, Inc. (see Map 18). The secondary level of service, by definition, consists of express service—that is, service provided over arterial streets with stops located only at intersecting transit routes and major traffic generators. These stops are generally located at terminal areas and at intersections with other transit routes, or at intersections adjacent to major land use activities. On some routes of the Milwaukee County Transit System—specifically, Route 5-Oklahoma Avenue UBUS, Route 30-Sherman-Wisconsin, and Route 66-Cudahy-South Milwaukee—skip-stop express transit service was provided over certain portions during peak periods. In this mode of operation, the motor buses stop only at designated signalized intersections and intersecting transit routes. On Route 66 between Oklahoma Avenue and the central business district, a slightly different mode of express service was provided which not only limited stops to those at signalized intersections and transfer points but also prohibited boarding over certain portions of the route and prohibits egress over other portions of the route. This type of express service reduces the number of stops made by the motor bus while operating in express mode, and has the potential to reduce the time spent at each stop. In the Milwaukee area, an average of 304 weekday vehicle trips were made on the Milwaukee County Transit System express routes in

Table 34

CHARACTERISTICS OF PRIMARY TRANSIT PARK-RIDE LOTS IN THE MILWAUKEE AREA: 1979

Code Number on Map 18	Route Number	Location	Civil Division	Parking Spaces Available	Average Weekday Vehicle Trips[a]			
					Inbound		Outbound	
					a.m.	p.m.	a.m.	p.m.
		Public Transit Stations						
1	49	North-South Freeway and W. Brown Deer Road	Village of River Hills	250	11	2	3	11
2	42	North-South Freeway and W. Silver Spring Drive	City of Glendale	190	11	3	3	10
3	41	Zoo Freeway and W. Watertown Plank Road	City of Wauwatosa	200	6	4	2	8
4	40	North-South Freeway and W. College Avenue	City of Milwaukee	300	8	2	4	7
5	48	Holt Avenue and North-South Freeway	City of Milwaukee	240	7	3	5	6
6	--[b]	East-West Freeway and Barker Road	Town of Brookfield	200	4	1	--	4
		Shopping Center Lots						
7	49	N. 76th Street and W. Brown Deer Road	City of Milwaukee	100	11	1	3	11
8	49	N. Green Bay Road and W. Brown Deer Road	Village of Brown Deer	100	11	1	3	11
9	42	N. Teutonia Avenue and Florist Avenue	City of Milwaukee	100	11	2	3	10
10	45	N. 125th Street and W. Capitol Drive	City of Brookfield	140	11	2	5	10
11	44	S. 108th Street and W. Cleveland Avenue	City of West Allis	100	9	2	4	8
12	46	S. 76th Street and W. Cold Spring Road	City of Greenfield	200	12	3	5	13
13	43	S. 108th Street and W. Grange Avenue	Village of Hales Corners	100	9	1	4	9

[a] *Service offered primarily between 6:30 a.m.-8:30 a.m. and 4:00 p.m.-6:00 p.m.*

[b] *Service provided by Wisconsin Coach Lines, Inc.*

Source: SEWRPC.

1979, and approximately 50 vehicle trips were made each weekday on the bus service provided by Wisconsin Coach Lines, Inc. The Milwaukee County express bus fare in 1979 was $0.50, the same as the tertiary service fare. However, on January 1, 1981, the fare was increased to $0.65. The Wisconsin Coach Lines express bus fare was distance-related.

Existing tertiary transit service provided in the Milwaukee area is shown on Map 18. The tertiary level of fixed route common carrier transit service, by definition, provides two basic functions: local service and collection-circulation-distribution service. Both are characterized by a high degree of accessibility and relatively low operating speeds. Local service is provided primarily over arterial and collector streets, with stops for passenger pickup and discharge generally located from 660 to 1,250 feet apart. Collection-circulation-distribution service is provided for the movement of passengers within major activity centers. In the Milwaukee area 45 local routes were operated by the Mil-

waukee County Transit System in 1979, with approximately 5,354 vehicle trips being made on those routes on an average weekday. Map 18 shows the location of these routes in the Milwaukee area. Weekday service was provided primarily between the hours of 5:00 a.m. and midnight. Local, or tertiary, service bus fare was $0.50 from May 18, 1975 to January 1, 1981, when it was increased to $0.65. There was no charge for transfers, and weekly, unlimited usage, bus passes were available for $5.00. Secondary and tertiary service provided in the Milwaukee area was utilized by an estimated 53,777,500 people, including school trip passengers, in 1979, or 190,000 riders per average weekday.

Only one tertiary service route in the Milwaukee area serves other than a local service function—the shuttle service operated by the Milwaukee County Transit System and extending from the Milwaukee central business district to the Marquette University area. The shuttle service provides a collection-circulation-distribution function between the hours of 9:30 a.m. and 4:00 p.m. In 1978 the downtown shuttle provided 229 weekday vehicle trips, and was utilized by approximately 3,500 revenue passengers per average weekday—or 899,700 passengers annually. The fare for shuttle bus service is $0.10.

Special carrier fixed route service in the Milwaukee area is currently provided by the Milwaukee County Transit System to selected public and private grade, junior high, and high schools and to the University of Wisconsin-Milwaukee. In addition, special carrier bus service to selected public and private grade, junior high, and senior high schools—particularly Milwaukee public schools—is provided by special charter school bus service. The UBUS special carrier fixed route service provided to the University was begun in the fall of 1973 as a single charter route. In 1979, the Milwaukee County Transit System operated 11 special carrier UBUS routes, as shown on Map 19. Five of these routes have been incorporated into the transit system as regular routes since 1973. The primary differences between the UBUS service and other motor bus service provided by the Milwaukee County Transit System are the direct routing to the University campus and the subsidization of the fare by the University. This service was intended for use primarily by university students, faculty, and staff. The UBUS tickets are purchased by the University at full fare and resold to students, staff, and faculty for $0.35. The UBUS routes eliminate transfers and provide faster, more convenient service to the University from outlying areas than the tertiary service routes. Three UBUS routes provide primary transit service as Freeway Flyers operating between outlying park-ride facilities and the University.

Special carrier service on nonfixed routes is currently provided to the elderly and handicapped in the Milwaukee area by more than 35 public and private agencies. An estimated 800,000 trips by elderly and handicapped individuals were made in special carrier service vehicles in 1976, based on an inventory of public, private, nonprofit public, and nonprofit private providers of elderly and handicapped transportation services conducted by the Commission.

Transit System Utilization

Annual transit ridership increased in the Milwaukee area between 1975 and 1979. This period of annual ridership increases follows a long period of general decline in transit ridership in the Milwaukee area. With the exception of a 1.4 percent increase between 1964 and 1966, transit ridership decreased steadily from the late 1940's until 1975. Figure 21 indicates the change in this trend in the Milwaukee area since 1975.

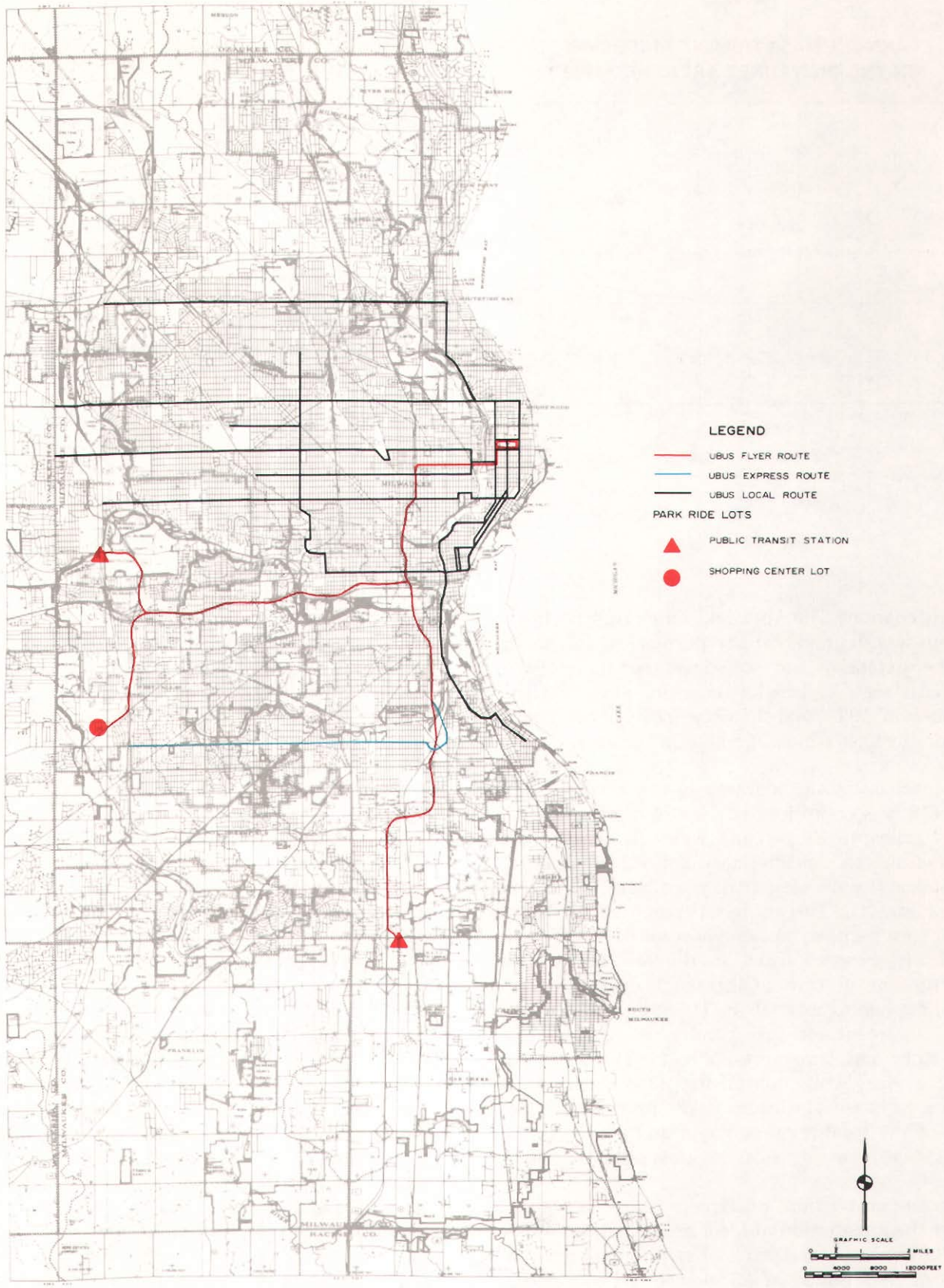
In 1979, 55.6 million revenue passenger transit trips were made in the Milwaukee area. The Milwaukee County Transit System carried 55.4 million of these revenue passengers. The majority of these passengers—53,777,500, or 97 percent—were carried by the local and express services. One type of local service for which separate ridership statistics are maintained, the central business district shuttle, carried 899,700 passengers, or 1.6 percent of all passengers carried in 1979. The Milwaukee County Transit System operated a fleet of 578 vehicles with an average daily mileage of 53,799 miles, or a total of 1,622,000 revenue vehicle hours in 1979. The system was subsidized with federal, state, and county funds, with the fare box providing about 48 percent of the necessary operating revenues.

SUMMARY

The objective of the Milwaukee area work time rescheduling study is to more effectively use the existing supply of transportation facilities and services through the spreading of peak travel demands. Therefore, the supply of transportation facilities which make up the transportation system in the Milwaukee area and their usage were considered

Map 19

UBUS SERVICE IN THE MILWAUKEE AREA: 1979

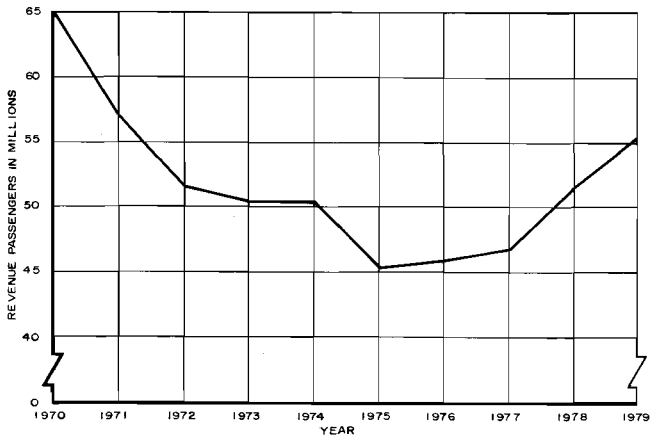


Special carrier fixed route UBUS service is provided by the Milwaukee County transit system to the University of Wisconsin-Milwaukee. This service was begun in 1973 as a single charter route providing local transit service to the University. By 1979 there were 11 UBUS routes. The primary differences between UBUS service and other motor bus service are the direct routing to the University campus and the subsidization of the fare by the University.

Source: SEWRPC.

Figure 21

ANNUAL MASS TRANSIT RIDERSHIP IN THE MILWAUKEE AREA: 1970-1979



Source: SEWRPC.

in this chapter. The Milwaukee area transportation system was defined, for the purpose of this study, as the extensive and well-developed network of arterial streets and highways which existed within the area in 1978, and the network of public transit motor bus lines which operated in the area.

The total street and highway system of the Region in 1978 was comprised of 10,436 miles, of which 3,294 miles, or 32 percent, were classified by primary function as arterials, and 7,142 miles, or 68 percent, were classified as collectors and land access streets. Forty-three percent of the total street and highway system—a total of 4,451 miles of facilities—was located in the Milwaukee area. Twenty-nine percent of this total, or 1,306 miles, was classified as arterials in 1978, and the remaining 71 percent, or 3,144 miles, was classified as collectors and land access streets. Thus, the Milwaukee area, while comprising 22 percent of the total area of the Region in 1978, contained 43 percent of the total regional street and highway mileage and 40 percent of the regional arterial mileage.

A larger proportion of streets and highways is under the jurisdiction of local municipalities within the Milwaukee area than within the Region. In the Region, 895 miles, or 27 percent of the arterial facilities in the Region, were classified as local trunk highways; 626 miles, or 48 percent of the total arterial facilities in the area, were so classified. Twenty-eight percent of the streets and highways in both the Region and the Milwaukee area are eligible to receive federal funds in partial support of needed improvements because of their inclusion in one of the federal aid highway systems. These 2,880 miles of facilities in the Region and 1,250 miles of facilities in the Milwaukee area represent 88 and 96 percent of all arterials in the Region and Milwaukee area, respectively. In Milwaukee County, 720 miles of roadway were a part of the federal aid system in 1978. These 720 miles constituted 26 percent of all street and highway facilities and 96 percent of all arterial facilities in the County.

The total vehicle miles of travel within the Region has steadily increased from 1963 to 1979, with only a temporary decline in growth of travel during the oil embargo of 1973-1974. By 1978 average weekday vehicle miles of travel in the Region totaled an estimated 24.5 million, an increase of 22 percent since 1972 and 53 percent since 1963. In the Milwaukee area an estimated 16.4 million vehicle miles of travel were made on an average weekday in 1978.

The Milwaukee area freeway system was heavily used in 1978, carrying on the average 56,800 vehicle miles of travel per mile of freeway per day. Although freeways constituted less than 9 percent of the arterial street and highway system in the Milwaukee area, they carried more than 62 percent of the arterial vehicle miles of travel in the area in 1978. Major standard arterials, particularly in the northwest portion of the City of Milwaukee, also carried substantial daily traffic volumes in 1978, with portions of 18 such facilities carrying more than 25,000 vehicles per day.

Public transit service in the Milwaukee area is limited largely to Milwaukee County and currently consists of fixed route common carrier service, fixed route special carrier service, and nonfixed route special carrier service. Primary, fixed route, common carrier service currently is provided via motor buses operated over 10 "Freeway Flyer" modified rapid transit routes by the Milwaukee County Transit System and over one such route operated by Wisconsin Coach Lines, Inc. This primary service is provided principally during peak travel hours from 12 outlying park-ride facilities to the Milwaukee central business district.

Secondary public transportation service in the Milwaukee area is currently composed of five express bus routes operating over arterial streets. An average of 304 weekday vehicle trips were made on these routes in 1979. Tertiary transit service in Milwaukee County is composed of 45 service routes. Approximately 5,359 weekday vehicle trips were made on these routes in 1979. The fare for both secondary and tertiary service in the Milwaukee area was $0.50 in 1979.

The two types of specialized transit provided by the Milwaukee County Transit System were the UBUS system and the Milwaukee central business district shuttle. The UBUS system provided direct, partially subsidized service directly to the University of Wisconsin-Milwaukee campus. The system included both primary and tertiary transit service for a fare of $0.35. The Milwaukee central business district shuttle provided service to the business district and adjacent Marquette University campus from 9:30 a.m. to 4:00 p.m. at six-minute headways for a $0.10 fare.

After a long period of declining ridership, transit ridership in the Milwaukee area began to increase in 1975. In 1979, 55.6 million revenue passenger transit trips were made in the Milwaukee area, of which 55.4 million were carried by the Milwaukee County Transit System. This system provided primary, secondary, and tertiary transit service with a fleet of 578 vehicles, an average daily mileage of 53,799 miles, and a ridership of 190,000 revenue passengers per day in 1979.

This chapter discussed the supply of Milwaukee area transportation facilities in 1978, along with the average daily vehicle travel on the streets and highways and the annual transit ridership, and identified the portions of the arterial street and highway network that were operating over design capacity on a 24-hour-average weekday basis. In order to evaluate the potential benefits of work time rescheduling programs, it will be necessary to more closely examine the demand for both the highway and transit facilities during periods of peak travel demand. This detailed examination is presented in the following chapters.

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Chapter VI

MILWAUKEE AREA TRANSPORTATION SYSTEMS PROBLEMS AND DEFICIENCIES

INTRODUCTION

This chapter identifies and discusses certain of the current problems and deficiencies in the arterial street and highway and public transit systems of the Milwaukee area. The problems discussed are centered around the fact that travel demand in the Milwaukee area exceeds the design capacity of the transportation system, especially during the peak morning and afternoon travel hours of 7:00 a.m. to 8:00 a.m. and 4:00 p.m. to 5:00 p.m. The objective of work time rescheduling is to alleviate the imbalance between transportation system demand and capacity, and the attendant congestion and excessive energy consumption and air pollutant emissions, by shifting travel demand from crowded peak travel hours to less crowded earlier or later hours. Work time rescheduling attempts to reduce traffic congestion without making any costly or potentially disruptive physical improvements to the transportation system.

The identification of existing transportation systems problems and deficiencies during peak travel hours is a particularly important step in the overall study. It is necessary to determine where peak-hour transportation system congestion occurs, and how severe it is, before the degree of relief, if any, affordable by work time rescheduling can be estimated. The morning and afternoon peak-travel-hour problems presented in this chapter have been identified by determining the degree to which the area transportation system presently meets the study objectives and standards for transportation set forth in Chapter II of this report. These objectives state, in essence, that the area transportation system should facilitate quick, convenient, and comfortable travel while minimizing transportation energy use and air pollutant emissions.

PEAK-PERIOD TRANSPORTATION PROBLEMS AND DEFICIENCIES

In the Milwaukee area, the highest demand for the transportation facilities, and therefore the greatest congestion on both the highway and transit systems, occurs during a relatively short morning and afternoon period. These heavy demands produce traffic congestion and attendant operating speed reductions, which in turn increase motor fuel consumption and the production of certain vehicle emissions, and at the same time, such demands increase the cost of operating the transit system and the travel times on that system, and decrease the assurance of obtaining a place on transit vehicles. The extent to which peak-period congestion is a problem in the Milwaukee area was analyzed by using hourly traffic count data for the highway network and peak passenger load count and hourly bus operation data for the transit system. This analysis revealed the problems and deficiencies of the transportation systems by indicating when and where each system was unable to meet the stated objectives.

Peak-Hour Arterial Highway Congestion

Although actual weekday hourly traffic counts were not available for every link of the Milwaukee area arterial street and highway network, a substantial amount of hourly count data was available. During 1978 hourly traffic counts were taken at about 1,700 locations, or on about one-half of all arterial street and highway links in the Milwaukee area, and 24-hour traffic counts were available for all the remaining links. It was possible to estimate the peak-hour and peak-period traffic volumes for every link of the arterial network by computing the proportion of the total weekday traffic represented by each hour in the peak period, and by computing the average hourly directional split of traffic during peak periods for those links for which such data were available. If directional hourly count data were unavailable for a link, the hourly percentage and directional split of similar surrounding links were applied to the 24-hour count data to derive an estimate of the hourly traffic volumes. In this manner, estimates of peak-hour traffic volumes were prepared for every link in the 1,300-mile arterial street and highway system in the Milwaukee area. With these estimates, it was possible to locate and quantify peak-hour arterial highway congestion in the Milwaukee area.

Based upon the traffic count data and the estimated volumes, the volume-to-design capacity (V/C) ratios in the peak direction were calculated for each link in the arterial system for both the

Table 35

DISTRIBUTION OF MILES OF ARTERIAL STREET AND HIGHWAY FACILITIES OPERATING AT VARIOUS SERVICE LEVELS IN THE MILWAUKEE AREA DURING THE MORNING AND EVENING PEAK HOURS: 1978

County and Service Level	Miles of Arterial Facility											
	7:00 - 8:00 a.m.						4:00 - 5:00 p.m.					
	Standard Arterials		Freeways		Total		Standard Arterials		Freeways		Total	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Milwaukee												
Under Design Capacity	588.2	85.9	32.2	46.5	615.6	81.6	537.1	78.5	29.2	42.2	560.3	74.3
At Design Capacity	44.5	6.5	14.5	21.0	63.8	8.5	81.8	11.9	15.7	22.7	103.5	13.7
Over Design Capacity	52.1	7.6	22.5	32.5	74.6	9.9	65.9	9.6	24.3	35.1	90.2	12.0
Subtotal	684.8	100.0	69.2	100.0	754.0	100.0	684.8	100.0	69.2	100.0	754.0	100.0
Ozaukee												
Under Design Capacity	136.9	98.1	12.2	100.0	149.1	98.2	136.9	98.1	12.2	100.0	149.1	98.2
At Design Capacity	2.1	0.9	--	--	2.1	1.4	1.3	0.9	--	--	1.3	0.9
Over Design Capacity	0.6	1.0	--	--	0.6	0.4	1.4	1.0	--	--	1.4	0.9
Subtotal	139.6	100.0	12.2	100.0	151.8	100.0	139.6	100.0	12.2	100.0	151.8	100.0
Washington												
Under Design Capacity	54.2	100.0	6.1	100.0	60.3	100.0	48.8	90.0	6.1	100.0	56.7	94.0
At Design Capacity	--	--	--	--	--	--	4.8	8.9	--	--	3.0	5.0
Over Design Capacity	--	--	--	--	--	--	0.6	1.1	--	--	0.6	1.0
Subtotal	54.2	100.0	6.1	100.0	60.3	100.0	54.2	100.0	6.1	100.0	60.3	100.0
Waukesha												
Under Design Capacity	281.4	90.8	11.5	49.6	292.9	87.8	266.1	85.8	14.9	64.2	279.4	83.9
At Design Capacity	14.4	4.6	8.1	34.9	22.5	6.8	27.8	9.0	4.7	20.3	34.1	10.2
Over Design Capacity	14.3	4.6	3.6	15.5	17.9	5.4	16.2	5.2	3.6	15.5	19.8	5.9
Subtotal	310.1	100.0	23.2	100.0	333.3	100.0	310.1	100.0	23.2	100.0	333.3	100.0
Milwaukee Area												
Under Design Capacity	1,060.7	89.3	62.0	56.0	1,117.9	86.0	988.9	83.2	62.4	56.4	1,045.5	80.5
At Design Capacity	61.0	5.1	22.6	20.4	88.4	6.8	115.7	9.7	20.4	18.4	141.9	10.9
Over Design Capacity	67.0	5.6	26.1	23.6	93.1	7.2	84.1	7.1	27.9	25.2	112.0	8.6
Total	1,188.7	100.0	110.7	100.0	1,299.4	100.0	1,188.7	100.0	110.7	100.0	1,299.4	100.0

Source: SEWRPC.

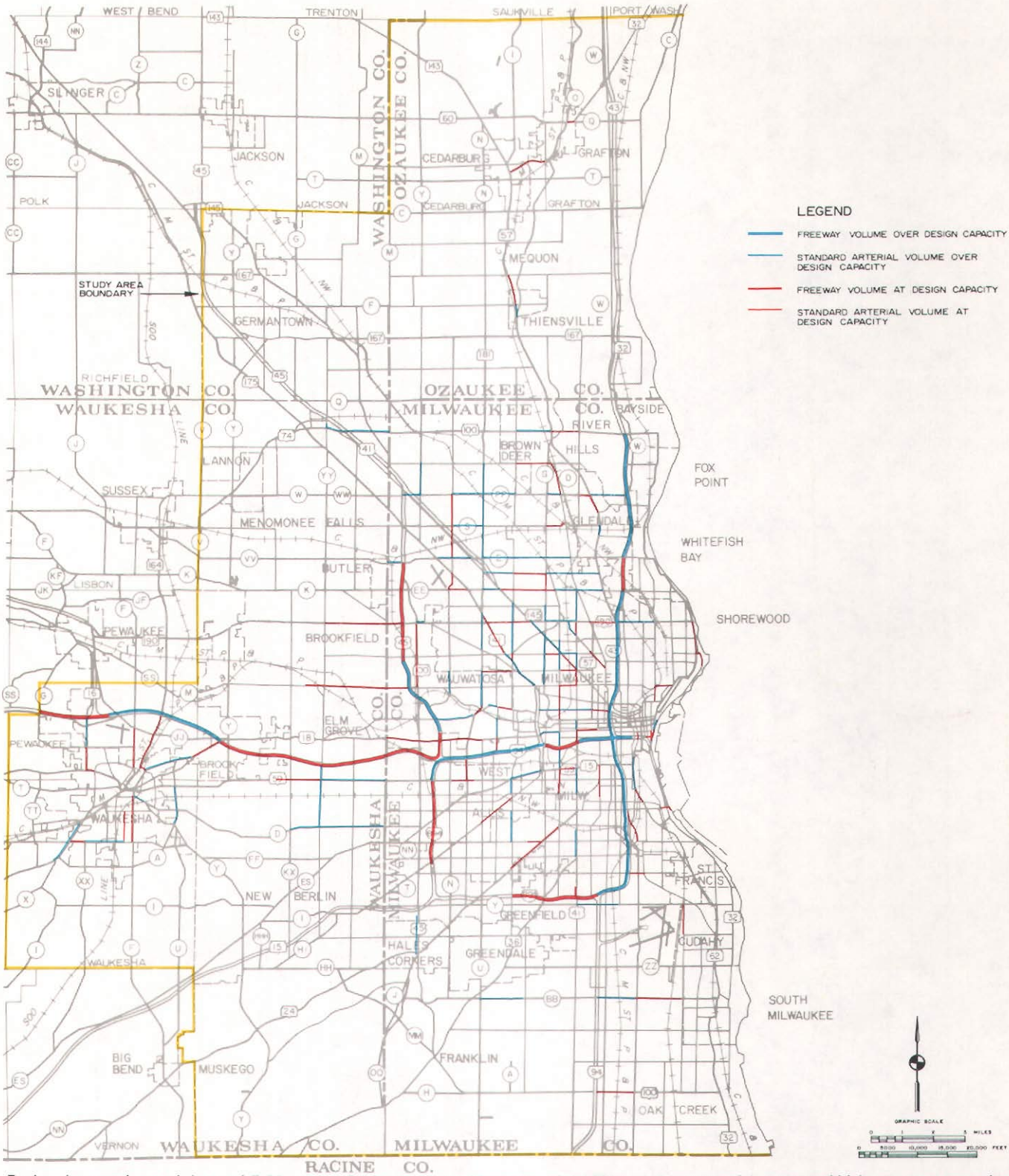
morning and afternoon peak hours. These V/C ratios were used to classify each link as operating under design capacity, V/C = 0.90 or less; at design capacity, V/C = 0.91 to 1.10; and over design capacity, V/C = 1.11 or more. Table 35 shows the mileage and proportion of the arterial facilities in the Milwaukee area operating at each of these volume-to-capacity ratios from 7:00 a.m. to 8:00 a.m. and 4:00 p.m. to 5:00 p.m. Maps 20 and 21 show the spatial distribution of these links for the morning and evening peak hours, respectively.

During the morning peak hour, 7:00 to 8:00 a.m., only 93 miles, or 7 percent of the arterial network in the Milwaukee area, were operating over design capacity. An additional 88 miles, or 7 percent, were operating at design capacity, while almost 86 percent of the total system mileage was operating under design capacity. Although the capacity problems are occurring only on a small proportion of the total arterial system, the facilities which are congested are particularly important to the quick, convenient, and comfortable travel of many Milwaukee area residents. The proportion of freeways operating over design capacity—24 percent—was almost four times as great as the proportion of standard arterials operating at this level—6 percent—indicating an uneven distribution of congestion by facility type. In Milwaukee County, about 23 miles of freeway, or 33 percent of all freeway mileage, were operating over design capacity, and about 15 miles, or 21 percent, were operating at design capacity. Therefore, more than half of the total freeway mileage in Milwaukee County was congested during the morning peak hour.

Map 20 clearly shows not only that the morning peak-hour congestion is concentrated on the freeways primarily within Milwaukee County, but that the heaviest concentration of all arterial facilities

Map 20

MILWAUKEE AREA ARTERIAL FACILITIES OPERATING BELOW, AT, AND OVER DESIGN CAPACITY—7:00 A.M. TO 8:00 A.M.: 1978

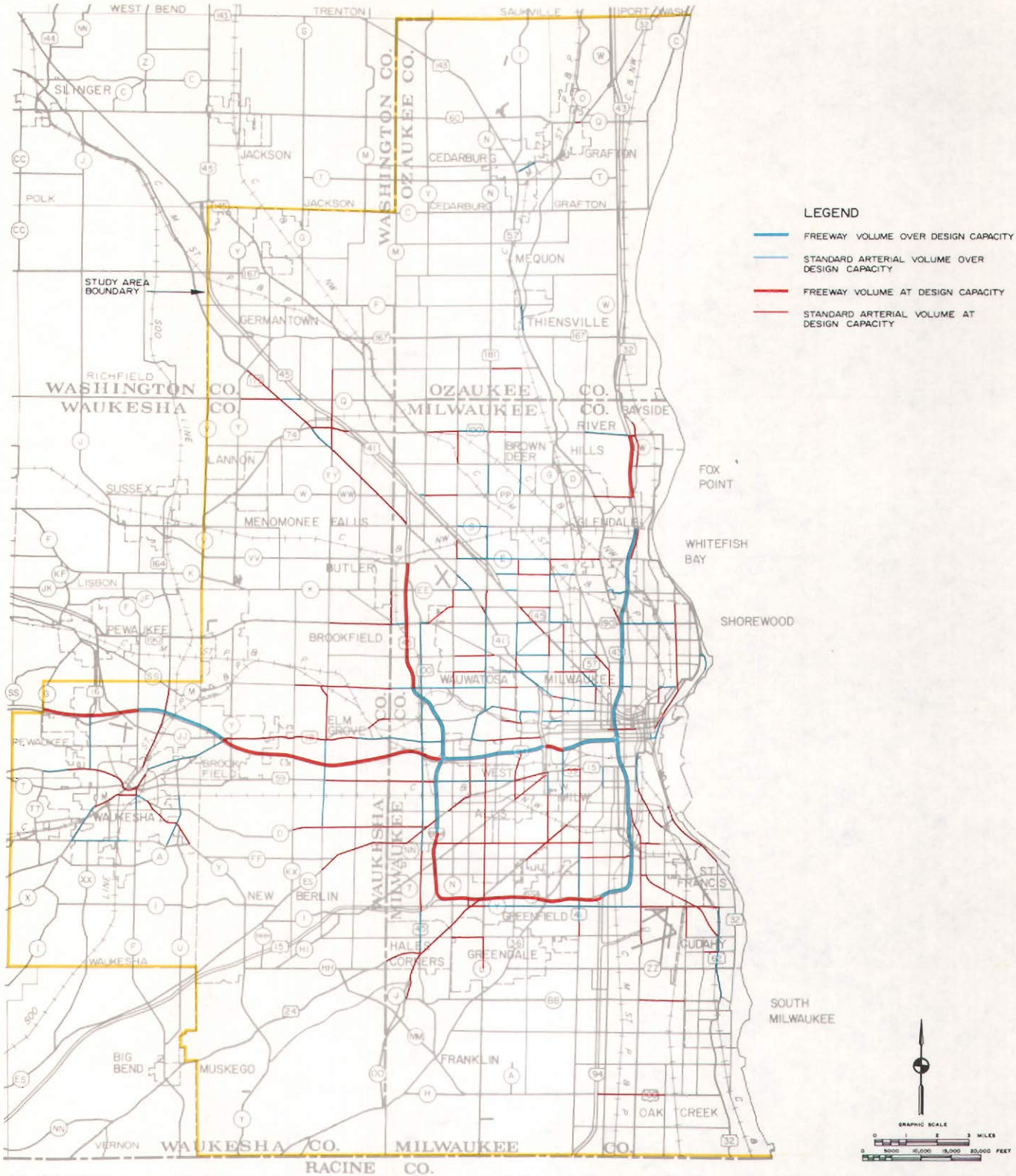


During the morning peak hour of 7:00 a.m. to 8:00 a.m., about 14 percent of the Milwaukee area arterial streets and highways were operating at or over design capacity. Although less than 60 percent of all arterial facilities were located in Milwaukee County, almost 80 percent of the congested arterials were located in Milwaukee County. On an areawide basis, a larger proportion of the freeway system than of the standard arterial system was congested, with about 44 percent of the freeways operating at or over design capacity, and only about 10 percent of the standard arterials so congested even though the absolute number of congested miles of standard arterials exceeded the miles of congested freeways. During the morning peak hour, the freeways carried about 10 percent of their total daily traffic volumes and about 35 percent of all arterial travel occurring between 8:00 and 9:00 a.m.

Source: SEWRPC.

Map 21

MILWAUKEE ARTERIAL FACILITIES OPERATING BELOW, AT, AND OVER DESIGN CAPACITY—4:00 P.M. to 5:00 P.M.: 1978



Arterial highway congestion is more severe during the afternoon peak hour—4:00 p.m. to 5:00 p.m.—than during the morning peak hour. Almost 20 percent of all Milwaukee area arterials were operating at or over design capacity during the afternoon peak hour in 1978, and almost 45 percent of the freeways were congested during the peak hour. Although much of this congestion is due to employees traveling home from work, some can also be attributed to the large number of shopping and personal business trips made during this hour which increase the total traffic volumes of the afternoon peak hour, compared with the almost exclusively work-oriented travel of the morning peak hour.

Source: SEWRPC.

operating over design capacity is located in the north-central portion of the County. Very little congestion occurs in the less developed suburban portions of the area with the exception of IH 94, which operated at or over design capacity from the City of Waukesha to the Milwaukee central business district.

During the afternoon peak hour, 4:00 to 5:00 p.m., 248 miles of arterial facilities, or almost 20 percent of the total, were operating at or over design capacity—an increase of more than 75 miles over the number congested during the morning peak hour. More specifically, 19 more miles were operating over design capacity and 54 more miles were operating at design capacity. The distribution of the facilities operating at and over design capacity is similar to that for the morning peak hour, with a larger proportion of freeways than of standard arterials operating at and over design capacity, and with the majority of the congested facilities being in Milwaukee County. During the afternoon peak hour, there was a somewhat more even distribution of congested links between the northern and southern portions of Milwaukee County. However, many of the same individual routes, especially the major freeways, were congested during both the morning and afternoon peak periods. Given the reciprocity of most vehicle trips—that is, the fact that most trips between origins and destinations are round trips, and that these trips usually follow the same path in each direction—this is not surprising.

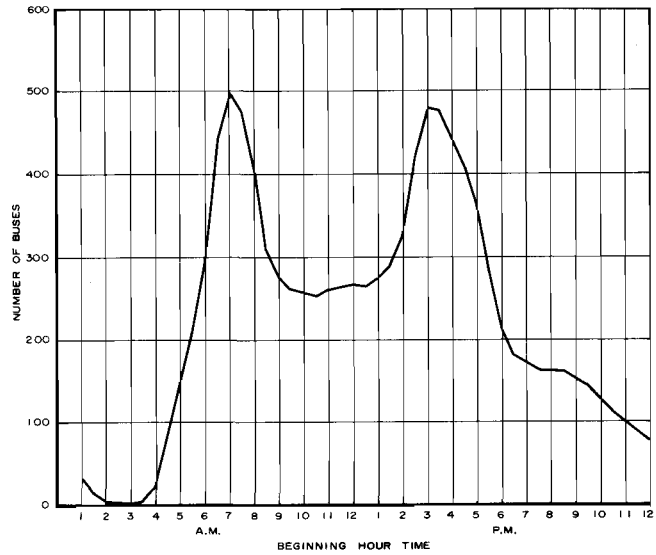
Peak-Hour Public Transit Congestion

The Milwaukee area's transit deficiencies are relatively minor in comparison to the area's highway deficiencies. In part, this is because the "capacity" of an all-bus transit system can be adjusted by changing the number of buses which serve any given route.

One of the goals of good transit management is to approximately match the number of seats provided throughout the day to the passenger demand. Because of the sharp peaking of the demand, this is difficult to do economically, as there are as many patrons during the six peak hours as there are during the rest of the day. Moreover, such peaking is highly directional—that is, buses on some routes may be running full in the predominant direction of demand, while others may be running nearly empty in the opposite direction. This is particularly true of routes oriented to the central business district. In order to meet demand on its 61 routes,

Figure 22

NUMBER OF BUSES IN SERVICE BY TIME OF DAY: 1979



Source: Milwaukee County Transit System and SEWRPC.

the Milwaukee County Transit System (MCTS) operates anywhere from 25 to 500 buses during different hours of the day. The number of buses in service on an average weekday in 1979 is shown in Figure 22. The peaks and valleys in the distribution generally follow those of the passenger demand at maximum load points. During the midday period, when passenger demand drops to about one-third of the morning peak demand, the number of buses in service is only about half the number needed during the morning peak.

The peak periods for buses in service are longer than the peak-passenger-demand periods, and the labor costs for peak-hour operation are higher than those for off-peak service. The physical movement of buses between garages and route terminals takes some time—for example, the 41 buses operated on Route 30 from 7:30 a.m. to 8:00 a.m. must all be on the route by 7:30 a.m., requiring that they leave the garage prior to that time. After 8:00 a.m., they must go to their next assigned route or return to the garage. Both requirements produce the differential between actual demand and the number of buses in service. Labor costs for peak-hour service tend to be higher because certain labor agreements between the operator and the Amalgamated Transit

Table 36

NUMBER OF BUSES IN SERVICE DURING PEAK HOURS BY ROUTE—MILWAUKEE COUNTY TRANSIT SYSTEM: 1979

Route		Number of Buses in Service	
Number	Name	7:00 a.m. - 8:00 a.m.	4:00 p.m. - 5:00 p.m.
10	Wells Street - Wisconsin Avenue	15	14
11	Vliet Street - Howell Avenue	14	14
12	12th Street - Wisconsin Avenue	14	13
13	St. Paul Avenue - Michigan Street	2	2
14	Holton Street - Michigan Street	21	18
15	Oakland Avenue - Delaware Avenue	14	15
18	National Avenue	12	12
19	N. 3rd Street - S. 13th Street	24	28
20	S. 16th Street - S. 20th Street	13	14
21	North Avenue	9	12
22	Center Street	6	10
23	Fond du Lac Avenue	16	19
27	27th Street	21	16
30	Sherman Boulevard - Wisconsin Avenue	41	37
31	Washington Street - Wisconsin Avenue	8	10
35	35th Street	9	11
51	Oklahoma Avenue	11	10
52	Clement Avenue	1	1
53	Lincoln Avenue	5	5
54	Mitchell Street - Burnham Street	6	5
57	Walnut Street - Lisbon Avenue	8	10
58	Green Bay Avenue	4	3
60	Burleigh Street	14	14
62	Capitol Drive	20	16
64	S. 60th Street - Hales Corners	2	3
66	South Milwaukee	13	17
67	N. 76th Street - S. 84th Street	10	10
68	Port Washington - Santa Monica Boulevard	4	4
71	State Street	5	5
73	Keefe Avenue - Ardmore	2	2
76	N. 60th Street - S. 70th Street	14	12
80	6th Street	17	14
82	Stevenson Street - Adler Street	1	1

Source: Milwaukee County Transit System.

Union make it difficult to match drivers' schedules against ridership demand peaks without payment of premium wages for split shifts and extended working hours.

Table 36 shows the number of buses in service at 7:00 a.m. and 4:00 p.m. on each of the MCTS routes on an average weekday in 1980. Twenty-five percent of the 496 buses in service between 7:00 a.m. and 7:30 a.m. are operating on Routes 30, 19, 14, 27, and 62. Three of these routes radiate from the Milwaukee central business district and two are crosstown routes. Route 30 (Sherman Boulevard-Wisconsin Avenue) is by far the most heavily serviced route, with half again as many buses as used on Route 19 (N. 3rd Street-S. 13th Street), and almost twice as many as used on Route 14 (Holton Avenue-Mitchell Street), Route 27 (27th Street), or Route 62 (Capitol Drive). Of these heavily used routes, only Routes 27 and 62 do not enter the central business district.

While provision of a seat for each passenger is a desirable service goal, economic factors often may not permit this, especially during peak hours. MCTS has adopted an average maximum load

factor of 1.33 during each peak half-hour time period. This loading standard is considered to be the maximum ratio of passengers to bus seats, and is measured at that point of the route having the maximum passenger load. Should a route exceed the allowable 1.33 peak load factor, additional buses are assigned to the route to maintain the standard. Because MCTS has acquired sufficient vehicles and has budgeted adequate operating funds to ensure that the supply of service is sufficient to meet ridership demand, none of the load factors shown in Table 37 exceed the standard.

Although the elimination of standees altogether may be impractical, spreading the peak passenger demand would improve present transit service. A longer peak demand period would provide a better opportunity for passengers to get a seat without increasing the number of buses operated and, in fact, could reduce bus requirements and attendant capital and operating costs. Also, the present operation of a large number of buses on some routes during a very short period of peak demand encourages the platooning of buses, with attendant delays. When buses operate at very short headways, platooning can occur—that is, one bus will fall behind schedule and following buses will bunch up behind it. The original behind-schedule bus will increasingly become more crowded than the following vehicles, for waiting passengers will attempt to board the original behind-schedule vehicle rather than wait for the next vehicle following closely behind. This platooning considerably slows boarding and deboarding and is self-perpetuating, since the need for passengers to board and deboard following buses in a platoon prevents these buses from passing the first behind-schedule bus. Another peak problem of current transit service is that, owing to the duration of the peak periods, many buses are able to complete only one trip during the peak hour. A longer peak demand period would permit the same driver and bus to complete two or more trips, thus providing the opportunity to reduce driver and vehicle requirements or to improve service and expand system capacity by increasing total bus trips.

CONSEQUENCES OF CONGESTION

Aside from its direct effects on transportation system users—in terms of time lost and money lost because of higher vehicle operating costs—traffic congestion has serious side effects. Air pollution and energy waste are two of the most critical. This section reviews the nature of such side effects, and discusses the improvements that might be afforded with the application of work time rescheduling.

Air Pollution

Fundamental to an understanding of air quality in the Milwaukee area are the air quality standards established by the U. S. Environmental Protection Agency (EPA) on the basis of laboratory, epidemiological, and toxicological data concerning air pollution and its observed effects on human, plant, and animal life. The six air pollutants for which standards have been promulgated for national application are: particulate matter, sulphur oxides measured as sulphur dioxide, carbon monoxide, nitrogen dioxide, hydrocarbons, and ozone. Table 38 shows that each of these has a primary, or health-related, standard and a secondary, or general welfare-related, standard. In some cases the primary and secondary standards are the same. For particulate matter, sulphur oxides, and carbon monoxide, standards have been established for more than one averaging period of time in order to prevent excessive short-term exposures to harmful levels, as well as to prevent the occurrence of harmful effects found with long-term exposures at generally lower levels.

A comprehensive air pollutant emissions inventory for the Region, utilizing both ambient air quality monitoring and mathematical modeling, was completed in 1977.[1] All sources of emissions were grouped into one of three categories: point sources, line sources, and area sources. Point sources are defined as large discrete sources, such as the tall stacks identified with coal-fired electric power generation plants. Line sources are defined as transportation-related emission sources, predominantly automobiles and trucks operating over arterial streets and highways (hence the term "line source"). Area sources are defined as the aggregation of many small, highly diffused sources of emissions, such as individual homes, which, while not major sources of pollutants individually, collectively have a significant impact on air quality. A total of 198 major industrial facilities in the Region, 4 classes of motor vehicles, and 30 classes of area sources were identified as air pollution sources in the inventory, and their emission rates quantified by pollutant type and geographic distribution.

[1] *See SEWRPC Planning Report No. 28, A Regional Air Quality Attainment and Maintenance Plan for Southeastern Wisconsin: 2000, formally adopted by the Commission on June 20, 1980.*

Table 37

TOTAL DAILY PASSENGERS PASSING MAXIMUM LOAD POINTS ON AN AVERAGE WEEKDAY ON LOCAL AND EXPRESS TRANSIT ROUTES OPERATED BY THE MILWAUKEE COUNTY TRANSIT SYSTEM: 1979

Route		Number of Passengers	Peak Load Factor	
Number	Name		a.m.	p.m.
10	Wells Street	5,268	1.02	1.09
11	Vliet Street	2,362	1.08	0.83
11	Howell Avenue	2.261	0.90	1.11
12	12th Street	4,062	1.21	1.18
13	St. Paul Avenue	237	0.32	0.42
14	Holton Avenue	3,299	1.10	1.01
14	Mitchell Street	3,150	1.15	1.11
15	Oakland Avenue	3,722	1.08	1.02
15	Delaware Avenue	2,166	0.97	0.82
18	National Avenue	4,481	1.19	1.07
19	N. 3rd Street	6,330	0.90	1.08
19	Greenfield Avenue	951	1.15	1.09
19	S. 13th Street	3,641	1.19	1.14
20	S. 16th Street - S. 20th Street	2,692	1.00	1.04
21	North Avenue	3,059	0.94	1.13
22	Center Street	2,188	0.80	0.98
23	Fond du Lac Avenue	5,246	1.14	1.16
27	N. 27th Street	4,709	1.22	1.20
27	S. 27th Street	3,566	0.98	1.01
30	Sherman Boulevard	10.761	0.97	1.01
30	Prospect Avenue	4,886	0.99	1.12
30	Jackson Street	5,082	1.12	--
31	Washington Street	2,881	0.93	1.03
35	N. 35th Street	3,000	1.08	1.12
35	S. 35th Street	2,334	1.03	0.94
51	Oklahoma Avenue	2,101	1.10	1.06
52	Clement Avenue	522	0.68	0.58
53	Lincoln Avenue	936	0.53	0.46
54	Mitchell Street	1,993	0.92	0.84
57	Walnut Street - Lisbon Avenue	1,845	1.04	1.01
58	Green Bay Avenue	477	0.65	0.37
60	Burleigh Street	1,666	0.94	0.80
62	Capitol Drive	4,673	1.01	1.01
64	Hales Corners	226	0.45	0.57
66	South Milwaukee	3,719	1.09	1.11
67	N. 76th Street	889	1.05	1.13
67	S. 84th Street	516	0.88	0.87
68	Port Washington Road	462	0.56	0.49
71	State Street	1,457	0.78	0.79
73	Keefe Avenue	87	0.17	0.20
76	N. 60th Street - S. 70th Street	1,567	1.02	0.97
76	S. 68th Street	669	0.89	0.70
76	S. 76th Street	762	0.66	0.71
80	N. 6th Street	2,969	1.16	1.08
80	S. 6th Street	1,984	1.01	0.87
82	Adler Street - Stevenson Street	113	0.53	0.34
Total	--	121,967	--	--

Source: Milwaukee County Transit System.

Table 38

SUMMARY OF NATIONAL AMBIENT AIR QUALITY STANDARDS ISSUED APRIL 30, 1971, AND REVISED SEPTEMBER 15, 1973 AND FEBRUARY 8, 1979

Pollutant[a]	Period of Measurement or Calculation	Concentration (weight of pollutant per cubic meter of ambient air corrected to 25°C and 760 millimeters of mercury)	
		Primary Standard	Secondary Standard
Particulate Matter (PM)	Annual (geometric mean)	75 micrograms	60 micrograms
	24 hour	260 micrograms[b]	150 micrograms[b]
Sulfur Oxides (SO_x) (measured as sulfur dioxide)	Annual (arithmetic mean)	80 micrograms (0.03 part per million)	--
	24 hour	365 micrograms (0.14 part per million)[b]	--
	3 hour	--	1,300 micrograms (0.5 part per million)[b]
Carbon Monoxide (CO)	8 hour	10 milligrams (9 parts per million)[b]	Same as Primary
	1 hour	40 milligrams (35 parts per million)[b]	Same as Primary
Hydrocarbons (HC) (nonmethane measured as methane)	3 hour (6 a.m. to 9 a.m.)	160 micrograms (0.24 part per million)[b]	Same as Primary
Nitrogen Dioxide (NO_2)	Annual (arithmetic mean)	100 micrograms (0.05 part per million)	Same as Primary
Ozone[c] (O_x)	1 hour	235 micrograms (0.12 part per million)[d]	Same as Primary

[a] *Ambient air quality standards for a seventh pollutant, lead, were promulgated by the Administrator of the U. S. Environmental Protection Agency on October 5, 1978. More detailed ambient air quality monitoring will be needed to determine whether the standard for this pollutant species is being exceeded in the Region and whether, in fact, a plan need be prepared to ensure the attainment and maintenance of the lead ambient air quality standard.*

[b] *Concentration not to be exceeded more than once per year.*

[c] *Formerly expressed as photochemical oxidants.*

[d] *Concentration not to be exceeded more than one hour averaged over any consecutive three-year period.*

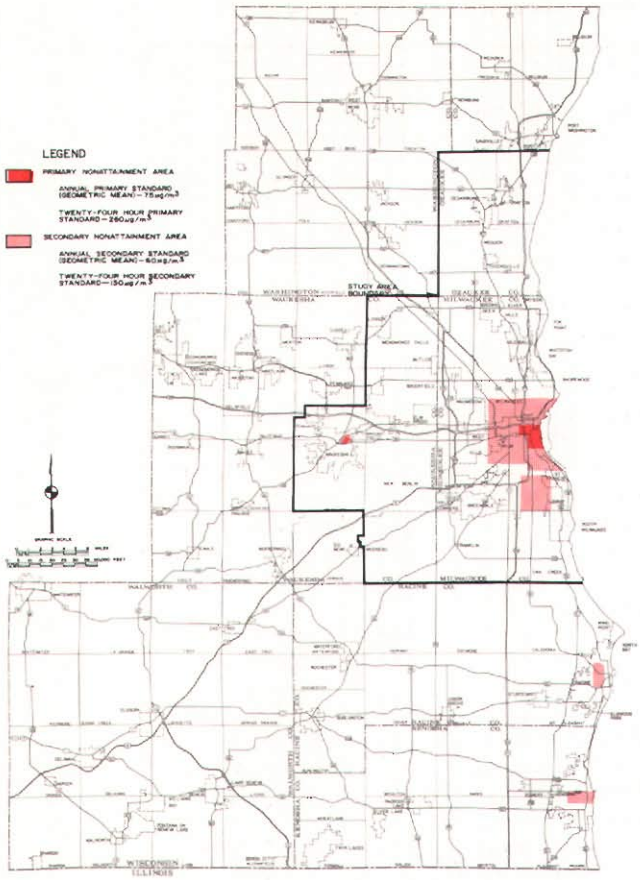
Source: Code of Federal Regulations Title 40, Part 50, 1973.

Based on 1977 monitoring data, the EPA formally designated parts of the Region as primary nonattainment areas for particulate matter, carbon monoxide, sulphur oxides, and ozone, and as secondary nonattainment areas for particulate matter. The designated areas of the Region where the standards for these pollutants are not met are shown on Maps 22 through 25.

Estimates of the total emissions of the major pollutants in the Region in 1977 are shown in Table 39 by source category (ozone is not shown because it is not emitted directly, but is formed in the atmosphere by the photochemical reaction of hydrocarbon and other pollutants and sunlight). Automobiles and trucks were major emitters of carbon monoxide, nitrogen dioxide, and hydrocar-

Map 22

PRIMARY AND SECONDARY PARTICULATE MATTER NONATTAINMENT AREA IN THE REGION

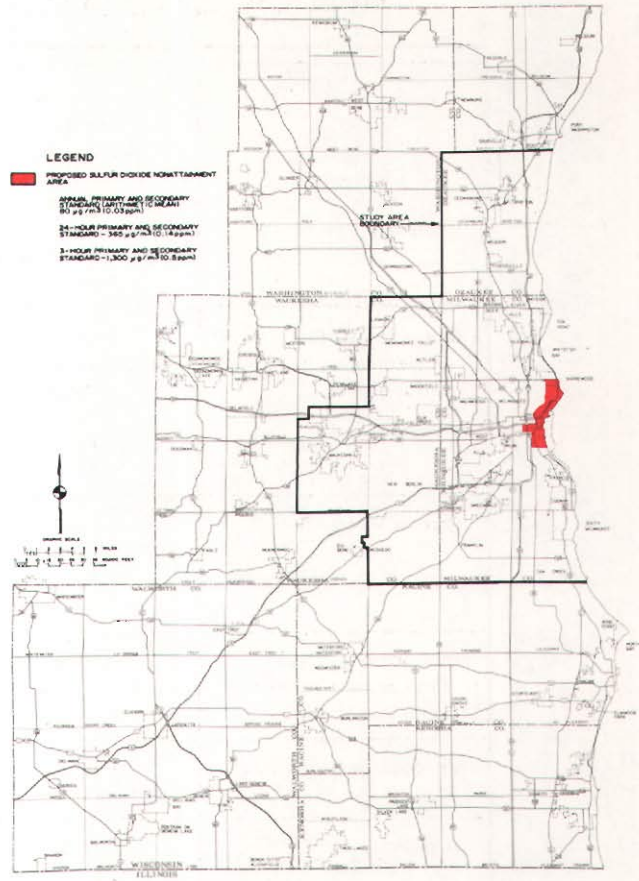


This map indicates the location of the primary and secondary particulate matter nonattainment areas in the Region as designated by the Wisconsin Department of Natural Resources in 1978. As may be seen on this map, there are two primary particulate matter nonattainment areas in the Region: one over a three-square-mile area in and around the heavily industrialized portion of the Menomonee River Valley in the City of Milwaukee comprising an estimated resident population of 16,500 persons, and one over a less than one-square-mile area in the northeast portion of the City of Waukesha comprising an estimated resident population of 3,700 persons. In addition, there are five secondary particulate matter nonattainment areas in the Cities of Milwaukee and Waukesha, one in and around General Mitchell Field in Milwaukee County, and one each in the Cities of Kenosha and Racine. In total, these secondary particulate matter nonattainment areas encompass an area of approximately 38.4 square miles and an estimated resident population of 335,300 persons.

Source: U. S. Environmental Protection Agency and Wisconsin Department of Natural Resources.

Map 23

SULFUR DIOXIDE NONATTAINMENT AREAS IN THE REGION



This map identifies the 7.4-square-mile area in Milwaukee County which the Wisconsin Department of Natural Resources designated as a sulfur dioxide nonattainment area based upon monitored violations of the 24-hour average sulfur dioxide ambient air quality standard in 1977 and 1978. An estimated resident population of 62,500 persons reside within the boundaries of this sulfur dioxide nonattainment area.

Source: Wisconsin Department of Natural Resources.

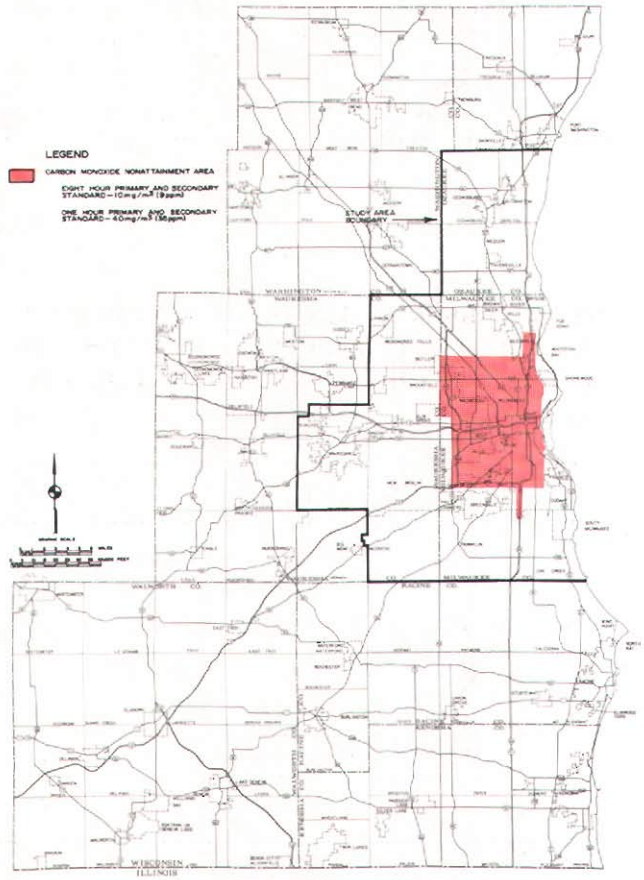
bon emissions in the Region, accounting for about 87 percent, 42 percent, and 36 percent of the total emissions for these pollutants, respectively.

The emissions levels of these pollutants are related not only to the number of vehicle miles of travel, but also to vehicle operating speeds (see Figures 23 through 25). Carbon monoxide and hydrocarbons are inversely related to speed, with about 37 percent more carbon monoxide and almost 36 percent more hydrocarbons produced when average speeds decrease from 35 miles per hour (mph) to 25 mph. Nitrogen oxide emissions are directly related to speed, but only 13 percent more nitrogen dioxide is produced at 35 mph than at 25 mph.

Assuming these relationships, the increased speeds during peak periods that would result from reduced traffic congestion would lower carbon monoxide and hydrocarbons levels significantly. This is important, because the entire Milwaukee study area is within an ozone nonattainment area—hydrocarbons being the principal precursor

Map 24

CARBON MONOXIDE NONATTAINMENT AREA IN THE REGION

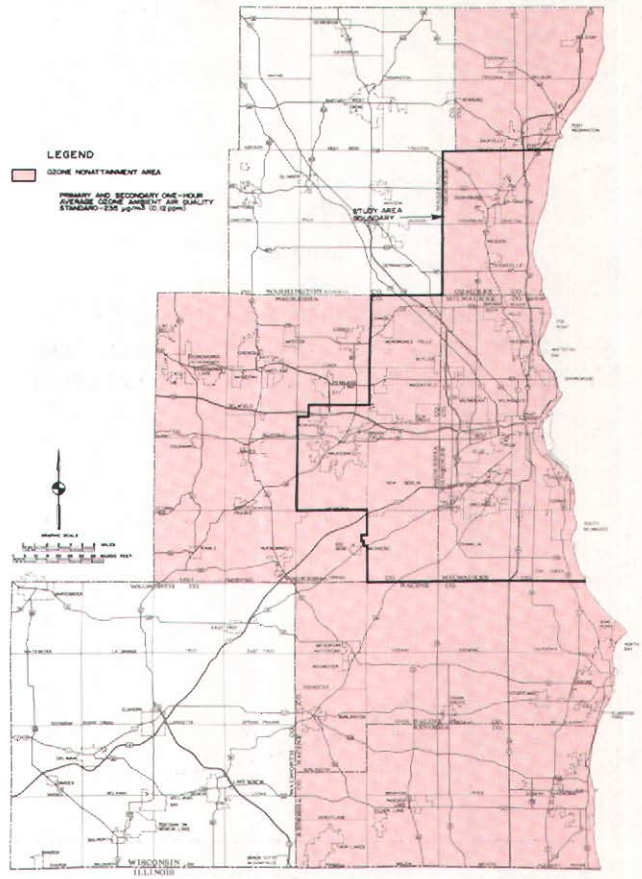


This map identifies that portion of Milwaukee County which was designated by the U. S. Environmental Protection Agency in March 1978 as a nonattainment area for carbon monoxide. Ambient air quality monitoring data from stations located within this designated nonattainment area indicate that the eight-hour average carbon monoxide ambient air quality standard has been violated on one or more occasions each year since monitoring for this pollutant species was initiated in 1973. The designated carbon monoxide nonattainment area encompasses approximately 85 square miles and an estimated resident population of 730,600 persons.

Source: U. S. Environmental Protection Agency and Wisconsin Department of Natural Resources.

Map 25

OZONE NONATTAINMENT AREA IN THE REGION



As may be seen on this map, five counties in the Region—Kenosha, Milwaukee, Ozaukee, Racine, and Waukesha—were designated in 1978 by the U. S. Environmental Protection Agency as a nonattainment area for ozone. Walworth and Washington Counties are presently designated as "unclassifiable" with respect to the attainment of the ozone ambient air quality standard because there are no monitoring data for these two counties. The designated five-county ozone nonattainment area encompasses approximately 1,675 square miles, or about 62 percent of the total area of the Region, and a resident population of about 1,629,000 persons, or about 92 percent of the total regional population. The entire Milwaukee area is included within this nonattainment area.

Source: U. S. Environmental Protection Agency and Wisconsin Department of Natural Resources.

of ozone—and a substantial portion of Milwaukee County is within a carbon monoxide nonattainment area. Although increases in peak-period vehicle speeds would slightly increase nitrogen oxide levels, the Region currently meets EPA standards for this pollutant, and the small increase would be unlikely to result in a violation of those standards.

To illustrate the relationship between traffic volumes and ambient air quality, the 1979 average hourly carbon monoxide levels recorded at each of the air quality monitoring sites in the Milwaukee area can be compared with the 1979 average hourly traffic volumes on the nearest arterial street or highway (see Figures 26 through 30). The carbon

Table 39

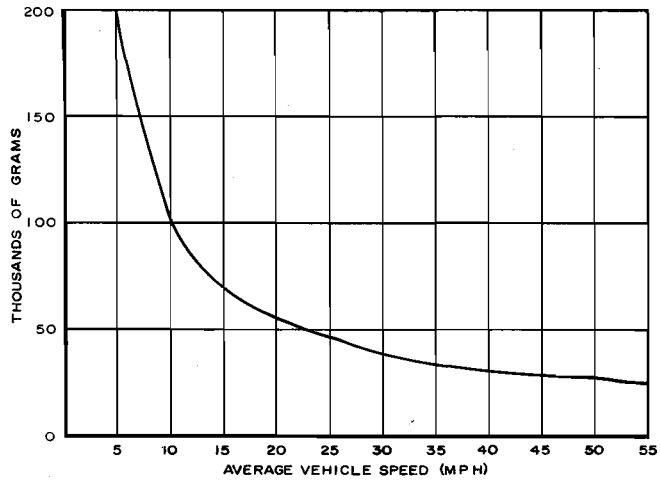
SUMMARY OF EMISSIONS IN THE REGION BY POLLUTANT AND SOURCE: 1977

Pollutant	Point Sources		Line Sources		Area Sources		Total	
	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent
Particulate Matter. . .	7,432	24.4	4,424	14.5	18,642	61.1	30,498	100.0
Sulfur Dioxide.	196,839	93.3	1,852	0.9	12,211	5.8	210,902	100.0
Carbon Monoxide. . .	8,573	1.4	519,788	86.8	70,456	11.8	598,817	100.0
Hydrocarbons	32,127	24.3	47,908	36.2	52,392	39.5	132,427	100.0
Nitrogen Oxides. . . .	46,296	40.5	47,668	41.7	20,325	17.8	114,289	100.0

Source: SEWRPC.

Figure 23

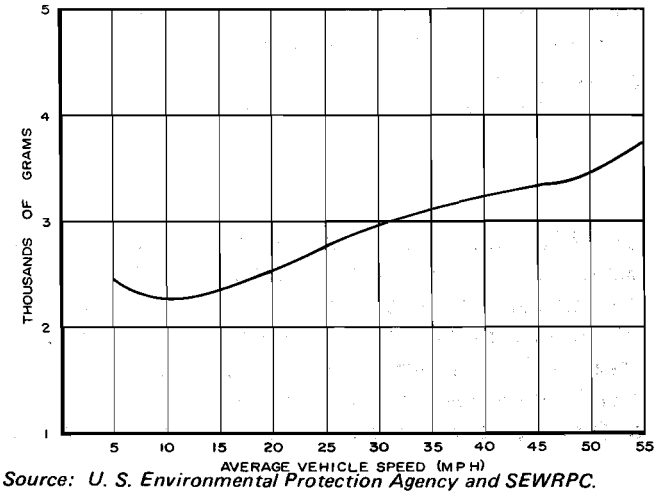
CARBON MONOXIDE EMISSIONS FOR AUTOMOBILES AND LIGHT TRUCKS PER 1,000 VEHICLE MILES OF TRAVEL AT VARIOUS SPEEDS



Source: U. S. Environmental Protection Agency and SEWRPC.

Figure 24

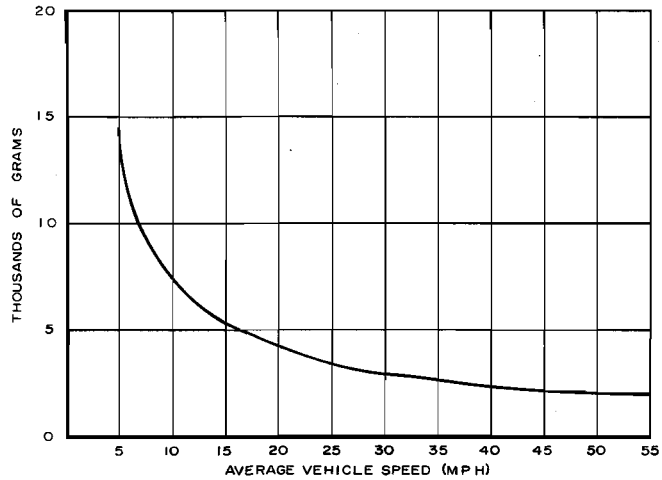
NITROUS OXIDE EMISSIONS FOR AUTOMOBILES AND LIGHT DUTY TRUCKS PER 1,000 VEHICLE MILES OF TRAVEL AT VARIOUS SPEEDS



Source: U. S. Environmental Protection Agency and SEWRPC.

Figure 25

HYDROCARBON EMISSIONS FOR AUTOMOBILES AND LIGHT DUTY TRUCKS PER 1,000 VEHICLE MILES OF TRAVEL AT VARIOUS SPEEDS



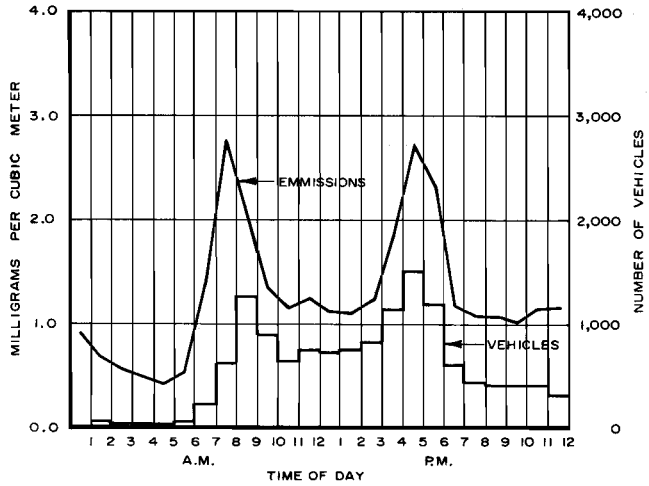
Source: U. S. Environmental Protection Agency and SEWRPC.

monoxide concentrations shown in these illustrations are representative of the hourly monitored pollutant levels averaged over the entire year, and thus do not directly relate to the EPA standards since the standards define annual extremes and not averages. It should be noted, however, that in 1979 a violation of the carbon monoxide standards occurred only at the monitor at 7528 W. Appleton Avenue, as shown in Table 40.

In addition to the traffic adjacent to any monitoring site, other factors such as meteorological conditions, including temperature, wind direction, and speed, and the emissions of nearby point sources and area sources influence measured pollutant levels. Figures 26 through 30 nevertheless show a remarkable correlation between carbon monoxide levels and traffic peaking. The highest 1979 average carbon monoxide level was recorded at the

Figure 26

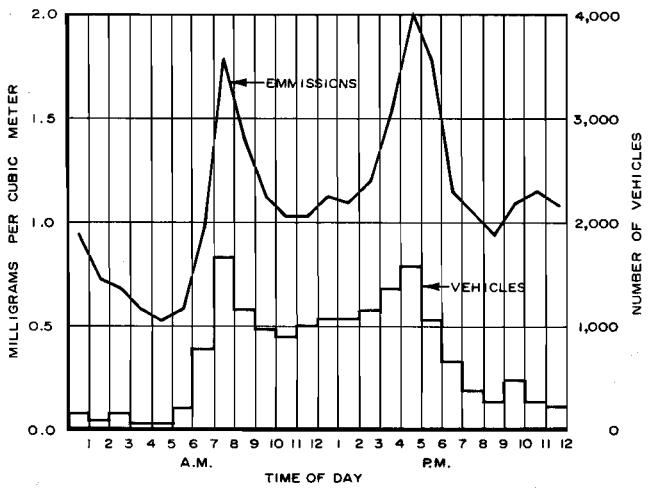
AVERAGE HOURLY CARBON MONOXIDE LEVELS AND ARTERIAL TRAFFIC VOLUMES AT 3716 W. WISCONSIN AVENUE: 1979



Source: Wisconsin Department of Natural Resources, Milwaukee Traffic Engineering Department, and SEWRPC.

Figure 27

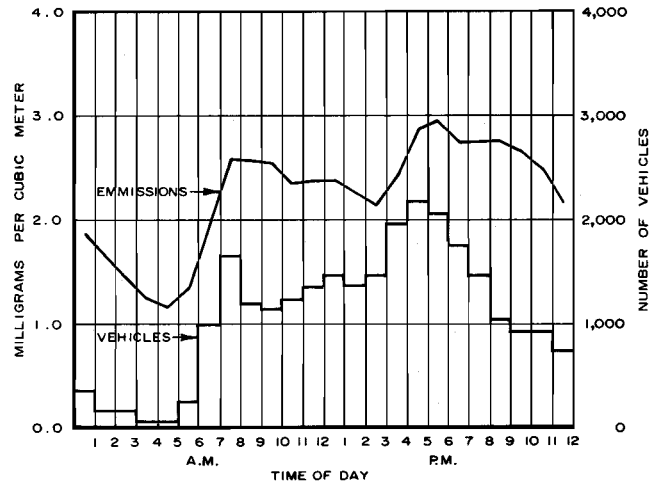
AVERAGE HOURLY CARBON MONOXIDE LEVELS AND ARTERIAL TRAFFIC VOLUMES AT 600 W. KILBOURN AVENUE: 1979



Source: Wisconsin Department of Natural Resources, Milwaukee Traffic Engineering Department, and SEWRPC.

Figure 28

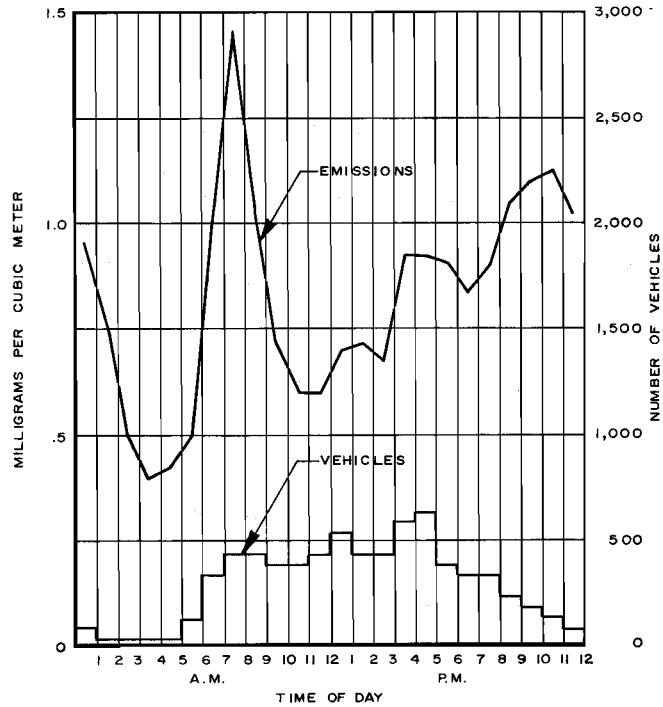
AVERAGE HOURLY CARBON MONOXIDE LEVELS AND ARTERIAL TRAFFIC VOLUMES AT 7528 W. APPLETON AVENUE: 1979



Source: Wisconsin Department of Natural Resources, Milwaukee Traffic Engineering Department, and SEWRPC.

Figure 29

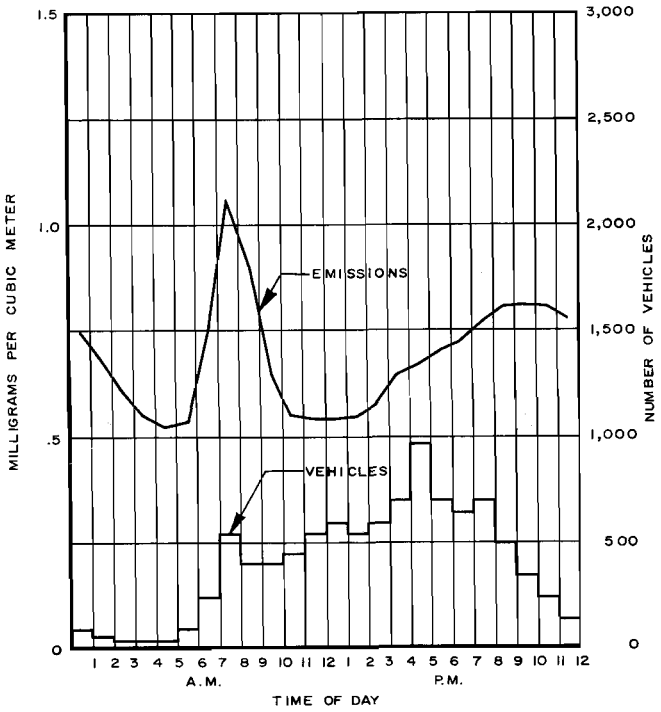
AVERAGE HOURLY CARBON MONOXIDE LEVELS AND ARTERIAL TRAFFIC VOLUMES AT 225 N. GRAND AVENUE, WAUKESHA: 1979



Source: Wisconsin Department of Natural Resources, Milwaukee Traffic Engineering Department, and SEWRPC.

Figure 30

AVERAGE HOURLY CARBON MONOXIDE LEVELS AND ARTERIAL TRAFFIC VOLUMES AT 3401 S. 39TH STREET: 1979



Source: Wisconsin Department of Natural Resources, Milwaukee Traffic Engineering Department, and SEWRPC.

Table 40

NUMBER OF VIOLATIONS OF THE EIGHT-HOUR AND ONE-HOUR CARBON MONOXIDE STANDARDS IN THE MILWAUKEE AREA: 1979

Monitoring Location	Number of Violations	
	Eight-Hour Standard	One-Hour Standard
Milwaukee County		
7528 W. Appleton Avenue . . .	12	--
1225 W. Carferry Drive	--	--
3401 S. 39th Street	--	--
3716 W. Wisconsin Avenue. . .	--	--
600 W. Kilbourn Avenue	--	--
Waukesha County		
225 W. Grand Avenue.	--	--

Source: SEWRPC.

Wisconsin Avenue station (see Figure 26) between 7:00 a.m. and 8:00 a.m., just preceding the highest peak morning traffic in this area. A similar pattern of carbon monoxide peaks and traffic peaks occurs at the 600 W. Kilbourn Avenue monitoring site (see Figure 27).

Energy Consumption

Traffic congestion wastes motor fuel. Not only is stop-and-go traffic frustrating to drivers, but it costs considerable money in wasted motor fuel. For every minute trapped in traffic, a typical medium-size automobile will idle away 2.6 ounces of gasoline; for every 10 minutes, 0.2 gallon; and for every hour, 1.4 gallons. Even if the vehicle is moving intermittently, it will burn gasoline at a greater rate than if it were moving steadily.

Although the United States has only 6 percent of the world's population, it consumes about one-third of the world's energy. Transportation accounts for about one-quarter of the total U. S. energy consumption, but more than half of its petroleum consumption. As shown in Table 41, automobile fuel use alone represents half of the State's transportation energy consumption. In addition, it accounts for about 30 percent of all petroleum consumption in Wisconsin. Urban automobile travel uses more than one-sixth of the total U. S. petroleum, and thus it is crucial that ways be sought to make such travel more energy-efficient.

Vehicle fuel consumption is a function of, among other things, average vehicle operating speed, vehicle weight, engine size, and average vehicle load. As shown in Figure 31, automobile fuel efficiency is lowest at average speeds below 30 mph, because such speeds usually coincide with stop-and-go traffic conditions. Fuel efficiency is generally best between average speeds of 30 mph and 50 mph, and begins to decrease at higher speeds. A typical automobile averaging 14 miles per gallon may be expected to get only eight miles per gallon at an average speed of 10 mph, one and one-half times that at 20 mph, and about 16 miles per gallon at 50 mph. Reducing traffic congestion can thus have a dramatic effect on total motor fuel consumption. There are an estimated 22 miles of freeways in the Milwaukee area with average operating speeds below 40 mph during the morning and afternoon peak hours.

Table 41

ENERGY USED FOR TRANSPORTATION IN WISCONSIN: 1977

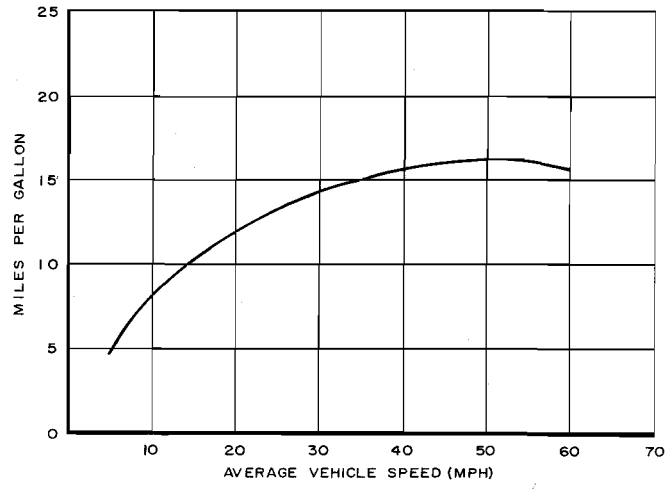
Fuel Type	Trillions of BTU's[a]	Percent of Total
Gasoline		
Auto	179.20	53.3
Truck	95.70	28.4
Urban Bus	0.03	--
Subtotal	274.90	81.7
Diesel		
Truck	36.4	10.8
Rail	11.5	3.4
Urban Bus	0.7	0.2
Subtotal	48.6	14.4
Aviation Fuel		
Gasoline	0.9	0.3
Kerosene (Jet)	10.4	3.1
Distillate and Residual		
Vessel Bunkering	1.7	0.5
Total	336.5	100.0

[a] *One gallon of gasoline is equivalent to 125,000 British Thermal Units (BTU's); one gallon of distillate or diesel fuel is equivalent to 138,800 BTU's; and one gallon of kerosene or jet fuel is equivalent to 135,000 BTU's.*

Source: Division of State Energy, Wisconsin Department of Administration.

Figure 31

AUTOMOBILE FUEL EFFICIENCY BY AVERAGE SPEED: 1980



Source: SEWRPC.

SUMMARY AND CONCLUSIONS

This chapter has examined the usage of the highway and public transit systems in the Milwaukee area on a peak-period basis. Both the morning and afternoon hours of peak traffic congestion, 7:00 a.m. to 8:00 a.m. and 4:00 p.m. to 5:00 p.m., were analyzed using hourly traffic count data to determine the traffic volumes and design capacities, and thereby identify capacity problems and deficiencies. The magnitude of the problems on the transit routes operated by the Milwaukee County Transit System was determined through examination of the distribution of transit demand, passenger load factors, and the number of buses in operation throughout an average weekday. The effect of traffic congestion upon vehicle operating speeds and the attendant effects upon air quality and motor fuel consumption were also examined.

Through analysis of the hourly traffic count data for the Milwaukee area, it was determined that during the morning peak hour, 7 percent of the arterial system operates at design capacity and 7 percent operates over design capacity; while during the afternoon peak hour, 11 percent of the arterial system operates at design capacity and almost 9 percent operates over design capacity. About 25 percent of the freeway element of the arterial system operates over design capacity during the morning and afternoon peak hours, and about 20 percent of the freeways operate at design capacity. More than 75 percent of all facilities operating either at and over design capacity are located within Milwaukee County.

The peak period of demand for transit services in the Milwaukee area occurs just slightly earlier than that for street and highway facilities. In 1978 about 10,600 passengers passed the maximum load points between 7:00 a.m. and 7:30 p.m., and about 10,100 passengers passed the maximum load points between 3:30 p.m. and 4:00 p.m. In order to meet this demand, as many as 500 buses were in opera-

tion during the peak periods, while fewer than 300 buses served the midday period. This peaking of demand creates the need for complex schedules and split shifts to provide the needed transit service during the peaks and reduced service during the off-peak periods.

Parts of the Milwaukee area have been designated nonattainment areas by the U. S. Environmental Protection Agency (EPA) for particulate matter, sulphur dioxide, carbon monoxide, and ozone. The emission rates for carbon monoxide, hydrocarbons (a principal precursor of ozone), and nitrogen oxides are related to vehicle operating speeds. An analysis of hourly traffic counts and average hourly measured pollutant levels reveals a remarkable correlation between carbon monoxide levels and traffic peaking. Therefore, if a reduction in peak-hour congestion through the rescheduling of work trips resulted in an increase in average vehicle operating speeds, it would produce a corresponding reduction in carbon monoxide emissions, as well as in hydrocarbon emissions.

Vehicle fuel consumption is a function of, among other things, average operating speed. Within the range of average urban operating speeds—10 miles per hour (mph) up to about 50 mph—fuel economy increases as the average speed increases mainly because idling time is reduced and there are fewer necessary speed changes. Therefore, an increase in average vehicle operating speeds will produce a corresponding reduction in fuel consumption.

Chapter VII

POTENTIAL AND FEASIBILITY OF WORK TIME RESCHEDULING IN THE MILWAUKEE AREA

INTRODUCTION

This chapter addresses the maximum potential benefits of work time rescheduling in the Milwaukee area. These benefits are measured by determining whether sufficient peak-hour work-related travel can be shifted from the morning and afternoon peak hours to surrounding hours of the three hour morning and afternoon peak periods to significantly abate peak-hour traffic congestion and transit vehicle needs. Without causing increased traffic congestion and transit vehicle needs in the hours surrounding the peak hours.

Also assessed in the chapter is the feasibility of increased participation by Milwaukee area employers in work time rescheduling programs. Based upon a survey of major and selected minor employers in the Milwaukee area, the extent of existing work time rescheduling by Milwaukee area employers was determined, employer attitudes toward increased participation in work time rescheduling programs were elicited, and the practical degree of participation of employers in new work time rescheduling programs was determined. Based upon this assessment, conclusions were reached concerning the desirability of promoting areawide work time rescheduling in the greater Milwaukee area for the purpose of abating areawide traffic congestion problems.

POTENTIAL MILWAUKEE AREA TRAFFIC CONGESTION ABATEMENT THROUGH WORK TIME RESCHEDULING

The determination of the maximum potential of work time rescheduling was accomplished in three steps. First, the major problem segments of arterial facilities operating at or over design capacity during the morning and afternoon peak travel hours of 7:00 a.m. to 8:00 a.m. and 4:00 p.m. to 5:00 p.m. in 1978 were identified. Second, the number of work trips made on each problem segment during the peak hours was calculated to establish the number of trips which could be shifted to preceding and/or following hours to reduce traffic congestion through work time rescheduling. Third, work trips in the peak hours were hypothetically shifted to adjacent hours and the attendant effect on traffic conditions in the hours surrounding the peak hours was determined.

Existing Problem Segments of the Arterial Street and Highway System

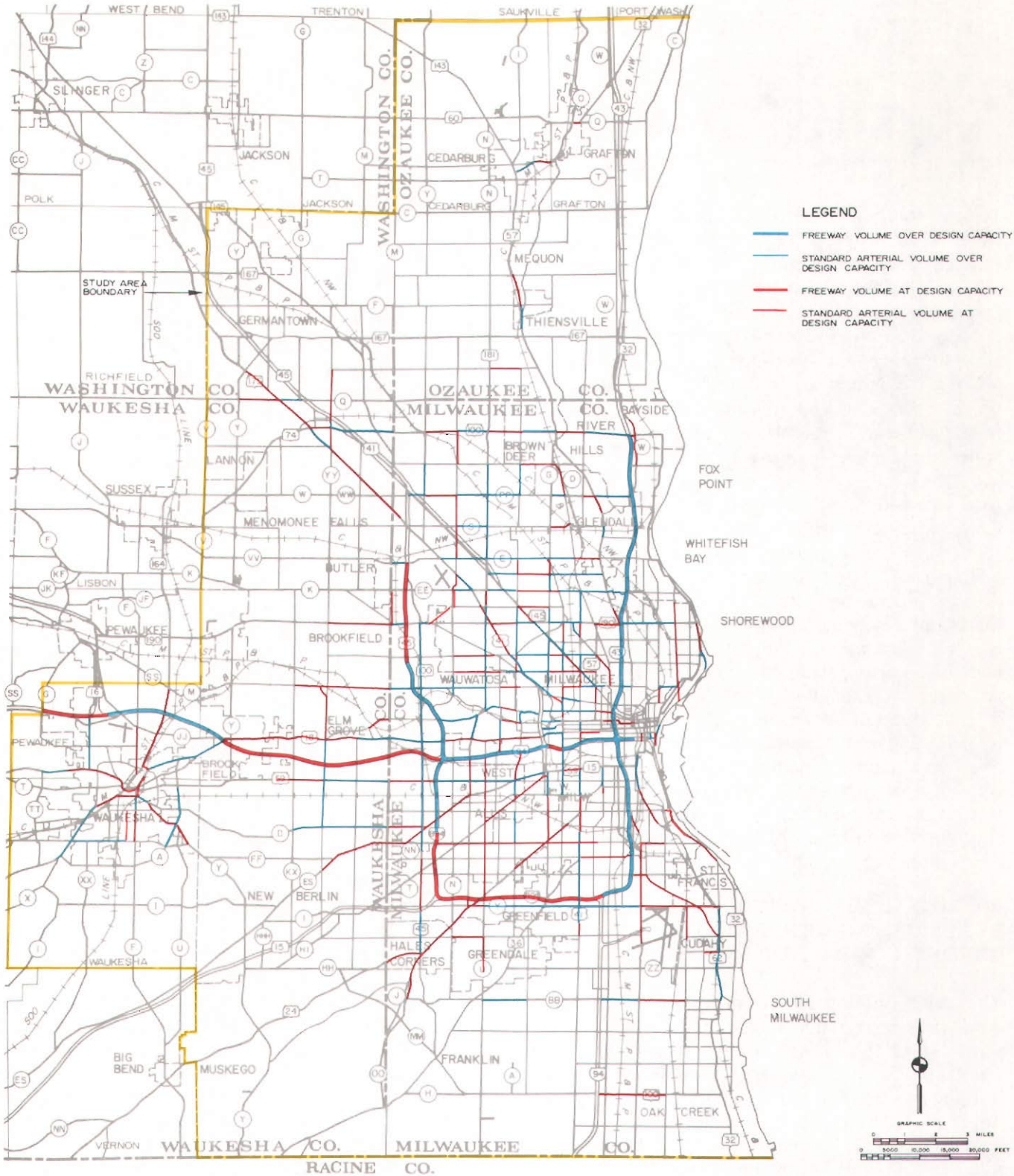
In 1978 about 286 miles, or 22 percent, of the total arterial street and highway system in the greater Milwaukee area—consisting of Milwaukee County, eastern Waukesha County, southeastern Washington County, and southern Ozaukee County—were operating at or over design capacity during either the morning or afternoon peak hour, or both. These congested facilities were grouped for analytical purposes into approximately 100 problem segments. The problem segments were defined as continuous arterial street segments which operated at or over design capacity during either the morning or the afternoon peak hour, or both. These segments are shown on Map 26. The problem segments included 52 miles, or 46 percent, of the area freeway system, and were concentrated in Milwaukee County, where 77 percent, or 221 miles, of the problem segments were located. Only three segments, totaling 3 miles, were located in Washington County; four segments totaling 4 miles were located in Ozaukee County; and about 40 segments totaling 58 miles were located in Waukesha County.

Work-Related Proportion of Peak-Hour Arterial Highway Traffic

During the peak hours, the major proportion of the trips made by automobile are destined either to or from work, although trips by automobile for other purposes—school, shopping, personal business, and social and recreational purposes—also occur during these hours. Since work time rescheduling primarily affects work trips, it was necessary to estimate the number of automobile work trips on each problem segment to determine the maximum number of work trips which could be shifted to abate peak-hour highway traffic congestion. The required estimates were made by calculating that proportion of all automobile driver trips constituting work-purpose trips on each problem segment using hourly trip tables and traffic assignments based upon the Commission's 1972 origin-destination

Map 26

SEGMENTS OF CONGESTED ARTERIAL STREETS AND HIGHWAYS IN THE MILWAUKEE AREA: 1978



This map shows the segments of the arterial street and highway system that are congested during the morning and afternoon peak hours—7:00 a.m. to 8:00 a.m. and 4:00 p.m. to 5:00 p.m., respectively. If a segment operates over design capacity during either or both of the peak hours, it is shown in red, while segments which operate at design capacity during either or both peak hours but do not operate over design capacity during either peak hour are shown in blue. The congested segments are concentrated in Milwaukee County, and include almost 45 percent of the freeways in the Milwaukee area.

Source: SEWRPC.

survey[1] of travel in the Region. These proportions were then applied to the peak-hour traffic volumes counted in 1978.

Work trips were determined to represent from 20 to 95 percent of the total automobile driver trips on the various problem arterial segments during the peak highway travel hours. Generally, work trips by automobile constituted a higher proportion of the morning peak-hour travel than of the afternoon peak-hour travel. During the morning peak hour, the average proportion of work trips on the problem segments was 80 percent, and during the afternoon peak hour the average proportion of work trips was 55 percent. These proportions, calculated from the 1972 data, were assumed to remain unchanged in 1978.

Determination of Maximum Potential Traffic Congestion Abatement Through Work Time Rescheduling

With the information acquired on hourly peak-period traffic volume counts and on the proportion of the peak-hour traffic volume for each problem segment made by automobile for work purposes, it was possible to quantify the maximum arterial highway traffic congestion that could be abated in the Milwaukee area through work time rescheduling. Specifically, the number of work trips which would need to be shifted in order to abate the peak-hour congestion was determined. This number was then shifted to the adjacent earlier and later hours—6:00 a.m. to 7:00 a.m. and 8:00 a.m. to 9:00 a.m. during the morning period and 3:00 p.m. to 4:00 p.m. and 5:00 p.m. to 6:00 p.m. during the evening peak period—in order to determine the potential impacts of work time rescheduling on traffic conditions in those hours.

Seven shift patterns of highway traffic from the peak travel hours to adjacent hours were hypothesized to define the possible range of maximum benefits of work time rescheduling in the Milwaukee area, and the limits on such rescheduling imposed by existing traffic volumes during adjacent hours. As shown in Table 42, the first five shift patterns were designed to demonstrate the maximum benefits of, and the potential limitations to, flexible, staggered, and shifted work hour programs. The last two shift patterns were designed to demonstrate the implications of shortened work weeks.

Shift Pattern 1 would shift work trips from the peak hour to adjacent hours in an attempt to maximize peak-hour congestion abatement. Enough work trips from the peak hour would be shifted on all peak-hour problem segments—including those operating at design capacity in the peak hour—to bring the volumes on these segments to a level below design capacity in the peak hour. The trips would be shifted from the peak hours equally to the hour preceding and the hour following.

Shift Pattern 2 would shift work trips in the same manner as Shift Pattern 1, but would have the more limited objective of attempting to abate only the more severe peak-hour congestion—that is, to abate congestion only on those facilities operating over design capacity in the peak hours. This pattern would have less impact on the hours adjacent to the peak hour because less traffic would be shifted to those hours.

Shift Pattern 3, like Shift Pattern 1, would seek to eliminate all peak-hour congestion. Under this shift pattern, an attempt would be made to shift enough work trips from the peak hour on all problem segments operating at or over design capacity in the peak hour to bring the volumes on such segments to a level below design capacity. The trips would be shifted from the peak hour equally to the hour preceding and the hour following the peak hour. If such shifting resulted in over-design-capacity operation, the trips to be shifted from the peak hour would instead be spread evenly among all three hours of the morning or afternoon peak periods—the peak hour, and the preceding and following hours. The intent of such spreading would be to achieve the maximum reductions in emissions and fuel consumption over the entire three-hour peak period.

Shift Pattern 4 would be similar to Shift Pattern 3, but only work trips from the more severely congested arterial segments would be shifted. Work trips would be shifted only from segments operating over design capacity. The shifted trips would be distributed equally between the hours preceding and following the peak hours. If such shifting

[1] *See SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, for a complete discussion of the 1972 home interview survey.*

Table 42

HYPOTHETICAL WORK TIME RESCHEDULING SHIFT PATTERNS OF PEAK-HOUR WORK TRIPS TO ADJACENT HOURS

Shift Pattern	Peak-Hour Trips Shifted if Peak-Hour Traffic Volumes Equals or Exceeds:[a]	Peak-Hour Trips Shifted Until Peak-Hour Traffic Volumes Reach:[a]	Distribution of Trips Shifted from Peak Hour[b]
1	At design capacity	Under design capacity	Half to preceding hour and half to following hour
2	Over design capacity	At design capacity	Half to preceding hour and half to following hour
3	At design capacity	Under design capacity[c]	Half to preceding hour and half to following hour[c]
4	Over design capacity	At design capacity[c]	Half to preceding hour and half to following hour[c]
5	Over design capacity	At design capacity[c]	Trips shifted first to preceding hour until it reaches the upper limit of at-design-capacity operation and then any remaining trips are shifted to the following hour[c]
6	At design capacity	Under design capacity	All to preceding hour in morning and all to following hour in evening (trips shifted are reduced by 20 percent as the pattern represents a shortened work week program)
7	Over design capacity	At design capacity	All to preceding hour in morning and all to following hour in evening (trips shifted are reduced by 20 percent as the pattern represents a shortened work week program)

[a] *The number of trips shifted cannot exceed the estimated number of work trips on a segment.*

[b] *Additional peak-hour trips cannot be shifted if they would cause the preceding or following hours to be assigned traffic volumes exceeding maximum capacity.*

[c] *If the number of peak-hour trips shifted would cause the preceding or following hour to operate over design capacity, the total peak-hour trips to be shifted would be evenly distributed among the peak hour and adjacent preceding and following hours.*

Source: SEWRPC.

resulted in over-design-capacity operation, the work trips shifted from the peak hour would be spread evenly among all three hours.

Shift Pattern 5, like Shift Pattern 4, would shift work trips from the peak hour only on problem segments operating over design capacity. However, the trips would first be shifted from the peak hour to the preceding hour until the problem segments during the peak hour were operating at design capacity, and then any remaining trips would be shifted to the hour following the peak hour. If such shifting caused trips adjacent to the peak hour to operate over design capacity, the trips would then be reshifted evenly among all three hours, as under the Shift Pattern 4. The intent of Shift Pattern 5 would be to attempt to take advantage of the fact that traffic volumes during the hour preceding the morning peak hour are slightly lower than those during the hour following the peak hour.

The sixth and seventh shift patterns would illustrate the effects of a shortened work week on peak-period traffic congestion. The most common program considered, and thus the program assumed

under these two patterns, is a four-day, 10-hour-per-day work week. To reflect the longer work days under such a program, the traffic removed from the morning peak hour under these two shift patterns would be shifted entirely to the preceding hour, and the traffic removed from the afternoon peak hour would be shifted entirely to the following hour. The traffic shifted to the hours adjacent to the peak hours would be reduced by 20 percent from the amount of traffic that would be shifted on an average day of a five-day work week. This reduction is based on the optimistic assumption that those workers on four-day work week programs would have their work days staggered to the maximum extent over the traditional Monday through Friday five-day work week. Specifically, it was assumed that on each day of the five-day work week, one-fifth of the workers on the four-day programs would be scheduled to not report to work. Shift Pattern 6 would seek to eliminate peak-hour congestion from facilities operating both at and over design capacity. Work trips would be shifted from the peak hours to bring the volumes on such facilities to below design capacity. Shift Pattern 7 would have the more limited objective of eliminating peak-hour congestion only from facilities operating over design capacity.

Results of the Hypothetical Shifting of Work Trips: The impact of each work time rescheduling shift pattern on traffic congestion, vehicle speed, air pollutant emissions, and fuel consumption on the problem arterial segments can be estimated by applying each pattern and calculating the resulting hourly peak-period traffic volumes. These impacts, as shown in Tables 43, 44, and 45, represent the maximum benefits of work time rescheduling which could be achieved in the Milwaukee area by shifting work trips from the peak hours to the hours preceding and following these hours.

Shift Pattern 1 Results: Shift Pattern 1 would seek to abate both at- and over-design-capacity peak-hour arterial facility operation by shifting a portion of the work-related peak-hour traffic volumes equally between the hours preceding and following the morning and afternoon peak hours.

Applying Shift Pattern 1 to the morning peak hour of 7:00 a.m. to 8:00 a.m. requires that an average of 280 trips be shifted from each problem segment, or approximately 22 percent of all work trips on the problem segments. Some problem segments require a shift as small as 1 percent of all work trips, and others require a shift as large as 62 percent. This shifting eliminates 87 percent, or 81 miles, of morning peak-hour over-design-capacity arterial congestion, and 97 percent, or 81 miles, of at-design-capacity arterial congestion. Not all peak-hour congestion can be abated because sufficient traffic-carrying capacity in the hours adjacent to the peak hour is not available to accommodate the traffic which has to be shifted from the peak hour.

The necessary shifting of traffic to adjacent hours produces a substantial increase in congestion during the hours preceding and following the morning peak hour. The mileage of severely congested facilities operating over design capacity from 6:00 a.m. to 7:00 a.m. increases by 27 miles, or 239 percent, to 38 miles, and that from 8:00 a.m. to 9:00 a.m. increases by 25 miles, or 95 percent, to 52 miles. The mileage of congested facilities operating at design capacity decreases by 4 miles from 6:00 a.m. to 7:00 a.m., and increases by 7 miles from 8:00 a.m. to 9:00 a.m., for a net increase in the two adjacent hours together of 3 miles, or 6 percent.

During the three-hour morning peak period the mileage of the more severely congested facilities—those operating over design capacity—decreases by 29 miles, or 22 percent, as a result of this shift pattern. At the same time, the mileage of the facilities operating at design capacity decreases by 78 miles, or 53 percent. Thus, the net change over the three-hour morning peak period is a reduction of 107 miles, or 37 percent, in congested facilities.

Air quality improvements and energy savings are also achieved on the problem segments during the three-hour morning peak period, with total decreases in carbon monoxide and hydrocarbon emissions of 10 and 9 percent, respectively, and a reduction in fuel consumption of 3,600 gallons, or 6 percent. The level of nitrogen oxide emissions does not change during the three-hour morning peak period. Therefore, while the shift in work trips does serve to increase traffic congestion during adjacent hours, peak-hour traffic congestion is nearly eliminated, and over the three-hour morning peak period traffic congestion is significantly reduced. This reduction results in an increase in average vehicle speed and in a decrease in automobile air pollutant emissions and fuel consumption on those problem segments during the morning peak hour. It should be noted that carbon monoxide and hydrocarbon emissions and fuel consumption increase during the adjacent hours because the shifting of work trips from the peak hour causes average vehicle speeds to be reduced during these

Table 43

CHANGE IN THE PEAK-PERIOD MILEAGE OF ARTERIALS OPERATING AT AND OVER DESIGN CAPACITY AFTER HYPOTHETICAL SHIFTS OF WORK TRIPS FROM THE MORNING PEAK HOUR

Service Level	6:00 a.m. to 7:00 a.m.						7:00 a.m. to 8:00 a.m.						8:00 a.m. to 9:00 a.m.						Net Change 6:00 a.m. to 9:00 a.m.		
	Miles of Standard Arterials[a]		Miles of Freeways[b]		Total Miles		Miles of Standard Arterials[a]		Miles of Freeways[b]		Total Miles		Miles of Standard Arterials[a]		Miles of Freeways[b]		Total Miles				
	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Arterials	Freeways	Total
Existing																					
At Design Capacity . . .	22	--	9	--	30	--	61	--	23	--	84	--	16	--	17	--	33	--	--	--	--
Over Design Capacity . .	9	--	2	--	11	--	67	--	26	--	93	--	25	--	2	--	27	--	--	--	--
After Shift Pattern 1																					
At Design Capacity . . .	22	0	5	-4	27	-4	2	-59	--	-23	2	-81	23	7	17	--	38	7	-51	-26	-78
Over Design Capacity . .	27	18	11	9	38	27	11	-56	--	-26	12	-81	39	14	13	11	52	25	-24	-6	-29
After Shift Pattern 2																					
At Design Capacity . . .	16	-5	11	3	28	-3	112	51	48	26	160	77	13	-3	15	-2	28	-5	43	26	69
Over Design Capacity . .	24	15	4	2	28	16	11	-56	--	-26	12	-81	35	10	7	5	42	15	-31	-19	-50
After Shift Pattern 3																					
At Design Capacity . . .	27	6	15	6	42	12	27	-34	15	-8	42	-42	27	12	16	-1	43	11	-16	-3	-19
Over Design Capacity . .	27	17	6	4	33	21	27	-41	6	-20	33	-61	27	2	6	4	33	6	-22	-12	-34
After Shift Pattern 4																					
At Design Capacity . . .	21	-1	9	--	30	-1	101	40	42	20	143	60	21	5	16	-1	36	4	43	19	63
Over Design Capacity . .	27	17	6	4	33	21	27	-41	6	-20	33	-61	28	3	6	4	34	7	-21	-12	-33
After Shift Pattern 5																					
At Design Capacity . . .	18	-4	9	--	28	-3	101	40	42	20	144	60	11	-5	13	-4	24	-9	32	16	48
Over Design Capacity . .	26	17	6	4	32	22	27	-40	6	-20	33	-60	32	7	6	4	38	11	-16	-12	-28
After Shift Pattern 6																					
At Design Capacity . . .	21	-1	7	-2	28	-2	4	-57	--	-23	4	-79	16	--	17	--	33	--	-57	-24	-81
Over Design Capacity . .	38	28	15	13	53	42	13	-54	--	-26	14	-80	25	--	2	--	27	--	-26	-13	-38
After Shift Pattern 7																					
At Design Capacity . . .	17	-5	4	-5	21	-9	115	54	48	26	163	80	16	--	17	--	33	--	49	21	71
Over Design Capacity . .	25	16	11	9	36	25	13	-54	--	-26	14	-80	25	--	2	--	27	--	-38	-17	-55

[a] *There are a total of 1,188.7 miles of standard arterials in the Milwaukee area.*

[b] *There are a total of 110.7 miles of freeways in the Milwaukee area.*

Source: SEWRPC.

Table 44

CHANGE IN THE PEAK-PERIOD MILEAGE OF ARTERIALS OPERATING AT AND OVER DESIGN CAPACITY AFTER HYPOTHETICAL SHIFTS OF WORK TRIPS FROM THE AFTERNOON PEAK HOUR

Service Level	3:00 p.m. to 4:00 p.m.						4:00 p.m. to 5:00 p.m.						5:00 p.m. to 6:00 p.m.						Net Change 3:00 p.m. to 6:00 p.m.		
	Miles of Standard Arterials[a]		Miles of Freeways[b]		Total Miles		Miles of Standard Arterials[a]		Miles of Freeways[b]		Total Miles		Miles of Standard Arterials[a]		Miles of Freeways[b]		Total Miles				
	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Number	Change	Arterials	Freeways	Total
Existing																					
At Design Capacity . . .	56	--	14	--	70	--	116	--	20	--	136	--	69	--	23	--	92	--	--	--	--
Over Design Capacity . .	57	--	12	--	69	--	84	--	28	--	112	--	60	--	13	--	73	--	--	--	--
After Shift Pattern 1																					
At Design Capacity . . .	40	-17	16	2	55	-15	12	-104	2	-18	14	-122	40	-29	16	-6	56	-36	-150	-23	-173
Over Design Capacity . .	95	37	17	7	113	44	24	-60	3	-25	27	-86	103	43	24	10	127	54	20	-8	13
After Shift Pattern 2																					
At Design Capacity . . .	46	-10	12	-2	58	-12	163	47	44	23	206	70	65	-4	17	-5	82	-9	33	16	48
Over Design Capacity . .	70	13	16	5	87	18	24	-60	3	-25	27	-86	66	6	19	5	84	11	-42	-16	-57
After Shift Pattern 3																					
At Design Capacity . . .	75	19	19	5	94	24	75	-41	19	-1	94	-42	75	6	19	-3	94	3	-16	1	-15
Over Design Capacity . .	66	8	16	5	82	13	66	-18	16	-12	82	-30	66	6	16	3	82	9	-4	-4	-9
After Shift Pattern 4																					
At Design Capacity . . .	44	-12	12	-2	56	-15	134	18	32	12	166	30	61	-9	20	-3	80	-12	-2	7	4
Over Design Capacity . .	73	15	16	5	89	20	66	-18	16	-12	82	-30	71	11	16	3	87	14	8	-4	4
After Shift Pattern 5																					
At Design Capacity . . .	46	-10	12	-2	58	-12	136	20	32	12	168	32	61	-9	17	-5	78	-14	2	4	6
Over Design Capacity . .	71	13	16	5	87	18	64	-20	16	-12	80	-32	71	11	19	5	89	16	4	-2	2
After Shift Pattern 6																					
At Design Capacity . . .	56	--	14	--	70	--	16	-100	--	-20	16	-121	27	-43	3	-19	30	-62	-143	-40	-182
Over Design Capacity . .	57	--	12	--	69	--	32	-52	5	-23	37	-75	100	41	26	12	126	53	-11	-11	-22
After Shift Pattern 7																					
At Design Capacity . . .	56	--	14	--	70	--	170	55	44	23	214	78	62	-7	19	-4	81	-11	48	20	67
Over Design Capacity . .	57	--	12	--	69	--	32	-52	5	-23	37	-75	69	9	19	6	88	15	-43	-17	-60

[a] *There are a total of 1,188.7 miles of standard arterials in the Milwaukee area.*

[b] *There are a total of 110.7 miles of freeways in the Milwaukee area.*

Source: SEWRPC.

Table 45

VEHICLE EMISSIONS AND FUEL CONSUMPTION ON CONGESTED ARTERIAL FACILITIES IN THE MILWAUKEE AREA BEFORE AND AFTER HYPOTHETICAL SHIFTS OF WORK TRIPS BY HOUR AND PEAK PERIOD

Item	6:00 a.m. - 7:00 a.m.	7:00 a.m. - 8:00 a.m.	8:00 a.m. - 9:00 a.m.	Morning Peak 6:00 a.m.-9:00 a.m.	3:00 p.m. - 4:00 p.m.	4:00 p.m. - 5:00 p.m.	5:00 p.m. - 6:00 p.m.	Afternoon Peak 3:00 p.m.-6:00 p.m.
Before Hypothetical Shifts								
Carbon Monoxide (kilograms) . .	9,700	26,600	12,000	48,300	23,100	31,800	24,300	79,200
Nitrogen Oxide (kilograms). . . .	800	1,100	900	2,800	1,200	1,300	1,200	3,700
Hydrocarbons (kilograms)	700	2,000	900	3,600	1,800	2,500	1,900	6,200
Fuel Consumption (gallons) . . .	15,000	32,000	17,700	64,700	29,900	38,400	31,200	99,500
After Shift Pattern 1								
Carbon Monoxide (kilograms) . .	13,300	14,100	16,200	43,600	29,700	21,300	30,100	81,100
Percent Change	37	- 47	35	- 10	29	- 33	24	2
Nitrogen Oxide (kilograms). . . .	890	950	960	2,800	1,300	1,200	1,300	3,800
Percent Change	11	- 14	9	- -	8	- 12	6	- -
Hydrocarbons (kilograms)	1,000	1,100	1,200	3,300	2,300	1,600	2,300	6,200
Percent Change	40	- 48	37	- 9	29	- 34	24	2
Fuel Consumption (gallons) . . .	18,900	20,100	22,100	61,100	36,300	27,900	36,800	101,000
Percent Change	26	- 37	25	- 6	21	- 27	18	2
After Shift Pattern 2								
Carbon Monoxide (kilograms) . .	11,100	20,800	13,800	45,700	25,700	29,400	26,000	81,100
Percent Change	14	- 22	15	- 5	11	- 8	7	2
Nitrogen Oxide (kilograms). . . .	800	1,100	900	2,800	1,200	1,300	1,200	3,700
Percent Change	4	- 5	3	- -	2	- 3	1	- -
Hydrocarbons (kilograms)	800	1,600	1,100	3,500	2,000	2,300	2,000	6,300
Percent Change	16	- 22	15	- 5	11	- 8	7	2
Fuel Consumption (gallons) . . .	16,500	26,600	19,500	62,600	32,400	35,800	32,800	101,000
Percent Change	10	- 17	10	- 3	8	- 7	5	2
After Shift Pattern 3								
Carbon Monoxide (kilograms) . .	12,900	14,700	13,300	40,900	25,300	25,700	25,300	76,300
Percent Change	33	- 45	11	- 15	10	- 19	4	- 4
Nitrogen Oxide (kilograms). . . .	900	1,000	900	2,800	1,200	1,300	1,200	3,700
Percent Change	13	- 9	- -	- -	- -	- -	- -	- -
Hydrocarbons (kilograms)	1,000	1,100	1,000	3,100	2,000	2,000	2,000	6,000
Percent Change	43	- 45	11	- 14	11	- 20	5	- 3
Fuel Consumption (gallons) . . .	18,700	21,100	19,300	59,100	32,200	32,700	32,300	97,400
Percent Change	24	- 34	9	- 9	8	- 15	4	- 2

Table 45 (continued)

Item	6:00 a.m. - 7:00 a.m.	7:00 a.m. - 8:00 a.m.	8:00 a.m. - 9:00 a.m.	Morning Peak 6:00 a.m.-9:00 a.m.	3:00 p.m. - 4:00 p.m.	4:00 p.m. - 5:00 p.m.	5:00 p.m. - 6:00 p.m.	Afternoon Peak 3:00 p.m.-6:00 p.m.
After Shift Pattern 4								
Carbon Monoxide (kilograms)	11,700	17,900	12,800	42,400	24,300	27,700	24,900	76,900
Percent Change	21	- 33	7	- 12	6	- 13	2	- 3
Nitrogen Oxide (kilograms)	800	1,000	900	2,700	1,200	1,300	1,200	3,700
Percent Change	5	- 6	2	- -	2	- 3	1	- -
Hydrocarbons (kilograms)	900	1,400	1,000	3,300	1,900	2,100	1,900	5,900
Percent Change	22	- 32	7	- 12	6	- 13	2	- 3
Fuel Consumption (gallons)	17,100	24,500	18,600	60,200	31,200	34,800	31,800	97,800
Percent Change	14	- 24	5	- 7	4	- 10	2	- 2
After Shift Pattern 5								
Carbon Monoxide (kilograms)	11,900	18,100	12,800	42,800	24,400	27,700	24,900	77,000
Percent Change	21	- 32	6	- 12	6	- 13	2	- 3
Nitrogen Oxide (kilograms)	900	1,000	900	2,800	1,200	1,300	1,200	3,700
Percent Change	6	- 6	1	- -	2	- 3	1	- -
Hydrocarbons (kilograms)	900	1,400	1,000	3,300	1,900	2,100	1,900	5,900
Percent Change	24	- 31	7	- 12	6	- 13	2	- 3
Fuel Consumption (gallons)	17,300	24,800	18,400	60,500	31,200	34,800	31,800	97,800
Percent Change	15	- 24	4	- 7	4	- 10	2	- 2
After Shift Pattern 6								
Carbon Monoxide (kilograms)	16,300	13,500	12,000	41,800	23,100	22,900	30,100	76,100
Percent Change	68	- 49	- -	- 13	- -	- 28	24	- 4
Nitrogen Oxide (kilograms)	900	900	900	2,700	1,200	1,200	1,100	3,500
Percent Change	13	- 18	- -	- 4	- -	- 8	- 8	- 5
Hydrocarbons (kilograms)	1,300	1,000	900	3,200	1,800	1,800	2,300	5,900
Percent Change	86	- 50	- -	- 11	- -	- 28	21	- 4
Fuel Consumption (gallons)	22,000	19,600	17,700	59,300	29,900	29,400	34,800	94,100
Percent Change	47	- 39	- -	- 8	- -	- 23	12	- 5
After Shift Pattern 7								
Carbon Monoxide (kilograms)	12,600	18,000	12,000	42,600	23,100	27,700	27,700	78,500
Percent Change	30	- 32	- -	- 12	- -	- 13	14	- 1
Nitrogen Oxide (kilograms)	900	1,000	900	2,800	1,200	1,300	1,300	3,800
Percent Change	13	- 9	- -	- -	- -	- -	3	- -
Hydrocarbons (kilograms)	1,000	1,400	900	3,300	1,800	2,100	2,000	5,900
Percent Change	43	- 30	- -	- 8	- -	- 16	5	- 4
Fuel Consumption (gallons)	17,800	24,400	17,700	59,900	29,900	34,500	34,400	98,800
Percent Change	19	- 24	- -	- 7	- -	- 10	10	- 1

Source: SEWRPC.

hours, which in turn results in an increase in exhaust emissions and fuel consumption during the same hours. These increases, however, do not offset the reductions in emissions during the peak hour, resulting in a net decrease in carbon monoxide and hydrocarbon emissions and motor fuel consumption during the three-hour peak period. The increase in average vehicle speed during the peak hour results in an increase in nitrogen oxide emissions from individual vehicles. However, this increase is offset by the decreased emissions from vehicles during the hours preceding and following the peak hour, when operating speeds are reduced. Thus, there is no net change in nitrogen oxide emissions during the three-hour morning peak period.

During the afternoon peak hour of 4:00 p.m. to 5:00 p.m., an average of 216 trips, or 26 percent of all work trips, are shifted on each problem segment under Shift Pattern 1. However, even the shifting of all of the work trips on portions of some problem segments does not eliminate peak-hour congestion. During the afternoon peak hour, the mileage of arterial facilities operating at or over design capacity is reduced from 248 to 41 miles, or to 17 percent of the original congested mileage. The mileage of facilities operating over design capacity is reduced from 112 to 27 miles, or by 76 percent. However, as a result of this shifting, the mileage of congested facilities operating at or over design capacity from 3:00 p.m. to 4:00 p.m. increases by 29 miles, or 20 percent, and the mileage of facilities operating over design capacity increases by 44 miles, or 64 percent, to more than 113 miles, or about the same as the amount of severely congested facilities during the present afternoon peak hour. Similarly, from 5:00 p.m. to 6:00 p.m., the mileage of congested facilities operating at or over design capacity increases by 18 miles, or 11 percent, and of the facilities operating over design capacity alone increases by 127 miles, or 73 percent—a 13 percent increase over the mileage of such congested facilities during the present afternoon peak hour.

Over the entire three-hour afternoon peak period, this shift pattern results in a net decrease of 160 miles, or 29 percent, in congested facilities. However, the mileage of the facilities operating over design capacity increases by 13 miles, or 5 percent.

Work time rescheduling under this shift pattern serves to increase the amount of carbon monoxide hydrocarbon, and nitrogen oxide emissions produced during the three-hour afternoon peak period on the problem arterial segments: carbon monoxide emissions increase by 2 percent, hydrocarbon emissions increase by 2 percent, and nitrogen oxide emissions increase by 1 percent. Fuel consumption during the afternoon peak period increases by about 1,500 gallons, or 2 percent, under this shift pattern.

Shift Pattern 2 Results: Shift Pattern 2, like Shift Pattern 1, would shift a portion of the work trips equally between the hour preceding and the hour following the peak hours; however, the objective of Shift Pattern 2 is more limited in that only segments operating over design capacity would be affected.

The result of applying Shift Pattern 2 during the morning peak hour, 7:00 a.m. to 8:00 a.m., is a shift of about 95 work trips from each over-design-capacity problem segment, or 16 percent of all automobile driver work trips on the problem segments. This shifting from the peak hour eliminates 81 miles, or 87 percent, of morning peak-hour over-design-capacity congestion. However, at-design-capacity congestion increases by 77 miles, or 92 percent. Thus, this shifting of traffic produces a substantial increase in congestion during both the hour preceding and the hour following the morning peak hour. The mileage of facilities operating over design capacity from 6:00 a.m. to 7:00 a.m. increases by 16 miles, or 144 percent, to 28 miles, and from 8:00 a.m. to 9:00 a.m. increases by 15 miles, or 56 percent, to 42 miles. The mileage of congested facilities operating at design capacity decreases in both adjacent hours by an average of 4 miles, or 12 percent. During the three-hour morning peak period, the mileage of the more severely congested facilities decreases by 50 miles, or 38 percent. At the same time, the mileage of the facilities operating at design capacity increases by 69 miles, or 47 percent. Thus, the net change over the three hours of the morning peak period is a 19-mile, or 7 percent, increase in congested arterials.

The shifting of work trips under Shift Pattern 2 results both in an improvement in air quality and in energy savings during the three-hour morning peak period on the problem segments. In total, carbon monoxide and hydrocarbon emissions each decrease by 5 percent, and fuel consumption decreases by 2,100 gallons, or 3 percent. There is no change in the level of nitrogen oxide emissions. Therefore, while the shift in work trips does serve to increase traffic congestion during adjacent hours,

the more severe traffic congestion is nearly eliminated during the peak hour and is decreased over the three-hour morning peak period.

During the afternoon peak hour of 4:00 p.m. to 5:00 p.m., a shift of about 110 work trips, or 12 percent of all automobile work trips, is required under Shift Pattern 2 on each over-design-capacity segment to abate the more severe peak-hour congestion. Under this pattern, the mileage of arterial facilities operating over design capacity during the peak hour is reduced from 112 miles to 27 miles, or to 24 percent of the original congested mileage. The mileage of facilities operating at design capacity during the afternoon peak hour increases from 136 to 206 miles, or 51 percent. From 3:00 p.m. to 4:00 p.m., the mileage of facilities operating at or over design capacity increases by 5 miles, or 4 percent. The mileage of facilities operating over design capacity increases by 18 miles, or 25 percent, to 87 miles. From 5:00 p.m. to 6:00 p.m., the mileage of facilities operating at or over design capacity increases by 2 miles, or 1 percent, although the mileage of the more severely congested over-design-capacity facilities increases by 15 percent to 84 miles. Over the entire three-hour afternoon peak period, this shift pattern results in a 9-mile increase in congested facilities, and a 57-mile, or 10 percent, decrease in over-design-capacity facilities.

This shift pattern results in a 2 percent increase in the amount of carbon monoxide and hydrocarbon emissions produced during the three-hour afternoon peak period on the problem arterial segments, and a 1,500-gallon, or 2 percent, increase in fuel consumption. There is no change in the level of nitrogen oxide emissions.

Shift Pattern 3: Shift Pattern 3, like Shift Pattern 1, has the more ambitious objective of abating both at- and over-design-capacity peak-hour arterial operation. It would, however, attempt to distribute work trips among all three hours of the peak period if a simple shift of the traffic equally between the hour preceding and the hour following the peak hour would cause congestion in those hours.

During the morning peak hour, this shift results in a 58 percent reduction in the number of arterial miles operating at or over design capacity—from 177 miles to 75 miles, and in a 61-mile, or 65 percent, reduction in the mileage of facilities operating over design capacity. Under this shift pattern, about 230 work trips are shifted from the peak hour on each problem segment, or about 18 percent of all automobile driver work trips on these segments. As a result of this shifting, however, the mileage of congested arterials during the hour preceding and the hour following the peak hour increases by 49 miles, or 49 percent. Furthermore, the mileage of the facilities operating over design capacity increases during the two adjacent hours by 27 miles, or 71 percent. During the three-hour morning peak period, the mileage of the more severely congested facilities decreases by 34 miles, or 26 percent. At the same time, the mileage of the facilities operating at design capacity decreases by 19 miles, or 13 percent. Therefore, the net change over the three-hour morning peak period is a reduction of 53 miles, or 19 percent, in congested facilities.

Both air pollutant emissions and fuel consumption decrease over the three-hour morning peak period under this shift pattern. Carbon monoxide emissions decrease by 15 percent, and hydrocarbon emissions decrease by about 14 percent. The level of nitrogen oxide emissions does not change. Fuel consumption is reduced by 5,600 gallons, or 9 percent, on the peak-hour problem segments.

During the afternoon peak hour, an average of 97 work trips, or 12 percent of the total work trips, are shifted from the peak-hour problem segments. This shifting acts to reduce the mileage of congested arterials operating at or over design capacity during the afternoon peak hour by 72 miles, or 29 percent. The mileage of facilities operating over design capacity is reduced by 30 miles, or 27 percent. This shifting of work trips to the adjacent hours results in a net increase of 48 miles, or 16 percent, in the mileage of congested facilities. The mileage of arterials operating over design capacity in the two adjacent hours increases by 22 miles, or 15 percent. Thus, over the three-hour afternoon peak period the mileage of congested arterials changes only slightly: at-design-capacity arterials decrease by about 15 miles, or 5 percent, while over-design-capacity arterials decrease by 9 miles, or 3 percent.

Under this shift pattern, carbon monoxide emissions are reduced by about 4 percent during the afternoon peak period, hydrocarbon emissions are reduced by 3 percent, and the level of nitrogen oxide emissions does not change. Fuel consumption is reduced over the three-hour period by 2,300 gallons, or 2 percent.

Shift Pattern 4: Shift Pattern 4 is similar to Shift Pattern 3, but has a less ambitious objective of reducing the peak-hour traffic volumes on all facilities operating over design capacity to at-design-capacity levels. Thus, this shift results in no change in the total number of miles of arterials operating at or over design capacity during the morning and afternoon peak hours. However, this shift pattern does result in a 60-mile, or 63 percent, reduction in the mileage of the arterial facilities operating over design capacity.

Under this pattern an average of 240 work trips, or 17 percent of all automobile driver work trips, are shifted from the peak hour on each problem segment operating over design capacity. During the hour preceding the morning peak hour, the mileage of congested arterials increases by 20 miles, or 49 percent, and the mileage of arterials operating over design capacity increases by 21 miles, or 186 percent. During the hour following the morning peak hour, there is an 11-mile increase in the mileage of congested facilities, and a 7-mile, or 25 percent, increase in the mileage of facilities operating over design capacity.

Therefore, over the entire three-hour morning peak period the net mileage of congested facilities increases by 30 miles, or 11 percent. The aggregate length of facilities operating over design capacity decrease by 33 miles, or 24 percent, while the net mileage of facilities operating at design capacity increases by 63 miles, or about 43 percent.

The changes in operating speeds attributable to this decreased congestion result in corresponding decreases in exhaust emissions and fuel consumption. Carbon monoxide and hydrocarbon emissions decrease by 12 percent over the three-hour morning peak period, and fuel consumption decreases by 4,500 gallons, or 7 percent. The level of nitrogen oxide emissions does not change.

During the afternoon peak hour, Shift Pattern 4 requires that an average of 104 work trips, or 11 percent of the work trips on over-design-capacity problem segments, be shifted from the peak hour. The aggregate length of total congested arterials during the afternoon peak hour does not change under this shift pattern, but the mileage of facilities operating over design capacity is reduced by 30 miles, or 27 percent. The shifting of these work trips to the adjacent hours increases the mileage of congested facilities in those hours by about 8 miles, or 2 percent of the original mileage. The net mileage of arterials operating over design capacity in these two hours increases by 34 miles, or 24 percent. During the entire three-hour afternoon peak period, the net mileage of congested arterials increases by about 8 miles, or 1 percent. Furthermore, the mileage of more severely congested facilities increases by 4 miles, or 2 percent, over the three-hour period.

Under this shift pattern, carbon monoxide and hydrocarbon emissions are reduced by 3 percent and fuel consumption is reduced by 1,700 gallons, or 2 percent during the afternoon peak period. The level of nitrogen oxide emissions does not change.

Shift Pattern 5: Like Shift Pattern 4, Shift Pattern 5 has the limited objective of abating over-design-capacity, peak-hour congestion. Also like Shift Pattern 4, Shift Pattern 5 distributes the peak-hour traffic to be shifted among the three hours in the peak period if the shifting to the hours adjacent to the peak hour causes over-design-capacity operation in these hours. The pattern differs from the preceding shift patterns in that it shifts peak-hour trips first into the hour preceding the peak hour and then into the following hour, rather than shifting the peak-hour traffic equally between the preceding and following hours. The intent of this shift pattern is to better utilize the arterial street and highway system by first shifting work trips to the hour when traffic volumes are less—that is, to the hour before the peak hour—and then shifting any remaining trips to the hour following the peak hour.

The results of this shift pattern are similar to those of Shift Pattern 4. The mileage of arterial facilities operating at or over design capacity during the morning peak hour remains unchanged, but the arterial mileage operating over design capacity during the peak hour is reduced by 60 miles, or 64 percent. This shift pattern requires that an average of 230 work trips, or 16 percent of the peak-hour work trips on each over-design-capacity segment, be shifted from each segment operating over design capacity during the peak hour. This shift results in a net increase in the mileage of congested facilities in the hours preceding and following the peak hour of about 20 miles, or 20 percent. The mileage of the facilities operating over design capacity increases by 32 miles, or 83 percent. During the entire three-hour morning peak period, this shift pattern results in a net increase in total congested arterials of 20 miles, or 7 percent, and in a net decrease in facilities operating over design capacity of 28 miles, or 21 percent.

Under this shift pattern, nitrogen oxide emissions remain unchanged, and carbon monoxide and hydrocarbon emissions decrease by 12 percent during the morning peak period. Fuel consumption decreases by 4,400 gallons, or 7 percent.

During the afternoon peak hour, Shift Pattern 5 requires a shift of about 125 trips from each over-design-capacity, peak-hour problem segment, or about 11 percent of the work trips on these segments. This shifting results in no net change in the mileage of total congested arterials, but it does cause a 32-mile, or 29 percent, reduction in the mileage of arterials operating over design capacity during the peak hour. However, under this shift pattern the mileage of facilities operating at or over design capacity during the hours adjacent to the peak hour increases by 8 miles, or 3 percent. The net mileage of facilities operating over design capacity during these two hours increases by 34 miles, or 24 percent. During the entire three-hour afternoon peak period, Shift Pattern 5 results in a net increase in the mileage of facilities operating at or over design capacity of 8 miles, or less than 2 percent, and of facilities operating over design capacity of 2 miles, or 1 percent.

This pattern results in a net decrease of 3 percent in carbon monoxide emissions and 4 percent in hydrocarbon emissions during the afternoon peak period. The level of nitrogen oxide emissions does not change. Fuel consumption decreases by 1,700 gallons, or 2 percent, during the three-hour afternoon peak period under this shift pattern.

Shift Pattern 6: Shift Pattern 6 assumes that all trips shifted from the peak hour will be rescheduled to the hour preceding the morning peak hour and to the hour following the afternoon peak hour, thus illustrating the effects of a four-day, 10-hour-per-day work week. As previously mentioned, the amount of traffic shifted from the peak hours has been reduced by 20 percent from the amount that would be shifted on an average day of a five-day work week to reflect the maximum potential reduction in average weekday work travel if the four days worked are staggered to the maximum extent over the five-day work week. The objective of Shift Pattern 6 is to eliminate both at- and over-design-capacity, peak-hour arterial facility operation.

This shift pattern results in a 90 percent reduction in the total number of miles of arterials operating at or over design capacity during the morning peak hour—from 177 miles to 18 miles. At the same time, the mileage of facilities operating over design capacity is reduced by 80 miles, or 85 percent. This shift pattern requires the shifting of about 280 work trips from each problem segment during the peak hour, or about 22 percent of all automobile driver work trips on these problem segments. As a result of this shifting, the mileage of arterials operating at design capacity from 6:00 a.m. to 7:00 a.m. increases by 39 miles, or 94 percent. Furthermore, the mileage of arterials operating over design capacity increases by 42 miles, or about 364 percent. Over the three-hour morning peak period, the mileage of facilities operating at design capacity decreases by 81 miles, or 55 percent, and the mileage of facilities operating over design capacity decreases by 38 miles, or 29 percent. Therefore, the total mileage of congested facilities decreases by 119 miles, or 43 percent.

Both air pollutant emissions and fuel consumption decrease over the three-hour morning peak period under this shift pattern. Carbon monoxide emissions decrease by 13 percent, hydrocarbon emissions decrease by 11 percent, and nitrogen oxide emissions decrease 4 percent. Fuel consumption decreases by 5,400 gallons, or 8 percent.

This shift pattern requires that an average of 200 work trips, or 24 percent of the total work trips, on the problem segments during the peak hour be shifted. As a result of this shifting, the aggregate length of congested arterials operating at or over design capacity during the afternoon peak hour is reduced by 195 miles, or 79 percent. Furthermore, the mileage of facilities operating over design capacity is reduced by 75 miles, or 67 percent. The shifting of work trips to the hour following the peak hour increases the mileage of congested facilities in that hour by 9 miles, or about 5 percent. The mileage of facilities operating over design capacity is increased by 53 miles, or 72 percent. Consequently, the amount of congested arterials decreases substantially over the three hours of the afternoon peak period. The mileage of congested facilities operating at design capacity decreases by 182 miles, or 61 percent, during the three-hour afternoon peak period, and the mileage of facilities operating over design capacity decreases by 22 miles, or 9 percent. Thus, the net change over the three hours of the afternoon peak period is a 204-mile, or 37 percent, decrease in congested facilities. All changes occur during the peak hour—4:00 p.m. to 5:00 p.m.—and the hour following the peak hour—5:00 p.m. to 6:00 p.m.—since no trips are shifted into the earlier hour.

Under this shift pattern, nitrogen oxide and hydrocarbon emissions decrease by 5 percent during the afternoon peak period, carbon monoxide emissions decrease by 4 percent, and fuel consumption decreases by 5,400 gallons, or 5 percent.

Shift Pattern 7: Shift Pattern 7, like Shift Pattern 6, assumes that all trips shifted from the peak hour will be rescheduled to the hour preceding the morning peak hour and to the hour following the afternoon peak hour. Again, the amount of traffic shifted has been reduced by 20 percent from the amount that would be shifted on an average day of a five-day work week to reflect the maximum potential reduction in average weekday work travel under a four-day, 10-hour-per-day work week. Shift Pattern 7, however, has a more limited objective of abating only over-design-capacity, peak-hour arterial facility operation.

This shift results in no change in the total number of miles of arterials operating at or over design capacity during the morning peak hour. However, the mileage of facilities operating over design capacity is reduced by 80 miles, or 85 percent. This shift pattern requires the shifting of about 250 work trips from each over-design-capacity segment during the peak hour, or about 18 percent of all automobile driver work trips on these segments. As a result of this shifting the mileage of congested arterials increases by 16 miles, or 38 percent, from 6:00 a.m. to 7:00 a.m. Furthermore, the mileage of the facilities operating over design capacity increases by 25 miles, or about 218 percent. No trips are shifted to the hour following the peak hour under this shift pattern. Therefore, over the three-hour morning peak period the mileage of facilities operating at design capacity increases by 71 miles, or 48 percent, and the mileage of facilities operating over design capacity decreases by 55 miles, or 42 percent. Thus, the net change over the three hours of the morning peak period is a 16-mile, or 5 percent, increase in congested facilities.

This shift pattern results in decreases in both exhaust emissions and fuel consumption during the morning peak period. Carbon monoxide emissions decrease by 12 percent, hydrocarbon emissions decrease by about 8 percent, and the level of nitrogen oxide emissions does not change. Fuel consumption decreases by 4,500 gallons, or 7 percent.

During the afternoon peak hour, an average of 135 work trips, or 14 percent of the total work trips, are shifted from each over-design-capacity, peak-hour problem segment. As a result of this shifting, the mileage of facilities operating at or over design capacity decreases by 3 miles, while the mileage of facilities operating over design capacity decreases by 75 miles, or 67 percent. The shifting of work trips to the hour following the peak hour increases the number of miles of congested facility in that hour—5:00 p.m. to 6:00 p.m.—by 4 miles, or about 2 percent. Furthermore, the mileage of facilities operating over design capacity increases by 15 miles, or 20 percent. Consequently, the amount of congested arterials decreases over the three hours of the afternoon peak period. The mileage of facilities operating at design capacity during the three-hour afternoon peak period increases by 67 miles, or 22 percent, and the mileage of facilities operating over design capacity decreases by 60 miles, or 24 percent. Thus, the net change over the three hours of the afternoon peak period is a 7-mile, or 1 percent, decrease in congested facilities. All changes occur during the peak hour—4:00 p.m. to 5:00 p.m.—and the hour following the peak hour—5:00 p.m. to 6:00 p.m.—since no trips are shifted into the earlier hour.

This shift pattern results in decreases in both exhaust emissions and fuel consumption over the three-hour afternoon peak period. Hydrocarbon emissions decrease by 4 percent, carbon monoxide emissions decrease by 1 percent, and the level of nitrogen oxide emissions does not change. Fuel consumption decreases by 1,000 gallons, or 1 percent.

Summary of Maximum Potential Benefits of Work Time Rescheduling

The analyses indicated that all of the seven hypothetical rescheduling patterns could be expected to significantly reduce peak-hour arterial highway congestion in the Milwaukee area and attendant excessive fuel consumption and air pollutant emissions. Some patterns would, by design, reduce the number of miles of facility operating both at and over design capacity in the peak hours. Others would reduce only the number of miles of facility operating over design capacity in the peak hour. Nevertheless, each of the patterns would result in increases in traffic and traffic congestion and attendant fuel consumption and air pollutant emissions during the hours preceding and following the peak hours. Thus, the overall potential transportation, air quality, and fuel consumption benefits of work time rescheduling in the Milwaukee area can be properly assessed only in terms of the congestion reduction and attendant reduction in air pollution and fuel consumption effected over the

entire three-hour morning and afternoon peak periods through implementation of the hypothetical shift patterns.

As shown in Table 46, those shift patterns with the ambitious objective of reducing both at- and over-design-capacity operation on the peak-hour problem segments—Shift Patterns 1, 3, and 6—were determined to have the potential to reduce such operation significantly on the peak-hour problem segments over the three-hour morning peak period. For facilities operating at design capacity, this reduction ranged from 19 to 81 miles, or a 13 to 56 percent reduction in such facilities during the three-hour period. For facilities operating over design capacity, this reduction ranged from 29 to 38 miles, or a 22 to 29 percent reduction in such facilities. Fuel consumption could be expected to decline by from 6 to 9 percent over the morning peak period under these shift patterns. Furthermore, carbon monoxide emissions would decrease by from 10 to 15 percent, hydrocarbon emissions would decrease by from 9 to 14 percent, and nitrogen oxide emissions would decline by up to 4 percent. Over the three-hour afternoon peak period, only two of these three shift patterns would result in considerable congestion reduction. Moreover, this reduction—about 180 miles of arterials, or 60 percent of the congested facilities over the three-hour period—would be limited to those facilities operating at design capacity. The change in fuel consumption on the problem segments over the three-hour afternoon peak period could be expected to vary from an increase of 2 percent to a decrease of 5 percent under these shift patterns. In addition, the change in carbon monoxide emissions would vary from an increase of 2 percent to a decrease of 4 percent; in hydrocarbon emissions would vary from a slight increase to a decrease of 5 percent; and in nitrogen oxide emissions would very from nothing to a decrease of 5 percent.

Three of the four shift patterns with the limited objective of reducing only over-design-capacity operation during the peak hours—Shift Patterns 2, 4, 5, and 7—were determined to have the potential to eliminate, during the three-hour morning peak period, between 28 and 55 miles of such operation, or 21 to 42 percent of over-design-capacity operation during the morning peak period. However, each of these patterns would result in an increase in at-design-capacity operation on the problem segments, with such increases ranging from 48 to 71 miles of facilities, or from 33 to 48 percent. The four patterns would result in a 3 to 7 percent reduction in motor fuel consumption on the problem segments during the morning peak period, and a 5 to 12 percent reduction in carbon monoxide emissions, a 5 to 12 percent reduction in hydrocarbon emissions, and no change in nitrogen oxide emissions.

Over the three-hour afternoon peak period, only two of the patterns, Shift Pattern 2 and Shift Pattern 7, would have any appreciable effect on traffic congestion and, as in the morning peak period, the reduction achieved would be balanced by an increase in at-design-capacity operation. Under this shift pattern, afternoon peak-period over-design-capacity operation would decrease by from 57 to 60 miles, or 22 to 24 percent. At the same time, at-design-capacity operation would increase by from 48 to 67 miles, or 16 to 23 percent. The change in fuel consumption on the problem segments under these four shift patterns over the three-hour afternoon peak period could be expected to vary from an increase of 2 percent to a decrease of 1 percent. Moreover, the change in carbon monoxide emissions would vary from an increase of 2 percent to a decrease of 1 percent and in hydrocarbon emissions would vary from an increase of 2 percent to a decrease of 5 percent. Nitrogen oxide emissions would remain unchanged.

Based on the foregoing analysis, work time rescheduling programs with a limited objective of minimizing only over-design-capacity, peak-hour operation may be expected to result in substantial reductions in over-design-capacity operation over both the three-hour morning and afternoon peak periods. However, these decreases may be expected to be accompanied by increases in the mileage of facilities operating at design capacity during both peak periods. Those work time rescheduling programs with the more ambitious objective will have a greater impact on congestion, particularly in the morning peak periods, when substantial reductions would be made in the mileage of facilities operating both at and over design capacity. In the afternoon peak period, a substantial reduction in congestion could also be expected, but only for those arterials operating at design capacity. Under both the ambitious and limited programs, fuel consumption and carbon monoxide and hydrocarbon air pollutant emissions would be reduced on the problem segments during both peak travel periods, but particularly in the morning period. Nevertheless, the maximum reduction in the level of emissions of any of the measured pollutants or the amount of fuel consumed during either peak

Table 46

MAXIMUM POTENTIAL ARTERIAL HIGHWAY BENEFITS OF WORK TIME RESCHEDULING IN THE MILWAUKEE AREA

Item	Shift Pattern													
	1		2		3		4		5		6		7	
	Morning Peak Period	Afternoon Peak Period	Morning Peak Period	Afternoon Peak Period	Morning Peak Period	Afternoon Peak Period	Morning Peak Period	Afternoon Peak Period	Morning Peak Period	Afternoon Peak Period	Morning Peak Period	Afternoon Peak Period	Morning Peak Period	Afternoon Peak Period
Arterial Traffic Congestion														
Net Change in Miles at Design Capacity	-78	-173	69	48	-19	-15	63	4	48	6	-81	-182	71	67
Percent Change	-53	-58	47	-16	-13	-5	43	1	33	2	-56	-61	48	23
Net Change in Miles at Design Capacity	-29	13	-50	-57	-34	-9	-33	4	-28	2	-38	-22	-55	-60
Percent Change	-22	5	-38	-22	-26	-3	-25	1	-21	1	-29	-9	-42	-24
Automobile Fuel Consumption														
Percent Change on Problem Segments	-6	2	-3	2	-9	-2	-7	-2	-7	-2	-8	-5	-7	-1
Percent Change in Area Peak-Period Consumption	-2	--	-1	--	-2	--	-2	--	-2	--	-2	-1	-2	--
Percent Change in Area Daily Consumption	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Air Pollutant Emissions														
Carbon Monoxide														
Percent Change on Problem Segments	-10	2	-5	2	-15	-4	-12	-3	-12	-3	-13	-4	-12	-1
Percent Change in Area Peak-Period Emissions	-3	--	-1	--	-4	-1	-3	-1	-3	-1	-3	-1	-3	--
Percent Change in Area Daily Emissions	--	--	--	--	-1	--	-1	--	-1	--	-1	--	-1	--
Nitrogen Oxide														
Percent Change on Problem Segments	--	--	--	--	--	--	--	--	--	--	-4	-5	--	--
Percent Change in Area Peak-Period Emissions	--	--	--	--	--	--	--	--	--	--	-1	-1	--	--
Percent Change in Area Daily Emissions	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hydrocarbons														
Percent Change on Problem Segments	-9	2	-5	2	-14	-3	-12	-3	-12	-4	-11	-5	-5	-4
Percent Change in Area Peak-Period Emissions	-2	--	-1	--	-4	-1	-3	-1	-3	-1	-3	-1	2	-1
Percent Change in Area Daily Emissions	--	--	--	--	-1	--	-1	--	-1	--	-1	--	--	--

Source: SEWRPC.

period would be no more than 4 percent of the total emissions produced or fuel consumed on all arterials during either peak period. These reductions constitute less than 1 percent of the emissions and fuel consumption on the entire arterial system on an average weekday in the Milwaukee area.

It is important to recognize that to achieve these impacts, the more ambitious work time rescheduling programs would require the shifting of from 18 to 22 percent of the peak-hour work trips from the 177 miles of morning peak-hour problem segments, and of from 12 to 26 percent of such trips from the 248 miles of afternoon peak-hour problem segments. The more limited work time rescheduling programs would require the shifting of from 16 to 18 percent of the peak-hour work trips from the 93 miles of morning peak-hour over-design-capacity problem segments, and of from 11 to 14 percent of such trips from the 112 miles of afternoon peak-hour over-design-capacity problem segments.

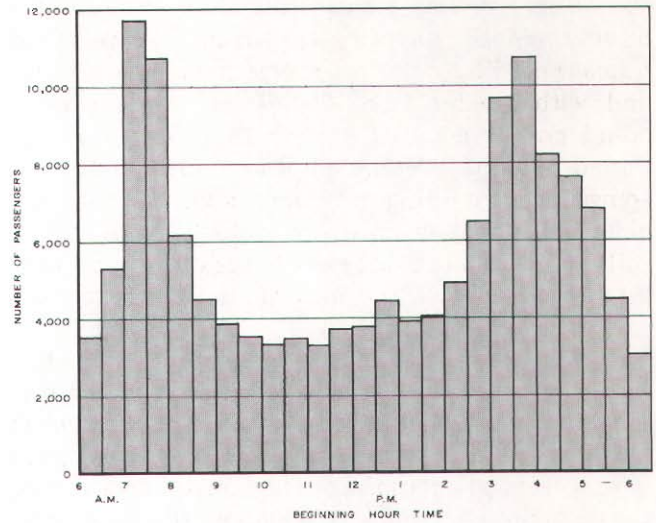
POTENTIAL MILWAUKEE AREA PUBLIC TRANSIT BENEFITS THROUGH WORK TIME RESCHEDULING

It is important also to consider the potential impacts of work time rescheduling on the public transit system in the Milwaukee area, because transit use on an average weekday in the Milwaukee area is even more peaked than automobile traffic, as shown in Figure 32. The peaking of transit use directly affects transit system operating and capital costs, because total bus fleet requirements are dictated by the highest peak in current transit passenger demand, as shown in Figure 33. In addition, total bus driver requirements and the need for special wage differentials for split-shift drivers are established by the peaking in bus fleet requirements.

Currently, the peak half hour for buses during the three-hour morning peak period is 7:00 a.m. to 7:30 a.m., when 496 buses are required, and during the three-hour evening peak period is 3:00 p.m. to 3:30 p.m., when 480 buses are required. Over the entire three-hour morning peak period, an average of 404 buses are required each half-hour period, and over the three-hour afternoon peak period an average of 410 buses are needed each half hour. Therefore, spreading peak-period transit travel demand could reduce transit fleet needs by 92 buses in the morning and 70 buses in the after-

Figure 32

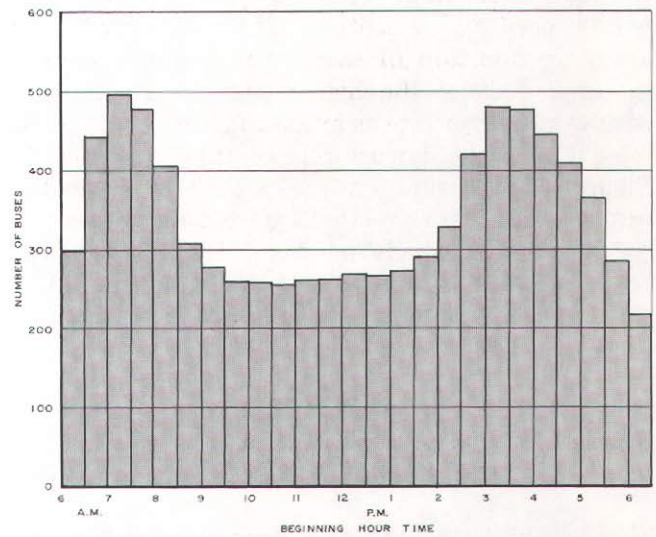
TOTAL TRANSIT PASSENGERS PASSING MAXIMUM LOAD POINTS BY HALF-HOUR PERIODS ON AN AVERAGE WEEKDAY IN SPRING OF 1980



Source: Milwaukee County Transit System.

Figure 33

TOTAL BUSES IN SERVICE BY HALF-HOUR PERIODS ON AN AVERAGE WEEKDAY IN WINTER OF 1979



Source: Milwaukee County Transit System and SEWRPC.

noon. Furthermore, the shifting of buses to the hours of 6:00 a.m. to 7:00 a.m. and 8:00 a.m. to 9:00 a.m. in the morning peak period should result in increased transit operating cost savings, and possibly also in capital cost savings, as buses could be shifted for use to times other than the morning hour of peak highway congestion. The shifted buses would be able to traverse their routes faster and with greater reliability. These latter benefits could not be achieved during the afternoon peak period, as the present afternoon peak hours of transit needs and highway congestion do not coincide, and thus buses would actually have to be shifted into the existing peak hours of highway congestion to achieve the maximum fleet reduction.

It should be noted that the estimated fleet reduction is conservative because significant transit passenger demand could be shifted from the peak half-hour to other times during the three-hour peak period without requiring additional buses during those times. At times other than the peak one-half hour, there is a surplus of seats on buses in operation during the morning and afternoon peak travel periods, as shown in Figure 34.

Importantly, achievement of the maximum reduction in bus fleet requirements through work time rescheduling would likely require shifting a significant proportion of work trips made during the peak half hours of transit use. Based on the Commission's 1972 origin-destination survey of travel, about 50 percent of the work-related trips made on public transit during the morning hour of 7:00 a.m. to 8:00 a.m. and nearly 60 percent of the work-related trips made on public transit during the afternoon hour of 3:00 p.m. to 4:00 p.m. would need to be shifted. The shifting of such a large proportion of work-related transit trips is required because the high peaking characteristics of transit demand are as much a factor of nonwork-related trips as of work-related trips, as shown in Figure 35.[2] However, while a shift of a smaller proportion of work-related transit trips would not reduce transit vehicle needs, it could reduce the crowding on existing buses during the peak hours and increase passengers' opportunities of obtaining a seat.

FEASIBILITY OF MILWAUKEE AREA EMPLOYER PARTICIPATION IN WORK TIME RESCHEDULING

The feasibility of the voluntary participation of Milwaukee area employers in a work time rescheduling program is an important consideration in determining whether such a program should be pursued on an areawide basis in the Milwaukee area. Without sufficient employer participation, little will be accomplished, regardless of the degree of maximum potential benefits. Establishing the feasible degree of participation will, in fact, determine the degree of benefits which can be expected to be achieved.

In order to determine the feasibility of expanded work time rescheduling in the Milwaukee area, Milwaukee area employers were surveyed to ascertain their current employment schedules and use of work time rescheduling programs, and their willingness and ability to implement new or additional rescheduling programs. An eight-page questionnaire was sent to 295 employers having 100 or more employees, and to 100 employers having fewer than 100 employees.[3] Emphasis was placed upon employers with more than 100 employees for a number of reasons. First, by emphasizing large employers, information about a large number of employees could be obtained from a small sample of employers. Sixty-five percent of the jobs in the Milwaukee area are provided by less than 3 percent of the employers—those 758 employers with 100 or more employees. Second, it was recognized that if the survey findings did indicate work time rescheduling was indeed feasible, implementation of a work time rescheduling program would be more readily accomplished with a limited number of employers. And lastly, it was postulated that larger employers are more apt to cause traffic congestion than are smaller employers, as such congestion requires not only a spatial concentration of employees, but a spatial concentration of employees with similar work schedules. Because

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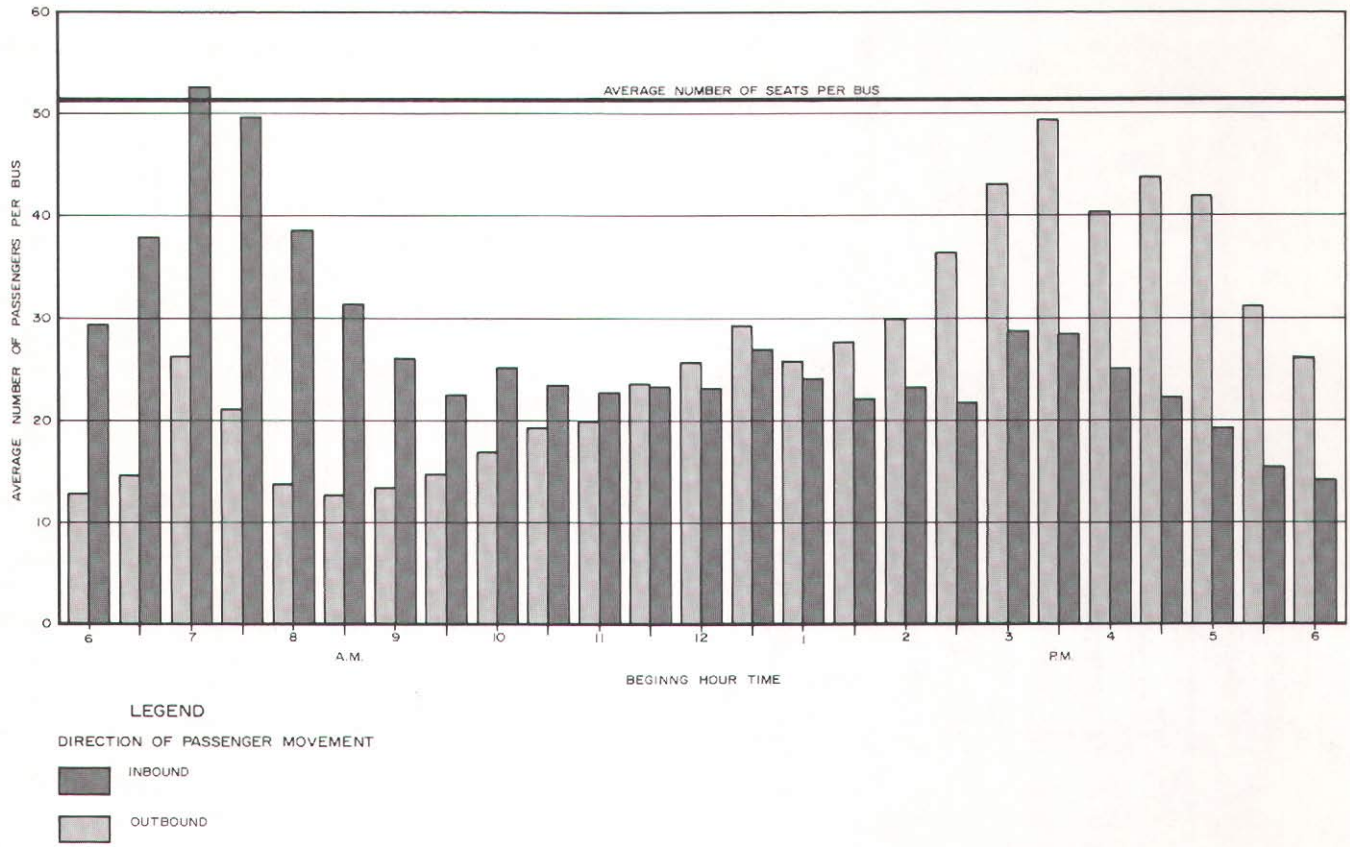
[2] *The ability of work time rescheduling to reduce bus fleet requirements is dependent upon the trip purpose of passenger trips passing the maximum load point. While there is no information available as to trip purpose at the maximum load point, it would seem that maximum load points located in proximity to major employment centers, such as the central business district, would attract a higher than average percentage of trips that are work-related.*

[3] *A more detailed discussion of the findings of this survey is contained in Appendix A of this report.*

Figure 34

AVERAGE LOAD PER BUS PASSING MAXIMUM LOAD POINTS BY HALF-HOUR PERIODS ON AN AVERAGE WEEKDAY IN SPRING OF 1980



Source: Milwaukee County Transit System and SEWRPC.

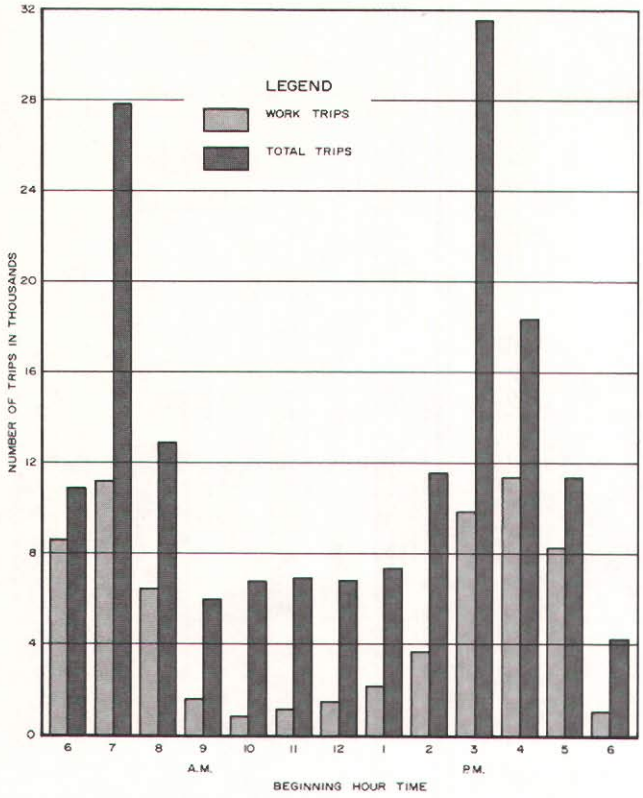
it was recognized that concentrations of smaller employers in high-density employment areas also have the potential to contribute substantially to peak-hour traffic congestion, 100 smaller employers—those with fewer than 100 employees—located in areas of concentrated employment, such as the Milwaukee central business district, were also surveyed.

Certain economic sectors were excluded from the survey. Retail sales firms were excluded because they generally open after the morning peak hour—7:00 a.m. to 8:00 a.m.—and close after the afternoon peak hour—4:00 p.m. to 5:00 p.m. Construction trades and trucking and transportation firms were excluded because the location of their activities and employment can change. Only the 15 largest health care facilities and larger government offices were included. The employment of all firms to which questionnaires were mailed was estimated at 189,600, or 31 percent of the total Milwaukee area employment.

A 52 percent return of the questionnaires provided information on 204 employers and their 122,000 employees. Questionnaires were returned in about equal proportions by employers in all of the sampled economic sectors and size categories. The employment described in the returned questionnaires was concentrated in the larger manufacturing firms, just as the total employment in the Milwaukee area is so concentrated. In addition, the spatial distribution of employers returning the tionnaire was similar to the spatial distribution of

Figure 35

TRANSIT PASSENGER TRIPS TO AND FROM WORK AND TOTAL TRANSIT TRIPS IN THE MILWAUKEE AREA BY ONE-HOUR PERIODS: 1972



Source: SEWRPC.

employers sent the questionnaire. Therefore, the results of the survey should be representative of all employers in the Milwaukee area having employees traveling during the peak periods, including smaller employers located in areas of high employment density. In total, the employment of the responding employers represents almost one-fifth of the Milwaukee area employment.

Peaking of Starting and Quitting Times

The response to this survey indicated that the starting times of Milwaukee area employees during the peak travel period of 6:00 a.m. to 9:00 a.m. are highly peaked, as shown in Figure 36. About 50 percent of all employees working for the responding firms, or about 58,000 employees, are scheduled to start at either 7:00 a.m. or 8:00 a.m. Between 6:00 a.m. and 9:00 a.m., starting times either 15 minutes before or 15 minutes after the hour are used by only 12,700 employees, or 11 percent of the total. Starting times on the half hour are only slightly more common, with 13,900 employees, or 12 percent, starting at 6:30 a.m., 7:30 a.m., or 8:30 a.m. In addition, nearly 47 percent of all employees starting work between 6:00 a.m. and 9:00 a.m. start between 7:15 a.m. and 8:00 a.m., requiring travel during the morning peak travel hour.

The scheduled quitting times are not nearly as peaked as the starting times. Figure 37 shows that the maximum number of employees scheduled to quit at any of the 12 quarter-hour time periods between 3:00 p.m. and 6:00 p.m. is only 19,000 at 5:00 p.m., which is about twice the uniform average, or 17 percent of the total. An almost equal number of employees, 15,600 to 16,700, is scheduled to quit at 3:00 p.m, 3:30 p.m., and 4:30 p.m. Quitting times on the quarter hour are no more common with Milwaukee area employers than starting times at those intervals, accounting for only 9,600 employees, or 9 percent. However, quitting times on the half hour are more frequently used than starting times on the half hour, with almost 32,400 employees, or 29 percent, quitting at 3:30 p.m. or 4:30 p.m. Nearly 36 percent of all employees quitting work between 3:00 p.m. and 6:00 p.m. quit between 4:00 p.m. and 4:45 p.m., contributing to travel during the afternoon peak hour.

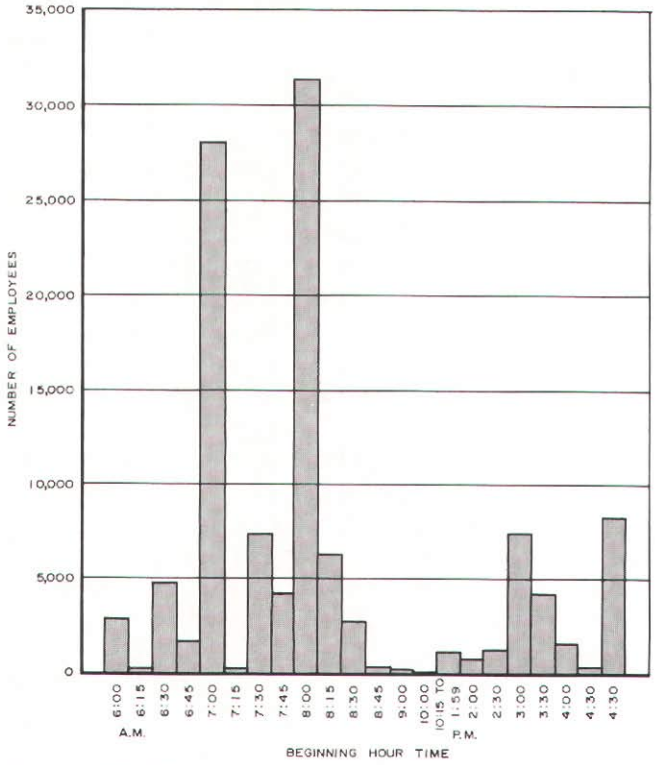
Existing Work Time Rescheduling

Eighty-five existing work time rescheduling programs were reported by the 204 employers surveyed. These programs include flexible, shifted, and staggered work hours as well as shortened work week programs and summer work schedules. The programs were reported by both large and small employers from all economic sectors included in the survey. Altogether, these 85 programs affect the work schedules of 60 different employers, since some employers have more than one rescheduling program. A total of 39,000 employees, or 32 percent of the employment represented in the survey, participated in an existing work time rescheduling program.

Although all five types of work time rescheduling programs are found within the Milwaukee area, some programs are more common and affect larger numbers of employees than other programs. By far, the largest number of employees, 22,000, is affected by the 33 staggered work hour programs determined to exist in the Milwaukee area. In addi-

Figure 36

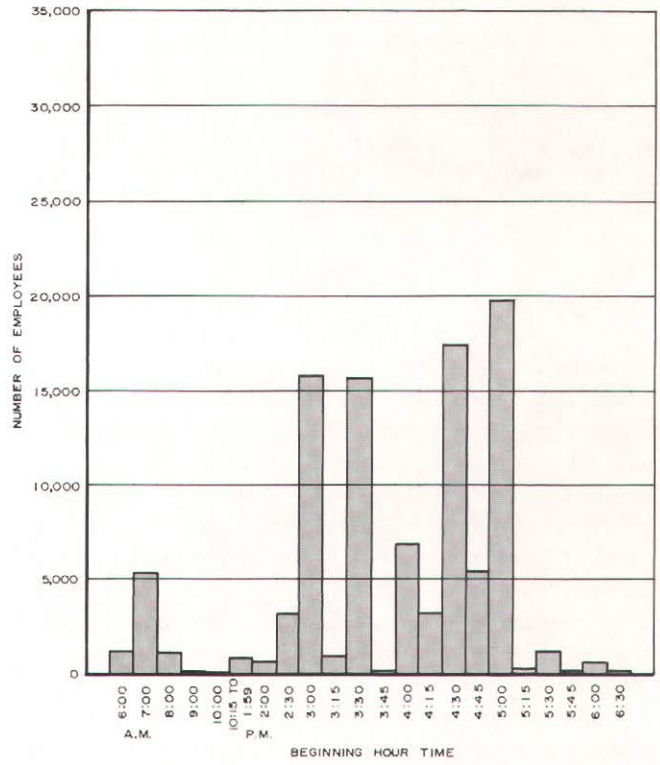
DISTRIBUTION OF SCHEDULED STARTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA: 1978



Source: SEWRPC.

Figure 37

DISTRIBUTION OF SCHEDULED QUITTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA: 1978



Source: SEWRPC.

tion to the 30 firms which reported staggered work hour programs, 90 firms with a total of 47,000 employees reported more than one starting time for their employees, but did not consider these multiple starting times as a formal staggered work hour program. These firms included some of the largest manufacturing firms in the Milwaukee area, with seven firms having more than 1,000 employees. This acceptance of multiple starting times without considering such actions as staggered work hours may stem from long-term traditions among Milwaukee area employers, since 44 of these 90 employers indicated that multiple starting times were used because "it had always been that way." The 30 shifted work hour programs affected 13,000 employees, while the 13 flexible work hour programs affected 2,400 employers and the 14 shortened work week programs affected only about 1,000 employees. Limitations were generally placed upon participation in flexible work hour and shortened work week programs based upon occupational categories, while few limitations were placed upon staggered or shifted work hour programs. Therefore, the differences in the number of employees in each of the programs are due largely to these limitations, rather than to the employment size of the firms implementing the different types of programs.

Attitudes and Constraints Concerning Work Time Rescheduling

A number of surveyed firms, 76 of the 204 respondents, or 37 percent, indicated a willingness to consider implementing either new or additional staggered, shifted, or flexible work hours or shortened work weeks. These programs, if actually implemented, would affect the work schedules of about 25 percent of the total employment of the sample, or 30,000 of the 122,000 employees represented in the survey. These programs are in

addition to the above-mentioned rescheduling programs affecting 39,000 employees, and staggered work hour programs affecting 47,000 employees. Therefore, a total of 116,000 employees, or 95 percent of the surveyed employment, could potentially participate in work time rescheduling programs if all employers willing to consider rescheduling would implement a program and all existing programs are continued.

Almost half of the firms willing to consider implementing a new program indicated that they would prefer either staggered, shifted work hour, or flexible work hour programs. Shortened work week programs were the least preferred, with only 34 percent of the firms indicating a willingness to consider that type of rescheduling. Although a similar proportion of the employers indicated a willingness to consider each type of rescheduling, the number of employees affected by each program was more varied. Employers frequently indicated that the use of flexible work hours and shortened work weeks would have to be limited to certain employment categories, but seldom limited participation in shifted or staggered work hour programs. Therefore, 18,200 additional employees could be potentially affected by shifted work hour programs, and 18,000 by flexible work hour programs, while shortened work week programs would affect 8,100 employees and staggered work hour programs only 7,400 employees. Forty employers indicated a willingness to consider implementing more than one program. Therefore, the total number of employees potentially affected by work time rescheduling programs is less than the total of the numbers of employees affected by the four types of rescheduling considered.

Public sector employers reported the greatest willingness to consider implementing work time rescheduling—about 60 percent. Utilities and warehousing firms reported a 56 percent willingness, finance and public service firms, a 47 percent willingness, manufacturing firms, a 32 percent willingness, and wholesale trade firms, an 18 percent willingness to consider implementing work time rescheduling programs.

The presence of collective bargaining units apparently has little influence on a firm's willingness to consider work time rescheduling programs. Firms of which fewer than half the employees were unionized were only slightly more willing to consider implementing rescheduling than firms of which more than half the employees were unionized, but both groups were more willing to implement rescheduling than firms without union representation.

The larger the firm, the more willing it is to consider implementation of work time rescheduling programs. Only 26 percent of the 58 employers with fewer than 100 employees are willing to consider implementing some form of rescheduling, compared with 42 percent of the firms with 200-249 employees and 52 percent of the firms with 250 or more employees. The starting and quitting times of all the employers willing to consider work time rescheduling programs are similar to those of the entire sample. The starting times peak at 7:00 a.m. and 8:00 a.m. and the quitting times are almost evenly distributed among 3:00 p.m., 3:30 p.m., 4:30 p.m., and 5:00 p.m.

Although the firms willing to consider work time rescheduling are spatially distributed throughout the Milwaukee area, the greatest proportion of employers indicating a willingness to consider rescheduling programs—35 percent—is located in the Milwaukee central business district.

Responding firms indicated a variety of problems and constraints that they thought would influence their decision to implement any work time rescheduling program. Shortened work week programs created the greatest concern, with possible operational problems within the plant or office cited as a problem by 35 percent of the firms, and possible legal or contractual problems cited by 32 percent of the firms. Concerns about operational problems and legal and contractual problems were also the most frequent concerns cited for the other types of work time rescheduling programs. The fewest concerns were indicated for shifted work hour programs, followed by staggered work hour programs and flexible work hour programs.

Potential Effect of Additional Rescheduling on Starting and Quitting Times

To establish the potential impact of a practicable work time rescheduling program on traffic conditions in the Milwaukee area, the aggregate change in the work schedules of the surveyed employers that would result from the implementation of work time rescheduling programs by the surveyed employers indicating a willingness to participate in such programs was determined. Several assumptions had to be made concerning which rescheduling programs would be implemented by which employers and how the programs would affect

work schedules. First, it was assumed that all firms indicating a willingness to consider implementing a new work time rescheduling program would implement such a program. Further, unless specific limitations were indicated in the survey, the rescheduling was assumed to apply to all employees. The 12 employers which indicated that they would only be willing to expand their existing programs were not included because the degree of practical expansion of the currently limited programs could not be ascertained. Omitting these employers had little impact on this analysis because their total employment was only 4,000, and less than one-third of these 4,000 employees were scheduled to start or quit work during peak travel hours.

Second, each employer willing to consider implementing a new program was assumed to implement only one rescheduling program. Employers which indicated that they would be willing to consider multiple rescheduling programs were assumed, based upon the proportion of actual rescheduling programs implemented by the employers surveyed, to first implement shifted work hour programs, and then to implement, in successive order, staggered work hour programs, shortened work week programs, and lastly, flexible work hour programs. On this basis, 63 percent of the interested employers would participate in shifted work hour programs, 29 percent would participate in staggered work hour programs, 3 percent would participate in flexible work hour programs, and 5 percent would participate in flexible work hour programs.

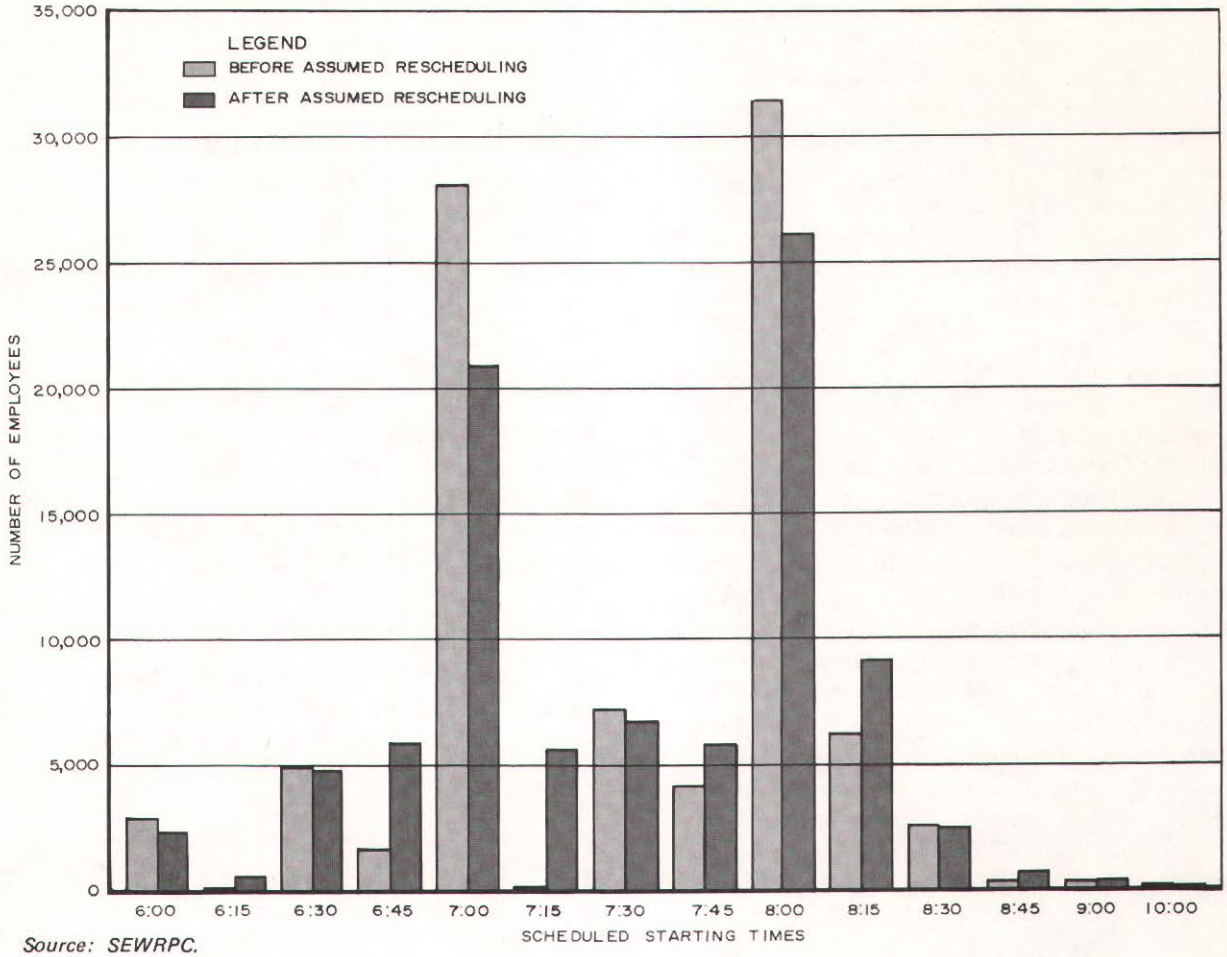
Each type of rescheduling program was assumed to have a different effect on work schedules. Under flexible work hour programs 25 percent of the employees were assumed to start and quit one-half hour earlier, another 25 percent, one hour earlier, and another 25 percent, one-half hour later, with the remaining 25 percent assumed to maintain their present work schedules. Fifty percent of the employees of those firms willing to implement shortened work week programs were assumed to start one hour earlier than presently scheduled and to quit one hour later, and the total number of employees starting and quitting at all times was assumed to be reduced by 20 percent from the number that would be shifted on an average day of a five-day work week. This 20 percent reduction was based on the assumption that the work week would be reduced from five days to four days, and that there would thus be 20 percent fewer employees making work trips on any given work day. This assumption is optimistic and made for convenience, since most employees working a four-day week would likely choose to take either Monday or Friday off rather than Tuesday, Wednesday, or Thursday. Under staggered work hour programs, 25 percent of the involved employees were assumed to be rescheduled one-quarter hour earlier and 25 percent one-quarter hour later, with the remaining 50 percent of the employees assumed to maintain their present schedules. Three different shifted work hour programs were analyzed. The first program assumed that starting and quitting times would be shifted only 15 minutes, and that 50 percent of the employees under the program would start 15 minutes earlier and the other 50 percent would start 15 minutes later. The second shifted work hour program assumed a 30-minute shift in starting and quitting times, and the third assumed a 60-minute shift. Under each shifted work hour program, the above-described staggered and flexible work hour programs and shortened work week programs were assumed to be in effect as well.

The potential impact of implementation of the four assumed work time rescheduling programs, with the shifted work hour program limited to a 15-minute change, is shown in Figures 38 and 39. While the number of workers starting at 7:00 a.m. and 8:00 a.m. may be expected to be reduced, a substantial number of employees would still start at those times. The reductions which would occur would primarily result from an increase in the number of employees starting on the quarter hour, thereby more evenly distributing the starting times throughout the morning peak hour of 7:00 to 8:00 a.m. The number of workers starting at 7:00 a.m. would be reduced by 24 percent—from 27,200 employees to 20,700; and at 8:00 a.m. the number of workers starting would be reduced by 16 percent—from 30,700 employees to 25,900.

Quitting times during the afternoon peak period are already more dispersed than starting times during the morning peak period; however, the assumed additional work time rescheduling would reduce peaks at 4:30 p.m. and 5:00 p.m. by increasing the number of quitting times on the quarter hour. This assumed rescheduling would have the greatest impact on traffic at 3:30 p.m., when the number of employees quitting work may be expected to be reduced by 10,400, a decrease of 33 percent.

Figure 38

DISTRIBUTION OF SCHEDULED MORNING PEAK-PERIOD STARTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA BEFORE AND AFTER IMPLEMENTATION OF THE FOUR ASSUMED RESCHEDULING PROGRAMS: SHIFTED WORK HOUR PROGRAMS RESCHEDULED BY ONE QUARTER HOUR



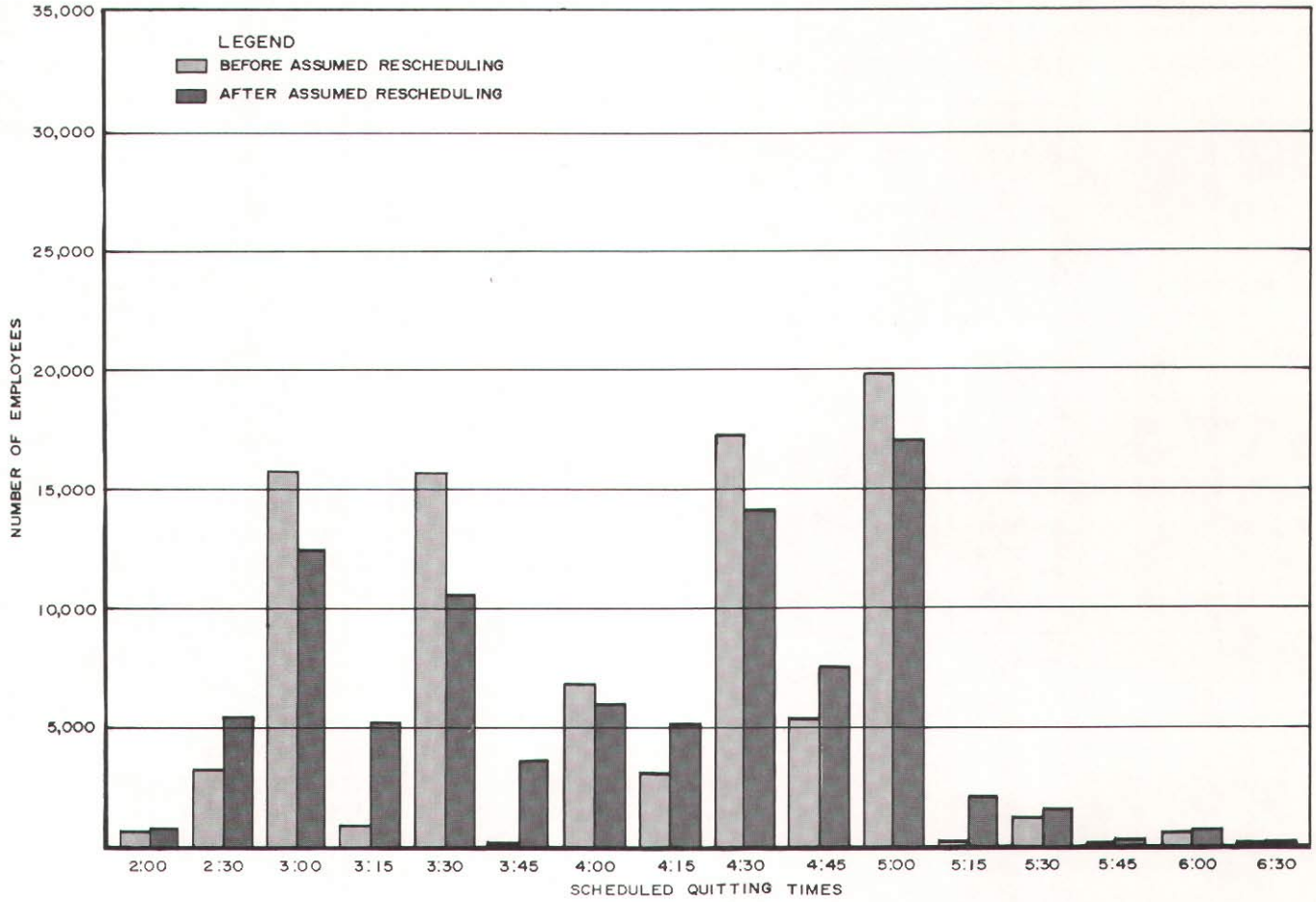
Source: SEWRPC.

The total number of employees starting work during the morning peak hour and quitting work during the afternoon peak hour, and hence required to travel during these hours, may be expected to actually increase under the assumed work time rescheduling program. Figure 40 indicates the number of employees scheduled to start and quit during the peak hours before and after implementation of the assumed work time rescheduling programs. Because of the increase in the number of employees with starting times on the quarter hour that would result from implementation of the shifted work hour program, the total number of employees scheduled to start between 7:15 a.m. and 8:00 a.m. would increase. The number of employees scheduled to quit between 4:00 p.m. and 4:45 p.m. may also be expected to increase through implementation of the assumed rescheduling. Thus, the 76 new work time rescheduling programs could be expected to decrease the peaking of employees at 7:00 a.m. and 8:00 a.m. and 4:00 p.m. and 4:30 p.m.; however, the total number of employees starting and quitting during the peak hours may be expected to actually increase, as shown in Figure 40.

A more uniform distribution of employee starting and quitting times during the peak travel hours and periods could also be accomplished if the surveyed employers willing to consider implementing shifted

Figure 39

DISTRIBUTION OF SCHEDULED AFTERNOON PEAK-PERIOD QUITTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA BEFORE AND AFTER IMPLEMENTATION OF THE FOUR ASSUMED RESCHEDULING PROGRAMS: SHIFTED WORK HOUR PROGRAMS RESCHEDULED BY ONE QUARTER HOUR



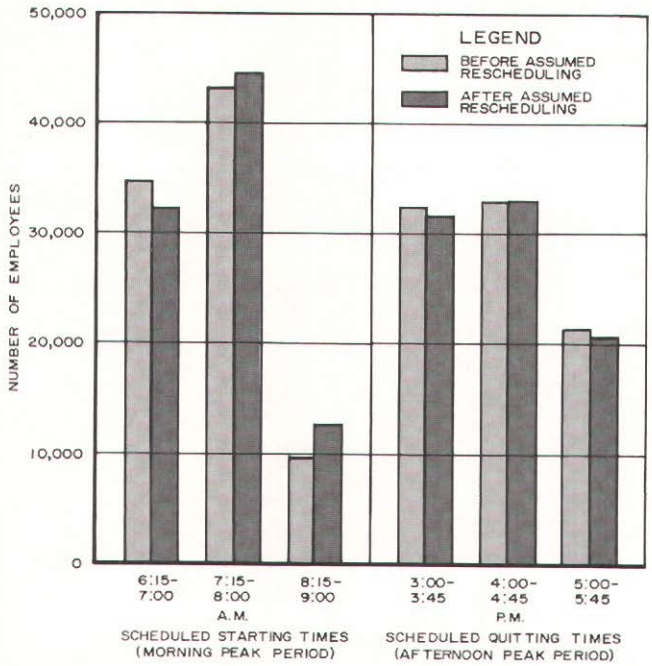
Source: SEWRPC.

work schedules rescheduled starting and quitting times by one half hour rather than one quarter hour, as shown in Figures 41 and 42. Such a shift could, moreover, be expected to result in a small reduction in the number of employees starting and quitting during the peak hours, as shown in Figure 43. The number of employees traveling during the morning peak hour could be expected to be reduced by 5 percent, and during the afternoon peak hour, by 2 percent.

Based on the survey of Milwaukee area employers, current employee starting and quitting times could be altered enough to affect peak-hour work travel substantially only if shifted work hour programs rescheduled starting and quitting times by a full hour. As shown in Figures 44 through 46, with one-hour rescheduling starting and quitting times would be more uniform during both the morning and afternoon peak hours and peak periods. Also, the number of employees starting and quitting during the peak hours could be expected to be reduced by 8,500, or 16 percent, during the morning peak hour, and by 700, or 2 percent, during the afternoon peak hour. Most Milwaukee area employers, however, may not be willing to implement such a shift in work hours. Ten of the 12 large employers indicating a willingness to consider implementing shifted work hours indicated that a one-half-hour shift may be possible, but that a one-hour shift would be difficult to impossible.

Figure 40

HOURLY DISTRIBUTION OF PEAK-PERIOD SCHEDULED STARTING AND QUITTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA BEFORE AND AFTER IMPLEMENTATION OF THE FOUR ASSUMED RESCHEDULING PROGRAMS: SHIFTED WORK HOUR PROGRAMS RESCHEDULED BY ONE QUARTER HOUR



Source: SEWRPC.

Thus, the survey indicates that the implementation of feasible work time rescheduling programs in the Milwaukee area could result in a 5 percent decrease in work-related peak-hour traffic during the morning peak hour and a 2 percent decrease during the afternoon peak hour. Furthermore, the implementation of the feasible programs would have the potential to reduce substantially the number of employees scheduled to start and quit at the most common starting and quitting times during the morning and afternoon peak hours. It is the large number of employees scheduled to start and quit at these common times that causes traffic demand to be unevenly distributed during the peak hours. Therefore, the arterial street and highway facilities in the Milwaukee area are generally designed to provide 5 to 10 percent additional capacity beyond that necessary to accommodate the total peak-hour flow in order to assure that traffic congestion and backups do not occur at any time during the peak travel hours. The reduction in peaking that would result from additional work time rescheduling would not, however, affect the extent of peak-hour traffic, and probably would not significantly reduce congestion problems throughout the Milwaukee area, although such reduction could reduce somewhat the duration and degree of some of the more severe congestion during the peak travel hours.

SUMMARY AND CONCLUSIONS

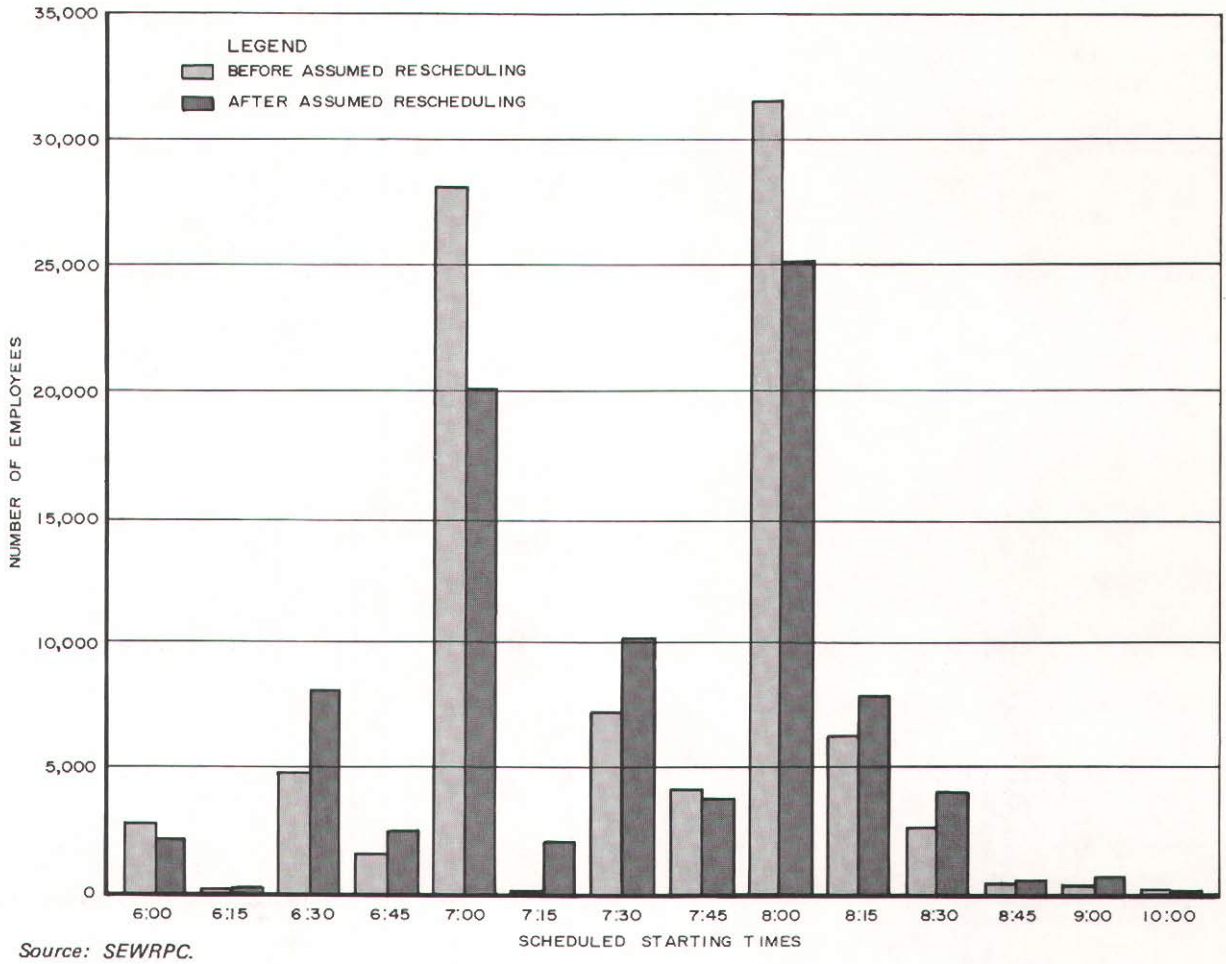
In the Milwaukee area there is substantial peaking of highway and transit travel. Highway traffic congestion in the Milwaukee area is primarily limited to the morning peak travel hour of 7:00 a.m. to 8:00 a.m. and the afternoon peak travel hour of 4:00 p.m. to 5:00 p.m. In 1978, approximately 93 miles of arterials, or 7 percent of the area's arterial system, were operating over design capacity during the morning peak travel hour. Another approximately 84 miles, or 6 percent of the Milwaukee area's arterial system, were operating at design capacity during the morning peak hour in 1978. The traffic congestion in the morning peak travel hour accounted for about 71 percent of the mileage of over-design-capacity facilities during the three-hour morning peak travel period—which includes the peak hour and the hour preceding and following that hour—and 57 percent of the mileage of at-design-capacity facilities during the three-hour morning peak period.

During the afternoon peak travel hour, approximately 112 miles of arterials were operating over design capacity in the Milwaukee area in 1978, or 9 percent of the area's arterial system. Another approximately 136 miles, or 10 percent of the Milwaukee area arterial system, were operating at design capacity during the afternoon peak hour. The traffic congestion in the afternoon peak travel hour accounted for about 45 percent of the mileage of both the over- and at-design-capacity facilities during the three-hour afternoon peak travel period.

Seven hypothetical work time rescheduling programs were analyzed to determine the maximum potential of work time rescheduling to reduce peak-hour highway traffic congestion in the Mil-

Figure 41

DISTRIBUTION OF SCHEDULED MORNING PEAK-PERIOD STARTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA BEFORE AND AFTER IMPLEMENTATION OF THE FOUR ASSUMED RESCHEDULING PROGRAMS: SHIFTED WORK HOUR PROGRAMS RESCHEDULED BY ONE HALF HOUR



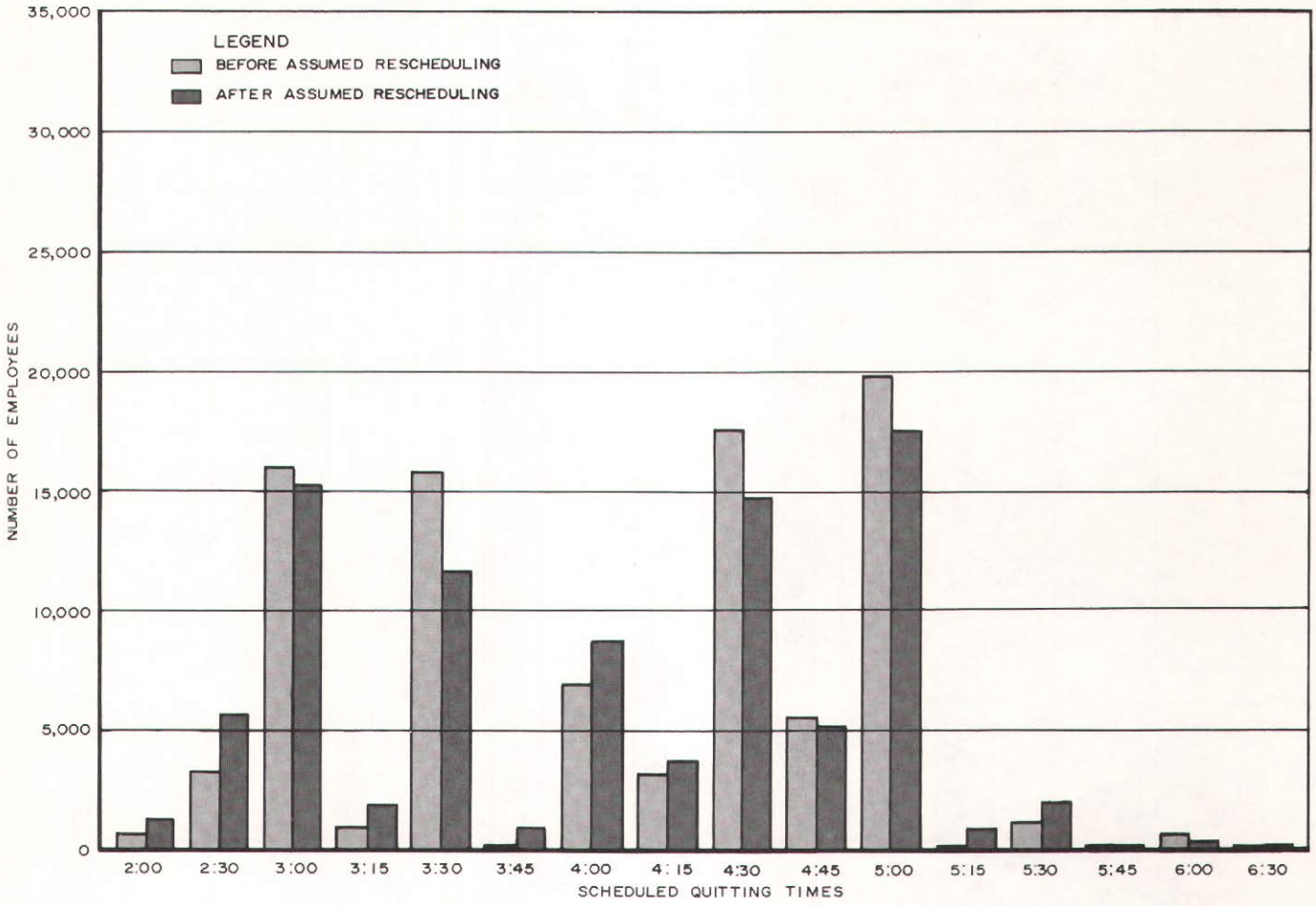
Source: SEWRPC.

waukee area by shifting peak-hour, work-related automobile traffic to the one hour preceding or one hour following the peak hours. Five of the programs were designed to indicate the maximum implications of shifted, staggered, and flexible work hour programs. Two of these programs had the objective of abating both the over-design-capacity and at-design-capacity peak-hour operation of arterial facilities. The other three sought to abate only the over-design-capacity, peak-hour operation of arterial facilities. The remaining two of the seven programs analyzed were designed to provide benefits similar to those of shortened work week programs, with one program having the ambitious objective of eliminating both at- and over-design-capacity operation during the peak hours, and the other having the more limited objective of eliminating only over-design-capacity operation during the peak hour.

It was determined that all seven hypothetical rescheduling patterns would reduce peak-hour arterial highway congestion in the Milwaukee area and attendant fuel consumption and air pollutant emissions. However, each of the patterns was also determined to result in increases in traffic congestion

Figure 42

DISTRIBUTION OF SCHEDULED AFTERNOON PEAK-PERIOD QUITTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA BEFORE AND AFTER IMPLEMENTATION OF THE FOUR ASSUMED RESCHEDULING PROGRAMS: SHIFTED WORK HOUR PROGRAMS RESCHEDULED BY ONE HALF HOUR



Source: SEWRPC.

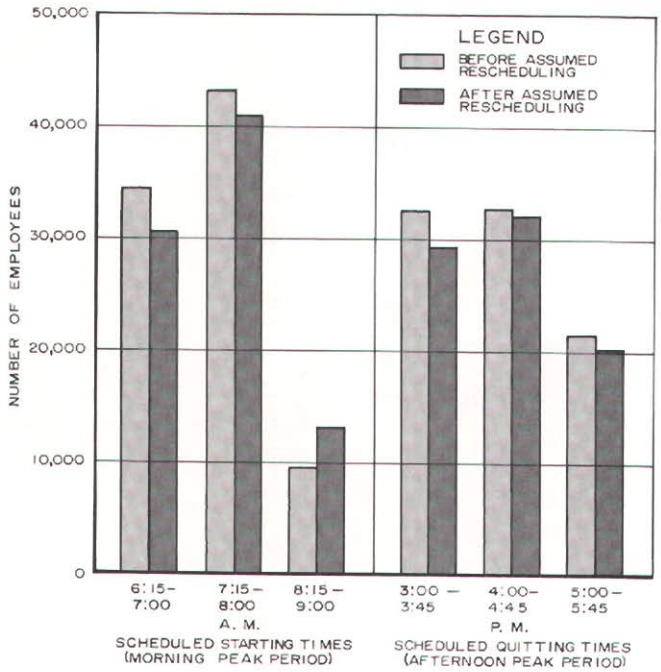
and attendant fuel consumption and air pollutant emissions during the hours preceding and following the peak hours.

Those shift patterns with the more ambitious objective of reducing both at- and over-design-capacity operation on the peak-hour problem segments were determined to have the potential to significantly reduce such operation not only during the morning peak hour but during the entire three-hour morning peak period. The analyses indicated that congestion could be reduced on from 19 to 81 miles of facilities operating at design capacity during that three-hour morning peak period under these shift patterns. Such reduction would represent a 13 to 56 percent net decrease in the mileage of congested arterials over this period. The reduction for the over-design-capacity arterial facilities could range from 29 to 38 miles under these shift patterns, representing a 22 to 29 percent decrease in the mileage of such arterials over the three-hour morning peak period.

Under these shift patterns, fuel consumption could be expected to be reduced by 6 to 9 percent on the problem segments over the morning peak period. Moreover, carbon monoxide and hydrocarbon emissions would be reduced by from 9 to 15 percent, and nitrogen oxide emissions would decrease by up to 4 percent.

Figure 43

HOURLY DISTRIBUTION OF PEAK-PERIOD SCHEDULED STARTING AND QUITTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA BEFORE AND AFTER IMPLEMENTATION OF THE FOUR ASSUMED RESCHEDULING PROGRAMS: SHIFTED WORK HOUR PROGRAMS RESCHEDULED BY ONE HALF HOUR



Source: SEWRPC.

The analyses indicated that only two of these three shift patterns could be expected to result in significant congestion reduction over the three-hour afternoon peak period, and this reduction would be limited to the at-design-capacity arterial facilities. Under each of these two patterns, at-design-capacity operation would be eliminated on about 180 miles of arterials in the three-hour period, representing a 60 percent reduction in the mileage of at-design-capacity facilities over the afternoon peak period.

Under these two shift patterns, the change in fuel consumption could be expected to vary from an increase of 2 percent to a decrease of 5 percent on the problem segments during the afternoon peak period. In addition, the change in carbon monoxide emissions could vary from an increase of 2 percent to a decrease of 4 percent; in hydrocarbon emissions could vary from a slight increase to a decrease of 5 percent; and in nitrogen oxide emissions could vary from nothing to a decrease of 5 percent.

Three of the four shift patterns with the more limited objective of reducing only peak-hour, over-design-capacity operation were determined to have the potential to reduce over-design-capacity operation during the three-hour morning peak period by from 28 to 55 miles. This represents a 21 to 42 percent decrease in over-design-capacity arterial operation during the morning peak period. However, each of these patterns could be expected to result in an even greater increase in at-design-capacity operation on the problem segments—from 48 to 71 miles of arterials, or a 33 to 48 percent increase in at-design-capacity operation during the three-hour morning peak period.

These four patterns were estimated to result in a 3 to 7 percent reduction in motor fuel consumption on the problem segments during the morning peak period, and a 5 to 12 percent reduction in carbon monoxide emissions, a 5 to 12 percent reduction in hydrocarbon emissions, and no change in nitrogen oxide emissions. Only two of these patterns were determined to have any appreciable effect on traffic congestion over the three-hour afternoon peak period, and, as in the morning peak period, the reduction achieved in over-design-capacity operation—from 57 to 60 miles, or 22 to 24 percent of the three-hour peak-period mileage of such arterials—would be balanced by an increase in at-design-capacity operation—from 48 to 67 miles, or 16 to 23 percent of the three-hour peak-period mileage of such arterials. The change in fuel consumption under the four patterns could be expected to vary from an increase of 2 percent to a decrease of 1 percent. With respect to air pollutant emissions, the change in carbon monoxide emissions could be expected to range from an increase of 2 percent to a decrease of 1 percent, and in hydrocarbon emissions to range from an increase of 2 percent to a decrease of 4 percent. Nitrogen oxide emissions would remain unchanged.

Thus, work time rescheduling programs with a more limited objective of minimizing only over-design-capacity, peak-hour operation can be expected to result in fairly substantial reductions in such operation over both the three-hour morning and afternoon peak periods; however, this decrease would be offset by the resulting increase in the amount of at-design-capacity operation during the peak

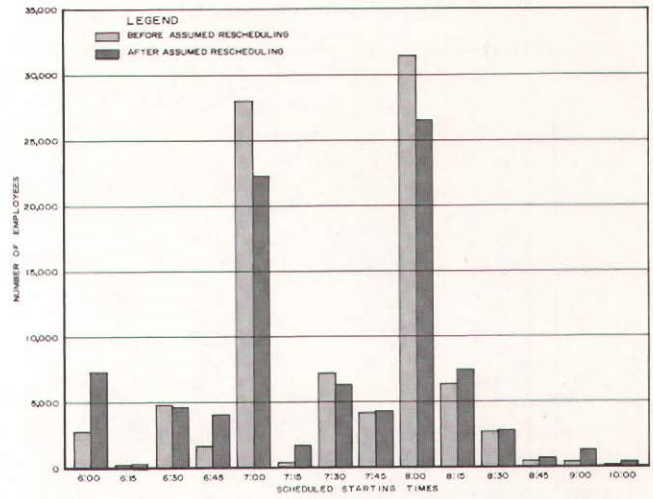
periods. Those work time rescheduling programs with the more ambitious objective may be expected to have a greater impact on congestion, and in fact would nearly eliminate congestion, particularly during the morning peak period, when substantial reductions could be made in both at- and over-design-capacity operation of arterials. In the afternoon peak period, a substantial reduction in congestion would also be made, but only on those arterials operating at design capacity. Under both the ambitious and limited programs, fuel consumption and carbon monoxide and hydrocarbon air pollutant emissions would be reduced on the problem segments during both peak travel periods, but particularly during the morning period. Nevertheless, the maximum reduction in the level of emissions of any of the measured pollutants or the amount of fuel consumed during either peak period would be no more than 4 percent of the total emissions produced or fuel consumed on the entire arterial system during either peak period. These reductions constitute less than 1 percent of the emissions and fuel consumption on the entire arterial system on an average weekday in the Milwaukee area.

Existing transit use on an average weekday in the Milwaukee area is even more peaked than automobile traffic. More evenly distributing transit travel demand over the three-hour morning and afternoon peak periods could reduce total peak bus fleet and driver requirements by at least 20 percent and, accordingly, reduce transit system operating and capital costs.

These potentially large benefits of work time rescheduling in the Milwaukee area can only be achieved with a very high degree of participation in such programs. To achieve the maximum highway congestion reduction impacts, the more ambitious work time rescheduling programs would require shifting an average of 18 to 22 percent of the peak-hour work trips from the 177 miles of morning peak-hour problem segments, and 12 to 26 percent of the peak-hour work trips from the 248 miles of afternoon peak-hour problem segments. The more limited work time rescheduling programs would require shifting an average of 16 to 18 percent of the peak-hour work trips from the 93 miles of morning peak-hour, over-design-capacity problem segments, and 11 to 14 percent of the work trips from the 112 miles of afternoon peak-hour, over-design-capacity problem segments. Achievement of the 20 percent maximum potential reduction in bus fleet requirements through

Figure 44

DISTRIBUTION OF SCHEDULED MORNING PEAK-PERIOD STARTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA BEFORE AND AFTER IMPLEMENTATION OF THE FOUR ASSUMED RESCHEDULING PROGRAMS: SHIFTED WORK HOUR PROGRAMS RESCHEDULED BY ONE HOUR



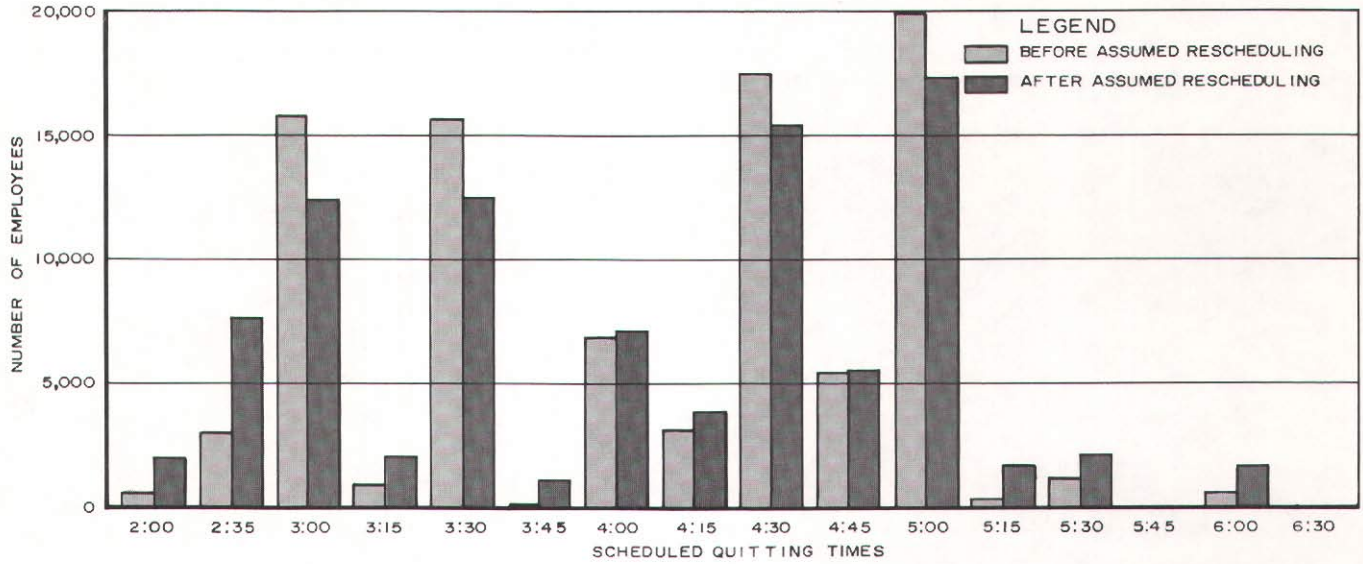
Source: SEWRPC.

work time rescheduling would require shifting 50 percent of the work-related trips made on public transit out of the morning hour of 7:00 a.m. to 8:00 a.m. and shifting 60 percent of the work-related trips made on public transit out of the afternoon hour of 3:00 p.m. to 4:00 p.m.

However, analysis of a survey of Milwaukee area employers indicated that the feasible shift of highway peak-hour travel to surrounding hours would be limited to about 5 percent of existing areawide morning peak travel and 2 percent of existing areawide afternoon peak travel. It was also determined from the survey that it would be feasible to reduce some areawide peaking of employees scheduled to begin work at the most common starting times and to leave work at the most common quitting times during the peak travel hours. This feasible reduc-

Figure 45

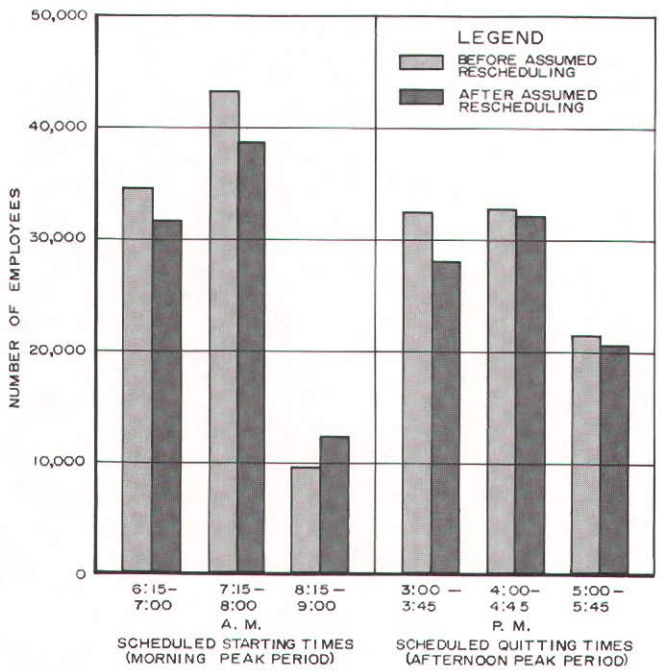
DISTRIBUTION OF SCHEDULED AFTERNOON PEAK-PERIOD QUITTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA BEFORE AND AFTER IMPLEMENTATION OF THE ASSUMED RESCHEDULING PROGRAMS: SHIFTED WORK HOUR PROGRAMS RESCHEDULED BY ONE HOUR



Source: SEWRPC.

Figure 46

HOURLY DISTRIBUTION OF PEAK-PERIOD SCHEDULED STARTING AND QUITTING TIMES OF SURVEYED EMPLOYERS IN THE MILWAUKEE AREA BEFORE AND AFTER IMPLEMENTATION OF THE FOUR ASSUMED RESCHEDULING PROGRAMS: SHIFTED WORK HOUR PROGRAMS RESCHEDULED BY ONE HOUR



Source: SEWRPC.

tion, however, probably would not substantially affect either the total peak-hour traffic volume or extent of traffic congestion in the Milwaukee area, but could reduce somewhat the duration and degree of the more severe peak-hour traffic congestion.

Based on the information presented above, it is recommended that no further consideration—through preparation, test, and evaluation of areawide alternative work time rescheduling plans—be given to work time rescheduling as a transportation systems management measure to abate traffic congestion in the Milwaukee area. It is recommended, however, that work time rescheduling be given consideration along with other traffic management measures on a case-by-case basis as part of the continuing traffic management planning of the Commission and local units and agencies of government in the Milwaukee area. Work time rescheduling may be feasible for congestion reduction in corridors or areas where a larger-than-average employer participation in work time rescheduling is feasible, or where a smaller-than-average shift of work travel from the peak hour would be required to effect improved traffic conditions. The potential benefits of areawide work time rescheduling are significant and, consequently, implementation of any work time rescheduling in the Milwaukee area would constitute a desirable action.

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Chapter VIII

SUMMARY AND CONCLUSIONS

INTRODUCTION

The Milwaukee area work time rescheduling study is one of a number of transportation systems management studies conducted by the Southeastern Wisconsin Regional Planning Commission in order to identify practical ways to obtain the maximum efficiency from existing transportation facilities and services and thereby to abate existing arterial street and public transit system congestion in the Milwaukee area. A study of the potential of work time rescheduling to reduce peak-period travel demands was recommended in the Commission's 1978 short- and long-range regional transportation systems management plans. This emphasis on transportation systems management stemmed from the then sharp division of public opinion within Milwaukee County with respect to further freeway and major arterial street construction, and the increasing emphasis of national transportation policy on the planning for, and implementation of, transportation systems management measures in urban areas.

Generally, traffic congestion is severe and transit vehicle needs are high in the Milwaukee area only during one early morning and one late afternoon hour of the weekday, when travel is at its peak in the area principally as a result of the concentration of travel to and from work in these two hours. The objective of the work time rescheduling study was to determine the extent to which this congestion and attendant excessive air pollutant emissions and motor fuel consumption could be abated by spreading peak-hour work travel over surrounding hours. Accordingly, the Milwaukee area work time rescheduling study was to develop a recommended plan for such rescheduling in the Milwaukee area, if it could be demonstrated that such a plan was practical—that is, if sufficient employer participation in new or expanded existing work time rescheduling programs could be anticipated to effect a reasonable degree of abatement of traffic and transit congestion in the Milwaukee area.

The study involved the collation of pertinent data on existing population and employment levels and on land use development in the Milwaukee area; on the characteristics of travel demand and patterns; and on the characteristics and usage of transportation facilities and services. Through analyses of these data, the maximum traffic congestion abatement and transit vehicle fleet reduction possible through the shifting of work travel from the morning and afternoon peak travel hours to earlier and later hours in the three-hour morning and afternoon peak travel periods was determined. In addition, under the study an inventory was conducted of the current extent of work time rescheduling in the Milwaukee area, and information on employer attitudes toward expanding such rescheduling was collected. Based upon this information, the maximum practicable traffic congestion abatement and transit vehicle fleet reduction which could be expected to be achieved by an expanded work time rescheduling program in the Milwaukee area was determined.

POPULATION, EMPLOYMENT, AND LAND USE IN THE MILWAUKEE AREA

In 1975, the Milwaukee area accounted for about 70 percent of the resident population of the seven-county Southeastern Wisconsin Region, and for about 75 percent of its jobs. The population of the Milwaukee area has been decreasing since 1970. From 1970 to 1975, the population declined by 12,400 people, or about 1 percent, and from 1975 to 1978 the population declined by another 34,100 people, or 3 percent.[1] Prior to 1970, the population of the Milwaukee area had been steadily increasing—by 238,300 people, or 25 percent, from 1950 to 1960, and by 86,800 people, or 7 percent, from 1960 to 1970.

At the same time that the population was declining, employment opportunities in the Milwaukee area were increasing. In Milwaukee County, which accounts for almost 90 percent of the area's employment opportunities, the number of jobs

[1] *Early population counts from the 1980 Census of Population indicate that population in the Milwaukee area has continued to decrease. Between 1975 and 1980, the population has declined by about 45,400 residents, or about 4 percent.*

increased from 486,200 in 1960, to 510,900 in 1970, and to 521,300 in 1975.[2] The majority of the jobs in the Milwaukee area were determined to be in manufacturing, 30 percent, followed by approximately 23 percent in private services and about 12 percent in government services and education. Furthermore, most of the jobs in the Milwaukee area were provided by a relatively few employers. In 1975, 393,000 jobs, or about 65 percent of all the jobs in the area, were provided by about 760 employers having 100 or more employees, or by 3 percent of the total employers in the area.

Land use development in the Milwaukee area has changed significantly since 1950 from one of concentrated development at medium densities in concentric rings contiguous to existing urban centers, to one of diffused, low-density "urban sprawl," which is often discontinuous and occurs in small isolated enclaves.

TRAVEL DEMAND, HABITS, AND PATTERNS

The data collated on travel demand provided information on not only the total amount of travel in the Milwaukee area, but also the purpose, mode, and time of travel, with particular emphasis on work travel during the peak travel periods of 6:00 a.m. to 9:00 a.m. and 3:00 p.m. to 6:00 p.m. With respect to personal travel by all modes in 1972 within the Milwaukee area, the afternoon peak period has more travel demand than the morning peak period, is less peaked in demand than the morning period, and has more nonwork travel during its peak hour. In the afternoon peak period, nearly 840,000 person trips were estimated to be made within the Milwaukee area in 1972, 285,000 of which were made within the afternoon peak hour of total travel of 4:00 p.m. to 5:00 p.m. Nearly 42 percent of these peak-hour trips were made for work purposes. In the morning peak period, about 566,000 person trips were estimated to be made within the Milwaukee area, 270,000 of which were made within the morning peak hour of total travel of 7:00 a.m. to 8:00 a.m. Nearly 53 percent of these peak-hour trips were made for work purposes.

The peak-hour and -period characteristics of travel by automobile within the Milwaukee area were very similar to those of personal travel by all modes in 1972, as automobile travel constituted nearly 90 percent of total personal travel in the Milwaukee area in 1972. Travel on public transit, however, had slightly different peak-hour and -period travel characteristics in the Milwaukee area in 1972. First, the amount of transit travel during the two peak periods was more similar, 51,000 transit trips in the morning period and 61,000 trips in the evening period. Second, travel in both periods was more peaked, with 54 percent of the morning peak-period trips occurring in the morning peak transit travel hour of 7:00 a.m. to 8:00 a.m. and 51 percent of the afternoon peak-period trips occurring in the afternoon peak transit travel hour of 3:00 p.m. to 4:00 p.m. Finally, only about 39 percent of the morning peak-hour transit trips and 26 percent of the afternoon peak-hour transit trips were for work purposes. The majority of the transit trips made during both peak hours in 1972 were school-purpose trips, 56 percent in the morning peak hour and 52 percent in the afternoon peak hour.[3] The afternoon peak transit travel hour—3:00 p.m. to 4:00 p.m.—was different from the afternoon peak highway travel hour—4:00 p.m. to 5:00 p.m.—because of the concentration of school-purpose trips in the transit peak travel hours. The afternoon peak hour of transit travel for work purposes coincided with the afternoon peak highway travel hour. It should be noted that these highway and transit peak travel hours remained unchanged in 1978.

TRANSPORTATION FACILITIES AND SERVICES AND THEIR USE

Information on the supply of, as well as the demand for, transportation facilities and services is essential to the identification of existing problems of traffic congestion and of excessive demand for transit vehicles. For the purpose of this study, the transportation system of the Milwaukee area was defined as the system of arterial streets and highways which exists for the movement of heavy volumes of through traffic in the area, and the network of public transit motor bus lines which are operated in the area.

[2] *Preliminary 1980 employment estimates for Milwaukee County indicate an employment level of about 519,800 jobs, approximately equal to the employment level in 1975.*

[3] *Some of these morning peak-hour and -period school trips were shifted to other hours in 1980 when the Milwaukee Public Middle Schools were rescheduled from an 8:25 a.m. starting time to a 9:07 a.m. starting time.*

Based on an inventory of the transportation facilities, there were 4,451 miles of street and highway facilities in the Milwaukee area in 1978. Of this total, 1,299 miles, or 29 percent, were classified as arterials, and the remaining 3,152 miles, or 71 percent, were classified as collectors and land access streets.

The use of these arterial facilities steadily increased from 1963 to 1978, as indicated by the increase in total vehicle miles of travel in the Milwaukee area, with only a temporary setback in this increase occurring during the oil embargo and attendant motor fuel shortages of 1973-1974. A total of 16.4 million vehicle miles of travel were made on the arterial street system of the Milwaukee area on an average weekday in 1978, an increase of 22 percent over the 1972 total. Available freeway and surface arterial traffic counts in the Milwaukee area indicate this trend may have reversed in 1979 and in 1980, probably as a result of motor fuel price increases in 1979 and the declining economy in 1980, as generally small decreases in average weekday traffic volumes were measured in these years.

In 1979 Milwaukee County was provided primary (rapid), secondary (express), and tertiary (local) transit service by the Milwaukee County Transit System. These services combined required a fleet of 578 buses and the operation of an average of 53,800 bus miles daily. The primary element of the transit service was provided principally during peak travel hours by 10 "Freeway Flyer" motor bus routes; an average of 12 vehicle trips were made each weekday on each of these routes from 12 outlying park-ride facilities to the Milwaukee central business district. Secondary public transit service was provided by five limited-stop bus routes operating over arterial streets in mixed traffic, making an average of 304 weekday vehicle trips in 1979. Tertiary transit service was provided over 45 routes, on which approximately 5,354 weekday vehicle trips were made in 1979. In addition, two types of specialized transit service were provided by the Milwaukee County Transit System, the UBUS service to the University of Wisconsin-Milwaukee and the shuttle bus service in the Milwaukee central business district. Portions of Milwaukee and Waukesha County were also provided express transit service by two routes operated by Wisconsin Coach Lines, Inc.

After a long period of declining ridership, transit use began to increase in the Milwaukee area in 1975. In 1979, 55.6 million revenue passenger transit trips were made in the Milwaukee area, an increase of 25 percent over the 1975 total and about 6 percent over the 1972 total. Despite this increase in transit travel, transit still was estimated to carry a very small percentage of the total personal travel in the Milwaukee area. In 1972 transit was estimated to carry less than 6 percent of the Milwaukee area total person travel, and 8 percent of area travel during peak travel periods.

TRANSPORTATION SYSTEM PROBLEMS AND DEFICIENCIES

In 1978, approximately 93 miles of arterials, or 7 percent of the total arterial system, were operating over design capacity in the Milwaukee area during the morning peak highway travel hour of 7:00 a.m. to 8:00 a.m. An additional 88 miles, or 7 percent of the total arterial system, were operating at design capacity during the morning peak hour. The traffic congestion during the morning peak travel hour accounted for over 71 percent of the total mileage of arterial facilities operating over design capacity in the Milwaukee area during the three-hour morning peak travel period—which includes the peak hour and the hour preceding and following the peak hour—and over 57 percent of the mileage of arterials operating at design capacity in the three-hour morning peak period.

During the afternoon peak highway travel hour, approximately 112 miles of arterials in the Milwaukee area, or 9 percent of the total arterial system, were operating over design capacity. An additional 136 miles, or 10 percent of the total arterial system, were operating at design capacity during the afternoon peak hour. The traffic congestion in the afternoon peak travel hour accounted for about 45 percent of the total mileage of arterials in the Milwaukee area operating over and at design capacity during the three-hour afternoon peak travel period.

The demand for, and operation of, transit service in the Milwaukee area was even more peaked in the morning and afternoon than the demand for arterial street and highway facilities. In the winter of 1978, nearly 10,600 passengers passed the maximum load points on Milwaukee County Transit System local bus routes between 7:00 a.m. and 7:30 a.m., and about 10,100 passengers passed local bus route maximum load points between 3:30 p.m. and 4:00 p.m. In a typical half-hour midday period, the number of passengers passing maximum load points totaled only about 3,500

passengers. As a result, as many as 500 buses were required to be in operation during the peak periods, while fewer than 300 buses were required to be in operation during the midday period. This peaking of transit service, besides affecting total bus fleet and driver needs, created the need for complex driver schedules and split shifts to provide adequate transit service during the peak and off-peak time periods.

MAXIMUM POTENTIAL OF WORK TIME RESCHEDULING TO REDUCE TRAFFIC AND TRANSIT CONGESTION

Work time rescheduling has the potential to reduce highway peak-hour traffic congestion in two ways. One way involves using work time rescheduling to shift traffic out of the peak hour to earlier and later hours in the peak travel period, thereby essentially accomplishing an "averaging" of traffic loadings during the peak travel periods. The second way involves using work time rescheduling to shift traffic within the peak hour in an attempt to reduce the peaking of traffic within that hour, thereby accomplishing an "averaging" of traffic during the peak hour. The latter way of applying work time rescheduling is considered to have limited potential for significant congestion abatement in the Milwaukee area. Available data indicate that, if the peak-hour volume were averaged, such averaging would result in only a 5 to 10 percent decrease in traffic volume for a 15-minute peak period on standard arterials, and in a 5 to 10 percent decrease in traffic volume for a 5-minute peak period on freeways.

The former way of applying work time rescheduling is considered to have greater potential for reducing traffic congestion. The potential for this type of rescheduling to reduce traffic congestion in the Milwaukee area was measured under the study by establishing whether sufficient traffic on congested segments of the arterial street and highway system during the peak highway travel hours could be shifted to hours preceding and/or following the peak hours to abate peak-hour congestion without causing an increase in traffic congestion in those adjacent hours. This determination of the maximum potential of work time rescheduling was accomplished in three steps. First, major problem segments of arterial facilities operating at or over design capacity during the morning and afternoon peak highway travel hours of 7:00 a.m. to 8:00 a.m. and 4:00 p.m. to 5:00 p.m. in 1978 were identified. Second, the number of work trips made by automobile on each problem segment during the peak hours was determined to establish the maximum number of trips which could potentially be shifted to reduce traffic congestion through work time rescheduling. Third, work-related automobile traffic in the peak hours was hypothetically shifted to adjacent hours, and the attendant effect on traffic conditions in these hours was determined.

Seven hypothetical work time rescheduling programs were tested to determine the maximum potential of work time rescheduling to abate peak-hour highway traffic congestion in the Milwaukee area through the shifting of peak-hour, work-related automobile traffic to the preceding or following hour. Five of the programs were designed to determine the impact of shifted, staggered, and flexible work hour programs. Two of these five programs were designed to eliminate the at-design-capacity, peak-hour operation of arterials, as well as the more severe, over-design-capacity peak-hour operation of arterials. Three of these five programs sought to abate only the over-design-capacity, peak-hour operation of arterials. The remaining two of the seven programs tested were designed to provide a measure of the potential benefits of shortened work week programs. One of these programs had the ambitious objective of reducing both at- and over-design-capacity operation, while the other had the more limited objective of reducing only over-design-capacity operation.

All seven hypothetical work time rescheduling programs were found to provide some reduction of peak-hour arterial highway congestion in the Milwaukee area and of attendant fuel consumption and air pollutant emissions. However, each of the programs was also found to result in increases in traffic congestion and attendant fuel consumption and air pollutant emissions during the hours preceding and following the peak hours.

Those work time rescheduling programs with the more limited objective of minimizing only over-design-capacity, peak-hour arterial operation were found to result in from 21 to 42 percent reductions in the total mileage of arterial facilities operating over design capacity during the three-hour morning and afternoon peak periods. However, the total mileage of arterial facilities operating at design capacity during those three-hour peak periods was found to increase, with the percentage of increase being greater than the percentage of decrease in the mileage of arterials operating over design capacity.

Those work time rescheduling programs with the more ambitious objective were determined to have a greater potential for congestion reduction; in fact, implementation of these programs would result in substantial abatement of peak-hour congestion without substantially increasing congestion in surrounding hours. During the three-hour morning peak period, the total mileage of arterials operating over design capacity could be reduced by 22 to 29 percent, and the total mileage of arterials operating at design capacity could be reduced by 13 to 56 percent. In the afternoon peak period, a substantial reduction in congestion could also be expected, but only in the mileage of those arterials operating at design capacity.

Under both the ambitious and more limited programs, fuel consumption and carbon monoxide and hydrocarbon air pollutant emissions would generally be reduced on the problem segments. During the morning peak travel period, motor fuel consumption could be expected to be reduced by an average of 7 percent, carbon monoxide emissions by 11 percent, and hydrocarbon emissions by 10 percent. During the afternoon peak travel period, motor fuel consumption could be expected to be reduced by an average of 1 percent, carbon monoxide emissions by 2 percent, and hydrocarbon emissions by 2 percent. However, even the greatest of these reductions in the peak periods on the problem segments would be no more than 4 percent of the total emissions and fuel consumption over the entire Milwaukee area arterial street system during the peak periods, and no more than 1 percent of the same on an average weekday.

Work time rescheduling was found to have somewhat greater potential public transit benefits. Averaging of transit travel demand over the three-hour morning and afternoon peak periods was determined to provide a potential reduction in total peak bus fleet and driver requirements of about 20 percent and, accordingly, an attendant reduction in transit system operating and capital costs. The magnitude of the potential savings in capital cost is indicated by the fact that replacement of 20 percent of the Milwaukee County Transit System fleet in 1979 would require the purchase of 115 buses at a total estimated capital cost of $16,100,000 in 1979 dollars. The magnitude of the potential savings in operating costs is indicated by the fact that the difference in cost between strictly peak-hour service on the Milwaukee County Transit System—$25 per bus-hour—and the off-peak service currently operated—$20 per bus-hour—is $5 per bus-hour expressed in 1978 dollars.

FEASIBILITY OF ATTAINMENT OF POTENTIAL WORK TIME RESCHEDULING BENEFITS

It is unlikely that the potential benefits of work time rescheduling discussed above could be attained within the Milwaukee area, given the practical degree of employer participation determined to be possible in the area under the study. To achieve the maximum highway congestion reduction impacts, the more ambitious work time rescheduling programs would require an average shifting of 20 percent of the work trips made on both the 177 miles of morning peak-hour and 248 miles of afternoon peak-hour problem segments. The more limited work time rescheduling programs would require an average shifting of 17 percent of the work trips made on the 93 miles of morning peak-hour, over-design-capacity problem segments, and of 12 percent of the work trips made on the 112 miles of afternoon peak-hour, over-design-capacity problem segments. Achievement of the 20 percent maximum potential reduction in bus fleet requirements through work time rescheduling would require the shifting of nearly 50 percent of the work-related trips made on public transit out of the morning peak transit travel hour of 7:00 a.m. to 8:00 a.m., and of 60 percent of the work-related trips made on public transit out of the afternoon peak transit travel hour of 3:00 p.m. to 4:00 p.m.

A survey conducted under the study of the current work schedules and attitudes of Milwaukee area employers toward work time rescheduling indicated that the feasible shift of morning and afternoon peak-hour travel to surrounding hours was substantially less than that required to achieve these maximum potential work time rescheduling benefits. All of the 295 employers in the Milwaukee area estimated to have 100 or more employees and work hours requiring peak-period travel were mailed survey questionnaires. Also included in the survey was a sample of 100 smaller employers located in parts of the Milwaukee area with higher-than-average employment densities, such as the Milwaukee central business district. Slightly more than one-half of the surveyed firms, representing nearly 122,000 employees, or about 20 percent of Milwaukee area employment, responded to the survey. Of these 122,000 employees, 86,000, or 71 percent, were found to be already participating in a work time rescheduling program, and of these 86,000, or over 80 percent, were in staggered work hour programs. Thirty-seven percent of the employers responding to the survey indi-

cated a willingness to consider implementing new or additional work time rescheduling. The surveyed employment that would be affected by such programs approaches 30,000 jobs, or nearly 25 percent of the employment of the employers responding to the survey.

The impact this new work time rescheduling would have on peak-hour work travel in the Milwaukee area was analyzed by determining the aggregate change in the work schedules of the employment of the surveyed employers that would result from the implementation of work time rescheduling. It was assumed in this analysis that every employer indicating a willingness to consider implementing new or additional work time rescheduling programs would, in fact, implement such programs. The results of this analysis indicated that fewer than 6,000 employees, or 5 percent of the surveyed employment, would not be involved in a future work time rescheduling program.

The analysis, as summarized in Table 47, indicated that the number of employees traveling during the 7:00 a.m. to 8:00 a.m. peak hour would only be reduced by up to 5 percent, and during the 4:00 p.m. to 5:00 p.m. peak hour by up to 2 percent. This estimated attainable reduction in peak-hour work-related travel is about one-fourth that necessary to achieve the maximum potential benefits of shifting arterial street and highway work travel out of the morning peak hour, and less than one-tenth the reduction necessary to achieve the maximum potential benefits of shifting arterial street and highway work travel out of the afternoon peak hour. Furthermore, this estimated attainable reduction is substantially less than that necessary to achieve the maximum potential benefits of shifting any transit work-related travel from the peak hour. As indicated in Table 47, any attempt through work time rescheduling to shift travel from the afternoon peak travel hour to surrounding hours will be complicated by the difference between the highway afternoon peak travel hour—4:00 p.m. to 5:00 p.m.—and the transit afternoon peak travel hour—3:00 p.m. to 4:00 p.m.

With regard to the practicality of attaining congestion abatement in the Milwaukee area by reducing the peaking of travel during the peak hour, it was determined from the analysis of the survey of employers that only a small reduction in the areawide peaking of employees scheduled to begin work at the most common starting times and to leave work at the most common quitting times during the peak travel hours would be feasible. Because work time rescheduling could be expected to have little impact as a practical matter on traffic congestion and transit fleet size in the Milwaukee area, it was recommended that no areawide work time rescheduling plans for the abatement of traffic congestion and reduction of transit vehicle needs in the Milwaukee area be prepared, tested, and evaluated at this time, and that the study be terminated. However, because of the potentially large benefits of work time rescheduling, and because any such rescheduling would constitute one step toward those benefits, it was recommended that work time rescheduling be promoted in the Milwaukee area, and specifically be given consideration on a case-by-case basis along with other traffic management measures as part of the continuing traffic management planning of the Commission and local units and agencies of government in the Milwaukee area. Work time rescheduling may be feasible for congestion reduction in small areas where a larger-than-average employer participation in work time rescheduling is feasible, or a smaller-than-average shift of work travel from or within the peak travel hour is required to effect improved traffic conditions. Work time rescheduling may also warrant consideration in a major emergency in which transportation system capacity is limited or travel must be curtailed.

The work time rescheduling implemented in such cases should attempt to shift work trips made by automobile from the peak hours of 7:00 a.m. to 8:00 a.m. and 4:00 p.m. to 5:00 p.m. These shifts could be made through implementation of any of the four types of work time rescheduling programs: flexible work hours, staggered work hours, shifted work hours, or shortened work weeks. If work starting and quitting times cannot be rescheduled to times which would permit travel to and from work to occur outside the present peak hours, starting times should then be rescheduled within the peak hour to other than 7:00, 7:30, or 8:00 a.m., and quitting times should be rescheduled to other than 4:30 or 5:00 p.m. in order to provide some reduction of peaking within the peak hour.

Work time rescheduling should attempt to shift work trips made by transit out of the morning hour of 7:00 a.m. to 8:00 a.m. and the afternoon hours of 3:00 p.m. to 5:00 p.m. Again, these shifts could be made through implementation of any of the four types of work time rescheduling programs. Through these shifts, peak-hour crowding between 7:00 a.m. and 8:00 a.m. and between 3:00 p.m.

Table 47

COMPARISON OF POTENTIAL AND FEASIBLE BENEFITS OF WORK TIME RESCHEDULING IN THE MILWAUKEE AREA

Type of Benefits	Basis of Analysis	Shift in Peak-Hour, Work-Related Travel Attendant to Analysis	Benefits					
			Arterial Street and Highway System					Public Transit System
			Congestion—Peak-Period Over- and At-Design-Capacity Arterial Facility Mileage	Air Pollutant Emissions			Motor Fuel Consumption	Motor Bus Fleet Requirements
				Carbon Monoxide	Hydrocarbons	Nitrogen Oxides		
Maximum Potential Benefits of Work Time Rescheduling in the Milwaukee Area	Maximum shifts of peak-hour, work-related travel within peak travel period on arterial street and highway system from peak hours of 7:00 a.m. to 8:00 a.m. and 4:00 p.m. to 5:00 p.m. with objective of eliminating peak-hour, over- and at-design-capacity operation of arterials. Maximum shifts on public transit system from peak hours of 7:00 a.m. to 8:00 a.m. and 3:00 p.m. to 4:00 p.m. with objective of minimizing bus fleet requirements	Arterial Street System Congested Facilities Morning Peak Hour—21 percent Afternoon Peak Hour—21 percent Public Transit System Morning Peak Hour—50 percent Afternoon Peak Hour—60 percent	Morning Peak Period—Reduction of 38 miles, or 29 percent, in mileage of over-design-capacity arterials, and reduction of 81 miles, or 56 percent, in mileage of at-design-capacity arterials Afternoon Peak Period—Reduction of 180 miles, or 60 percent, in mileage of at-design-capacity arterials	Morning Peak Period—4 percent reduction Afternoon Peak Period—No change	Morning Peak Period—3 percent reduction Afternoon Peak Period—1 percent reduction	Morning Peak Period—1 percent reduction Afternoon Peak Period—1 percent reduction	Morning Peak Period—2 percent reduction Afternoon Peak Period—1 percent reduction	Morning Peak Period—19 percent reduction Afternoon Peak Period—15 percent reduction
Practicable Benefits of Work Time Rescheduling in the Milwaukee Area	Aggregate work schedules of employers surveyed under study. All employers indicating willingness to consider work time rescheduling were assumed to implement work time rescheduling	Arterial Street system Morning Peak Hour—5 percent Afternoon Peak Hour—2 percent Public Transit System Morning Peak Hour—5 percent Afternoon Peak Hour—9 percent	Morning Peak Period—Reduction of 9 miles, or 7 percent, in mileage of design-capacity arterials, and reduction of 18 miles, or 12 percent, in mileage of at-design-capacity arterials Afternoon Peak Period—Reduction of 15 miles, or 5 percent, in mileage of at-design-capacity arterials	Morning Peak Period—1 percent reduction Afternoon Peak Period—No change	Morning Peak Period—1 percent reduction Afternoon Peak Period—No change	Morning Peak Period—No change Afternoon Peak Period—No change	Morning Peak Period—No change Afternoon Peak Period—No change	Morning Peak Period—2 percent reduction Afternoon Peak Period—2 percent reduction

Source: SEWRPC.

and 5:00 p.m. would be decreased, and opportunities for passengers to obtain a seat on buses during the peak hours would be increased. Furthermore, if the spreading of transit passenger demand were large enough, the size of the necessary transit motor bus fleet, as currently established by peak-hour bus requirements during the 7:00 a.m. to 8:00 a.m. and 3:00 p.m. to 4:00 p.m. transit peak hours, could be reduced. The spreading of transit passenger demand over a longer period of time may also improve the efficiency with which buses and drivers can be scheduled by reducing the need for split-shifts, thereby reducing the cost of peak-hour service.

SUMMARY

The principal conclusion of the Milwaukee area work time rescheduling study is that expanded areawide work time rescheduling plans should not be prepared, tested, and evaluated for the Milwaukee area at this time. The major reason for this conclusion is that the degree of employer participation in new or expanded existing work time rescheduling programs would be inadequate to provide any measurable reduction in traffic congestion or transit vehicle fleet requirements in the Milwaukee area, as determined by a survey of Milwaukee area employers under the study. The study did, however, establish that traffic congestion and transit vehicle needs could be significantly reduced if work travel could in some way be shifted from peak hours to the hours preceding and following them.

Therefore, it was recommended that work time rescheduling be promoted in the Milwaukee area, and specifically be given consideration on a case-by-case basis along with other traffic management measures as part of the continuing traffic management planning of the Commission and local units and agencies of government in the Milwaukee area. This recommendation was made because of the potentially significant benefits of work time rescheduling and because any such rescheduling would constitute a step toward the attainment of some margin of those benefits. In addition, it was recognized that work time rescheduling may be feasible in small areas where a larger-than-average employer participation in work time rescheduling is feasible, or a smaller-than-average shift of work travel from the peak hours is all that is required to effect improved traffic conditions.

APPENDICES

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Appendix A

MILWAUKEE AREA WORK TIME RESCHEDULING STUDY EMPLOYERS SURVEY

INTRODUCTION

The purpose of the Milwaukee area work time rescheduling study was to examine the extent to which alternative work schedules—flexible work hours, staggered work hours, shifted work hours, and shortened work weeks—could reduce peak-travel-period congestion on the arterial highways and public transit systems of the Milwaukee area. Work time rescheduling has been held to have the potential to reduce peak periods of transportation system congestion, improve air quality, and reduce motor fuel consumption, and thereby to minimize transportation problems without the high capital, social, and environmental costs attendant to the expansion of the capacity of the existing transportation system.

There are four basic types of work time rescheduling: flexible work hours, staggered work hours, shifted work hours, and shortened work weeks. All four types generally require the same number of hours of work per week from employees as required by traditional work schedules. Each may affect employers, employees, and peak travel demand in different ways.

Flexible work hour programs allow employees to determine their daily work hours according to personal preferences, as long as their total work hours equal a specified minimum number daily or weekly. In nearly all flexible work hour programs, all employees are required to work during a specified "core" period—for example, between 10:00 a.m. and 3:00 p.m.—and employees are not allowed to come to work before or leave from work later than specified times, such as 7:00 a.m. and 7:00 p.m.

Staggered work hour programs schedule employee starting and quitting times at short intervals, usually 15 minutes or so, over selected morning starting and evening quitting periods of one to three hours, rather than at a single common starting and quitting time.

Shifted work hour programs reschedule the starting and quitting times of an entire firm or plant rather than rescheduling different portions of the work force as do staggered work hour programs. For example, a firm which now operates from 8:00 a.m. to 5:00 p.m., with all employees starting and quitting at those times, may change its hours to 7:00 a.m. to 4:00 p.m., or 9:00 a.m. to 6:00 a.m. All employees still start and quit at one time, but the hours of the work day are shifted.

Staggered work hours, shifted work hours, and flexible work hours have the potential to reduce localized and, perhaps, areawide peaking in travel demand, and associated congestion. Staggered work hours and shifted work hours spread the required times of arrival to and departure from work. Flexible work hours also reduce such peaking, since not all employees may be expected to select the same starting and quitting times when given a choice, and since employees may choose to travel to and from work when travel is not at its peak.

The shortened work week most commonly requires employees to work a total of 40 hours each week, while reducing the number of days worked each week from five to four. The shortened work week has the potential to reduce peak travel demand, because longer work days generally cause travel either to or from work and, in some cases, both to occur during off-peak periods. The shortened work week also results in a reduction of total work travel one weekday each week.

In order to determine the potential for traffic congestion reduction during the peak periods through work time rescheduling in the greater Milwaukee area, it was necessary to obtain detailed, definitive information on the location and characteristics of traffic congestion, the proportion of trips in the peak travel periods which are work-related, the work schedules of Milwaukee area employees, and the willingness of employers and employees to change those work schedules. The necessary information concerning the location and characteristics of traffic congestion was available through existing hourly traffic volume counts, and the necessary information concerning work-related trips during the peak periods was available from previous Commission inventories. However,

a survey of Milwaukee area employers was necessary to obtain information concerning work schedules and the potential for changing these schedules.

THE SAMPLE OF EMPLOYERS

The Wisconsin Department of Industry, Labor and Human Relations reported that in 1975, about 603,000 workers were employed by approximately 26,000 firms in the Milwaukee area—that area being defined as all of Milwaukee County and the southern portion of Ozaukee County as far north as the Towns of Grafton and Cedarburg, the portion of Washington County which includes the Town and Village of Germantown, the eastern townships of Waukesha County, and the City and Town of Waukesha and part of the Town of Pewaukee. About 25,500 of these firms, or 97 percent of the total, had fewer than 100 employees. About 76 percent, or 19,500, of these smaller firms, which provided less than 25 percent of the jobs in the Milwaukee area, were in the wholesale or retail trade, finance, or service sectors of the economy. The greater share of all jobs was concentrated in larger manufacturing firms, and in larger firms in the finance and service sectors of the economy. Together, 245 larger firms having 250 or more employees, representing less than 2 percent of all employers in these two economic sectors, provided 39 percent of all jobs in the Milwaukee area in 1975, while 758 firms in all sectors of the economy with 100 or more employees provided 65 percent of all jobs the area in 1975.

Because of the concentration of a large amount of the total employment in a relatively small number of firms, the large employers were selected as a focal point for the survey to determine the existing status of work time rescheduling in the Milwaukee area, and the potential to extend such rescheduling. Emphasis was placed on employers with more than 100 employees because of the magnitude of the employment involved. Also, larger firms frequently have a number of employees capable of carrying out any given type of task, thereby providing increased flexibility for work time rescheduling programs since every employee does not have to be working throughout the entire business day of the firm.

Retail trade, construction, and transportation firms, and all but the 15 largest health care facilities in the area, were not included in the survey because their impact on peak-hour congestion was thought to be minimal. Retail trade firms were excluded because their business hours tend to fall outside traditional peak travel periods in the Milwaukee area. Construction trades and trucking firms were excluded from the survey because their activities and employment locations are either dispersed throughout the entire Milwaukee area or constantly changing. Educational facilities, including the public elementary and secondary school systems, were excluded because much of the work-related travel they generate is largely outside the traditional peak travel hours.

One-hundred smaller firms—those with fewer than 100 employees—from the same sectors of the economy as the larger firms were selected for inclusion in the survey because geographic areas with concentrations of smaller firms can potentially generate as much peak-period traffic congestion, and place as high a demand upon the transportation system, as areas with only a small number of larger firms. These firms were selected by first determining the number of employees in each U. S. Public Land Survey quarter section—the smallest geographic area, about 160 acres in size, for which the Commission maintains data—employed by firms with fewer than 100 employees. From those 50 quarter sections with the largest employment in smaller firms, a 5 percent random sample was drawn for the survey.

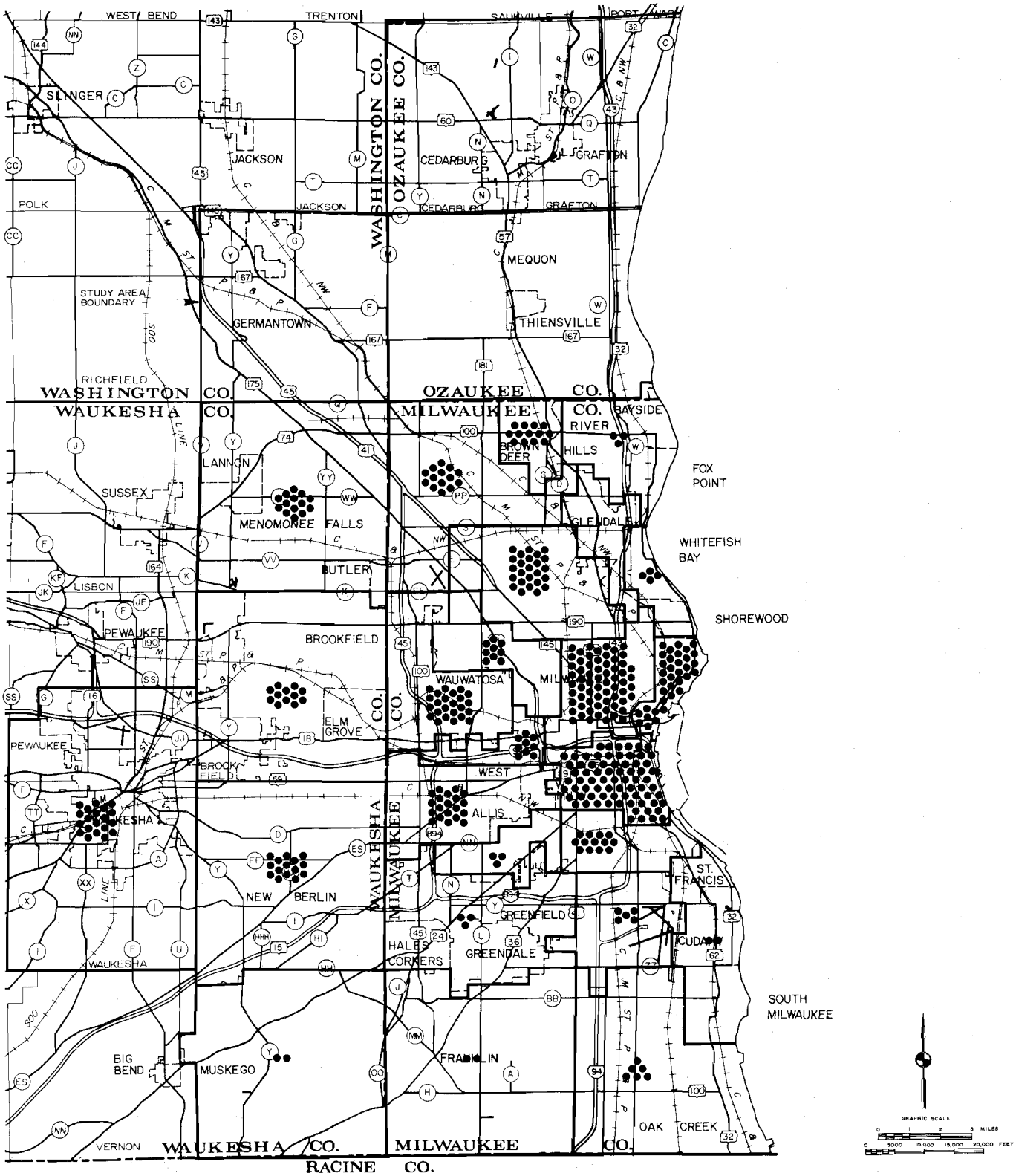
The final sample of all firms thus consisted of 295 employers with more than 100 employees, and 100 employers with between 10 and 100 employees. These 395 firms together provided almost 190,000 jobs, or 31 percent of the total employment in the Milwaukee area. The 295 larger firms in the sample represented approximately 80 percent of all jobs in the Milwaukee area in 1975 in the economic sectors of manufacturing, utilities, wholesale trade, finance, and public administration. The spatial distribution of these firms is shown on Map A-1.

THE QUESTIONNAIRE

Each employer was sent one questionnaire for each employment location, a fact sheet describing the reasons for the work time rescheduling study of the Milwaukee area, definitions of the types of work time rescheduling being considered, and a map showing the Milwaukee area. The questionnaire was divided into four sections: 1) general information; 2) prior consideration and use of

Map A-1

LOCATION OF EMPLOYERS RECEIVING QUESTIONNAIRES FOR THE MILWAUKEE AREA WORK TIME RESCHEDULING STUDY



The employers selected to be surveyed as part of the work time rescheduling study were distributed throughout Milwaukee and Waukesha Counties. The most intense concentration of these employers was located in and around the Milwaukee central business district, with both the number and density of employers decreasing as the distance from the central business district increased. No employers in the selected size and economic categories were located in Washington and Ozaukee Counties.

Source: SEWRPC.

work time rescheduling; 3) present work schedules and practices; and 4) attitudes and constraints concerning work time rescheduling.

The questionnaire was seven pages long and printed in booklet format, with a brief letter describing the work time rescheduling study and soliciting cooperation in the survey. The form is reproduced as Figure A-1.

The questionnaire form was developed after a careful review of work time rescheduling studies conducted elsewhere in the country and revised after a pretest. Ten firms in the Milwaukee area were selected to pretest the form. These firms are considered to be representative of both the types of firms to be surveyed and the various traditional and nontraditional work schedules used by employers in the Milwaukee area. Five of the firms were manufacturing firms, two were utilities, and three were financial institutions. Together, these firms employed almost 18,000 employees. The pretest indicated that the questionnaire provided the necessary information concerning the activities and size of the firms, their past and present attitudes toward work time rescheduling, and the starting and quitting times of employees using both traditional and nontraditional work schedules. However, several refinements in the distribution of time categories used and the reasons for various types of work schedules were made based upon the results of the pretest.

The final questionnaire and accompanying materials were mailed January 31, 1980, to the chief executive of each firm with a cover letter requesting the firm's cooperation in the survey. A return within two weeks was requested. On February 22, 1980, one week after the requested return date, a follow-up letter was sent to those firms which had not responded. One week later, the larger unresponsive employers were contacted by telephone to encourage their cooperation. By March 15, 1980, completed questionnaires had been returned by 204 firms, or 52 percent of the surveyed firms. The 204 firms represent 231 separate employment locations and 122,000 employees in the Milwaukee area.

Table A-1 shows that a slightly larger proportion of smaller firms than larger firms responded: 58 percent compared with 49 percent. This is primarily due to the lower-than-average response rate of larger firms in the manufacturing and wholesale trade sectors, 47 percent and 26 percent, respectively, and the 100 percent response of smaller

Table A-1

RETURN RATE BY SECTOR OF THE ECONOMY AND SIZE OF EMPLOYMENT

Economic Sector	Number of Employees		
	0-99	100 or More	Total
Manufacturing	0.44	0.47	0.47
Utilities and Warehousing	--[a]	0.82	0.82
Wholesale Trade	0.48	0.26	0.39
Finance and Services	1.00	0.56	0.65
Public Administration	--[a]	0.83	0.83
Total	0.58	0.49	0.52

[a] *No firms of this category and size were included in the sample.*

Source: SEWRPC.

firms in the finance and service sector. The overall response, however, was well balanced, no sector of the economy was unrepresented, and both large and small firms provided adequate responses. Table A-2 indicates the number of employers in the Milwaukee area, the number of employers sent questionnaires, and the number of firms which responded, broken down by type of economic activity and number of employees. Table A-3 indicates the total number of employees of the firms included in Table A-2 broken down by the same characteristics. The manufacturing sector represented 68 percent of the jobs of the responding firms, with 92 percent of these jobs located in the 60 manufacturing firms with 250 or more employees; the finance and private service sector represented 12 percent; the public administration and transportation, warehousing, and utility sectors represented 10 and 8 percent, respectively; and the 17 firms involved in wholesale trade represented 2 percent. The geographic distribution of the responding firms closely approximates the distribution of sampled firms, with concentrations in the Milwaukee central business district and in major industrial areas.

SURVEY RESULTS

The completed survey forms were coded and keypunched to allow use of the computer in the analysis of the information provided. The results of the analyses performed are reported here. The basic sequence of the questionnaire provides the framework for presentation of these results.

Figure A-1

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 NO. EAST AVENUE • P.O. BOX 769 • WAUKESHA, WISCONSIN 53187 • TELEPHONE (414) 547-6721

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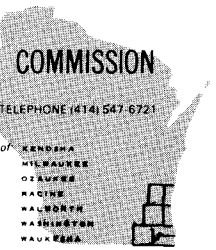


EMPLOYER SURVEY
MILWAUKEE AREA WORK TIME RESCHEDULING STUDY

Major employers in the Milwaukee area are being asked to complete this survey for the Milwaukee Area Work Time Rescheduling Study. The purpose of this study is to determine the feasibility of decreasing peak-hour congestion on the highway and transit elements of the transportation system through the rescheduling of work times. This study is sponsored by federal and state agencies as well as the Southeastern Wisconsin Regional Planning Commission.

The information requested in this survey will be aggregated so that individual establishments surveyed will not be identifiable in any published reports. The information will only be used to aid in assessing the potential of work time rescheduling in the Milwaukee area. Please complete one survey form for each of your company's work locations in the Milwaukee area. (See Map in Fact Sheet) Please return the completed survey(s) to the Southeastern Wisconsin Regional Planning Commission by February 15, 1980.

The survey has been divided into four sections:

1. General Information;
2. Prior Consideration or Use of Work Time Rescheduling;
3. Present Work Schedules and Practices; and
4. Attitudes and Constraints Concerning Work Time Rescheduling.

It is important that each part of the survey be completed. Since this survey form is being used to obtain information from varied companies, not every question may apply to your company's practices. Please answer as completely as you can all questions which do apply. The first section collects information on the characteristics of your company and its employees, which will allow it to be aggregated with others of a similar nature. The second part of the survey gathers information on your past experiences with, or consideration of, work time rescheduling. The third section gathers information on your existing work schedules and current use of work time rescheduling. The final section asks for a description of your present attitudes toward and constraints concerning the implementation of work time rescheduling.

If you desire further information about the survey or the study in general, or have any hesitancy as to how to complete the survey, please call Mr. Craig A. Murawski at the Southeastern Wisconsin Regional Planning Commission at 547-6721.

Without the cooperation of Milwaukee area employers in this survey, an assessment of the extent of existing work time rescheduling and the feasibility of additional participation in new work time rescheduling programs cannot be made. Thank you for your cooperation.

Sincerely,

Kurt W. Bauer
Executive Director

PART I - GENERAL INFORMATION

For Office Use Only

1. Name of Company _____ ☐☐☐

2. Work location to which this particular questionnaire applies: _____ ☐☐

_____ ☐☐☐☐☐☐
(street address)

3. Name, title, and phone number of person completing this particular questionnaire: ☐☐ 20

_____ _____ _____

4. What Company activities are performed at this location? (If multiple functions, please check each.)

Corporate Management	☐ 21	Research and Development	☐ 22
Manufacturing	☐	Wholesale Trade	☐
Warehousing	☐	Other	☐
Shipping and Receiving	☐		

5. What is your Company's approximate total employment at this location?

Total Employment ☐☐☐☐

How many of these employees work part time? (More than eight hours per week, but fewer hours than your full-time employees) ☐☐☐☐

6. Approximately what percentage of your total employment is represented by collective bargaining units? ☐☐ %

7. Since some employees can vary their work schedules easier than others, please classify employment at this location by the approximate percentages that are office workers, production or plant workers, and other.

38 ☐☐ percent Office Workers
40 ☐☐ percent Production or Plant Workers
42 ☐☐ percent Other (Specify) _____ ☐ 44
45 ☐☐ percent Other (Specify) _____ ☐ 47

8. Has this firm participated in a carpool/vanpool program operating at this location?

☐ 1 Yes ☐ 2 No

If yes, please describe: _____

_____

_____ ☐☐ 50

Figure A-1 (continued)

PART II – PRIOR CONSIDERATION OR USE OF WORK TIME RESCHEDULING

1. In the last five years, has any consideration been given to the rescheduling of employee work hours? ☐ 1 Yes ☐ 2 No

2. If yes, did you consider:

	1	2
Flexible Work Hours	☐ Yes	☐ No
Shifted Work Hours	☐ Yes	☐ No
Shortened Work Week	☐ Yes	☐ No
Staggered Work Hours	☐ Yes	☐ No
Other	☐ Yes	☐ No

(Please specify) _____ 57

3. If rescheduling has been considered, but was not implemented, could you please indicate the reasons below?

_____

_____

_____ 59

4. If rescheduling of work hours has been implemented at your location in the past five years, could you indicate the type of rescheduling and its effects (even if it was discontinued)?

a. Type of Rescheduling Implemented:	b. Is This Rescheduling Still in Effect? 1	2
Flexible Work Hours ☐ 60	61 ☐ Yes	☐ No
Shifted Work Hours ☐	☐ Yes	☐ No
Shortened Work Week ☐	☐ Yes	☐ No
Staggered Work Hours ☐	☐ Yes	☐ No
Summer Work Hours ☐	☐ Yes	☐ No

Other (Please describe) _____

_____ 70

c. What were the effects of work time rescheduling implementation?

	A Decrease 1	About the Same 2	An Increase 3
Employee productivity	71 ☐	☐	☐
Employee morale	☐	☐	☐
Employee absenteeism	☐	☐	☐
Employee tardiness	☐	☐	☐
Local traffic and transit congestion	☐	☐	☐
Ease of employees to park at work	☐	☐	☐
Use of carpools/vanpools	☐	☐	☐

CARD 2

d. If you discontinued this rescheduling, would you please list the principal reasons below.

_____

_____

_____ 79

PART III – PRESENT WORK SCHEDULE AND PRACTICES

Since nearly all congestion in the Milwaukee Area is limited to the morning and afternoon peak periods, detailed information concerning the current starting and quitting times of your employees is important to allow evaluation of different work time rescheduling strategies. Therefore, please be as detailed as possible in completing this section.

1. For your employees who are NOT ON FLEXIBLE WORK HOURS OR A SHORTENED WORK WEEK (four or fewer working days each week), please list the approximate number of employees scheduled to start and quit at the nearest appropriate time listed below.

a. Starting Times

Time	Number of Employees
6:00 a.m.	☐☐☐☐ 83
6:15	☐☐☐☐ 87
6:30	☐☐☐☐ 91
6:45	☐☐☐☐ 95
7:00	☐☐☐☐ 99
7:15	☐☐☐☐ 10
7:30	☐☐☐☐ 14
7:45	☐☐☐☐ 18
8:00	☐☐☐☐ 22
8:15	☐☐☐☐ 26
8:30	☐☐☐☐ 30
8:45	☐☐☐☐ 34
9:00	☐☐☐☐ 38
10:00	☐☐☐☐ 42
After 10:00 a.m. but before 2:00 p.m.	☐☐☐☐ 46
2:00	☐☐☐☐ 50
2:30	☐☐☐☐ 54
3:00	☐☐☐☐ 58
3:30	☐☐☐☐ 62
4:00	☐☐☐☐ 66
4:30	☐☐☐☐ 70
After 4:30 p.m. but before 6:00 a.m.	☐☐☐☐ 74
Total	☐☐☐☐ 78

b. Quitting Times

Time	Number of Employees
6:00 a.m.	☐☐☐☐ 82
7:00	☐☐☐☐ 86
8:00	☐☐☐☐ 90
9:00	☐☐☐☐ 94
10:00	☐☐☐☐ 98
After 10:00 a.m. but before 2:00 p.m.	☐☐☐☐ 10
2:00	☐☐☐☐ 14
2:30	☐☐☐☐ 18
3:00	☐☐☐☐ 22
3:15	☐☐☐☐ 26
3:30	☐☐☐☐ 30
3:45	☐☐☐☐ 34
4:00	☐☐☐☐ 38
4:15	☐☐☐☐ 42
4:30	☐☐☐☐ 46
4:45	☐☐☐☐ 50
5:00	☐☐☐☐ 54
5:15	☐☐☐☐ 58
5:30	☐☐☐☐ 62
5:45	☐☐☐☐ 66
6:00	☐☐☐☐ 70
6:30	☐☐☐☐ 74
After 6:30 p.m. but before 6:00 a.m.	☐☐☐☐ 78
Total	☐☐☐☐ 82

CARD 3

Figure A-1 (continued)

c. Please note that if your employees start or quit at different times, your company, in effect, already has some type of Staggered Work Hours. If such staggering of start and finish times is evident in your above listing of existing work schedules, is such staggering a result of: (you may check more than one)

83 ☐ Office personnel starting at different times than plant personnel?

☐ Staggering of start and/or quitting times of plant personnel? (Please specify) _____ 85

☐ Staggering of start and/or quitting times of office personnel? (Please specify) _____ 87

d. Please identify the reasons for this staggering of work hours.

88 ☐ Reduce traffic congestion on nearby streets.

☐ Reduce traffic congestion in company parking lot(s).

☐ Facilitate the use of public transit.

☐ It has always been that way.

☐ Negotiated work schedules.

☐ Other (Please specify) _____

_____ 94

FLEXIBLE WORK HOURS

2. If you have any full-time employees at this location on Flexible Work Hours, please list the approximate number of employees by their required "core time"—that is, those hours during the day when they must be at work.

CARD 4

a. Core Time Hours		Number of Employees
From ☐☐:☐☐	to ☐☐:☐☐ 10	☐☐☐ 14
From ☐☐:☐☐	to ☐☐:☐☐ 22	☐☐☐ 26
None		☐☐☐ 30
	Total	☐☐☐ 34

b. Please estimate the percentage of employees on flexible working hours arriving at these times on a typical work day.

		Approximate Percent
35	☐☐	Before 6:00 a.m.
37	☐☐	6:30 a.m.
39	☐☐	7:00 a.m.
41	☐☐	7:15 a.m.
43	☐☐	7:30 a.m.
45	☐☐	7:45 a.m.
47	☐☐	8:00 a.m.
49	☐☐	8:15 a.m.
51	☐☐	8:30 a.m.
53	☐☐	8:45 a.m.
55	☐☐	9:00 a.m.
57	☐☐	9:30 a.m.
59	☐☐	After 9:30 a.m.
	Total	100%

c. What is the latest the Flexible Work Hours employee can leave work in the evening? ☐☐☐ p.m. 64

d. Do employees on Flexible Work Hours have a fixed-length lunch period?

1 ☐ Yes 2 ☐ No (Please indicate how long) _____ 67

e. Are employees on Flexible Work Hours required to work a fixed number of hours each day?

☐ Yes ☐ No (Please indicate how many hours) _____ 70

f. Are your Flexible Work Hours employees limited to only those of certain occupational categories:

☐ Yes ☐ No (Please indicate the limitations) _____

_____

_____ 72

SHORTENED WORK WEEK

3. If you have any full-time employees at this location on a Shortened Work Week, please list the approximate number of employees by their starting time and days worked

Starting Time	Number of Employees	Days Worked	Number of Employees
Before 6:00 a.m.	☐☐☐ 76	Monday	☐☐☐ 30
6:15	☐☐☐ 80	Tuesday	☐☐☐ 34
6:30	☐☐☐ 84	Wednesday	☐☐☐ 38
6:45	☐☐☐ 88	Thursday	☐☐☐ 42
7:00	☐☐☐ 92	Friday	☐☐☐ 46
7:15	☐☐☐ 96	*Saturday*	☐☐☐ 50
7:30	☐☐☐ 100	Sunday	☐☐☐ 54
7:45	☐☐☐ 10		
8:00	☐☐☐ 14		
8:15	☐☐☐ 18		
8:30 a.m. or after	☐☐☐ 22		
Total	☐☐☐ 26		

CARD 5

4. For those employees on a Shortened Work Week, what is the length of their total working day, lunch time included? _____ hours. 57

5. Are your employees on Shortened Work Weeks limited to only those of certain occupational categories?

☐ Yes ☐ No

If yes, please indicate the limitations _____

_____ 59

PART IV – ATTITUDES AND CONSTRAINTS CONCERNING WORK TIME RESCHEDULING

1. In your opinion, would your Company consider implementing work time rescheduling at this time? (If work time rescheduling currently is in practice, would you consider other rescheduling programs or expanding the current program?)

☐ Yes ☐ No

Figure A-1 (continued)

2. If yes, would this rescheduling be necessarily limited to certain departments or divisions?

☐ Yes ☐ No

If yes, please indicate which departments or divisions _____

_____ 62

Please state why it must be limited to these departments or divisions. _____

_____ 63

Please indicate what specific rescheduling programs you would consider implementing or expanding. (more than one is possible)

		Implementing 1	Expanding 2
Flexible Work Hours	64	☐	☐
Shifted Work Hours	65	☐	☐
Shorter Work Week	66	☐	☐
Staggered Work Hours	67	☐	☐

3. If no rescheduling programs would be considered, could you please indicate and explain the reasons and particularly any constraints.

a. Shortened Work Week

1. Legal or contractual problems _____ 68
2. Operational problems within this plant or office _____ 69
3. Operational problems coordinating with other plants or offices _____ 70

_____

4. Other _____ 71

b. Flexible Working Hours

1. Legal or contractual problems _____ 72
2. Operational problems within this plant or office _____ 73
3. Operational problems coordinating with other plants or offices _____

_____ 74

4. Other _____ 75

c. Staggered Work Hours

1. Legal or contractual problems _____ 76
2. Operational problems within this plant or office _____ 77
3. Operational problems coordinating with other plants or offices _____

_____ 78

4. Other _____ 79

Please complete back page

d. Shifted Work Hours

1. Legal or contractual problems _____ 80
2. Operational problems within this plant or office _____ 81
3. Operational problems coordinating with other plants or offices _____

_____ 82

4. Other _____ 83

* * * * * * * * *

PLEASE USE THIS SPACE TO OFFER ANY COMMENTS, CRITICISMS, OR SUGGESTIONS YOU MAY HAVE

_____ 85

WE SINCERELY THANK YOU FOR YOUR COOPERATION IN COMPLETING THIS SURVEY. YOUR RESPONSE IS IMPORTANT TO PLANNING IMPROVEMENTS TO THE MILWAUKEE AREA TRANSPORTATION SYSTEM, AND TO MAINTAINING THE ATTRACTIVENESS OF MILWAUKEE.

Table A-2

DISTRIBUTION OF EMPLOYERS IN THE MILWAUKEE AREA, THE EMPLOYERS SENT QUESTIONNAIRES, AND THE EMPLOYERS RETURNING QUESTIONNAIRES BY ECONOMIC SECTOR AND EMPLOYMENT SIZE

Economic Sector	Number of Employers										
	Milwaukee Area				Receiving Questionnaires			Returning Questionnaires			
	0-99 Employees	100-249 Employees	250 or More Employees	Total	0-99 Employees	100 or More Employees	Total	0-99 Employees	100-249 Employees	250 or More Employees	Total
Agriculture and Mining	257	--	--	257	--	--	--	--	--	--	--
Construction	2,680	13	4	2,697	--	--	--	--	--	--	--
Manufacturing	2,259	129	111	2,499	63	198	261	28	34	60	122
Transportation, Warehousing, and Utilities	792	25	12	829	--	11	11	--	4	5	9
Wholesale and Retail Trade	9,258	90	33	9,381	25	19	44	12	3	2	17
Finance and Services	10,242	174	134	10,550	12	43	55	12	8	16	36
Public Administration	53	17	16	86	--	24	24	6	8	6	20
Total	25,541	448	310	26,299	100	295	395	58	57	89	204

NOTE: The number of employees in the Milwaukee area and the sample was based upon 1975 data, and the employment of the returns was based upon data provided in the questionnaire.

Source: Wisconsin Department of Industry, Labor and Human Relations and SEWRPC.

Table A-3

DISTRIBUTION OF EMPLOYEES IN MILWAUKEE AREA FIRMS, IN THE MILWAUKEE AREA FIRMS SENT QUESTIONNAIRES, AND IN THE MILWAUKEE AREA FIRMS RETURNING THE QUESTIONNAIRES BY ECONOMIC SECTOR AND EMPLOYMENT SIZE

Economic Sector	Number of Employees										
	Milwaukee Area				Receiving Questionnaires			Returning Questionnaires			
	0-99 Employees	100-249 Employees	250 or More Employees	Total	0-99 Employees	100 or More Employees	Total	0-99 Employees	100-249 Employees	250 or More Employees	Total
Agriculture and Mining	801	--	--	801	--	--	--	--	--	--	--
Construction	14,442	1,874	1,387	17,703	--	--	--	--	--	--	--
Manufacturing	35,829	20,475	130,054	186,358	1,932	127,343	129,275	1,114	5,664	76,104	82,882
Transportation, Warehousing, and Utilities	7,614	3,905	17,553	29,072	--	13,377	13,377	--	819	9,218	10,037
Wholesale and Retail Trade	78,826	13,355	37,069	129,250	748	4,607	5,355	466	515	1,062	2,043
Finance and Services	71,231	26,916	106,960	205,107	547	16,287	16,834	375	1,554	13,213	15,142
Public Administration	13,338	2,914	30,667	34,919	--	24,808	24,809	451	1,258	10,145	11,854
Total	210,081	69,439	323,417	603,210	3,227	186,423	189,650	2,406	9,810	109,742	121,958

NOTE: The number of employees in the Milwaukee area and the sample was based upon 1975 data, and the employment of the returns was based upon data provided in the questionnaire.

Source: Wisconsin Department of Industry, Labor and Human Relations and SEWRPC.

Part I: General Information

The employers were asked to provide information about each employment location in the Milwaukee area, the number and type of employees, the kinds of corporate activities performed, and involvement in carpooling programs. This information was used not only to describe the employers by size and activity type, but to determine if the size and type of the firms were related to the existence of, or willingness to consider, various types of work time rescheduling programs.

For the purpose of describing the total sample, 59 percent of the firms indicated that "corporate management" was performed at their location, making this the most common company activity

reported. "Manufacturing" and "shipping and receiving" activities were reported by over half of the firms—58 and 53 percent, respectively. "Warehousing" and "research and development" activities were reported by about a third of the firms, while only 7 percent indicated any "wholesale trade" activities. "Other" activities were reported by 31 percent of the sample firms.

As indicated above, over 70 percent of the firms responding had 100 or more employees, but the total reported employment ranged from as few as six employees to more than 6,800 employees in a given location, with an average of 528 employees. The majority of these employees, 95 percent, were full time, but 5,600 were reported as part-time employees. Two firms employed large numbers of part-time people, but 32 percent of the employment locations of these firms had no part-time employees, for an average of 24 part-time employees per employment location, or less than 5 percent of the average labor force.

Less than a majority of the respondents' employees were represented by collective bargaining units: 87, or 43 percent, reported none of their employees so represented, while 94, or 46 percent, reported that one-half or more of their employees were represented. Overall, 37 percent of all employees were represented by a collective bargaining unit.

Ninety-eight percent of the respondents had some onsite office staff, with 40 percent of all employees classified as office workers. Plant or production workers constituted 49 percent of all employees, even though 61 employers, or 26 percent, reported none. In contrast, only five employers indicated no office staff. Seventy-five employers reported other types of employees, ranging from technicians to managers, but these other types accounted for less than 20 percent of their total employment.

Carpool or vanpool programs were reported by 19 percent of the respondents, or 44 employers. Twenty-eight of these programs, or 64 percent, consisted simply of a bulletin board or other means of information exchange between individual employees. Only nine employers, having a total of 19,500 employees, either used a zip code matching system or were participating in the Milwaukee County carpool program.

Part II: Prior Consideration or Use of Work Time Rescheduling

Work time rescheduling is not new to American business and industry. Staggered work hours, for example, were used extensively during World War II to make the best use of limited transportation resources. Flexible work hours and shortened work weeks have been used by various firms for many years throughout the country and in the Milwaukee area. It was not surprising, therefore, that 48 percent of all respondents reported having considered some type of rescheduling of employee hours in the last five years. The most common methods considered were staggered and shifted work hours, considered by 50 and 48 of the firms, respectively. Slightly fewer firms, 44, had considered flexible work hours, and 36 firms had considered shortened work weeks. Ten employers indicated that they had considered other types of rescheduling, including flexible work weeks, summer hours, and changes in lunch schedules.

Of the firms indicating that work time rescheduling had been considered, 43 gave various reasons for not implementing a program. Production and cost problems were cited by 19 firms; collective bargaining-related problems by eight firms; inadequate employee interest or employee resistance by seven firms; and the consequent need to increase their labor force by two firms. Seven firms said programs were still under consideration.

Some type of work time rescheduling program had been implemented during the past five years by 77 of the respondents, most of which, 88 percent, were still in effect at the time of the survey (see Table A-4). Of 28 staggered work hour programs begun, 96 percent remained in effect. Of 30 shifted work hour programs begun, 83 percent remained in effect. On the other hand, almost one-third of the 16 shortened work week programs that had begun had been discontinued. Only 15 summer

Table A-4

TYPE OF WORK TIME RESCHEDULING IMPLEMENTED DURING THE PAST FIVE YEARS BY PRESENT DISPOSITION OF THE PROGRAM

Type of Rescheduling	Number of Programs	Percent Continued
Staggered Work Hours . .	28	96
Shifted Work Hours. . . .	30	83
Shortened Work Week . .	16	68
Summer Work Hours . . .	15	86
Flexible Work Hours . . .	10	90

Source: SEWRPC.

work hour and 10 flexible work hour programs had been started, but 86 percent and 90 percent of these programs, respectively, remained in effect. With the exception of shortened work week programs, only a very small proportion of the Milwaukee area work time rescheduling programs have been discontinued.

Positive transportation-related consequences—specifically, a decrease in local traffic and transit congestion, ease of employee parking at work, and the use of carpools/vanpools—were frequently cited as an effect of all of these work time rescheduling programs. These effects were generally reported even by firms which subsequently discontinued the work time rescheduling program.

Shifted Work Hours: The 30 employers that implemented shifted work hours generally reported positive effects from the program. Twelve reported increases in employee morale, with none reporting decreased morale. Nine reported an increase in productivity. Decreases in traffic congestion were reported by 19 employers. The majority of all other responses indicated no changes from the prior situation, with at least 17 employers reporting about the same amount of employee absenteeism, tardiness, use of carpools, and ease of parking at work. Of the six firms that discontinued their shifted hour programs, one reported union grievances and another reported a lack of employee interest in the program as reasons for the discontinuation.

Summer Work Hours: The 15 employers that implemented the summer work hour programs also found generally positive effects. None indicated a decrease in employee productivity or morale, while three indicated increases in productivity and six indicated increases in morale. Increases in employee absenteeism and tardiness, local traffic and transit congestion, and the use of carpools, and a decrease in the ease of parking at work, in the use of carpools, and in employee tardiness were all reported by at least one employer as an impact of summer work hours. Five firms indicated a decrease in the local traffic and transit congestion, and three indicated an increase in the ease of parking at work. The remaining responses indicated no change in these conditions as a result of summer work hours. The two firms that discontinued their summer work hour programs did not provide reasons for having done so.

Flexible Work Hours: None of the nine firms currently using flexible work hours indicated experiencing problems with employee productivity, morale, absenteeism, or tardiness as a result of these programs. Seven firms reported an increase in employee morale, four reported reduced absenteeism, and three reported reduced tardiness. Five firms noticed little change in traffic congestion due to the flexible work hour programs, but larger employers, two of which were located in the Milwaukee central business district, indicated a decrease in local traffic and transit congestion. Only one indicated a decrease in the ease of parking at work, and one indicated an increase and one a decrease in the use of carpools and vanpools. None reported discontinuing flexible work hour programs because of personnel or production problems. One program, however, was discontinued following a two-year trial because of coordinating, scheduling, and supervisory problems.

Shortened Work Week: Eight of the 16 employers in the Milwaukee area that implemented shortened work week programs reported no change in employee productivity, morale, absenteeism, tardiness, ease of parking at work, or the number of carpools and vanpools as a result of the programs. Six indicated an increase in employee productivity and decrease in local traffic and transit congestion, while five indicated an increase in employee morale. The decrease in local traffic and transit congestion may be due to the fact that the starting and quitting times for these employees were shifted from the traditional peak hours still used by the other employees of the firm or the employees of nearby firms. The six firms which discontinued shortened work week programs also indicated no change in employee productivity, absenteeism, tardiness, or ease of parking while the programs were in effect.

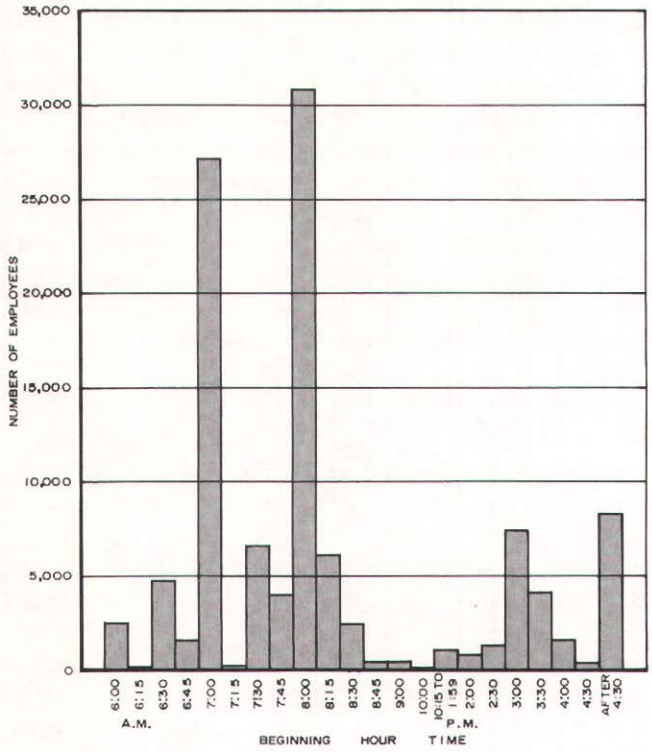
Part III: Present Work Schedule and Practices

The 204 employers who responded to the survey provided detailed information about the starting and quitting times of their employees and descriptions of any flexible work hour or shortened work week programs in effect at the time of the survey. The starting and quitting times of 112,500 employees of selected employers which were not on flexible working hour or shortened work week programs are shown in Figures A-2 and A-3. These employees were assumed to travel during the morning and afternoon peak periods. The distribution of work trips within these peak periods was determined from an analysis of the work schedules of these employees.

About 50 percent of the employees working for these Milwaukee area firms were scheduled to start at either 7:00 a.m. or 8:00 a.m., producing a rather dramatic peaking pattern (see Figure A-2). Between

Figure A-2

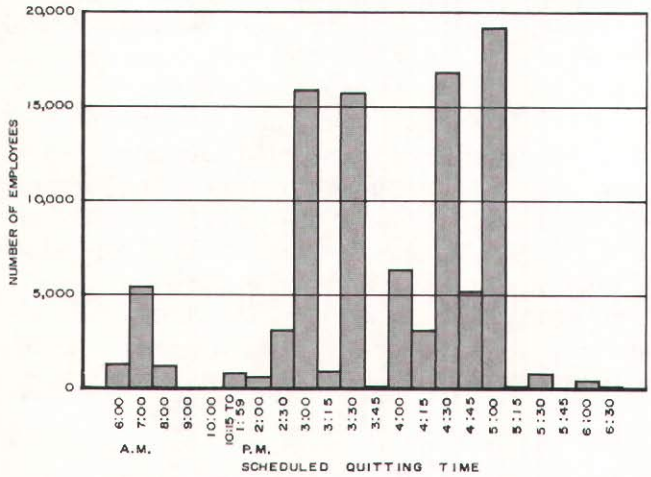
DISTRIBUTION OF STARTING TIMES OF EMPLOYEES OF SELECTED FIRMS IN THE MILWAUKEE AREA, EXCLUSIVE OF EMPLOYEES ON FLEXIBLE WORK HOURS OR A SHORTENED WORK WEEK: 1980



Source: SEWRPC.

Figure A-3

DISTRIBUTION OF QUITTING TIMES OF EMPLOYEES OF SELECTED FIRMS IN THE MILWAUKEE AREA, EXCLUSIVE OF EMPLOYEES ON FLEXIBLE WORK HOURS OR A SHORTENED WORK WEEK: 1980



Source: SEWRPC.

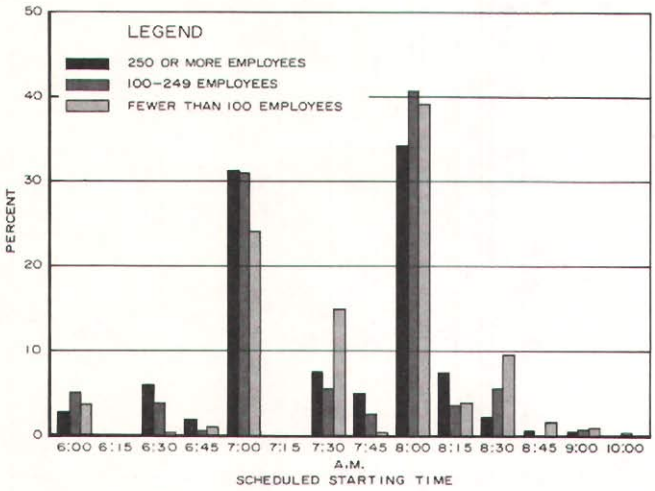
7:00 a.m. and 9:00 a.m., starting times either 15 minutes before or after the hour were used by only 12,700 employees, or 11 percent of the total. Starting times on the half hour were only slightly more common, with 13,900 employees, or 12 percent, starting at 6:30, 7:30, or 8:30 a.m. By classifying all employees starting between 6:00 a.m. and 10:00 a.m. as first shift employees, it was determined that 27,000 employees, or over 31 percent of all first shift employment, were scheduled to start work at 7:00 a.m., and almost 31,000, or 35 percent, were scheduled to start at 8:00 a.m. Only 11 percent of all first shift employees were scheduled to start either before 7:00 a.m. or after 8:00 a.m. During the afternoon, another peak occurred between 3:00 p.m. and 3:30 p.m. for second shift employees, but its magnitude was only one-fourth that of the morning peak.

Scheduled quitting times were not as peaked as starting times. Figure A-3 shows that the maximum number of employees scheduled to quit at any one time—5:00 p.m.—was only 19,000, or 17 percent of the total. Three other times followed closely, with almost an equal proportion—ranging from 15,600 to 16,700 employees—scheduled to quit at 3:00, 3:30, and 4:30 p.m. Quitting times on the quarter hour were no more common with Milwaukee area employers than starting times at those intervals: only 9,600 employees, or 9 percent, reported quitting times of 3:15, 3:45, 4:15, 4:45, 5:15, or 5:45 p.m. Quitting times on the half hour were, however, used more frequently than starting times on the half hour: almost 32,400 employees, or 29 percent, quit at 3:30 or 4:30 p.m. The quitting times of these first shift employees were distributed over a longer period of time than their scheduled starting times, thus reducing the magnitude of the afternoon peaking. A small morning peak occurred at 7:00 a.m., when about 5,300 third shift employees quit for the day.

Employment Size, Economic Sector, and Work Schedules: Some interesting variations on these starting and quitting patterns emerged when employers were disaggregated by size and economic sector. Figure A-4 shows the distribution of scheduled starting times of first shift employees by the number of employees in the firm. Owing to the prominence of the 8:00 a.m. and 9:00 a.m. starting times for firms of all sizes, only minor differences exist between the three categories plotted (fewer than 100 employees, 100 to 249 employees, and 250 or more employees). Because firms with 250 or more employees constitute 87 percent of the employment of the total sample,

Figure A-4

DISTRIBUTION OF SCHEDULED STARTING TIMES OF FIRST SHIFT EMPLOYEES OF SELECTED FIRMS IN THE MILWAUKEE AREA BY EMPLOYMENT SIZE, EXCLUSIVE OF EMPLOYEES ON FLEXIBLE WORK HOURS OR A SHORTENED WORK WEEK: 1980



Source: SEWRPC.

the distribution of the starting times of these firms is virtually identical to the distribution of the starting times of the total sample shown in Figure A-2. Firms with between 100 and 250 employees also have scheduled starting times similar to those of the total sample. The probability of having starting times scheduled on the half hour, however, was inversely related to the number of people employed by the firm. This was due to the smaller firms having a larger proportion of employees starting at 7:30 a.m. and 8:30 a.m. than the larger firms. Although the proportions are larger, the total first shift employment of these 58 smaller firms was only 2,300 employees, of which only 350 and 224 employees started at 7:30 a.m. and 8:30 a.m., respectively.

The starting times of firms differ by economic sector. As shown in Figure A-5, the largest proportion of first shift manufacturing employees starts work at 7:00 a.m.—25,700, or about 43 percent. The largest proportion of wholesale trade employees starts work at 8:00 a.m.— 700, or about 39 percent. Employees in the utilities, finance and service, and public administration sectors of the economy also started work predominantly at 8:00 a.m.—from 50 to 70 percent.

The distribution of scheduled quitting times of first shift employees by employer size group is shown in Figure A-6. Like quitting times for total employees, quitting times for first shift employees were more uniformly distributed over a longer period of time than starting times, but were less peaked for larger firms than for smaller firms. A larger proportion of the employees of firms with fewer than 100 employees was scheduled to quit later in the afternoon, 4:30 and 5:00 p.m. As with scheduled starting times, very few employees were scheduled to complete work at 15 minutes before or 15 minutes after the hour. Quitting times on the half hour were scheduled more frequently than starting times on the half hour. Only 3 percent of the first shift employees had quitting times scheduled after 5:00 p.m.

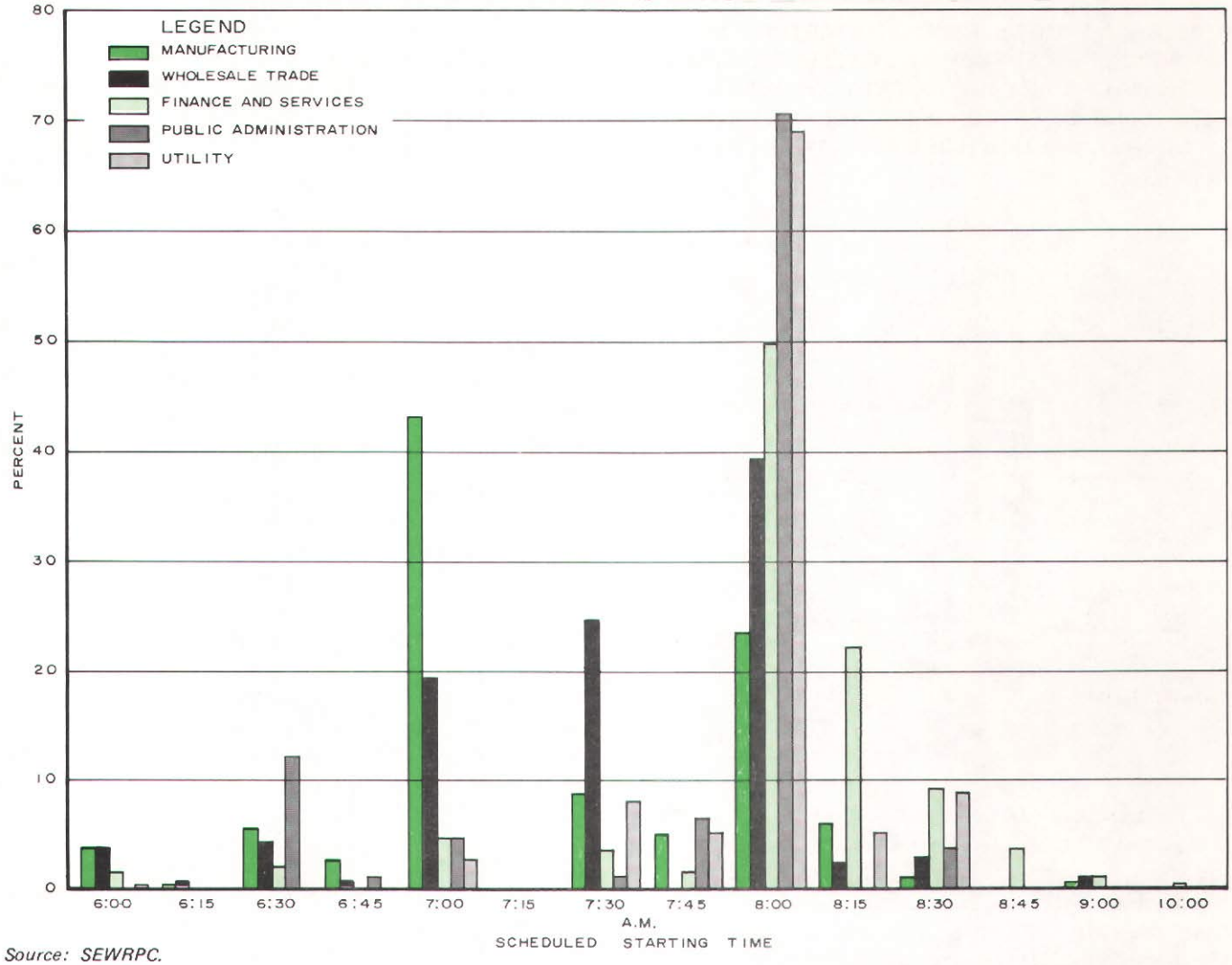
The quitting times of firms differ substantially by economic sector, as shown in Figure A-7. Fifty-four percent of the employees of manufacturing firms had quitting times before 4:00 p.m. The quitting times of employees of firms in the wholesale trade sector were fairly evenly distributed among 3:30, 4:00, 4:30, and 5:00 p.m. Utilities, financial and service firms, and public administration firms tended to have quitting times after 4:00 p.m., with 60 percent of all government employees reporting 5:00 p.m. as the scheduled quitting time.

Spatial Distribution of Starting Times: Scheduled starting and quitting times are related not only to the firm's economic sector and size but also to the firm's location within the Milwaukee area. Although differences in starting and quitting times are related to economic sector since manufacturing firms tend to be located in clusters in several areas throughout the Milwaukee area and financial institutions are concentrated in the central business district, the spatial distribution of these schedules is also important because traffic and transit congestion is a spatial phenomenon. Table A-5 shows the average starting time for all planning analysis areas for which the scheduled starting times of at least 500 employees were reported. Eight of these areas have average starting times between 7:15 and 7:25 a.m., and no area has an average starting time later than 7:51 a.m. Map A-2 shows the distribution of these areas and indicates the starting times in three categories: before 7:15, after 7:15 but before 7:30, and after 7:30 a.m.

The distribution of starting times for the area with the average earliest starting time, Oak Creek, for the area with the latest starting time, the central

Figure A-5

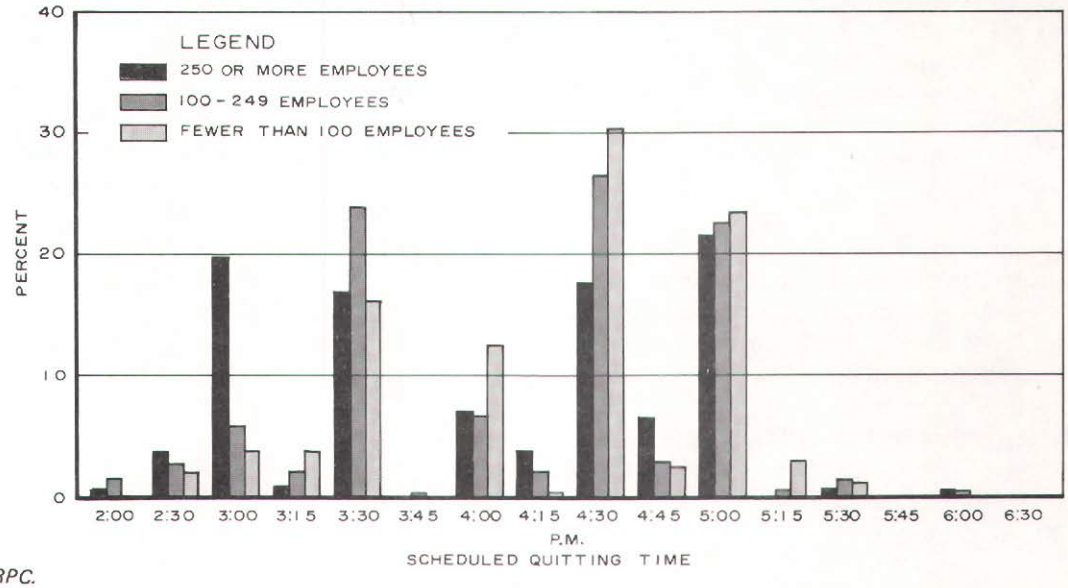
DISTRIBUTION OF SCHEDULED STARTING TIMES OF FIRST SHIFT EMPLOYEES OF SELECTED FIRMS IN THE MILWAUKEE AREA BY ECONOMIC SECTOR, EXCLUSIVE OF EMPLOYEES ON FLEXIBLE WORK HOURS OR A SHORTENED WORK WEEK: 1980



Source: SEWRPC.

Figure A-6

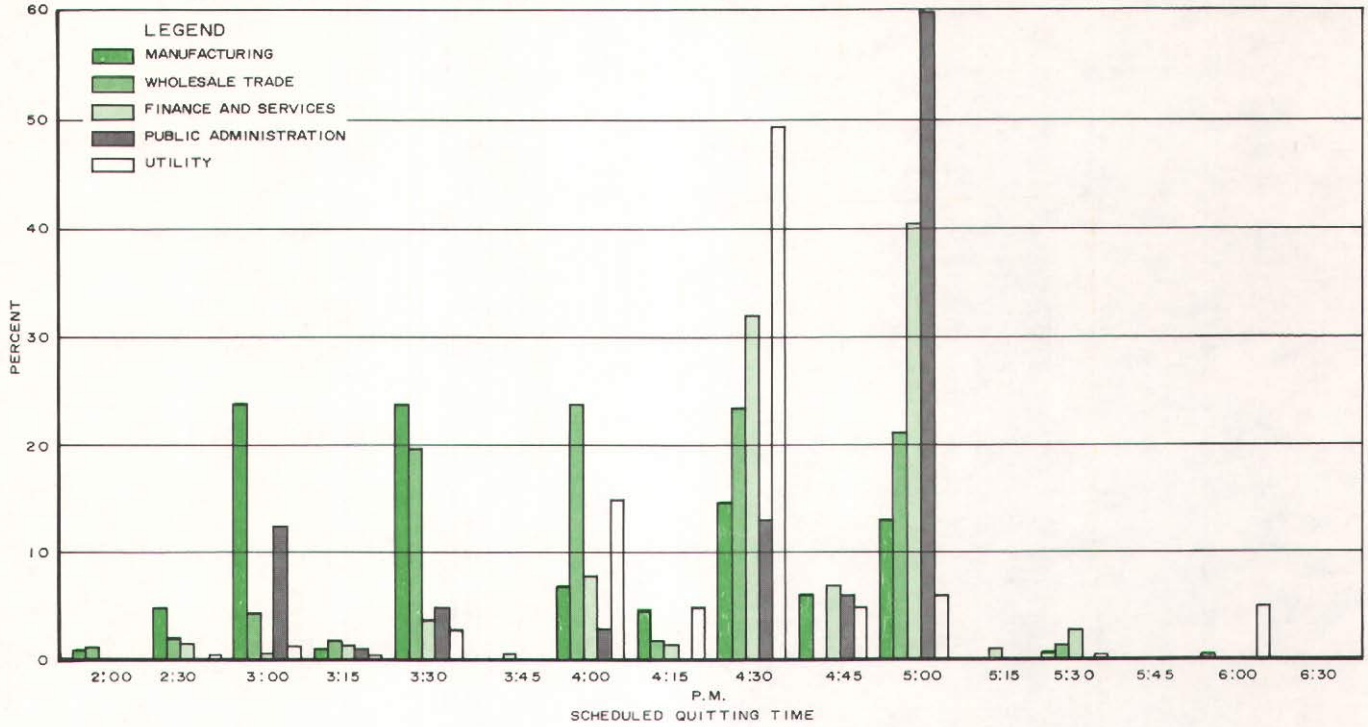
DISTRIBUTION OF SCHEDULED QUITTING TIMES OF FIRST SHIFT EMPLOYEES OF SELECTED FIRMS IN THE MILWAUKEE AREA BY EMPLOYMENT SIZE, EXCLUSIVE OF EMPLOYEES ON FLEXIBLE WORK HOURS OR A SHORTENED WORK WEEK: 1980



Source: SEWRPC.

Figure A-7

DISTRIBUTION OF SCHEDULED QUITTING TIMES OF FIRST SHIFT EMPLOYEES OF SELECTED FIRMS IN THE MILWAUKEE AREA BY ECONOMIC SECTOR, EXCLUSIVE OF EMPLOYEES ON FLEXIBLE WORK HOURS OR A SHORTENED WORK WEEK: 1980



Source: SEWRPC.

Table A-5

AVERAGE SCHEDULED STARTING TIMES FOR SELECTED PARTS OF THE MILWAUKEE AREA

Area	Average Scheduled Starting Time (a.m.)
27	6:50
25	7:02
34	7:07
17	7:11
26	7:13
24	7:17
18	7:19
21	7:19
19	7:22
40	7:22
14	7:23
20	7:25
31	7:25
15	7:27
33	7:30
30	7:41
61	7:51

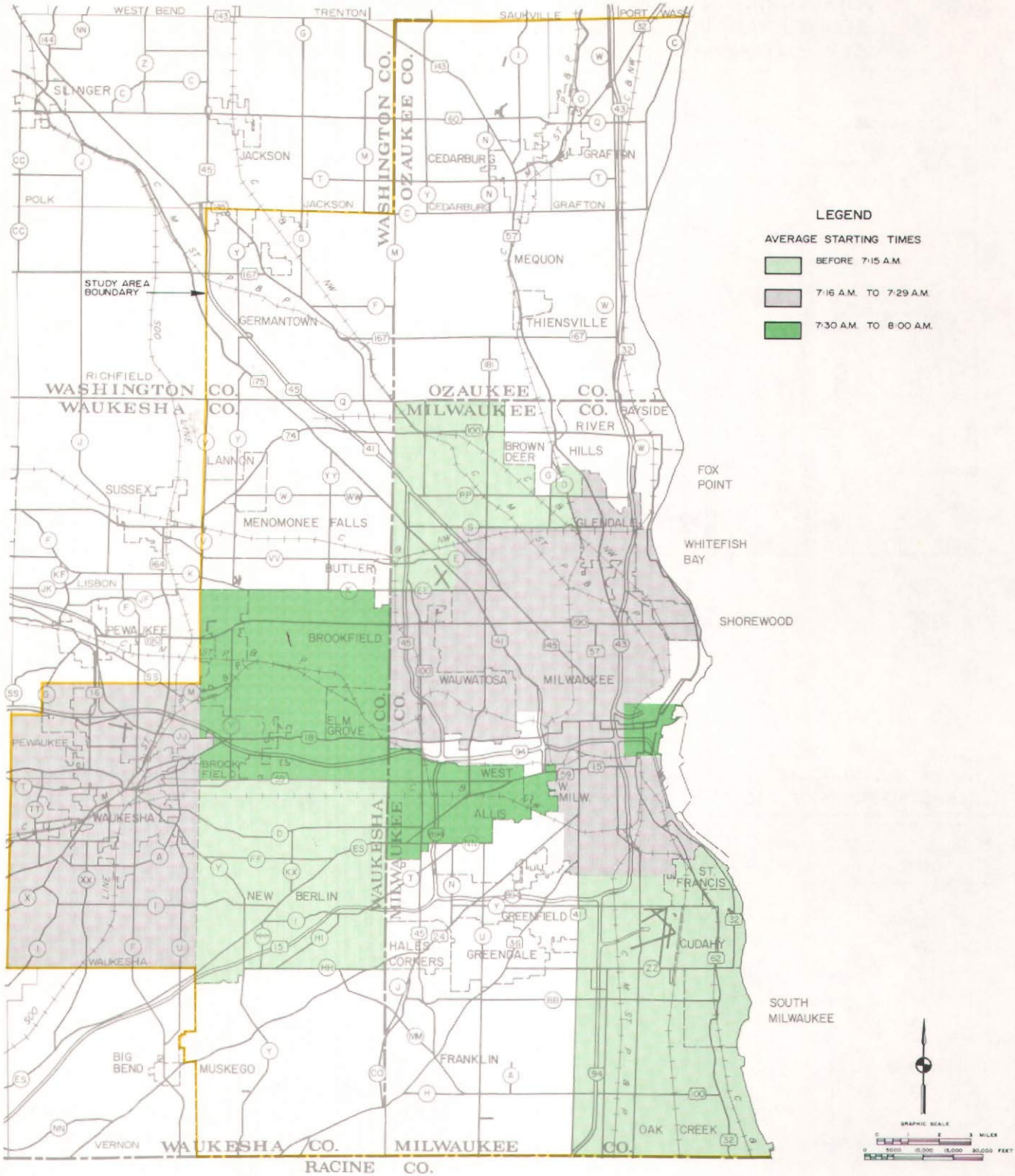
Source: SEWRPC.

business district, and for the remainder of the Milwaukee area is shown in Figure A-8. Seventy-two percent of all employees in Oak Creek are scheduled to start work by 6:30 a.m., while only 7 percent of the central business district employees and 7 percent of the other employees are so scheduled. Eighty percent of the Oak Creek first shift employees have reported for work by 7:30 a.m., and 100 percent have started by 8:00 a.m. In the central business district, only 80 percent of all employees have reported by 8:00 a.m., and in the remainder of the Milwaukee area, 93 percent have reported for work by 8:00 a.m.

Use of Staggered Work Hours: Examination of the scheduled starting times reported by all firms not on flexible work hours or a shortened work week revealed that about 60 percent of total employers had more than one starting time for first shift employees. Fifty-two percent staggered the working hours of their plant personnel, while 41 percent staggered the hours of their office staff.

Map A-2

SPATIAL DISTRIBUTION OF AVERAGE STARTING TIMES FOR FIRST SHIFT EMPLOYEES IN THE MILWAUKEE AREA

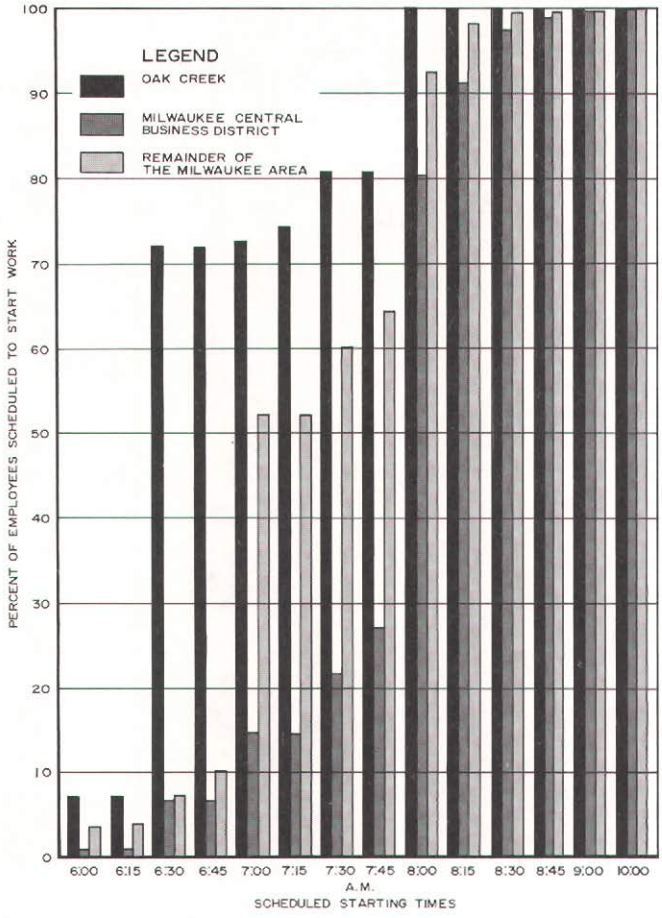


The earliest average starting times of first shift employees in the Milwaukee area occurred in the highly industrialized northwest and southeast portions of the City of Milwaukee and the suburbs of New Berlin, St. Francis, Cudahy, South Milwaukee, and Oak Creek. The latest average starting times occurred in the Milwaukee central business district and the suburbs of Brookfield, Elm Grove, West Allis, and West Milwaukee. Although variation in starting times did exist within the Milwaukee area, only Oak Creek had an average starting time which did not fall within the morning peak travel hour of 7:00 a.m. to 8:00 a.m.

Source: SEWRPC.

Figure A-8

DISTRIBUTION OF SCHEDULED STARTING TIMES FOR FIRST SHIFT EMPLOYEES IN THE MILWAUKEE CENTRAL BUSINESS DISTRICT, OAK CREEK, AND THE REMAINDER OF THE MILWAUKEE AREA: 1980



Source: SEWRPC.

The reasons for staggering work hours reported by these firms are shown in Table A-6. Most responses related to production scheduling either directly—to accommodate production schedules or to expand hours of service—or indirectly—to negotiate work schedules or because "it has always been that way." A reduction in traffic congestion both on nearby streets and in company parking lots was also frequently mentioned. The facilitation of employee use of public transit was mentioned, but less frequently than production and traffic congestion reasons.

Although most employers were using some form of staggered work hours, these programs frequently consisted of plant or production workers all starting at one time, generally 7:00 a.m., and all office personnel starting at another time, generally 8:00 a.m. Some other employees may have starting

Table A-6

REASONS REPORTED BY EMPLOYERS FOR IMPLEMENTING STAGGERED WORK HOUR PROGRAMS

Reason	Number of Responses
To Negotiate Work Schedules	56
"It Has Always Been That Way"	47
To Accommodate Production Schedules	31
To Expand Hours of Service	23
To Reduce Traffic Congestion on Nearby Streets	20
To Reduce Traffic Congestion in Company Parking Lots	16
To Increase Efficiency	14
For Employee Convenience	11
To Facilitate the Use of Public Transit	10
Other Reasons	12

Source: SEWRPC.

times before or between these two peak starting times, although these employees usually constitute only a small percentage of the total labor force. Therefore, these staggered hours reduce traffic and transit congestion from that which would occur with only one starting time, but they produce two peaks of substantial proportion which could be reduced and spread over a larger period of time by additional staggering.

Use of Flexible Work Hours: Nine employers in the Milwaukee area provided information about the flexible work hour programs they were using. All but two reported that only a portion of their employees used flexible work hours, the number ranging from two or three employees to 1,500, or from 1 percent to 70 percent of the reporting firms' total work forces. The five firms with more than 250 employees tended to limit the use of flexible work hours to only a portion of their employees, while one smaller firm and one large financial firm have programs open to all employees. In total, 2,400 employees, or 23 percent of the employees of the nine firms, use flexible work hour programs.

All of the programs described (see Table A-7) had core periods during which all employees had to be at work. These ranged from four to eight hours including lunch periods, which in some cases are also flexible and ranged from one-half to one-and-one-half hours in length. Generally, employees could not work beyond eight hours after the latest allowable starting time, plus the lunch period.

Table A-7

CHARACTERISTICS OF FLEXIBLE WORK HOUR PROGRAMS OF NINE MILWAUKEE AREA EMPLOYERS: 1980

Characteristic	Unit
Percent of Total Employment Using Flexible Work Hours. . .	23 percent
Length of Core Hours	4-7 hours (including lunch)
Minimum Hours per Day.	4-8 hours
Latest Starting Times.	7:00-9:00 a.m.

Source: SEWRPC.

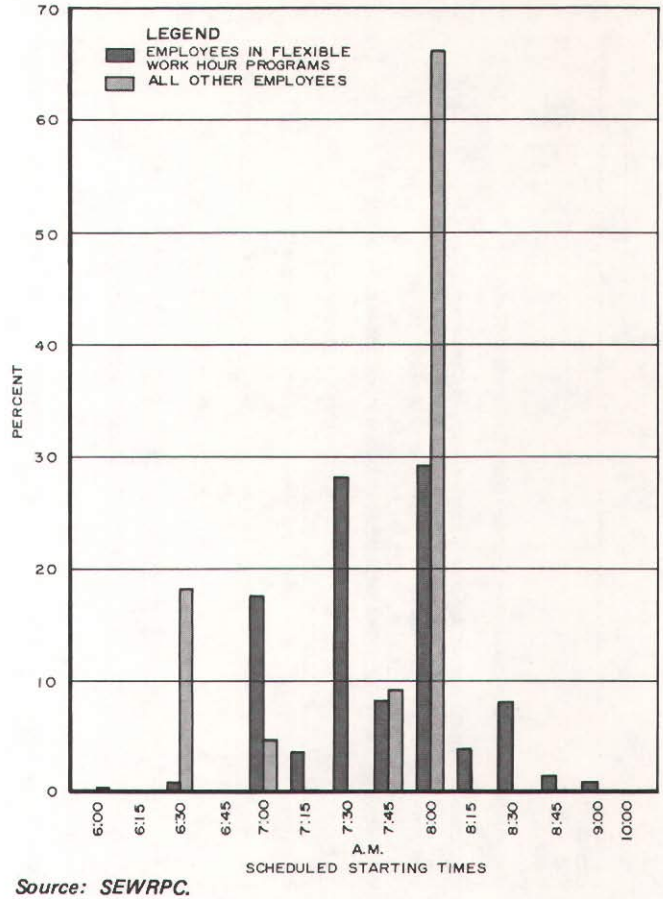
Responses from firms having both conventional and flexible work hours reveal that most employees will choose earlier starting and quitting times when given the opportunity. In addition, the distribution of starting times is more varied for employees on flexible work hours, as shown in Figure A-9. Fifty-eight percent of the employees on flexible work hours start before 8:00 a.m., while only 31 percent of the employees on conventional hours start before then. Less than 30 percent of the employees on flexible work hours start at any one time, while almost 70 percent of the employees of these same firms not on flexible work hours start at 8:00 a.m.

This more uniform distribution of starting times may be a response to present patterns of congestion, since surveys of employees on flexible work hours indicate that the avoidance of traffic congestion is considered important when selecting a work schedule. Such a response may indicate that flexible work hour programs could be self-adjusting in that employees seeking to reduce the congestion during their work trip would select a work schedule accordingly, thereby reducing peak-period congestion to less than the magnitude of the present peaks.

Use of Shortened Work Weeks: Of the 16 employers that reported using some form of shortened work week program, 13 provided detailed results of their program: eight in the manufacturing sector, two in the public sector, two in the service sector, and one in the finance sector. Of the eight firms in the manufacturing sector, four use shortened work weeks for production employees on a year-round basis, two use shortened work weeks only during the summer, and the remaining two use shortened work week programs only in their

Figure A-9

DISTRIBUTION OF STARTING TIMES OF EMPLOYEES IN FLEXIBLE WORK HOUR PROGRAMS AND EMPLOYEES OF THE SAME FIRMS NOT IN SUCH PROGRAMS



Source: SEWRPC.

data processing departments. The financial institution uses a shortened work week program to staff its data processing department 24 hours a day. Table A-8 shows the range of days per week and hours per day worked by employees on shortened work weeks in the Milwaukee area. In some of these programs, the number of days worked per week varied; for example, a program might have five nine-hour days one week and four the next, or four 12-hour days one week and three the next, and in some programs, full-time employees on shortened work weeks work fewer than 40 hours per week. Altogether, about 1,000 employees, or 8 percent of the total employment of these firms, worked shortened work weeks. The distribution of the scheduled starting times of employees on shortened work weeks and on conventional work hours is shown in Figure A-10. The starting times of employees on shortened work weeks are even more peaked than those of the other employees; however, these starting times are

Table A-8

CHARACTERISTICS OF SHORTENED WORK WEEK PROGRAMS OF 13 MILWAUKEE AREA EMPLOYERS: 1980

Characteristic	Unit
Percent of Total Employment Using Shortened Work Weeks	8 percent
Number of Days Worked per Week	3-4.5
Number of Hours Worked per Day (including lunch)	9-13

Source: SEWRPC.

earlier, before the morning peak hour for total employment of 7:00 a.m. to 8:00 a.m. Shortened work week programs in the Milwaukee area move trips to the earlier, less congested, hour before the morning peak hour and reduce the number of work trips being made on any given weekday.

Part IV: Attitudes and Constraints Concerning Work Time Rescheduling

A surprisingly large number of surveyed firms—76—indicated a willingness to consider implementing or expanding either staggered work hours, shifted work hours, flexible working hours, or shortened work weeks. Almost half of these firms indicated that they would consider implementing either staggered work hour, shifted work hour, or flexible work hour programs. Shortened work week programs were the least likely to be implemented, with only 32 percent of the firms indicating a willingness to consider that type of rescheduling.

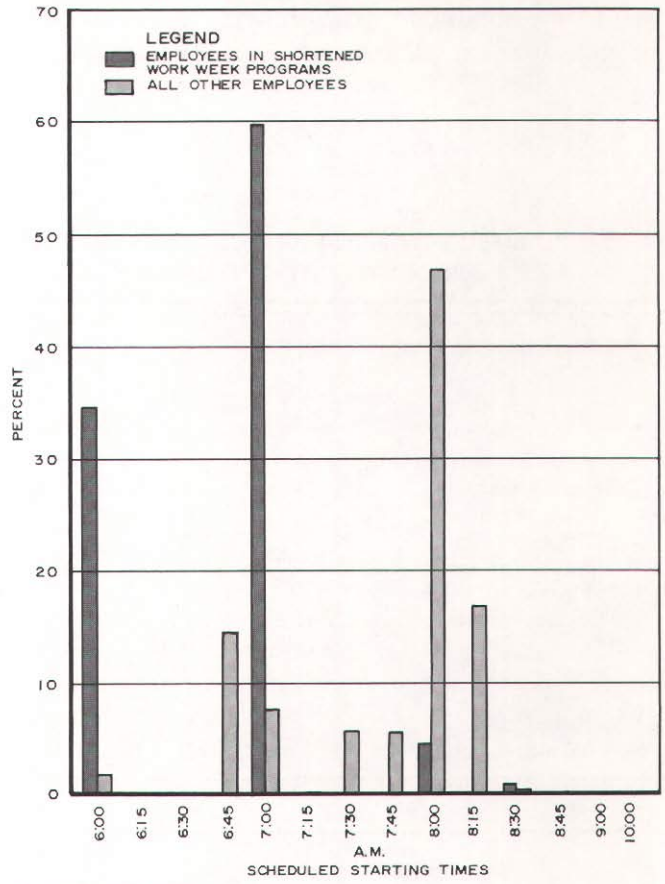
Public sector firms reported the greatest willingness to consider implementing work time rescheduling, about 60 percent. Utilities and warehousing firms reported a 56 percent willingness; finance and public services firms, 47 percent; manufacturing firms, 32 percent; and wholesale trade firms, 18 percent.

The presence of collective bargaining units apparently has little influence on the responding firms' willingness to consider work time rescheduling programs. Firms with less than half their employees unionized were only slightly more willing to consider implementing rescheduling than firms with more than half their employees unionized, but both groups were more willing to implement rescheduling than firms without union representation.

The larger the firm, the more willing it was to implement work time rescheduling programs. Only 26 percent of the smaller firms, compared with

Figure A-10

DISTRIBUTION OF STARTING TIMES OF EMPLOYEES IN SHORTENED WORK WEEK PROGRAMS AND EMPLOYEES OF THE SAME FIRMS NOT IN SUCH PROGRAMS: 1980



Source: SEWRPC.

42 percent of the firms with 100 to 249 employees and 52 percent of the firms with 250 or more employees, were willing to consider implementing some form of rescheduling.

The work time rescheduling program most acceptable to employers willing to consider the concept was staggered work hours, with 37 firms, or 18 percent of all firms, favoring this alternative, as shown in Table A-9. Utilities and warehousing firms expressed a 44 percent willingness to implement staggered work hours; public administration, a 30 percent willingness; manufacturing and finance and private service firms, a 25 percent willingness; and wholesale trade firms, an 18 percent willingness. Half of all willing firms said they would not have to limit the participation in the rescheduling program to certain departments or divisions.

Responding firms indicated a variety of problems and constraints that they thought would influence their decision to implement any work time rescheduling program (see Table A-10). Shortened work week programs created the greatest concern, with possible operational problems within the plant or office cited as a problem by 35 percent of the firms, and possible legal or contractual problems cited by 32 percent of the firms. Concerns about operational problems and legal and contractual problems were also the most frequent concerns cited for all types of work time rescheduling programs. The fewest problems were indicated for shifted work hour programs, followed by staggered work hour and then flexible work hour rescheduling programs.

Table A-9

EMPLOYERS CONSIDERING IMPLEMENTING OR EXPANDING WORK TIME RESCHEDULING PROGRAMS BY SECTOR OF THE ECONOMY AND NUMBER OF EMPLOYEES: 1980

Economic Sector and Size	Percent of Total Firms Considering Implementing or Expanding:				
	Staggered Work Hours	Flexible Work Hours	Shifted Work Hours	Shortened Work Week	Any Work Time Rescheduling Program[a]
Economic Sector					
Manufacturing	25	14	17	11	32
Utilities	44	22	11	11	56
Wholesale Trade	18	0	12	0	18
Finance and Services	25	22	8	11	47
Public Administration	30	25	20	30	60
Size					
Fewer than 99	16	9	9	9	26
100 to 249	26	19	19	18	42
More than 250	40	26	20	14	52
Number of Employers	37	32	31	24	76

[a] *An employer may indicate a willingness to consider more than one work time rescheduling program.*

Source: SEWRPC.

Table A-10

PERCENT OF TOTAL FIRMS INDICATING PROBLEMS AND CONSTRAINTS TO IMPLEMENTING WORK TIME RESCHEDULING

Problems or Constraints	Percent of Firms Indicating Problems or Constraints with Respect to:			
	Shortened Work Week	Flexible Work Hours	Staggered Work Hours	Shifted Work Hours
Legal or Contractual Problems	32	23	22	19
Operational Problems Within the Plant or Office	35	35	30	24
Operational Problems Coordinating With Other Plants or Offices	21	17	17	13
Other Problems	11	10	7	6

Source: SEWRPC.

At the conclusion of the questionnaire the respondents were asked for any comments, criticisms, or suggestions. Seventy respondents, or 30 percent, used this opportunity to comment. Although the individual responses were too varied to report here, they did provide helpful information concerning present work schedules and the potential for work time rescheduling programs. For reporting purposes, the comments have been grouped into seven broad categories, as presented in Table A-11. Nineteen comments provided additional information about or reasons for present work schedules. Seven comments suggested other transportation solutions, such as providing exclusive expressway lanes during rush hours and free parking for carpools, or were requests for survey results. The remaining comments were positive and negative reactions to and concerns about work time rescheduling programs.

Table A-11

SUMMARY OF COMMENTS INCLUDED WITH QUESTIONNAIRES

Number of Responses	Type of Comment
19	Additional information about current work schedules or the reasons for the schedules
11	Negative operational comments about work time rescheduling
10	Concern about implementing changes
10	Positive operational comments about work time rescheduling
7	General negative comments about work time rescheduling
6	General positive comments about work time rescheduling
7	Other transportation solutions to peak-hour congestion or other general comments

Source: SEWRPC.

SUMMARY

In order to determine the feasibility of expanded work time rescheduling in the Milwaukee area, Milwaukee area employers were surveyed to ascertain their current employment schedules and use of work time rescheduling programs, as well as their willingness and ability to implement additional rescheduling programs. A seven-page questionnaire was sent to 295 employers having 100 or more employees, and to 100 employers having fewer than 100 employees. Emphasis was placed upon employers with more than 100 employees, since 65 percent of the jobs in the Milwaukee area are provided by less than 3 percent of the employers—those 758 employers with 100 or more employees. By emphasizing large employers, information about a large number of employees could be obtained from a small sample of employers. Moreover, the severity of peak-hour traffic congestion is related to the spatial concentration of employees with similar work schedules, and implementation of any work time rescheduling program would be more readily accomplished with a limited number of employers. However, because a concentration of smaller employers in high-density employment areas has the potential to substantially contribute to peak-hour traffic congestion, 100 smaller employers—those with fewer than 100 employees—located in areas of concentrated employment, such as the Milwaukee central business district, were also surveyed.

Certain economic sectors were excluded from the survey. Retail sales firms, which generally open after the morning peak hour—7:00 to 8:00 a.m.—and close after the afternoon peak hour—4:00 to 5:00 p.m.—were not surveyed. Construction trades, trucking firms, and transportation firms were excluded because the location of their activities and employment can change. Only the 15 largest health care facilities and larger government offices were included.

The possible consequences of the limitations in the sample survey are that scheduled off-peak starting and quitting times of employees may be underrepresented and the concentration on large employers may understate the amount of existing work time rescheduling and overstate the amount of potential work time rescheduling. These possible consequences, however, were not deemed significant, since the employment of all firms mailed questionnaires was estimated at 189,600, or 31 percent of the total Milwaukee area employment.

A 52 percent return of the questionnaires provided information about 204 employers and their 122,000 employees. Questionnaires were returned in about equal proportions by employers in all of the sampled economic sectors and size categories. The employment described in the returned questionnaires was concentrated in the larger manufacturing firms, just as the total employment is so concentrated in the Milwaukee area, and the spatial distribution of employers returning the questionnaire was similar to the spatial distribution of employers sent the questionnaire. Therefore, the

results of this survey should be representative of all larger employers in the Milwaukee area that have employees traveling during the peak periods and smaller employers located in areas of high employment density. In total, the responding employers represent almost one-fifth of the Milwaukee area employment.

The survey was divided into four sections: a section requesting general information about the surveyed firm, a section determining whether there was prior consideration or use of work time rescheduling by the firm, a section obtaining information on present work schedules and practices, and a section obtaining the attitudes of the firm concerning work time rescheduling. An analysis of the survey yielded the following findings concerning the potential for implementation of work time rescheduling in the Milwaukee area.

- Starting and quitting times of Milwaukee area employees are highly peaked. Almost one-third of all employees represented by the survey are scheduled to start work at 7:00 a.m. and another one-third start at 8:00 a.m. Starting times scheduled on the half hour and quarter hour are relatively infrequent. Quitting times are not as peaked as starting times, but 22 percent of all employees are scheduled to quit at 5:00 p.m., and almost 20 percent are scheduled to quit at each of the following times: 3:00 p.m., 3:30 p.m., and 4:30 p.m.

- Approximately 30 percent of these employers currently have recognized work time rescheduling programs in effect. These programs affect 39,000 of the 122,000 employees represented in the survey. Another 47,000 employees presently work with staggered work hours, a situation which is not officially recognized by their employers as work time rescheduling. Of the four basic types of work time rescheduling programs, staggered work hour programs were implemented at the highest rate during the last five years (33 programs for the 204 employees), followed by shifted work hour programs (30 programs). Shortened work week programs have been implemented by 13 employers and flexible work hour programs by 9 employers. The major reasons cited for implementing these programs are related to production scheduling and expansion of service rather than to congestion-related problems. Once these programs have been adopted, they tend to be continued, with only 12 percent of the employers responding that they have discontinued rescheduling programs that had been adopted.

- About one-third of the firms surveyed indicated a willingness to consider implementing or expanding work time rescheduling programs. More than half of these employers indicated they would consider staggered or shifted work hours, while just under half would consider flexible work hours. Public sector employers, utility and warehousing firms, and finance and service firms indicated the highest rate of acceptance, and manufacturing and wholesale trade employers the lowest rate of acceptance. The highest concentration of employers willing to consider rescheduling was located in the Milwaukee central business district. However, about half of the firms willing to consider implementing or expanding work time rescheduling programs indicated they would have to limit the participation in the program to certain departments or divisions. A total of 30,000 of the 122,000 people employed by the surveyed firms would be affected by such programs.

Based on the above findings, it may be possible to implement enough work time rescheduling programs within the Milwaukee area to reschedule the work trips of as many as one-third of the workers in the area. However, the degree of peak-hour congestion abatement that would result from such rescheduling would depend upon the spatial distribution of the employers, the new work schedules, and the availability of additional transportation capacity in hours adjacent to the current-peak hours.