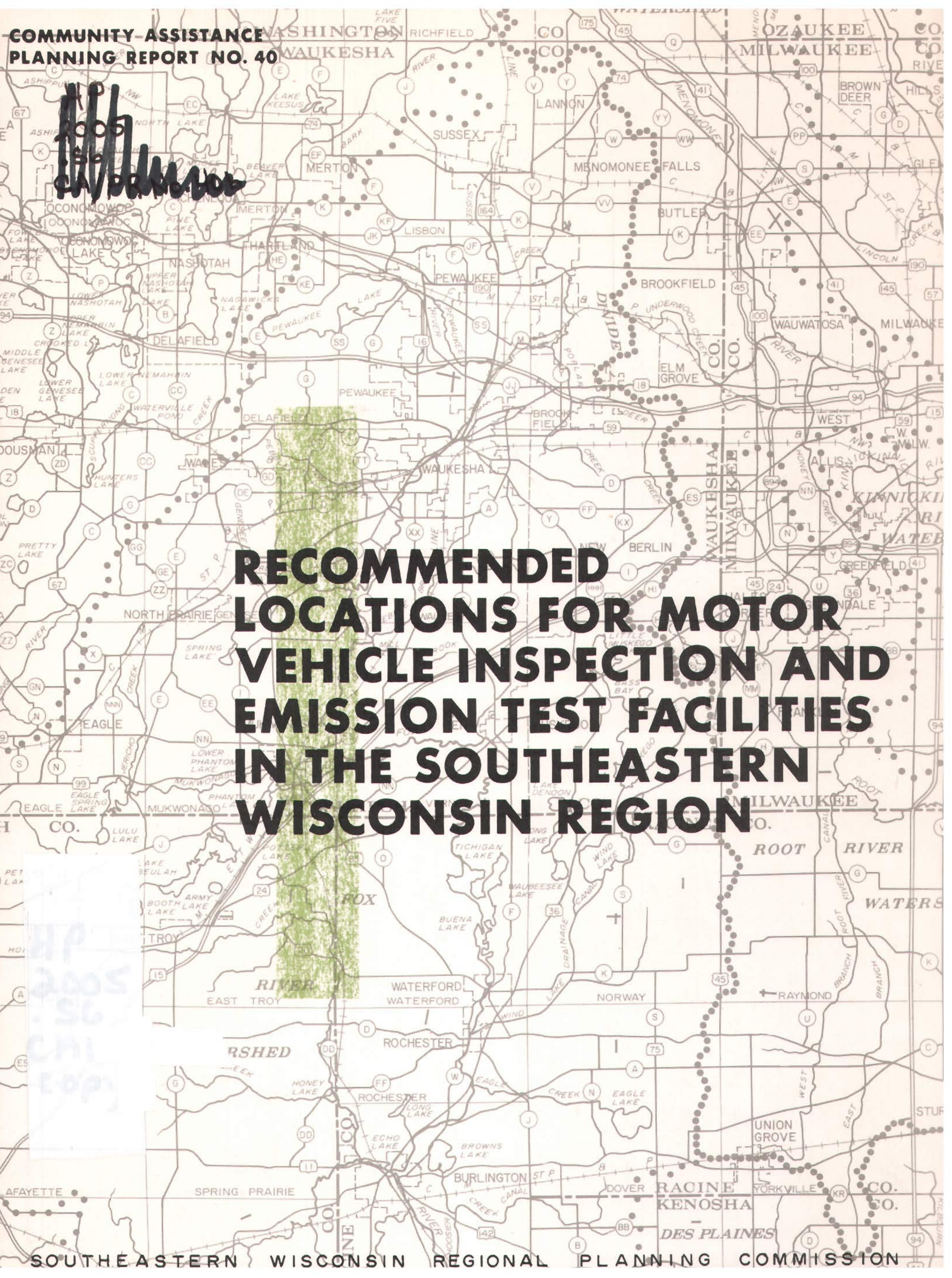
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 40



RECOMMENDED LOCATIONS FOR MOTOR VEHICLE INSPECTION AND EMISSION TEST FACILITIES IN THE SOUTHEASTERN WISCONSIN REGION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due Richard F. Pierce, SEWRPC Principal Air Quality Specialist, J. Douglas Wilson, SEWRPC Senior Air Quality Specialist, Steven N. Krafcheck, SEWRPC Air Quality Specialist, and Fredrick J. Zimmer, SEWRPC Senior Planner, for their contributions to this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 40

RECOMMENDED LOCATIONS FOR MOTOR VEHICLE INSPECTION AND EMISSION TEST FACILITIES IN THE SOUTHEASTERN WISCONSIN REGION

Prepared for the

Wisconsin Departments of Transportation and Natural Resources

by the

Southeastern Wisconsin Regional Planning Commission
P. O. Box 769
Old Courthouse
916 N. East Avenue
Waukesha, Wisconsin 53187

The preparation of this report was financed in part through a planning grant from the Wisconsin Department of Natural Resources and in part through a planning grant from the U. S. Environmental Protection Agency *utilizing Section* 175 funds provided under the Clean Air Act as amended in 1977.

October 1980

Inside Region $2.50
Outside Region $5.00

(This page intentionally left blank)

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA

October 12, 1980

Mr. Anthony S. Earl, Secretary
Wisconsin Department of Natural Resources
P. O. Box 7921
Madison, Wisconsin 53707

Mr. Lowell B. Jackson, Secretary
Wisconsin Department of Transportation
P. O. Box 7910
Madison, Wisconsin 53707

Gentlemen:

In October 1979, the Wisconsin Departments of Natural Resources and Transportation requested that the Southeastern Wisconsin Regional Planning Commission undertake a study of the configuration and general location of the test facilities required to implement a motor vehicle air pollution control equipment inspection and emission test program in the seven-county Southeastern Wisconsin Region. By proposing a convenient, as well as an efficient, configuration and location of such test facilities, the study was intended to help increase eventual public acceptance of the program by minimizing the inconvenience to vehicle owners in terms of travel time and distance to the inspection and test facilities.

The Commission staff has now completed the requested study, the findings and recommendations of which are set forth in the attached report. The study indicates that approximately 922,700 automobiles and 73,500 light-duty trucks registered in the seven-county Southeastern Wisconsin Region may be expected to be subject to an annual inspection and emission test by the year 1985. Considering retests for vehicles failing the initial test, a total of approximately 1.2 million inspections and emission tests will have to be administered each year under the vehicle inspection and maintenance program as envisioned by the State. In order to meet this total anticipated demand, and considering the temporal and spatial distribution of that demand, the Commission study indicates that 15 individual inspection and emission test facilities with a combined total of 37 test lanes should be provided. The 37 test lanes should adequately accommodate the anticipated number of vehicle inspections and emission tests during the peak demand month. The recommended locational configuration of the 15 facilities is such as to minimize the average time and distance that vehicle owners in the Region must travel to participate in the requisite inspection and emission test program. Commission analyses have indicated that the average over-the-road travel distance to a test facility within the Region under the recommended plan will be about 5.4 miles. The attendant average one-way travel time under the recommended plan will be about 11 minutes, less than the average shopping trip travel time within the Region of about 12 minutes.

The Commission recognizes the significant air quality benefits to be derived through a vehicle inspection and maintenance program and fully endorses the implementation of such a program in the Southeastern Wisconsin Region. It is believed that the recommended configuration of vehicle test facilities will minimize any inconvenience to affected vehicle owners, and thereby enhance public acceptance of, and participation in, the required vehicle inspection and maintenance program. The Commission staff stands ready to provide the Wisconsin Departments of Natural Resources and Transportation with any further assistance required to implement a successful vehicle inspection and maintenance program in the Southeastern Wisconsin Region.

Sincerely,

Kurt W. Bauer
Executive Director

(This page intentionally left blank)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

(This page intentionally left blank)

Chapter I

INTRODUCTION

In October 1979, the Commission, at the request of the Wisconsin Departments of Natural Resources and Transportation, undertook an analysis of the configuration and general location of test facilities required to implement a motor vehicle air pollution control equipment inspection and emission test program in the seven-county Southeastern Wisconsin Region. The Commission agreed to undertake the requested study, utilizing planning funds made available through the Wisconsin Department of Natural Resources, supplemented with air quality/transportation planning funds made available from the U. S. Environmental Protection Agency under Section 175 of the Clean Air Act as amended in August 1977.

This report sets forth the findings and recommendations of that analysis. The report consists of five chapters. Chapter I sets forth the need for and purpose of the study, provides a brief overview of the reasons for a vehicle inspection and emission test, and defines the geographic area included in the study. Chapter II describes the analytical procedures and mathematical techniques used in determining and evaluating alternative systems of test facilities. That chapter also identifies the underlying assumptions of the analyses, including the forecast demand for vehicle inspection and emissions tests and the capacity of the test facilities to meet such forecast demand. Chapter III presents the results of an analysis of the alternative test facility configurations and locations appropriate to the anticipated structure of the regional vehicle inspection and maintenance program. Each alternative is described and evaluated. The principal criterion used in the evaluation of each alternative is the average trip length expected to be traveled by vehicle owners to the nearest test facility. The average trip length, expressed in terms of both mean travel time and mean travel distance, is used as a measure of vehicle owner inconvenience. Gasoline consumption attendant to use of each alternative test facility configuration and location is also discussed in Chapter III. Chapter IV sets forth a recommended configuration of test facilities. Chapter V presents a summary of the findings and recommendations of the study.

NEED FOR AND PURPOSE OF THE STUDY

The federal Clean Air Act, as amended in August 1977, requires all states to prepare a plan for the attainment of the primary, or health-related, ambient air quality standards by December 31, 1982. If, however, a state demonstrates that attainment of either the carbon monoxide or ozone ambient air quality standard cannot be met by that date through the implementation and enforcement of reasonably available emission controls, the state may then apply to the U. S. Environmental Protection Agency for an extension of the 1982 compliance date to December 31, 1987. Concomitant with the request for an extension of the compliance date, a state must submit a specific schedule for the implementation of a motor vehicle inspection and maintenance (I/M) program in those areas which are not expected to attain either the carbon monoxide or the ozone ambient air quality standard, or both.

Recent studies conducted by the Commission and the Wisconsin Departments of Natural Resources (DNR) and Transportation (DOT) indicate that the eight-hour average carbon monoxide ambient air quality standard will not be attained in portions of Milwaukee County until 1983 or 1984—attainment at which time would be due principally to the anticipated impact of the federal motor vehicle emissions control program—and that the ozone ambient air quality standard may be expected to be violated throughout virtually all of the Region until at least the year 2000—the design year for the Commission's air quality studies—in the absence of further control measures.[1] Since the December 31, 1982 deadline for the attainment of the ambient

---

[1] *See SEWRPC Planning Report No. 28, A Regional Air Quality Attainment and Maintenance Plan for Southeastern Wisconsin: 2000, June 1980, and Wisconsin Department of Natural Resources, Wisconsin State Implementation Plan to Achieve the Ambient Air Quality Standards, July 1979 (Revised).*

air quality standards for these two pollutant species cannot be demonstrated for the Region, an extension of the compliance date and the establishment of an I/M program is required for southeastern Wisconsin pursuant to the mandates of the federal Clean Air Act. Accordingly, the Wisconsin State Legislature, on April 2, 1980, enacted legislation authorizing the Wisconsin Department of Transportation to establish a vehicle inspection and maintenance program in areas anticipated to exceed either of these standards.[2]

A vehicle I/M program serves an important function in attaining and maintaining the ambient air quality standards for carbon monoxide and ozone in the Region as a vital extension of, and adjunct to, the federal motor vehicle emissions control program. Motor vehicles are major sources of carbon monoxide and hydrocarbon emissions. Approximately 519,800 tons of carbon monoxide emissions, or nearly 87 percent of the total 598,800 tons of carbon monoxide emissions in the Region, were attributable to motor vehicles during 1977, the base year of the Commission's air pollution emission inventory. Motor vehicles also accounted for about 42,700 tons, or about 36 percent, of the total 118,300 tons of the emissions of those reactive hydrocarbon species known as volatile organic compounds—a principal precursor component of the pollutant mix necessary for ozone formation in the lower atmosphere—in the Region during 1977.

[2] *Chapter 274, Laws of 1979.*

The federal motor vehicle emissions control program has set forth a schedule for increasingly stringent limitations on the carbon monoxide and hydrocarbon emissions permissible from new model year vehicles. As newer model year vehicles enter the fleet and replace older model year vehicles, the amount of carbon monoxide and hydrocarbon emissions from such sources may be expected to decline significantly on a per vehicle mile of travel basis. The mechanical devices used by manufacturers to meet the emission limitations for motor vehicles, however, may operate inefficiently or improperly for several reasons, including maladjusted engine settings, premature parts failure, lack of maintenance, emission control systems that have been tampered with or rendered inoperable, illegal use of leaded fuels, and faulty design or poor production practices.

Table 1 and Figure 1 present a selected year summary of the number of in-service automobiles in the United States equipped with one or more types of air pollution control devices. As indicated in Table 1 and Figure 1, of the approximately 104.7 million automobiles in use in the United States during 1979, about 103.0 million, or more than 98 percent, had some air pollution

Table 1

ABSOLUTE AND RELATIVE NUMBER OF IN-SERVICE AUTOMOBILES IN THE UNITED STATES EQUIPPED WITH AIR POLLUTION CONTROL DEVICES IN SELECTED YEARS 1967-1979[a]

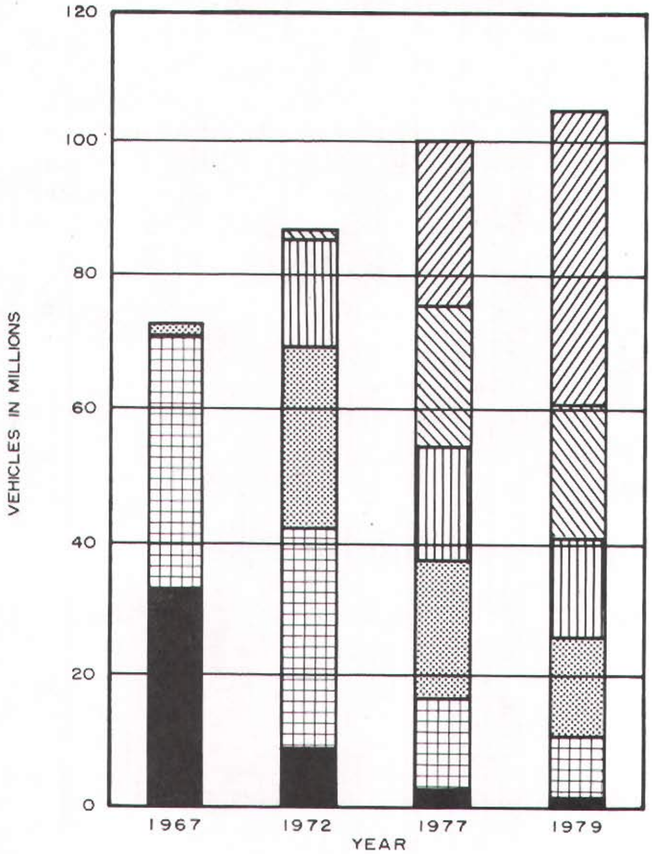
Air Pollution Control Equipment	1967		1972		1977		1979	
	Automobiles in Operation With Emission Controls	Percent of Automobiles in Operation With Emission Controls	Automobiles in Operation With Emission Controls	Percent of Automobiles in Operation With Emission Controls	Automobiles in Operation With Emission Controls	Percent of Automobiles in Operation With Emission Controls	Automobiles in Operation With Emission Controls	Percent of Automobiles in Operation With Emission Controls
Catalyst or equivalent; oxides of nitrogen, fuel evaporation, exhaust and crankcase controls	- -	- -	- -	- -	24,211,000	24.2	44,399,000	42.4
Oxides of nitrogen, fuel evaporation, exhaust and crankcase controls	- -	- -	726,000	0.8	21,401,000	21.4	19,882,000	19.0
Fuel evaporation, exhaust and crankcase controls	- -	- -	16,213,000	18.8	17,241,000	17.3	14,803,000	14.2
Exhaust and crankcase controls	1,371,000	1.9	27,214,000	31.5	20,448,000	20.5	14,941,000	14.3
Crankcase control only	38,385,000	52.6	32,789,000	37.9	13,930,000	13.9	8,937,000	8.5
No controls	33,212,000	45.5	9,469,000	11.0	2,673,000	2.7	1,715,000	1.6
Total	72,968,000	100.0	86,411,000	100.0	99,904,000	100.0	104,677,000	100.0

[a] *Data as of July 1 of each year, not model year.*

Source: Motor Vehicle Manufacturers Association.

Figure 1

DISTRIBUTION OF IN-SERVICE AUTOMOBILES IN THE UNITED STATES EQUIPPED WITH AIR POLLUTION CONTROL DEVICES SELECTED YEARS 1967-1979



LEGEND

- CATALYST OR EQUIVALENT CONTROL SYSTEMS WERE INTRODUCED ON CARS IN 1975 TO MEET MUCH TOUGHER EMISSION LEVELS FOR HYDROCARBONS AND CARBON MONOXIDE WHILE AT THE SAME TIME IMPROVING VEHICLE FUEL ECONOMY.
- IMPROVED OXIDES OF NITROGEN CONTROL SYSTEMS ON SOME 1971 AND 1972 MODELS, AND ON ALL MODELS FOR 1973 AND AFTER, LOWERED TOTAL VEHICLE EMISSIONS OF OXIDES OF NITROGEN.
- EVAPORATIVE FUEL LOSSES FROM GASOLINE TANKS AND CARBURETORS WERE NEARLY ELIMINATED BY CONTROLS ON ALL NEW CARS BEGINNING WITH 1971 MODELS.
- EXHAUST CONTROLS, INTRODUCED NATIONWIDE ON 1968 MODELS, ACCELERATED THE REDUCTION OF HYDROCARBON EMISSIONS AND BROUGHT MAJOR REDUCTIONS OF EMISSIONS OF CARBON MONOXIDE.
- CRANKCASE CONTROLS WERE INSTALLED NATIONWIDE STARTING WITH 1963 MODELS, TWO YEARS AFTER THEY WERE INTRODUCED IN CALIFORNIA.
- NO CONTROLS.

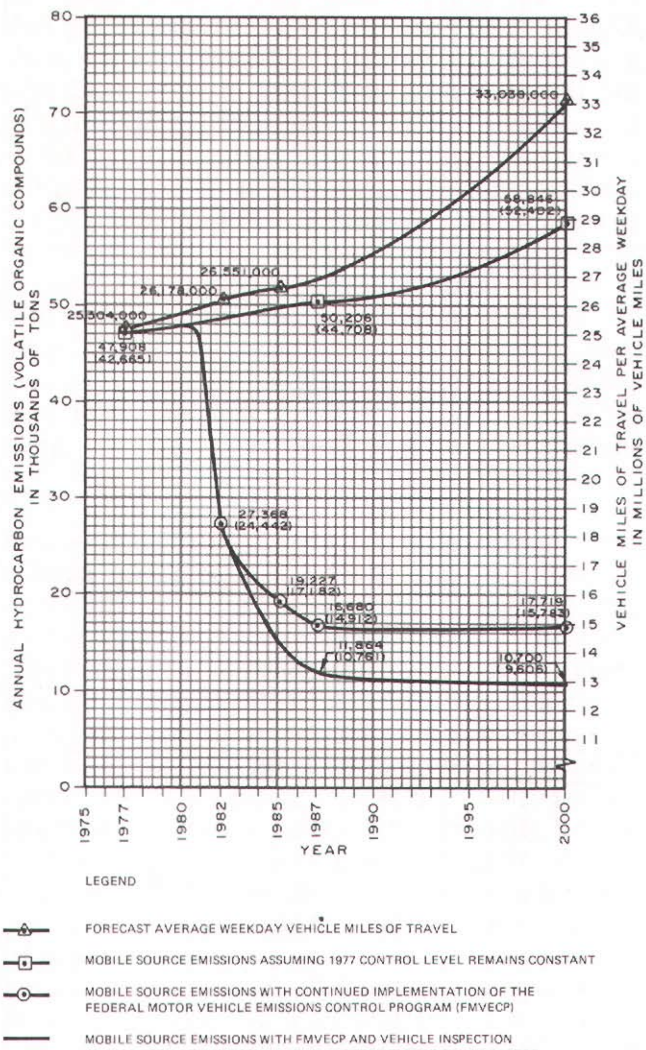
Source: Motor Vehicle Manufacturers Association and SEWRPC.

control equipment. Less than 2 percent of the automobiles in use had no air pollution control equipment. It is estimated that there were 2.3 million registered automobiles in the State of Wisconsin during 1979, of which about 844,700 automobiles, or about 37 percent, were registered within the seven-county Southeastern Wisconsin Region. It is reasonable to assume that the proportion of the automobile fleet within the State and the Region equipped with air pollution control devices does not differ substantially from that of the national fleet. The U. S. Environmental Protection Agency has estimated that 80 percent of the approximately 103 million automobiles equipped with emission control devices in the United States presently exceed the emission limits prescribed by the federal motor vehicle emissions control program. An annual vehicle inspection and emission test is intended to identify and correct any deficiencies which would cause vehicles equipped with control devices to exceed the established state emission limitations.

The emission reduction benefits to be gained and the associated air quality impacts to be derived through the implementation of a vehicle inspection and maintenance program in the Southeastern Wisconsin Region have been documented in SEWRPC Planning Report No. 28, A Regional Air Quality Attainment and Maintenance Plan for Southeastern Wisconsin: 2000. Figure 2 and Figure 3 illustrate the impact of the federal motor vehicle emissions control program and a vehicle inspection and maintenance program on hydrocarbon and carbon monoxide emissions, respectively, in the Region. As may be seen in Figure 2, without the continuing impact of the federal motor vehicle emissions control program, hydrocarbon emissions from motor vehicles in the Region may be expected to total about 58,800 tons in the year 2000. With the federal motor vehicle emissions control program, hydrocarbon emissions from motor vehicles in the year 2000 may be expected to total about 17,700 tons, about 41,100 tons, or nearly 70 percent, less than the anticipated emission level without such a program. Hydrocarbon emissions from motor vehicles under a vehicle inspection and maintenance program, and in conjunction with the federal motor vehicle emissions control program, may be expected to total about 10,700 tons in the year 2000—about 48,100 tons, or nearly 82 percent, less than the emission level without either program.

Figure 2

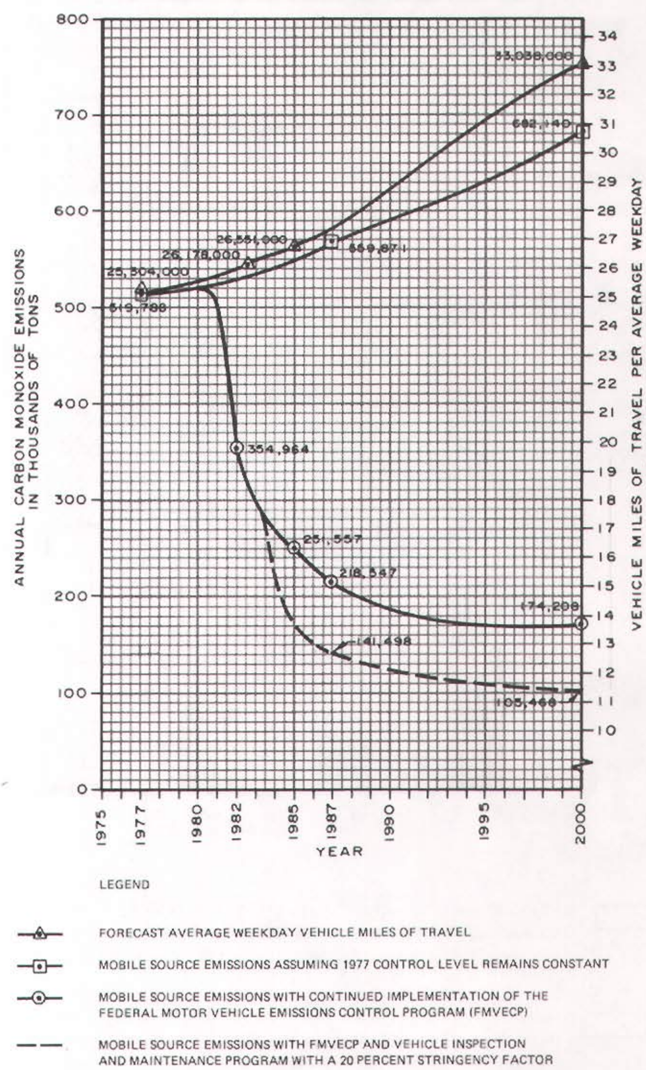
ANNUAL TOTAL HYDROCARBON (VOLATILE ORGANIC COMPOUND) EMISSIONS FROM MOBILE SOURCES UNDER THE ADOPTED TRANSPORTATION PLAN WITH AND WITHOUT A VEHICLE INSPECTION/ MAINTENANCE PROGRAM: 1977-2000



Source: SEWRPC.

Figure 3

ANNUAL TOTAL CARBON MONOXIDE EMISSIONS FROM MOBILE SOURCES UNDER THE ADOPTED TRANSPORTATION PLAN WITH AND WITHOUT A VEHICLE INSPECTION/ MAINTENANCE PROGRAM: 1977-2000



Source: SEWRPC.

Significant reductions in the anticipated level of carbon monoxide emissions from motor vehicles operating in the Region may be expected through the year 2000 with the continued implementation of the federal motor vehicle emissions control program and the establishment of a vehicle inspection and maintenance program. Without either program, carbon monoxide emissions from motor vehicles in the Region may be expected to total about 682,100 tons in the year 2000, as shown in Figure 3. As also shown in Figure 3, the federal motor vehicle emissions control program may be expected to reduce the 682,100 tons of carbon monoxide emissions in the year 2000 by about

507,900 tons, or about 74 percent, to about 174,200 tons. With both the federal motor vehicle emissions control program and a vehicle inspection and maintenance program, carbon monoxide emissions from motor vehicles in the Region may be expected to total about 105,500 tons—a reduction of about 576,600 tons, or nearly 85 percent, from the emission level anticipated without either program. Thus, a vehicle inspection and maintenance program, as an extension of the federal motor vehicle emissions control program, may be expected to yield significant reductions in the forecast level of carbon monoxide and hydrocarbon emissions from motor vehicles operating in southeastern Wisconsin.

The purpose of this study is to recommend an effective distribution and efficient configuration of required test facilities in southeastern Wisconsin which have the capacity to meet anticipated peak-period demand for vehicle tests without unnecessary lane capacity. The recommended configuration of test facilities is intended to minimize inconvenience to the owners of vehicles to be tested in terms of travel time and distance, and in terms of processing time at the facilities. It is believed that public acceptance of the I/M program can be enhanced by reducing any inconvenience to the vehicle owners through consideration of the important factor of site location for the test facilities.

STUDY AREA

The geographic area considered in this study is the seven-county Southeastern Wisconsin Region which consists of the Counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha (see Map 1). In 1979, these seven counties contained an estimated resident population of 1,780,000 persons, or about 40 percent of the total state population. Of these seven counties, only Walworth County is not within a Standard Metropolitan Statistical Area (SMSA). Because of the high degree of urbanization within the Region, as well as the fact that air pollution transcends political boundaries, any air quality attainment and maintenance plan for the area must consider the entire seven-county Region. For purposes of this study, these seven counties will be treated as one area for which the best configuration of the I/M test facilities is to be ascertained. Inherent within this decision is the assumption that automobiles need not be tested in the civil division in which they are registered within the Region.

SUMMARY

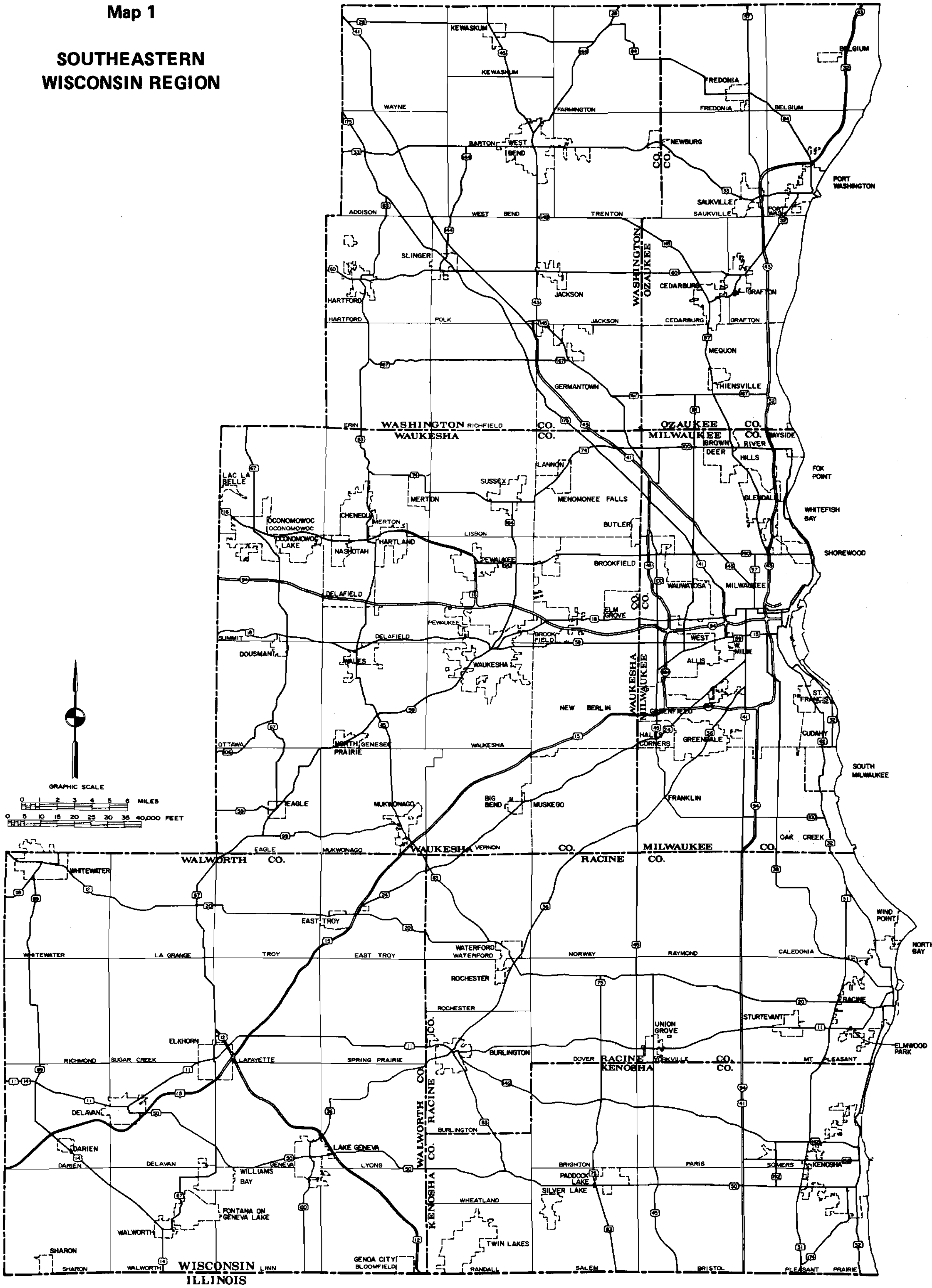
The established state and federal ambient air quality standards for ozone and carbon monoxide are presently exceeded in all or portions of the Southeastern Wisconsin Region. Moreover, the attainment of the ozone and carbon monoxide standards throughout the Region is not anticipated to occur prior to December 31, 1982—the date specified in the Clean Air Act Amendments of 1977 for achieving all primary, or health-related, ambient air quality standards. An extension to December 31, 1987 for compliance with these standards, however, may be granted by the U. S. Environmental Protection Agency under certain conditions. Principal among these conditions is the requirement that a state seeking an extension of the attainment date establish a vehicle inspection and emissions test program within the area anticipated to exceed the ambient air quality standards. Recognizing the need for an extension until December 31, 1987 to achieve the ozone and carbon monoxide standards, the Wisconsin State Legislature on April 2, 1980, enacted legislation authorizing the Wisconsin Department of Transportation to establish a vehicle inspection and maintenance program in areas anticipated to exceed either of these standards.

A vehicle inspection and maintenance program is a logical and vital extension of, and adjunct to, the federal motor vehicle emissions control program which defines the rate at which new motor vehicles may release pollutants to the atmosphere. A vehicle inspection and maintenance program may be expected to reduce tampering or removal of air pollution control equipment on motor vehicles, and to ensure that motor vehicles operate properly and efficiently within the manufacturer's specification.

In order to minimize inconvenience in terms of travel time and distance, and processing time to the owners of vehicles to be tested, the Southeastern Wisconsin Regional Planning Commission has, at the request of the Wisconsin Departments of Natural Resources and Transportation, undertaken a study of the configuration and general location of the test facilities required to implement an efficient vehicle inspection and emission test program in the Southeastern Wisconsin Region. The results of this study are documented in this report. This chapter has set forth the need for the study and provided a brief overview of the purpose of a vehicle inspection and maintenance program. The next chapter sets forth the procedures followed in the analysis.

Map 1

SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

Chapter II

SYSTEM DESIGN

INTRODUCTION

Recognizing the need for a vehicle inspection and maintenance program in the Southeastern Wisconsin Region, representatives of the Wisconsin Departments of Natural Resources and Transportation formed an interagency task force to investigate and evaluate alternative I/M programs for the Region. One of the important options considered by this task force in the development of an I/M program for the Region was whether the State should assume responsibility for performing the vehicle inspections and tests or, alternatively, if such functions would best be performed by persons under contract to the State. Another important option considered was whether the vehicle inspections and tests should be conducted through a centralized program, wherein all test facilities are owned, operated, and maintained under the control of a central management organization (either the State or a private contractor), or whether the program should be decentralized, wherein each test facility is privately owned and operated independently, reporting, however, to a central state management authority.

The interagency task force was aided in its evaluation of alternative programs by the GCA Corporation, working under contract to the U. S. Environmental Protection Agency.[1] Based in part on the technical assistance provided by the GCA Corporation, the interagency task force concluded that the needed vehicle inspection and maintenance program for the Southeastern Wisconsin Region would be most effective, both in terms of cost and consumer protection, if the program were performed by persons under contract to the State operating a number of conveniently located test facilities. Accordingly, the analyses on which the operating recommendations of this study are based assumed a contractor-operated, centrally administered test program. This chapter sets forth the design considerations pertinent to such a program, including the number and the spatial and temporal distribution of testable vehicles, and the configuration and capacity of test facilities to accommodate the anticipated demand for vehicle tests. This chapter also presents in summary form the mathematical techniques used to allocate and evaluate alternative test site configurations.

PROGRAM DESIGN CONSIDERATIONS

Lane Capacity

The first step in the analyses consisted of determining the total number of test lanes required to meet the anticipated emission test demand. The centralized nature of the proposed program requires that a limited number of test facilities be located in such a manner as to minimize user inconvenience. Since each test facility will be comprised of one or more drive-through traffic lanes containing a number of test positions, it was necessary to estimate the inspection test capacity for an individual test lane. The capacity of a single test lane was determined by considering the number of test positions within the test lane, the number of hours of operation, the average time to perform an emission test, and an overall efficiency factor based upon downtime and random arrivals in the test system. Values for these parameters were estimated for both a two-position and a three-position test lane operating 52 weeks per year at an estimated efficiency of 67 percent. The typical design for a three-position emission test lane includes check-in paperwork at the first lane position, emission analysis at the second position, and checkout and paperwork at the third position. Each position is estimated to require two minutes, for a total vehicle residence time of six minutes, with each three-position test lane capable of testing 30 vehicles per hour. A two-position test lane would perform the same functions compressed into two positions, or stops, each requiring approximately three minutes, producing a test lane capacity of 20 vehicles per hour. The formulas shown below were used to calculate the estimated annual test capacity for two- and three-position single-lane test facilities:

---

[1] *GCA/Technology Division, GCA Corporation, Evaluation of Motor Vehicle Inspection and Maintenance Programs in Wisconsin—Phase 3, Final Report, Bedford, Massachusetts, November 1978.*

TWO POSITION: Inspections per lane per year =

$$\frac{(60 \text{ minutes/hour})}{(3 \text{ minutes/position})} \times \frac{(40 \text{ hours})}{(\text{week})} \times \frac{(52 \text{ weeks})}{(\text{year})} \times (0.67) = 27{,}872$$

THREE POSITION: Inspections per lane per year =

$$\frac{(60 \text{ minutes/hour})}{(2 \text{ minutes/position})} \times \frac{(40 \text{ hours})}{(\text{week})} \times \frac{(52 \text{ weeks})}{(\text{year})} \times (0.67) = 41{,}808$$

It should be noted that any increase in the number of hours of operation per week would increase the test capacity of each lane; however, the 40-hour work week represents a conservative estimate of the hours of operation. Furthermore, at the request of the interagency task force, all test facilities were assumed, in the initial work effort, to be the three-position type having an annual test capacity of about 42,000 tests per lane.

Testable Vehicles

As presently envisioned, with certain exemptions, all light-duty gasoline vehicles (that is, automobiles) and light-duty gasoline trucks (that is, trucks with a gross weight of 8,000 pounds or less) registered in the seven-county Southeastern Wisconsin Region will be required to undergo an annual inspection and emissions test.[2] Thus, the initial consideration in allocating vehicle test facilities was the forecast number and spatial distribution of the vehicles subject to the annual inspection and test requirement. Also, since the State of Wisconsin uses a staggered expiration date system for automobiles based upon calendar months for annual registration and since all light-duty trucks are, after initial registration, registered in January, the temporal distribution of vehicles subject to the annual inspection and test requirement had to be identified in order to account for peak-period demand.

[2]*Exemptions to the annual inspection and emissions test requirement are expected to be allowed for vehicles having a gross weight greater than 8,000 pounds, research vehicles, vehicles more than 15 years old at the time of the test, and motor vehicles using diesel fuel as a primary energy source.*

Forecast of Vehicles to be Tested Annually: A critical element in determining the number of vehicle inspection and emission test facilities required to adequately implement a vehicle emission test program in the Southeastern Wisconsin Region is the size of the vehicle population to be tested. This forecast was made on the basis of the 1985 stage of the Commission's "no build" transportation system plan. This forecast was selected because it provides a reasonable basis for estimating automobile and light-duty truck availability within the 1983 to 1987 period envisioned for the inspection and emission test facilities.

Since the testable fleet is based upon the registration of vehicles and not upon the average weekday availability of vehicles for tripmaking purposes, it was necessary to adjust the vehicle availability forecasts to represent registered vehicles. As determined by the Commission through the 1963 inventory of travel and substantiated by 1972 inventory of travel, the proportion of the number of registered automobiles for tripmaking purposes is 89.9. It is important to note that while 10 percent of the vehicle fleet may not be available for the purpose of making trips on the average weekday, all vehicles to be registered must be tested and certified accordingly. The 1985 estimates of automobile availability were accordingly adjusted by a factor of 1.11 to estimate the total number of automobiles anticipated to be registered in 1985. With respect to light-duty gasoline trucks, the proportion of registered trucks which are available for use is 0.94, and the number of available trucks was adjusted by a factor of 1.06 to estimate the total number of such trucks anticipated to be registered. The forecast number of registered automobiles in the Region in 1985 is approximately 975,600, and the number of light-duty trucks is approximately 81,600.

Those vehicles more than 15 years old, vehicles having a gross weight greater than 8,000 pounds, and vehicles using diesel fuel will not be subject to the emission tests. Adjustments based on vehicle age and primary fuel were therefore made to the testable vehicle population forecast for 1985. Based on vehicle-age distribution estimates, 2.5 percent of the registered automobiles and 10 percent of the light-duty trucks are forecast to be over 15 years old, and therefore not subject to the annual emission test. In addition, 3 percent of the automobiles are estimated to be diesel powered and hence exempt from the emission test.[3] Based on these adjustments, the forecast number of testable vehicles in the Region in 1985 is approximately 922,700 automobiles, or about 92.6 percent of the testable vehicles, and 73,500 light-duty trucks, or about 7.4 percent of the testable vehicles.

Forecast of Annual Tests to be Performed: A determination of the forecast number of vehicle tests to be performed must be based on not only the number of testable gasoline-fueled automobiles and light-duty trucks in the Region, but also the number of vehicles which may be expected to have to be retested after failure of an initial emission test. The number of vehicles which will fail the emission test is dictated by the test stringency factor, which was assumed, based upon the work of the Interagency Task Force, to be 20 percent of the vehicle population subject to the emission test. It was also assumed that a similar stringency factor will apply to those vehicles which are retested after the initial test failure. Because of this assumed failure rate, the total number of emission tests to be conducted is 24 percent greater than the base vehicle population, or 20 percent plus 20 percent of 20 percent, to account for the initial test failures and retest failures.[4]

[3] *Based on national fleet averages, all light-duty gasoline trucks were assumed to be gasoline powered since the use of diesel fuel in such vehicles is negligible.*

[4] *It was assumed that the retest failure rate will be 20 percent, the same as the initial test failure rate. It should be noted that the retest failure rate is strongly dependent upon the effectivensss of the mechanics training program.*

Based on the 922,700 automobiles and 73,500 light-duty trucks which are anticipated to be subject to the test program in 1985, a total of 1,235,000 vehicle emission tests will be performed annually. Using the estimated annual test capacity per three-position test lane of approximately 41,800 vehicles, 30 test lanes will be required to meet the 1985 annual emission test demand of 1,235,000 vehicles.

Forecast of Vehicle Tests Considering Peak Testing Periods: Since the emissions testing program is proposed to be related to the annual license plate renewal—which is based on the month of initial vehicle registration in the State—the temporal distribution of emissions testing will vary with the temporal distribution of initial vehicle registration. Because the monthly vehicle registration is not temporally uniform, the emissions test facility network should be designed to adequately serve the peak monthly vehicle load. In order to assess the temporal variations in vehicle registration, the Commission referred to the 1979 vehicle registration files for the Region provided by the Wisconsin Department of Transportation, Division of Motor Vehicles.

As indicated in Table 2, the variation in the distribution of monthly automobile registrations was found to range from a high of about 10 percent during May to a low of about 6 percent during December, with the peak month of May exceeding the average monthly registrations by about 15 percent.

As may be seen in Table 3, the peak monthly demand for forecast 1985 automobiles and light-duty trucks combined is estimated to be 130,900 vehicles and to occur during the month of January. This peak is due principally to the fact that, after initial registration, all light-duty trucks in the State of Wisconsin are required to be registered by the end of the month of January. Thus, a significant peak in registration, and hence test demand, may be expected in January. Based on the estimated 130,900 vehicles to be tested, and using a 20 percent stringency factor and including retest failures, a peak monthly test demand of approximately 162,300 emission tests may be expected. Using the previously determined test lane capacity of about 3,500 tests per month, a total of 47 test lanes would be required if all vehicles subject to registration during the month of January were tested during that month.

Table 2

MONTHLY AUTOMOBILE REGISTRATIONS IN THE REGION: 1979

Month	Number of Registrations	Percent of Total
January	77,382	8.7
February	64,266	7.3
March	77,847	8.8
April	79,124	8.9
May	85,461	9.7
June	84,952	9.6
July	83,441	9.4
August	80,880	9.1
September	71,517	8.1
October	66,449	7.5
November	55,447	6.3
December	52,132	5.9
Not Determined	5,846	0.7
Annual Total	884,744	100.0

Source: Wisconsin Department of Transportation, Division of Motor Vehicles; and SEWRPC.

Table 3

DISTRIBUTION OF TESTABLE AUTOMOBILES AND LIGHT-DUTY TRUCKS: 1985

Month of Registration	Number of Testable Vehicles	Percent of Total
January	130,900	13.1
February	68,900	6.9
March	83,200	8.3
April	83,800	8.4
May	91,200	9.2
June	90,300	9.1
July	88,400	8.9
August	85,600	8.6
September	76,200	7.6
October	70,600	7.1
November	59,300	6.0
December	56,400	5.7
Not Determined	11,400	1.1
Annual Total	996,200	100.0

Source: SEWRPC.

Since the total number of testable light-duty trucks constitutes only 7.4 percent of the total testable fleet, it would be unreasonable to design a testing program which would accommodate an extremely high peak period of testing activity. The magnitude of this peaking is evidenced by the estimated 47 test lanes required to satisfy this peak demand as opposed to the 30 test lanes required to accommodate the total annual number of estimated tests.

In order to design a vehicle testing program based on the monthly registration peaking of light-duty trucks and automobiles, it will be necessary to design a system that will reduce the impact of light-duty truck registrations in the month of January. As may be seen in Table 4, the testing of all light-duty trucks in January would require 47 three-position test lanes. Since January is the single peak demand month, the peak monthly demand could be significantly reduced, and hence the number of test lanes could be reduced, if light-duty trucks were required to be tested over a three-month period preceding the registration deadline—that is, November, December, and January, the former two months having the lowest test demand for automobiles. If the light-duty trucks were to be assigned to specific months—November, December, and January—so as to smooth this demand distribution by assigning one-third of the trucks to each of these three months as shown in Alternative "A" in Table 4, the number of vehicles in the peak-month would be reduced to 98,200 vehicles, requiring a network of about 35 test lanes. Under Alternative B, which calls for the emission tests for light-duty trucks to be assigned to each of the three months so as to equal the monthly test demand by assigning 40 percent of the truck tests to November and December and 20 percent to January, the peak-month test demand would be only 33 test lanes. Under Alternative C, the approximately 73,500 light-duty trucks forecast to be subject to the emission test in the Region in 1985 would be evenly divided and assigned to each month of the year. Considering the retests required of vehicles failing the initial test, the peak demand would be about 118,500 tests and would occur during the month of May. Based on this peak monthly demand, the network would have to be designed to accommodate the equivalent of approximately 1.42 million tests annually. This alternative, therefore, would require a network with about 34 test lanes.

By distributing the emission test requirement for light-duty trucks over more than one month, the need to provide as many as 47 test lanes—which is

Table 4

DISTRIBUTION OF TESTABLE AUTOMOBILES AND LIGHT-DUTY TRUCKS FOR SELECTED MONTHS BY ALTERNATIVE LIGHT-DUTY TRUCK PROCEDURES

Month of Distribution	Distribution Under Existing Procedure[a]	Alternative Number of Vehicles to be Tested		
		A[b]	B[c]	C[d]
November . .	59,300	76,000	79,600	64,200
December . .	56,400	72,300	75,900	60,500
January. . . .	130,900	98,200	91,100	86,400

[a] *All light-duty trucks would be tested in January, the month of registration. Forty-seven test lanes would be required.*

[b] *Light-duty truck emission tests would be assigned uniformly over each of the three months. Thirty-five test lanes would be required.*

[c] *Light-duty truck emission tests would be assigned 40 percent in November, 40 percent in December, and 20 percent in January. This test distribution would result in a peak lane demand of 33 test lanes.*

[d] *Light-duty truck registration and emission tests would be uniformly assigned to each month of the year, and a peak lane demand of about 34 test lanes would be required in the month of May.*

Source: SEWRPC.

substantially in excess of the lane capacity needed to serve automobile test demand during any other month—can be avoided. Since the method that the Wisconsin Department of Transportation will use to distribute the registration of light-duty trucks is not known at this time, for the purpose of this analysis the total registration of light-duty trucks was distributed evenly throughout the year. Under this assumption, an initial 34 lanes are required to meet the anticipated test demand.

Spatial Distribution of Testable Vehicles: In order to develop a configuration and determine the general location of the vehicle emission test facilities in the Region, a desirable spatial distribution of the test demand had to be determined. This task was accomplished by using the spatial distribution of available vehicles forecast under the 1985 "no build" stage of the regional transportation plan. This spatial distribution of forecast automobiles available was analyzed on the basis of two spatial units: planning analysis areas (PAA) and traffic analysis zones (TAZ). The planning analysis areas, 60 of which have been delineated by the Commission within the Region, are intended to constitute rational subareas of the Region for various planning purposes used in other Commission studies. The traffic analysis zones, of which 1,220 have been delineated by the Commission, are all intended to permit the accurate simulation of the operation of the transportation system. In order to facilitate computer processing of the forecast test demand data, 375 spatial units were selected as basic geographical units to which the test demand was related. Within the Milwaukee, Kenosha, and Racine urbanized areas, the PAA was used as the basic geographical unit. In the remainder of the Region, the TAZ was used as the basic geographical unit on which the test demand was based. Map 2 presents the 375 spatial units, or analysis areas, used in the locational analysis. For the purpose of this analysis, the total test demand within each analysis area was assumed to be located at the geographical center of each spatial unit.

Methodology

Once an estimate had been made of the number of annual emission tests which would be required in the Region and the number of test lanes necessary to serve that number of tests during the peak month, objective analytical procedures for aggregating the test lanes into test facilities of two or more lanes were selected and a spatial location of those test facilities that would minimize user travel in terms of both time and distance was determined.

This task was accomplished using the Commission in-house computer facilities and a computer program applicable to location of facilities in such a manner as to maximize demand served while minimizing some measure of user inconvenience such as cost, time, or travel distance. This type of program, generally referred to as a location-allocation program (LAP), can be used to solve a variety of location-allocation problems. The problem addressed by this study is of the general type characterized by the following structure: assume that there are given 1) a set of n points distributed in the plane, 2) a numerical weight to be attached to each point representing demand, and 3) a set of m centroids and an allocation of each point, or fraction of a point, to some centroid so as to optimize an objective function. To this general form of the problem, an additional complication was added in the form of capacity restrictions on the centroids. Therefore, the objective function is to be optimized subject to these restrictions such that the final mathematical form of the function becomes:

$$\text{minimize } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} X_{ij} [(U_i * - u_j)^2 + V_i * - v_j)^2]^{½}$$

$$\text{subject to: } \sum_{j=1}^{n} X_{ij} \leq q_i \quad (i = 1, 2, \ldots, m)$$

$$\sum_{i=1}^{m} X_{ij} \geq r_j \quad (j = 1, 2, \ldots, n)$$

$$X_{ij} \geq 0,$$

where:

Z = the value of an objective function.

X_{ij} = the magnitude of some flow from i to j.

$[U_i^*, V_i^*]$ = the coordinates of the ith central facility.

$[u_j, v_j]$ = the coordinates of the jth source point.

q_i = the capacity of the central facility.

r_j = the demand at the jth source point.

This final form of the problem adds a significant complication, since the demand at the source points may be assigned in fractional units to more than one central facility. Because of this fractional distribution, this form of the problem is difficult to solve using the techniques applicable to more simple location-allocation problems such as linear programming and integer linear programming. However, methods have been developed to provide solutions to such problems. One method used to provide a solution to this complex problem is referred to as heuristic programming. A heuristic program consists of a set of rules for the solution of some given problem. These rules define a solution process which converges in the direction of optimality, but which does not necessarily provide a fully optimal result. The heuristic used within the LAP was developed in 1963 by L. Cooper.[5] This algorithm appears to give consistently good results while minimizing the amount of computations required. This was a key factor in selecting this algorithm for use in the analysis because of the sheer size of the initial computational problem: 375 source areas containing demands for approximately 1.4 million tests—based upon the annual equivalent of the peak monthly demand—to be distributed to 34 test lanes located in an area of approximately 2,700 square miles.

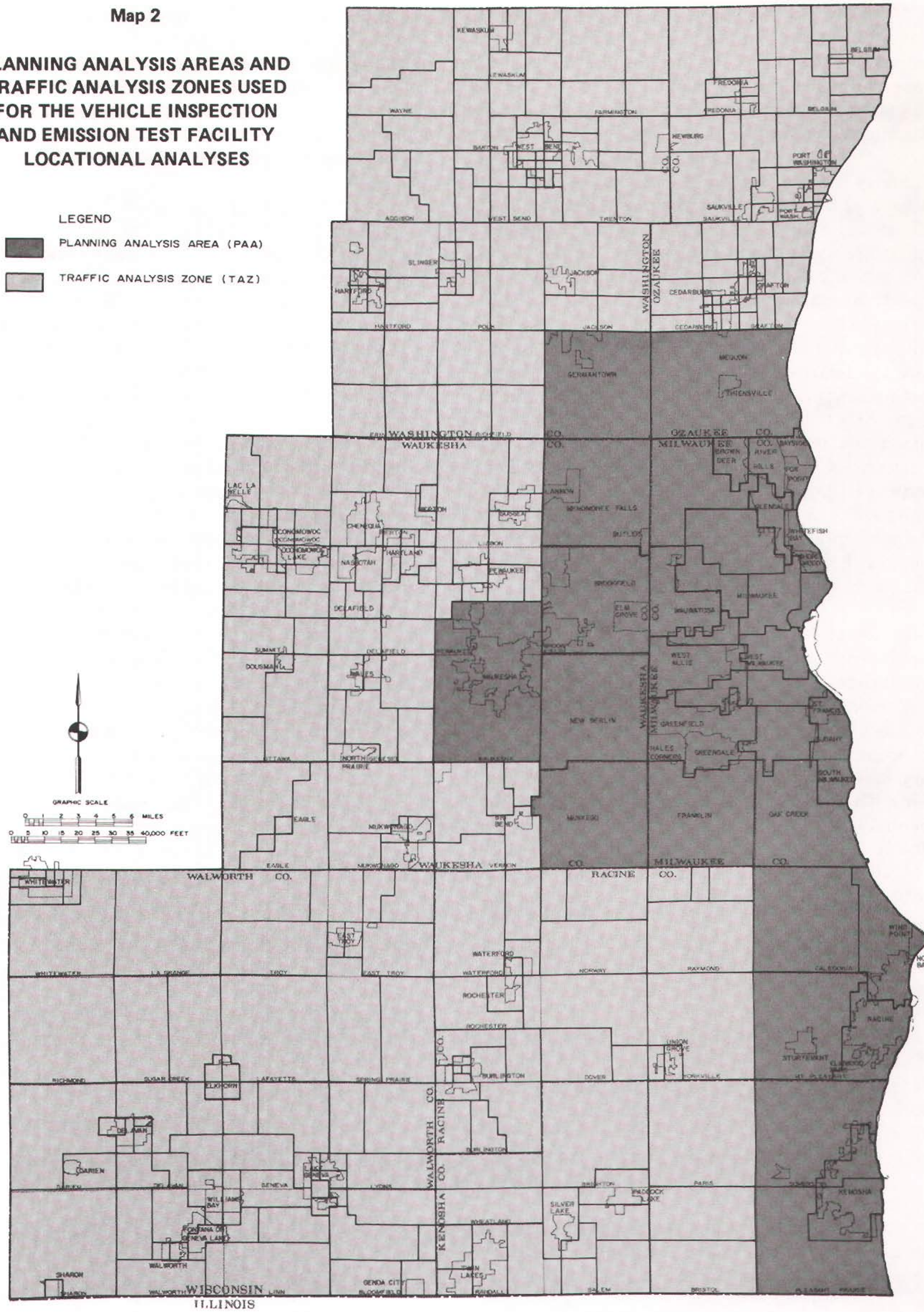
The information required as input to the LAP was relatively simple in structure and consisted of two general types: demand information and capacity information. The demand information consisted of test demand and the X and Y coordinates for each of the 375 regional subareas. The test demand was based upon forecast vehicle availability factored upward to account for peak monthly test demand and failure rates. The X and Y coordinates were determined for the centroid of each of the demand areas and were based upon the Wisconsin State Plane Coordinate system, truncated to the nearest 1,000 feet. The capacity information required was minimal since the LAP used an internal function to generate random starting locations for each of the test facilities. Thus, it was only necessary to supply the capacity constraint for each test facility, this having been previously calculated at approximately 41,800 tests per test lane per year.

While the input requirements of the LAP were relatively simple, the output provided by this program was extensive. Included in the output were the randomly assigned starting positions for

[5] *L. Cooper, "Location-Allocation Problems,"* *Operations Research, Vol. 11, 1963, pp. 331-343.*

Map 2

PLANNING ANALYSIS AREAS AND TRAFFIC ANALYSIS ZONES USED FOR THE VEHICLE INSPECTION AND EMISSION TEST FACILITY LOCATIONAL ANALYSES



Source: SEWRPC.

each of the test facilities, the step-by-step movement of these locations as the heuristic algorithm proceeded, the final location of each test facility in state plane coordinates, and a matrix of demand assignments to respective test facilities. Based upon this output, it was possible to produce a map showing the location of each test facility as well as the tributary service area for each test facility. The output also contained two measures of relative efficiency: the total aggregate travel distance for the entire system and the percent of the population served by the nearest, or proximal, test center. The total aggregate travel distance is based upon a straight line distance calculated by the program. This aggregate travel distance can be used to compare the relative efficiency of the various emission test program options with the overall system efficiency. Efficiency gains or losses can then be determined for changes in both the number and the location of the test facilities. In contrast, the percent of population served by the nearest center could only be used to compare efficiency within a single option and thus served only as a measure location efficiency while holding the number of test facilities constant.

The output from the LAP, which consists of the geographic location of each test site by X and Y coordinates based on minimum aggregate straight line travel distance and a matrix of emission test demand assignments by analysis area, was used to prepare a map of each individual test site tributary service area under various site/lane configurations. The tributary service area boundary was then manually adjusted in such a manner so as to more closely approximate existing geopolitical boundaries. In the adjustment of these boundaries, measures were taken to eliminate the assignment of isolated geographic areas to second and third choice testing facilities and to ensure that no service area exceeded the established test capacity for any given site. With the tributary service areas defined, over-the-road, street, and highway system travel distance and travel time data maintained as a part of the Commission's continuing land use and transportation studies were combined to summarize vehicle hours and vehicle miles of travel between the vehicle garage location and the test facility for each service area.

Overriding Considerations

In addition to such basic system design considerations as the number of vehicles subject to the emissions tests, the spatial distribution of the vehicles, and the temporal distribution of the test demand, a number of other factors were considered in the spatial design of an effective emissions test site network. Two of these considerations are the cost constraints of establishing single-lane test facilities and the actual physical site characteristics of the test facilities. These considerations, in effect, are overriding in that because of their basic importance they must be met in any system configuration.

The cost constraints associated with establishing test facilities having only an individual test lane are severe. The direct cost of locating and purchasing necessary real estate parcels has been estimated at $6,000 per site; therefore, the fewer sites required, the lower this total cost.[6] Additionally, the costs of title searches, title transfers, site planning, and other functions may be expected to add about 10 percent to the actual purchase price of each parcel. Similarly, the cost of the actual test facility also reflects economies of scale. A single-lane test facility would require that about 50 percent of the "under roof" area be devoted to storage and administrative space. By comparison, a two-lane facility would require no additional storage or administrative area; thus, the "under roof" area would increase by only about 50 percent in order to gain a 100 percent increase in capacity. Three- and four-lane facilities would reflect similar economies. Since much of the actual testing would be done by state-of-the-art electronic data processing equipment, further economies can be realized by combining lanes because one onsite data processing system can handle more than one test lane. Thus, equipment costs would also reflect the economies of scale. Finally, since each test facility would have to have some administrative and management personnel present, an increase in the number of lanes per test facility and a reduction in the number of test facilities would serve to reduce the number of onsite administrative and management personnel and thus reduce overhead costs. Based upon these cost-related factors, the Interagency Task Force recommended that no single-lane test facilities be included in the recommended plan unless deemed to be absolutely necessary by other factors, such as severe public inconvenience.

---

[6] *GCA/Technological Division, GCA Corporation, Evaluation of Motor Vehicle Inspection and Maintenance Programs in Wisconsin-Phase II, Bedford, Massachusetts, September 1978.*

Additional constraints which affect the determination of the locations of the emissions test facilities relate to the actual physical site of the facilities. Because the tests will be conducted on motor vehicles, it is apparent that the test facilities should be located in such a manner as to be readily accessible to motor vehicle traffic. The road network must be capable of carrying the traffic generated by these facilities and the facilities must be designed to handle a traffic flow through the system in such a manner as to provide easy and safe ingress and egress to and from the road network. An additional constraint is presented by the fact that as the number of lanes of the facility increases, more land must be devoted to access roads, queuing space, and staff parking. An examination by the Interagency Task Force of other operating I/M facilities in states which have implemented I/M test programs indicated that a facility containing more than four test lanes becomes impractical because of induced traffic congestion at the site, as well as the amount of real estate required to accommodate the actual test facility and its related service and support areas. Because of these problems, it was assumed that a four-lane facility would be the largest practical.

One limitation to the specific location of an inspection and emission test facility in the State is imposed by the legislation authorizing the establishment of a vehicle inspection and maintenance program in the State of Wisconsin. This restriction states that no inspection and emission test facility may be established within one-half mile of an air quality monitoring station which reported a violation during the period from 1976 to 1979 of the primary national ambient air quality standards for carbon monoxide as defined by the Wisconsin Department of Natural Resources. This limiting factor must be considered in the evaluation of the recommended test facility location plan.

Based upon these factors, it was apparent that the vehicle inspection and emission test facilities should consist of two, three, or four test lanes, with each lane containing three test positions. Only under unusual circumstances would the use of a single-lane facility, or of lanes having fewer than three test positions, be considered in the recommended site location plan.

---

[7] *Chapter 274, Laws of 1979, signed by the Governor on May 1, 1980.*

SUMMARY

The objectives of the initial phase of this study were to determine the capacity of various emission test lane configurations, to establish a reliable estimate of the number of motor vehicle emission tests required in the 1985 design year, to determine the number of emission test lanes that will be necessary to handle the forecast emission test demand, and to select and refine a set of objective procedures for aggregating the required number of emission test lanes and spatially locating these into motor vehicle emission test facilities so as to minimize user inconvenience in terms of both travel time and travel distance. In addition, the site selection process should include considerations so as to ensure reasonable accessibility by the existing traffic network in the Region to the proposed test facility locations, and to ensure that the proposed sites will be compatible with the adopted long-range land use plan for the Region.

The initial step in the design of the vehicle inspection and emission test facility network was the determinaton of the single lane test capacity of two-position and three-position loaded mode (using a dynamometer) emission test facilities. The two-position test station capable of inspecting 20 vehicles per hour and operating 40 hours per week, 52 weeks per year, at an efficiency of 0.67 was estimated to have a test capacity of 27,872 emission tests per year. The three-position test station capable of inspecting 30 vehicles per hour and operating 40 hours per week, 52 weeks per year, at an efficiency of 0.67 was estimated to have a test capacity of 41,808 emission tests per year.

The number of motor vehicles that will be subject to the vehicle emission test requirement in the Region in 1985 was estimated based on the Commission's 1985 stage of the "no build" alternative transportation system plan. The 1985 automobile and truck availability forecasts were adjusted by a factor of 1.11 and 1.06, respectively, in order to estimate total vehicle registrations in that year. This adjustment was required since existing data indicate that only 89.9 percent of the registered automobiles and 94.0 percent of the registered trucks are actually available for use. The forecast of total registered automobiles and light-duty trucks in the Region during 1985 was subsequently adjusted to account for vehicles more than 15 years old—2.5 percent of the registered automobiles and 10.0 percent of the registered trucks—and for automobiles powered by diesel fuel—about 3 percent of the total fleet. Using this procedure, 922,700 automobiles and 73,500 light-duty trucks were forecast to be subject to the emission test procedure. The total annual emission test demand was then estimated by multiplying the vehicle total by a factor of 1.24 to account for the emission test and retest based on a stringency factor of 20 percent. The resulting number of annual vehicle emission tests required was 1,235,000. Using the assumption that all test lanes would be three-position lanes with an annual test capacity of about 41,800 tests, an initial estimate of 30 emission test lanes was derived.

Because light-duty trucks, after initial registration, are required to register annually in the month of January, an estimated 47 lanes would be required to serve the peak monthly test demand for both automobiles and trucks. However, if the truck emission test demand were distributed over a twelve-month period, then 34 test lanes could serve the peak monthly vehicle test demand (see Table 4). Therefore, based on the peak monthly demand, and assuming light-duty truck tests are distributed evenly throughout the year, it was determined that the network would have to be designed to accommodate the equivalent of approximately 1.4 million inspection and emission tests annually. Thus, a 34 test lane demand was used in the initial test design.

The 1985 "no build" stage of the Commission's regional transportation plan was used to determine the spatial distribution of the motor vehicles forecast to be subject to the annual emission test. Based on the planning analysis areas and traffic analysis zones that have been delineated within the Region by the Commission, 375 analysis areas were selected as the basic spatial units to which the emission test demand was related.

In order to assess the optimal spatial location of the motor vehicle emission test facilities in the Region, a location-allocation program (LAP) was used. This program uses heuristic programming methods to optimally allocate spatial demand to supply centers. The input into this program consisted of X and Y geographic coordinates for the 375 analysis areas and the number of test centers and assigned test capacities. The program output used in this analysis consisted of the total aggregate straight line travel distance for each test facility service area and a matrix of demand assignments to each emission test facility. Using this output, a map was produced which delineated the tributary service area for each test facility under various site/lane configurations.

Chapter III

EVALUATION OF ALTERNATIVE TEST FACILITY LOCATIONS

INTRODUCTION

The principal objective of this study is to evaluate various alternative site and lane configurations for motor vehicle emission test facilities in the Region in order to minimize aggregate travel time and travel distance from garage locations to the emission test facilities for motor vehicles subject to emission test. The various alternative locations and test lane aggregations were developed utilizing the initially estimated minimum of 34 three-position test lanes necessary to meet the forecast emission test demand in the year 1985. Each alternative was based on the results of the location-allocation program (LAP) and the map of general site location and service area produced using the program output. For comparative purposes, each alternative was evaluated using average one-way over-the-road travel time and average one-way over-the-road travel distance as surrogate measures of inconvenience to vehicle owners.

34-Site/34-Lane Alternative

In order to initially assess a desirable spatial distribution of the test demand and to further assist in the selection of a desirable configuration of test facilities, and in order to avoid beginning the analysis with a randomly and arbitrarily grouped test network, it was determined to make an initial computer run using the LAP based on 34 individual one-lane, three-position inspection and test facilities. By locating the individual test lane facilities in response to where the test demand dictated, a general assessment of the test demand pattern for the facilities could be more easily and rationally determined, and from this initial pattern a desirable configuration of facilities could more logically be pursued. The starting location for each facility was randomly determined using the computer program, thus assuring an unbiased approach.

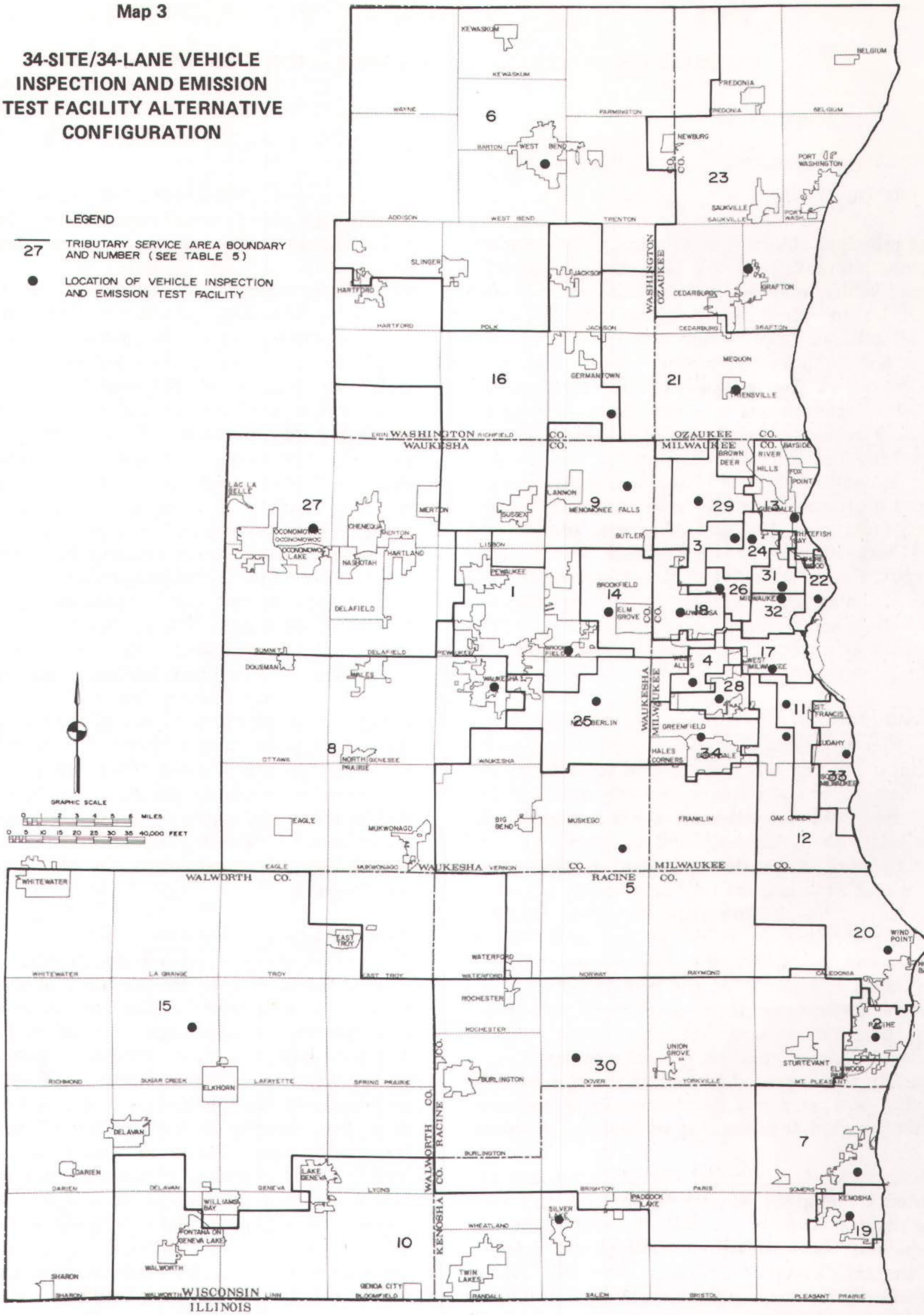
The results of this initial computer run are presented on Map 3. As may be seen on this map, the highest density of test facilities, reflecting a spatially concentrated area of high test demand, occurs in Milwaukee County. Under this 34-site/34-lane alternative, a more dispersed and less dense pattern of test facilities is found progressing radially away from the center of Milwaukee County. The average over-the-road one-way trip lengths for the 34 single-lane inspection facilities, measured in time and distance, are presented in Table 5. Based upon these measures, the average one-way driving time required to reach a test facility is slightly less than 10 minutes, while the average one-way trip length is 4.5 miles. By comparison, the average travel time and average trip length for home-based work trips in the Region in 1972 was 17.9 minutes and 5.4 miles, respectively. Home-based work trips generally represent the longest of all major trip purposes, but because the actual trip to the emission test facility may be made only once each year, it was felt that the trip length for this purpose could reasonably be assumed to approximate the journey to work distance, which is a daily trip, in terms of both time and distance without causing undue inconvenience. The range of trip lengths in terms of time and distance for this design alternative indicates considerable variation, with one-way trip time ranging from a low of 5.1 minutes to a high of 24.6 minutes, while average one-way distance traveled ranged from a low of 1.7 miles to a high of 16.3 miles. The estimated annual vehicle miles of travel required under this emission test network alternative is 5,483,000 miles. This travel demand to and from the emission test sites would require an estimated 386,000 gallons of gasoline annually.

19-Site/34-Lane Alternative

Because of the cost advantages previously noted in this report—that is, the economy of scale associated with multi-lane facilities—and because of the concentration of single-lane facilities in high test demand areas, it became apparent that a number of the single-lane test facilities could reasonably be combined into multi-lane facilities having the same test capacity as the number of single-lane facilities replaced. The initial location of the multi-lane facilities would then become the geographic center of the cluster of single-lane test facilities which were replaced. The geographic coordinates of each new multi-lane facility were then used as input into the computer algorithm; however, the actual location of these new facilities was allowed to "float" by the program. That is, the computer

Map 3

34-SITE/34-LANE VEHICLE INSPECTION AND EMISSION TEST FACILITY ALTERNATIVE CONFIGURATION



Source: SEWRPC.

Table 5

AVERAGE ONE-WAY TRIP LENGTHS FOR THE 34-SITE/34-LANE VEHICLE INSPECTION AND EMISSION TEST FACILITIES

Facility	Average One-Way Trip Length	
	Minutes	Miles
1	8.5	5.1
2	6.1	1.8
3	7.1	2.6
4	7.8	2.5
5	13.4	9.4
6	10.5	5.3
7	7.2	3.4
8	12.0	7.1
9	6.0	2.7
10	24.6	16.3
11	8.8	2.5
12	9.3	3.8
13	7.5	2.9
14	7.5	3.7
15	17.7	12.5
16	15.5	10.9
17	9.8	1.8
18	7.9	2.9
19	5.1	1.7
20	7.2	3.2
21	10.0	4.9
22	10.3	1.8
23	9.8	5.9
24	5.9	1.9
25	9.0	4.1
26	7.7	2.2
27	10.1	6.7
28	5.5	1.8
29	6.1	2.6
30	16.7	11.9
31	10.5	2.3
32	12.1	2.3
33	7.2	2.3
34	15.9	2.7
Region	9.9	4.5

Source: SEWRPC.

algorithm was free to locate each new facility in such a manner so as to minimize travel distance at each new location.

As a result of the grouping of these single lanes, the total number of test facilities was reduced from 34 to 19. After making the necessary changes to the computer input data, the computer algorithm was again used to determine the optimal location for each of these 19 test facilities. The results of this 19-site alternative are presented on Map 4.

The major criteria used to evaluate the locational distribution of the test facilities under the 19-site/34-lane alternative are presented in Table 6. It can be seen that both mean travel time and mean travel distance have increased over the initial 34-site configuration. These increases are to be expected, since the number of test sites has been reduced. However, the reduction in the number of test sites from 34 to 19, or 44 percent, is much greater than the resultant increase in mean travel time or distance. Under the 19-site alternative, mean travel time increased from 9.9 minutes to 11.1 minutes, an increase of 1.2 minutes, or 12 percent, while mean travel distance increased from 4.5 miles to 5.1 miles, an increase of 0.6 mile, or 13 percent. Both the mean travel time and mean travel distance are below their respective averages for journey-to-work trips, and thus would appear to represent a reasonable trip length to an emission test site. These data also indicate that while mean travel time and mean travel distance have increased, the range of these values has either decreased or stabilized. The range of travel time values for the 34 single-lane facilities was 19.5 minutes, while the range for travel time values based upon 19 facilities was reduced to 15.4 minutes. By comparison, the range of mean travel distances traveled in order to reach the test facilities remains relatively uniform between the 34 and the 19-facility option, decreasing from a 14.6-mile range in values to a 14.5-mile range in values. This indicates that a 19-facility alternative is more equitable than a 34-facility alternative in terms of dispersing the test locations such that most driving times and distances fall into a reasonably narrow range, indicating less variance between site service areas in terms of driving time and distance. The estimated annual vehicle miles of travel required under this 19-site emission test network alternative is 6,208,000 miles. This travel demand to and from the emission test sites would require an estimated 437,200 gallons of gasoline annually.

In addition to evaluating the mean travel time and distance for each test facility, an examination was made of the service area shape and size. As shown on Map 4, the service areas for each respective test facility are based upon demand assignments made by the computer algorithm and indicate which travel analysis zone and planning analysis area demand was assigned to a particular test facility. It is apparent that the overall number of service areas presents problems concerning the maximum distance required to be driven in order to reach a test facility. For example, Facility 19 on Map 4

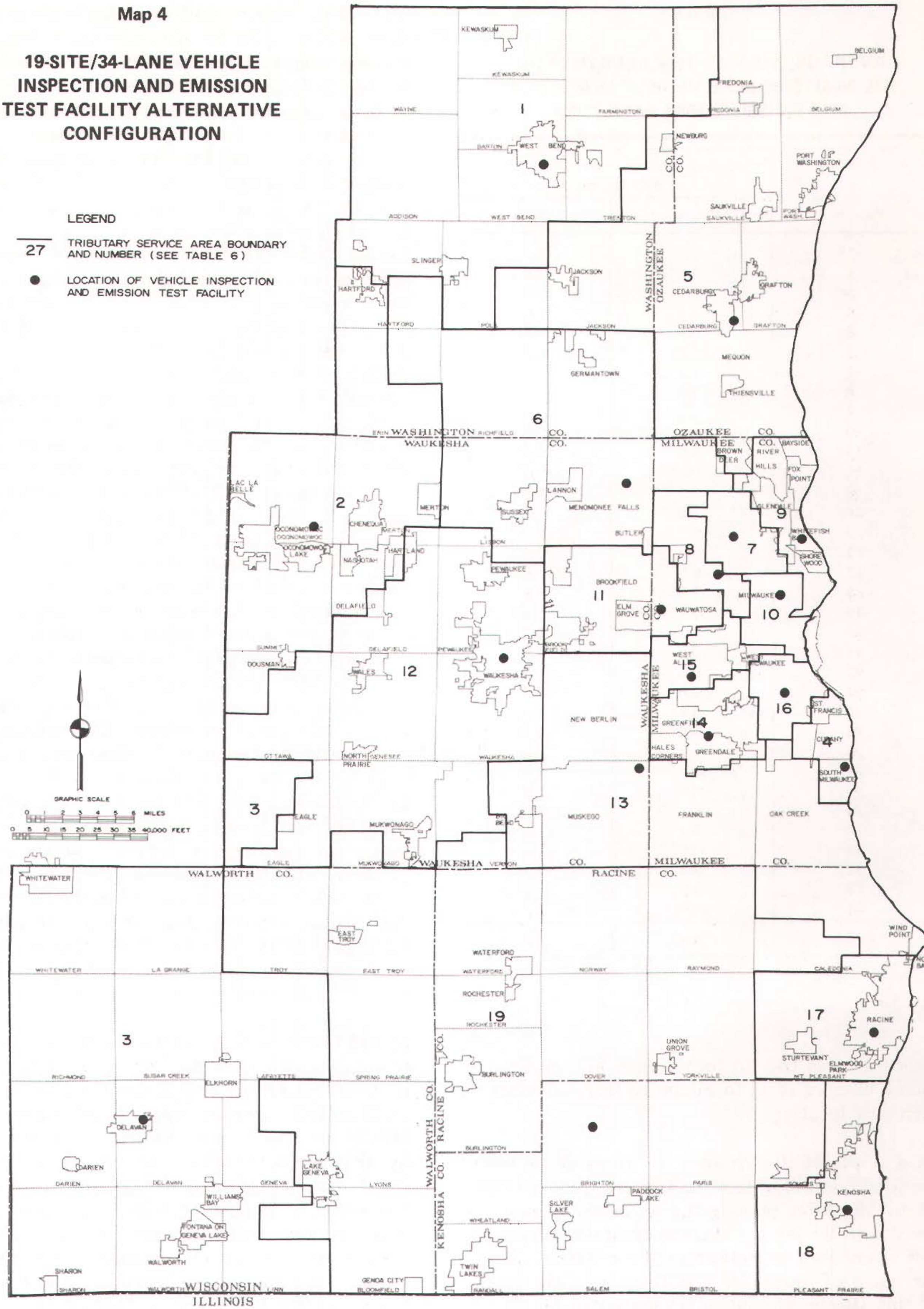
Map 4

19-SITE/34-LANE VEHICLE INSPECTION AND EMISSION TEST FACILITY ALTERNATIVE CONFIGURATION

LEGEND

27 — TRIBUTARY SERVICE AREA BOUNDARY AND NUMBER (SEE TABLE 6)

● — LOCATION OF VEHICLE INSPECTION AND EMISSION TEST FACILITY



Source: SEWRPC.

Table 6

AVERAGE ONE-WAY TRIP LENGTHS FOR THE 19-SITE/34-LANE VEHICLE INSPECTION AND EMISSION TEST FACILITIES

Facility	Number of Lanes	Average One-Way Trip Length	
		Minutes	Miles
1	1	10.6	5.3
2	1	12.2	7.8
3	1	15.7	10.2
4	1	7.1	2.3
5	2	13.9	7.9
6	2	9.8	5.2
7	2	6.4	2.1
8	2	8.9	3.2
9	2	10.4	3.6
10	2	11.5	2.2
11	2	9.5	4.1
12	2	12.8	5.6
13	2	15.8	8.3
14	2	9.4	3.4
15	2	9.4	3.1
16	2	8.7	2.3
17	2	9.1	3.1
18	2	7.5	2.9
19	2	21.8	16.6
Region	34	11.1	5.1

Source: SEWRPC.

is a case of a facility having a comparatively large service area. Additionally, some service areas are shaped such that some vehicles garaged near the periphery of the service area may be located closer to adjacent test facilities than to the facility assigned by the computer algorithm. It should be noted that under actual conditions, the vehicles would not be assigned to a specific test facility. Rather, owners would select facilities perceived to be conveniently located. Test facilities 13 and 8 on Map 4 have rather sinuous or elongated-shaped service areas and are thus particularly subject to such "crossover" effect.

13-Site/34-Lane Alternative

Based upon the analysis of mean travel time, mean travel distance, and service area configurations, additional changes were suggested in the manner in which lanes are aggregated into test facilities. An effort was again made to reduce the number of single-lane test facilities by combining some single-lane facilities into double-lane facilities. Using the 19-site alternative, Facilities 2 and 12 in Waukesha were combined and Facilities 4 and 16 in Milwaukee County were combined. As a result of this action, only two single-lane facilities remained in the emission test facilities network. Additional changes regarding lane aggregations included combining a number of two-lane facilities into four-lane facilities. Using the 19-site alternative as the base, Facilities 13 and 14, 11 and 15, 9 and 10, and 7 and 8—all in Milwaukee and Waukesha Counties—were combined to form four 4-lane test facilities. As a result of these changes, the total number of test facilities was reduced from 19 to 13. As in the construction of the 19-site/34-lane alternative, the geographic midpoint of the combined facility locations was used as the initial starting location for the newly created facilities. Those test facility sites that were unchanged were initialized at their established location. During the computer processing, all facility locations were again allowed to "float."

The results of the computer analysis of optimum locations for the 13 test facilities are presented in Table 7 and on Map 5. Under this network alternative, the number of test facilities was reduced from 19 to 13, or a decrease of 32 percent, while the average distance driven to reach each new test facility increased from 5.1 miles to 5.6 miles, an increase of 0.5 mile, or about 10 percent. The mean travel time required to reach a test facility decreased from 11.1 minutes to 10.8 minutes, a reduction of 0.3 minute, or about 3 percent from the 19-facility alternative. Analysis of the data presented in Table 7 also indicates that the range of travel time and travel distance again decreased from levels under previous alternative network configurations. Mean travel times for the 13-facility alternative ranged from 7.5 minutes to 19.2 minutes, for a total range of 11.7 minutes. This is a 24 percent reduction from the 19-facility range of 15.4 minutes. The range of mean travel distance also decreased from the 19-facility alternative of 14.5 miles to a range of 10.9 miles—a reduction of 3.6 miles, or 25 percent. These reductions in the range of both mean travel times and mean travel distances indicate that the tributary service areas are becoming more uniform with regard to the demand being served. The estimated annual vehicle miles of travel required under this emission test network alternative is 6,825,000 miles. This travel demand to and from the emission test sites would require an estimated 480,600 gallons of gasoline annually.

13-Site/36-Lane Alternative

While the reduction in the number of test facilities from 19 to 13 sites produced positive results with respect to travel time and travel distance, the size and shape of some of the tributary service areas presented some design problems. For example, Facility 5 in Ozaukee County, Facility 13 in western Racine County-Kenosha County, and Facility 3 in Waukesha County each were characterized by large service areas. Facility 10 in Milwaukee County exhibited a relatively large and elongated service area. Because of these shortcomings, additional changes in lane aggregation were considered appropriate at selected facilities. Those facilities in the City of West Bend and in Walworth County were changed from single-lane, three-position test facilities to two-lane, two-position test facilities. The test facility in the City of Burlington was changed from a two-lane, three-position facility under the 13-site/34-lane alternative to a two-lane, two-position facility under the 13-site/36-lane alternative. As a result of this modification, the test capacity of these three facilities increased by about 34 percent. In addition, this aggregation in facility configuration eliminated all single-lane test facilities. In an attempt to reduce the size of the service area of Facility 10, one test lane was removed from this facility and was added to Facility 11 in the City of Racine. The total number of test facilities thus remained at 13, but the number of test lanes was increased to 36. These changes were made to the input data and a second run of the locational computer algorithm was made for the 13-test facility network. The numerical evaluative measures and the locations for this second phase of the 13-facility alternative are presented in Table 8 and on Map 6, respectively. These changes in the 13-facility network resulted in an increase in mean driving time from 10.8 minutes to 12.0 minutes—an increase of 1.2 minutes, or 11 percent, while mean trip length decreased from 5.6 miles to 5.5 miles when compared with the 13 facility, 34-lane alternative. Perhaps more importantly, the range of both driving time and trip distance decreased. The range of driving time decreased from 11.7 minutes to 9.3 minutes—a decrease of 2.4 minutes, or over 20 percent, while the range of trip length decreased from 10.9 miles to 8.0 miles—a decrease of 2.9 miles, or about 27 percent. Map 6, which contains the service area boundaries for these 13 test facilities, indicates that the tributary service areas have become more uniform in terms of both size and shape. The estimated annual vehicle miles of travel required under this emission test network alternative is 6,669,000.

Table 7

AVERAGE ONE-WAY TRIP LENGTHS FOR THE 13-SITE/34-LANE VEHICLE INSPECTION AND EMISSION TEST FACILITIES

Facility	Number of Lanes	Average One-Way Trip Length	
		Minutes	Miles
1	1	12.6	6.7
2	1	15.8	10.3
3	3	14.8	8.8
4	3	10.7	4.4
5	2	13.8	7.9
6	2	9.2	5.0
7	4	8.3	3.2
8	4	13.3	3.3
9	4	11.2	4.8
10	4	13.4	6.1
11	2	9.4	3.2
12	2	7.5	2.9
13	2	19.2	13.8
Region	34	10.8	5.6

Source: SEWRPC.

This travel demand to and from the emission test sites would require an estimated 469,600 gallons of gasoline annually. Both of these values are slightly lower than those for the 13-site/34-lane alternative.

11-Site/34-Lane Alternative

Since reducing the number of emission test facilities while increasing the number of test lanes, and thus the test capacity, at each facility has produced positive results as evaluated in terms of mean travel time and distance to reach the test facility, this reduction and aggregation process was continued. Because of the high demand for emission tests within the Milwaukee area, a pattern of facility locations in relatively close proximity to each other is necessary. Therefore, the locational results of aggregating test lanes into larger individual test facilities was examined. Although initial discussions with representatives of the Interagency Task Force tentatively eliminated the use of facilities with more than four testing lanes—due to onsite congestion and space efficiencies—it was decided to examine such an option in order to determine if the benefits of large-scale test facilities, in terms of reduced driving time and distance, would outweigh the negative effects of potential onsite congestion. In order to examine this problem, three 4-lane facilities were combined to produce two 6-lane

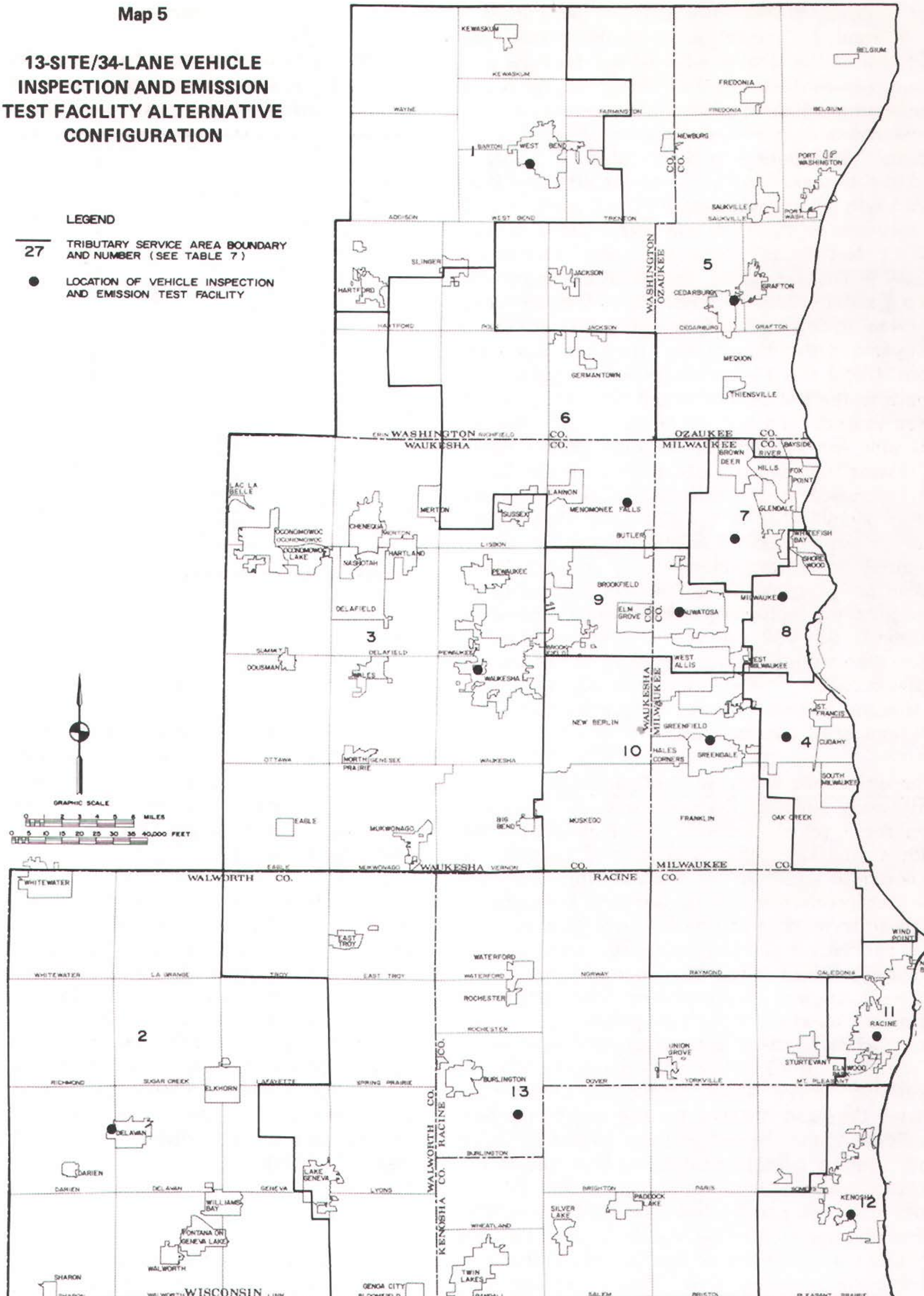
Map 5

13-SITE/34-LANE VEHICLE INSPECTION AND EMISSION TEST FACILITY ALTERNATIVE CONFIGURATION

LEGEND

27 TRIBUTARY SERVICE AREA BOUNDARY AND NUMBER (SEE TABLE 7)

● LOCATION OF VEHICLE INSPECTION AND EMISSION TEST FACILITY



Source: SEWRPC.

test facilities, all located in high test demand areas of Milwaukee County. As a result of this lane aggregation, the total number of test facilities was reduced from 13 to 11, or 15 percent. As in the preparation of the previous site alternatives, the necessary changes were made to the input data to reflect the reduction in the number of facilities, and the changes were made to facility capacities as a result of the aggregation of test lanes. Again, The computer algorithm was performed such that all 11 test facility locations were allowed to "float." The results of this analysis, shown on Map 7 and in Table 9, indicate further increases in mean driving time and mean trip distance when compared with either of the two 13-facility solutions. Under this 11-site alternative, the mean trip length to the test facility of 6.0 miles exceeds the mean journey to work trip length of 5.4 miles by 0.6 mile, or 11 percent. In addition, the range of driving time and trip distance to the test facilities increased under this alternative the values exhibited by either of the 13-facility alternatives. The estimated annual vehicle miles of travel required under this emission test network alternative is 7,271,000 miles. This travel demand to and from the emission test sites would require an estimated 512,000 gallons of gasoline annually. These two values are the highest of the five alternative emission networks examined. Based on these results, no further attempts were made to reduce the number of test facilities.

Table 8

AVERAGE ONE-WAY TRIP LENGTHS FOR THE 13-SITE/36-LANE INSPECTION AND EMISSION TEST FACILITIES

Facility	Number of Lanes	Average One-Way Trip Length	
		Minutes	Miles
1	2[a]	13.3	7.7
2	2[a]	17.1	11.3
3	3	15.9	8.0
4	3	9.9	4.1
5	2	13.7	8.5
6	2	9.3	4.8
7	4	8.8	3.3
8	4	14.2	3.4
9	4	11.4	5.0
10	3	10.8	5.2
11	3	11.1	5.3
12	2	8.2	3.7
13	2[a]	17.5	10.9
Region	36	12.0	5.5

[a] *Denotes two-position test lanes.*

Source: SEWRPC.

Comparison of Alternative Configurations

This study included the determination of a location for a vehicle emission test facility network with a total lane capacity capable of meeting the peak-month emission test demand while minimizing user inconvenience as measured by such criteria as mean travel time and mean travel distance. The five alternatives for inspection and emission test facilities evolved from the computer analysis of different site/lane configurations. Each alternative represents an attempt to: 1) objectively locate the test facilities while aggregating the test lanes; 2) minimize the number of facilities capable of meeting the emission test demand; and 3) minimize driving time and distance for the user of the test facilities. As may be seen in Table 10 and Figure 4, both average over-the-road travel time and travel distance increased with the reduction from 34 test lanes at 34 sites to 34 test lanes at 19 sites. The further aggregation of 34 test lanes into 13 sites produced a reduction in average travel time but an increase in average travel distance. Because the first three alternatives each included at least two one-lane test facilities, and in view of the fact that at one-lane test facilities a mechanical or electrical problem could temporarily close the entire facility and thus create considerable user inconvenience, further aggregation of test lanes was considered desirable.

The 13-site/36-lane and 11-site/34-lane alternatives were constructed so as to eliminate all single test-lane facilities. However, as shown in Table 10 and Figure 4, the average trip time under these alternatives was longer than under the three initial test network configurations. However, the average trip length for the 13-site/36-lane configuration was shorter than that for both the 13-site/34-lane and the 11-site/34-lane configurations. Based on this last network configuration, no further reduction in the number of individual test facilities was deemed advisable.

SUMMARY

The principal objective of the analyses reported in this chapter was to prepare and evaluate a number of alternative motor vehicle emission

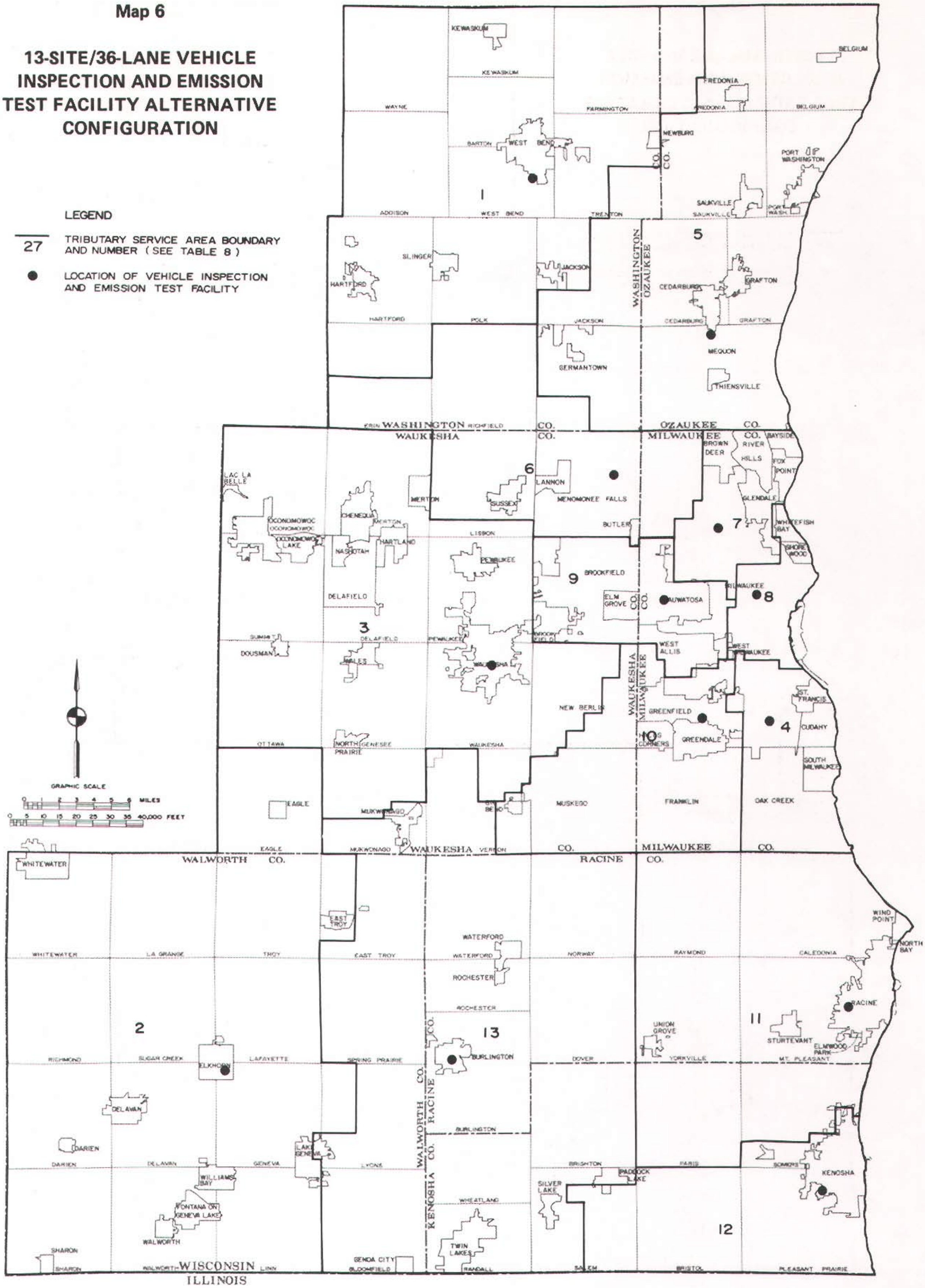
Map 6

13-SITE/36-LANE VEHICLE INSPECTION AND EMISSION TEST FACILITY ALTERNATIVE CONFIGURATION

LEGEND

27 TRIBUTARY SERVICE AREA BOUNDARY AND NUMBER (SEE TABLE 8)

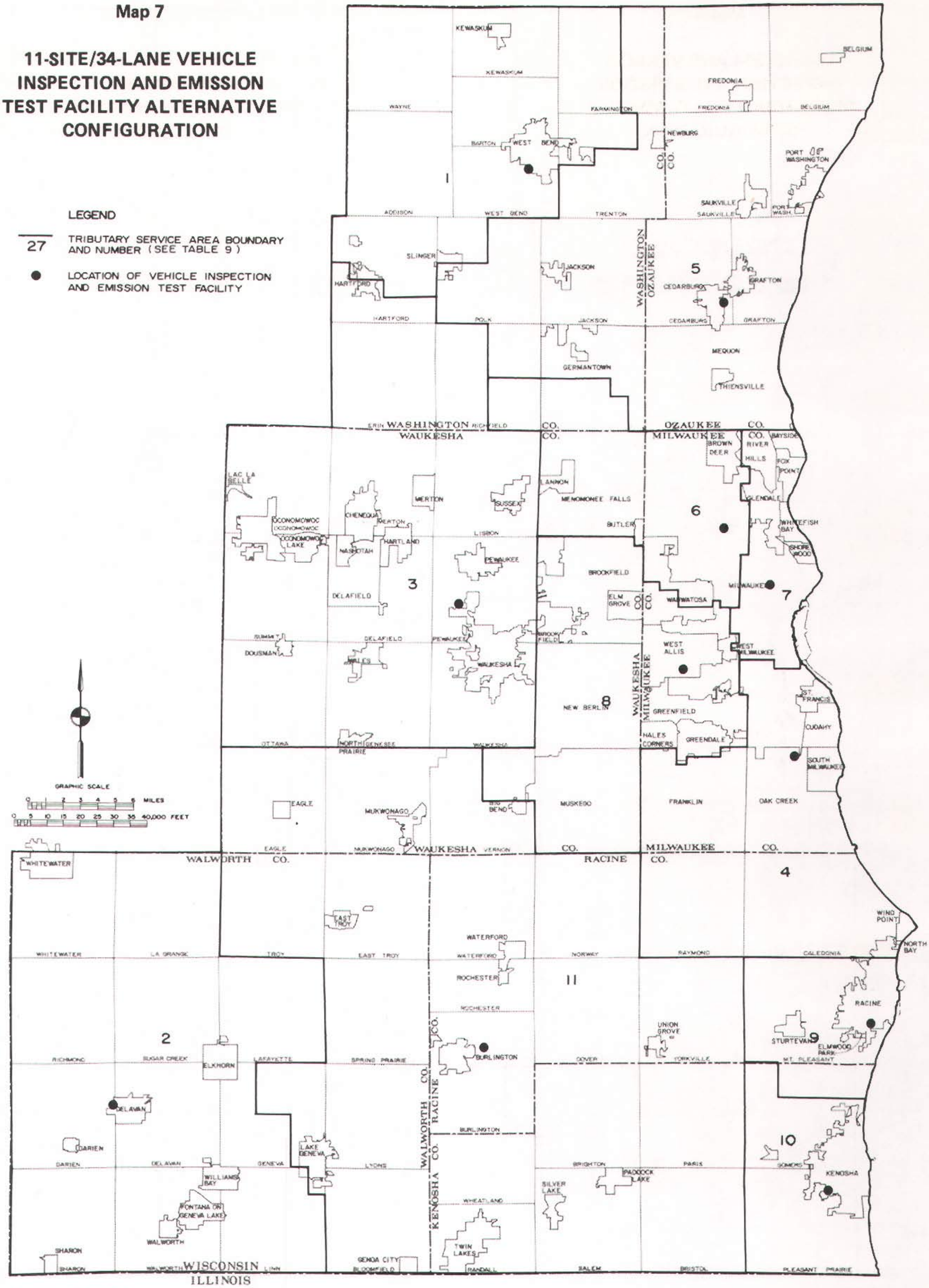
● LOCATION OF VEHICLE INSPECTION AND EMISSION TEST FACILITY



Source: SEWRPC.

Map 7

11-SITE/34-LANE VEHICLE INSPECTION AND EMISSION TEST FACILITY ALTERNATIVE CONFIGURATION



Source: SEWRPC.

Table 9

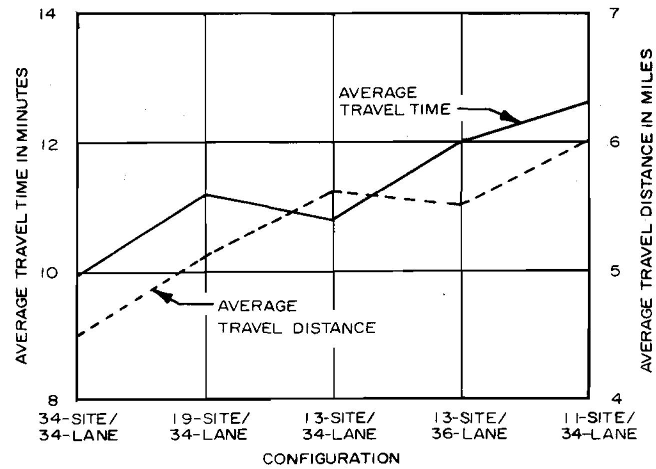
AVERAGE ONE-WAY TRIP LENGTHS FOR THE 11-SITE/34-LANE INSPECTION AND EMISSION TEST FACILITIES

Facility	Number of Lanes	Average One-Way Trip Length	
		Minutes	Miles
1	1	11.3	5.6
2	1	15.8	10.3
3	3	14.6	9.6
4	4	13.0	6.5
5	2	14.1	8.2
6	6	11.1	4.7
7	5	13.6	3.8
8	6	11.3	5.1
9	2	8.1	2.8
10	2	7.7	3.1
11	2	21.7	14.8
Region	34	12.6	6.0

Source: SEWRPC.

Figure 4

AVERAGE TRAVEL TIME AND AVERAGE TRAVEL DISTANCE FOR THE FIVE VEHICLE INSPECTION AND EMISSION TEST FACILITY ALTERNATIVE CONFIGURATIONS



Source: SEWRPC.

Table 10

SUMMARY OF TRAVEL CHARACTERISTICS FOR THE VEHICLE INSPECTION AND EMISSION TEST FACILITY ALTERNATIVE CONFIGURATIONS

Alternative Configurations		Average Travel Time		Average Trip Length		
Number of Facilities	Number of Lanes	Time (minutes)	Range (minutes)	Length (miles)	Range (miles)	Total Vehicle Miles Traveled
34	34	9.9	19.5	4.5	14.6	5,483,000
19	34	11.1	15.4	5.1	14.5	6,208,000
13	34	10.8	11.7	5.6	10.9	6,825,000
13	36	12.0	9.3	5.5	8.0	6,669,000
11	34	12.6	14.0	6.0	12.0	7,271,000

Source: SEWRPC.

test lane and test facility network alternatives for the Southeastern Wisconsin Region so as to identify a configuration of facilities that would reasonably minimize aggregate vehicle travel time and travel distance to the emission test facilities. Five alternative test facility networks, each based on various lane configurations using a maximum of 36 emission test lanes, were prepared and evaluated. In addition to an evaluation of each alternative network on the basis of the average one-way trip length as measured in both time and distance, and taking into consideration the ranges of these averages, the size and shape of each tributary service area for each test facility under each of the five alternative networks were examined.

The initial alternative test network of 34 single lanes at 34 individual sites, as would be expected, exhibited the lowest mean vehicle travel time and travel distance. This network also resulted in the greatest range in both travel time and travel distance. The second alternative test network of

34 test lanes at 19 individual test facilities produced an increase in mean travel time and distance, but a decrease in the range of each factor. A further aggregation of 34 test lanes into 13 test facilities slightly reduced the mean travel time but produced an increase in mean travel distance. Because of the limitations of single-lane test facilities, particularly those associated with equipment down time, the first three alternatives—each of which contained a number of single-lane configurations—were removed from further consideration as the recommended vehicle emission test network. The fourth test network alternative, also calling for 13 test sites but with an additional two test lanes, for a total of 36 lanes, resulted in an increase in mean travel time to the highest value of the four alternatives, but a slight decrease in mean travel distance. The final test network configuration was based on the aggregation of 34 test lanes into 11 test facilities. Under this configuration, mean travel time and mean travel distance reached the highest values of the five alternative network designs, indicating that fewer facilities would further increase user inconvenience.

Chapter IV

RECOMMENDED CONFIGURATION AND LOCATION OF MOTOR VEHICLE INSPECTION AND EMISSION TEST FACILITIES

INTRODUCTION

The five test facility alternatives described in the previous chapter were based upon a numerical analysis using a computer locational algorithm which established the initial pattern of test facility locations as well as all succeeding locations. The basic initial input into the computer program was a logical grouping of single-lane test facilities into multi-lane test facilities. Once this grouping was established, the algorithm determined the location of the test facilities based upon numerical evaluations. Although the computer-generated analysis was considered to be a useful analytical tool in determining the comparative strengths and weaknesses of various alternative facility configurations, it was considered to have certain shortcomings. Important among these is the fact that the Region is not a uniform plane with equal access to all points as assumed in the model construct. Further, vehicle trips are not made in a random pattern about a point; rather, trips which are made from a point tend to have a definite focus or pattern. Accordingly, the recommended plan for the configuration of an emission test facility network, although based primarily upon the results of the computer-generated locational pattern, represents a modification of that pattern to account for the characteristics of the street and highway network in the Region, as well as the documented trip-making pattern of the resident population, and included consideration of the land use, urban infrastructure, and support services necessary for the operation of the emission test facilities. Based on these factors, a final recommended locational plan was developed for the Region and is presented in this chapter.

Based on analysis of the five emission test network alternative configurations and their associated tributary service areas as described in Chapter III of this report, the recommended test facility network for southeastern Wisconsin was developed based upon refinements and modifications to the 13-site/36-lane test configuration. The 13-site/36-lane alternative was selected as the basic network because it contained no one-lane test facilities and because the analyses indicated further reduction in the number of test facilities. That is, the 11-site network may be expected to be characterized by an increase in both average travel time and average travel distance when compared with the 13-site alternative. Modifications were made in the basic network, taking into consideration the additional factors of existing and planned land use, the existing urban infrastructure, including the availability of sanitary sewerage and water supply facilities and police and fire protection services, major arterial highway network characteristics, and the known trip-ending patterns of the resident population of each test facility tributary service area.

RECOMMENDED PLAN

The basic 13-site/36-lane configuration was modified to eliminate all four-lane test facilities, thereby reducing traffic and queuing congestion at large multi-lane facilities, and two test facilities were added in order to reduce the size of the tributary service areas and/or test demand of the proposed four-lane facilities in the 13-site alternative. As shown on Map 8, a two-lane, two-position test facility, number 14, was added in western Waukesha County, absorbing part of the tributary service area of Facilites 2, 3, and 6 of the 13-site alternative.[1] The service area of Facility 3, in turn, absorbed a portion of the service area of Facilities 9, 10, and 13. As may be seen in Table 11, this modification reduced the average one-way travel time for the service area of Facility 3 from 15.9 to 12.2 minutes. Facility 15, a two-lane, three-position facility, was added in northeastern Milwaukee County from tributary service areas 7 and 8 of the 13-site/36-lane alternative. This modification reduced Facilities 7 and 8 of the 13-site alternative from four 3-position test lane facilties to three 3-position test lane facilities. Although the

[1] *Because of the assumed desirability of having no inspection and emission test facility with a single test lane, those tributary service areas with lower test demands were designed using the lower test capacity, two-position test lanes.*

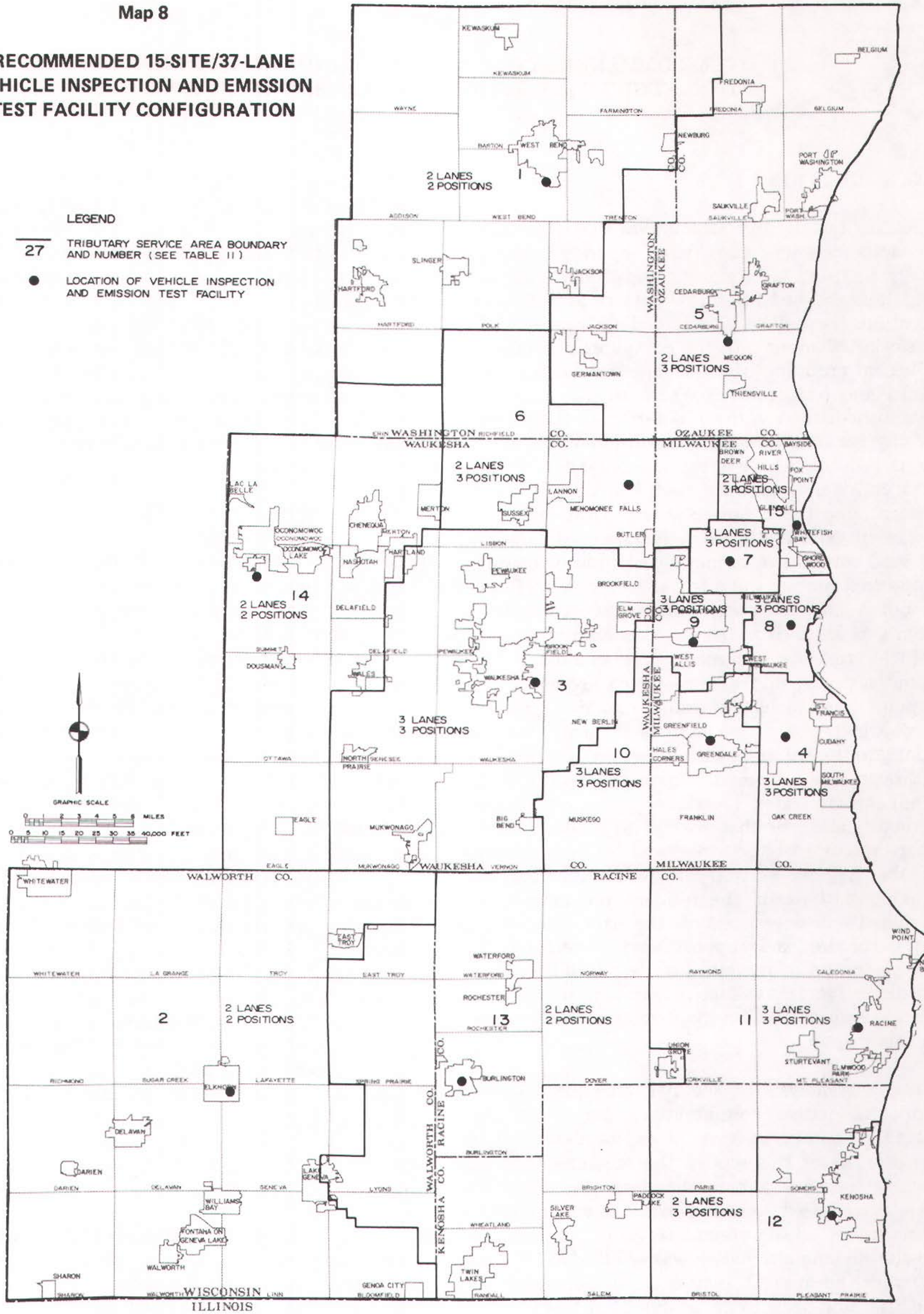
Map 8

RECOMMENDED 15-SITE/37-LANE VEHICLE INSPECTION AND EMISSION TEST FACILITY CONFIGURATION

LEGEND

27 — TRIBUTARY SERVICE AREA BOUNDARY AND NUMBER (SEE TABLE II)

● LOCATION OF VEHICLE INSPECTION AND EMISSION TEST FACILITY



Source: SEWRPC.

Table 11

AVERAGE ONE-WAY TRIP LENGTHS FOR THE RECOMMENDED VEHICLE INSPECTION AND EMISSION TEST FACILITIES IN THE REGION

Facility	General Location	Number of Lanes	Average One-Way Trip Length	
			Minutes	Miles
1	West Bend	2[a]	13.3	7.7
2	Elkhorn	2[a]	17.3	11.6
3	Waukesha East.	3	12.2	9.5
4	Milwaukee-Southshore . .	3	9.9	4.1
5	Cedarburg/Grafton	2	13.7	8.5
6	Menomonee Falls	2	9.0	4.6
7	Milwaukee-Northwest . .	3	9.3	2.7
8	Milwaukee-Midtown . . .	3	12.2	2.9
9	Wauwatosa.	3	9.2	3.3
10	Milwaukee-Southwest . .	3	10.5	4.8
11	Racine-South	3	10.7	5.0
12	Kenosha-South	2	8.3	3.4
13	Burlington	2[a]	15.7	9.9
14	Oconomowoc	2[a]	12.7	7.3
15	Milwaukee-Northshore . .	2	9.6	3.9
Region		37	11.2	5.4

[a] *Denotes a two-position test lane.*

Source: SEWRPC.

Table 12

TOTAL VEHICLE MILES TRAVELED AND TOTAL ANNUAL FUEL CONSUMPTION FOR ALTERNATIVE EMISSION TEST FACILITY LOCATIONS IN THE REGION

Alternative Configuration	Annual Total Vehicle Miles Traveled	Annual Estimated Fuel Consumption[a] (gallons)	Annual Estimated Fuel Costs[b]
34-Site/34-Lane	5,483,000	386,100	$463,400
19-Site/34-Lane	6,208,000	437,200	524,600
15-Site/37-Lane	6,511,000	458,500	550,200
13-Site/34-Lane	6,825,000	480,600	576,700
13-Site/36-Lane	6,669,000	469,600	563,500
11-Site/34-Lane	7,271,000	512,000	614,400

[a] *Estimates based upon an assumed fleet average of 14.2 miles per gallon.*

[b] *Estimates based upon an assumed fuel cost of $1.20 per gallon.*

Source: SEWRPC.

average one-way travel time from tributary service area 7 increased from 8.8 to 9.3 minutes, the average mean one-way travel time for tributary service area 8 decreased by 2.0 minutes, from 14.2 to 12.2 minutes. In addition, the average one-way trip length decreased for both service area 7 and service area 8 from 3.3 to 2.7 miles and 3.4 to 2.9 miles, respectively.

Table 11 shows the average driving time and average trip distance required to reach each of the 15 facilities in the recommended network. The average one-way trip time for all facilities is 11.2 minutes, an average which is considerably less than the average journey to work time in the Region of 17.9 minutes while closely approximating the average shopping trip length of 11.6 minutes. Shopping trips are the shortest trips made in the Region. The average trip time of 11.2 minutes for the recommended test network does represent an increase of 1.3 minutes, or 13 percent, over the initial 34-site/34-lane network alternative. However, the number of facilities is reduced from 34 to 15, a reduction of 19 facilities, or 56 percent. It should also be noted that the longest average trip time in the recommended network, 17.3 minutes, is still less than the average journey to work time. The average trip distance for the recommended network of 5.4 miles is equal to the average journey to work distance recorded in the Region. This average trip distance represents an increase of 0.9 mile, or 20 percent, over the initial 34-site/34-lane network trip distance of 4.5 miles. The 15-site/37-lane test facility network thus appears to balance the need to minimize driving time and distance while reducing the total number of test facilities required.

As may be seen in Table 12, an estimated 6.5 million vehicle miles of travel to the emission test facilities, including trips for retesting, will be required annually under the recommended 15-site network. Based on an assumed vehicle fleet average of 14.2 miles per gallon of gasoline and a cost of $1.20 per gallon, the total annual fuel consumption for the recommended test network is approxmately 459,000 gallons at an estimated cost of $550,000.

In order to more objectively evaluate the five alternative vehicle emission test site/lane configurations and the recommended configuration, five relevant criteria were chosen as surrogate measures of inconvenience: average travel time, range of travel time between all tributary service areas, average trip length, range of trip length between all tributary service areas, and total vehicle miles traveled to reach the emission test facilities. To aid in the evaluation of this set of criteria, a weighted score ranging from 1 to 6 was assigned in rank order, with the value of 1 being the most favorable

Table 13

COMPARISON OF TRAVEL CHARACTERISTICS FOR ALTERNATIVE AND RECOMMENDED EMISSION TEST FACILITY CONFIGURATIONS

Alternative Configurations		Average Travel Time				Average Trip Length						
Number of Facilities	Number of Lanes	Time (minutes)	Rank	Range (minutes)	Rank	Length (miles)	Rank	Range (miles)	Rank	Total Vehicle Miles Traveled	Rank	Total Rank Score
34	34	9.9	1	19.5	6	4.5	1	14.6	6	5,483,000	1	15
19	34	11.1	3	15.4	5	5.1	2	14.5	5	6,208,000	2	17
15	37	11.2	4	9.0	1	5.4	3	8.9	2	6,511,000	3	13
13	34	10.8	2	11.7	3	5.6	5	10.9	3	6,825,000	5	18
13	36	12.0	5	9.3	2	5.5	4	8.0	1	6,669,000	4	16
11	34	12.6	6	14.0	4	6.0	6	12.0	4	7,271,000	6	26

Source: SEWRPC.

and the value of 6 the least favorable. The rank scores for these five criteria were then summed for each site/lane network configuration. Using this procedure, the best score possible is 5, indicating the best possible alternative, while the poorest score is 30, indicating the least desirable alternative. As may be seen in Table 13, based upon this relatively simple evaluative procedure the 15-site/37-lane recommended configuration ranks first with a total of 13 points. This score indicates that, based upon five criteria for evaluating these six site/lane configurations, the recommended emission test facility network is the most efficient overall in terms of user inconvenience.

EVALUATION OF THE RECOMMENDED PLAN

Because of the possible lack of available suitable land for the location of an inspection and emission test facility—with associated access roads, queuing lanes, and parking areas—it was deemed appropriate to specify a general area, rather than a specific site, as the recommended location for the emission test facilities. Thus, as shown on Map 9 and in Table 14, the inspection and test facilities are recommended to be established in nine U. S. Public Land Survey quarter sections. In locating facility sites within these areas, careful attention will have to be given to local land use plans and zoning requirements. Generally, commercially and industrially zoned areas will be best suited for the location of the facilities.

It will also be necessary to ensure that there is adequate access from the testing facilities to the existing arterial street and highway network. The arterial streets and highways which serve each emission test facility area are presented in Table 14. It should be noted that all recommended general site areas are adequately served by arterial street and highway facilities and, with proper consideration to the location and design of the ingress and egress drives, may be expected to accommodate the traffic demand associated with vehicle inspection and emission tests.

The 15 areas recommended as test facility locations were evaluated for compliance with the statutory restriction that no test facility be located within one-half mile of a carbon monoxide monitor that recorded a violation of the national ambient air quality standard between 1976 and 1979. Of the 15 recommended areas, only one—that designated as the Milwaukee Midtown Test Facility—was located within one-half mile of a carbon monoxide monitor. This monitor, located in U. S. Public Land Survey Section 29 of Township 7 North, Range 22 East, recorded a violation of the eight-hour carbon monoxide standard in 1977. However, considering the area encompassed within the nine quarter sections recommended for the inspection and emission test facilities, location of this test facility site more than one-half mile from the monitor location should be possible.

Based on the forecast peak monthly demand of approximately 118,500 tests, including retests—with light-duty truck emission tests distributed over a 12-month period rather than concentrated in January—the 15-site/37-lane recommended network meets the test demand requirements. Using the 40-hour-per-week operating schedule, the recommended test facility network could perform 119,600 tests on a monthly basis, a capacity adequate to meet the estimated emission test demand in the Region.

SUMMARY

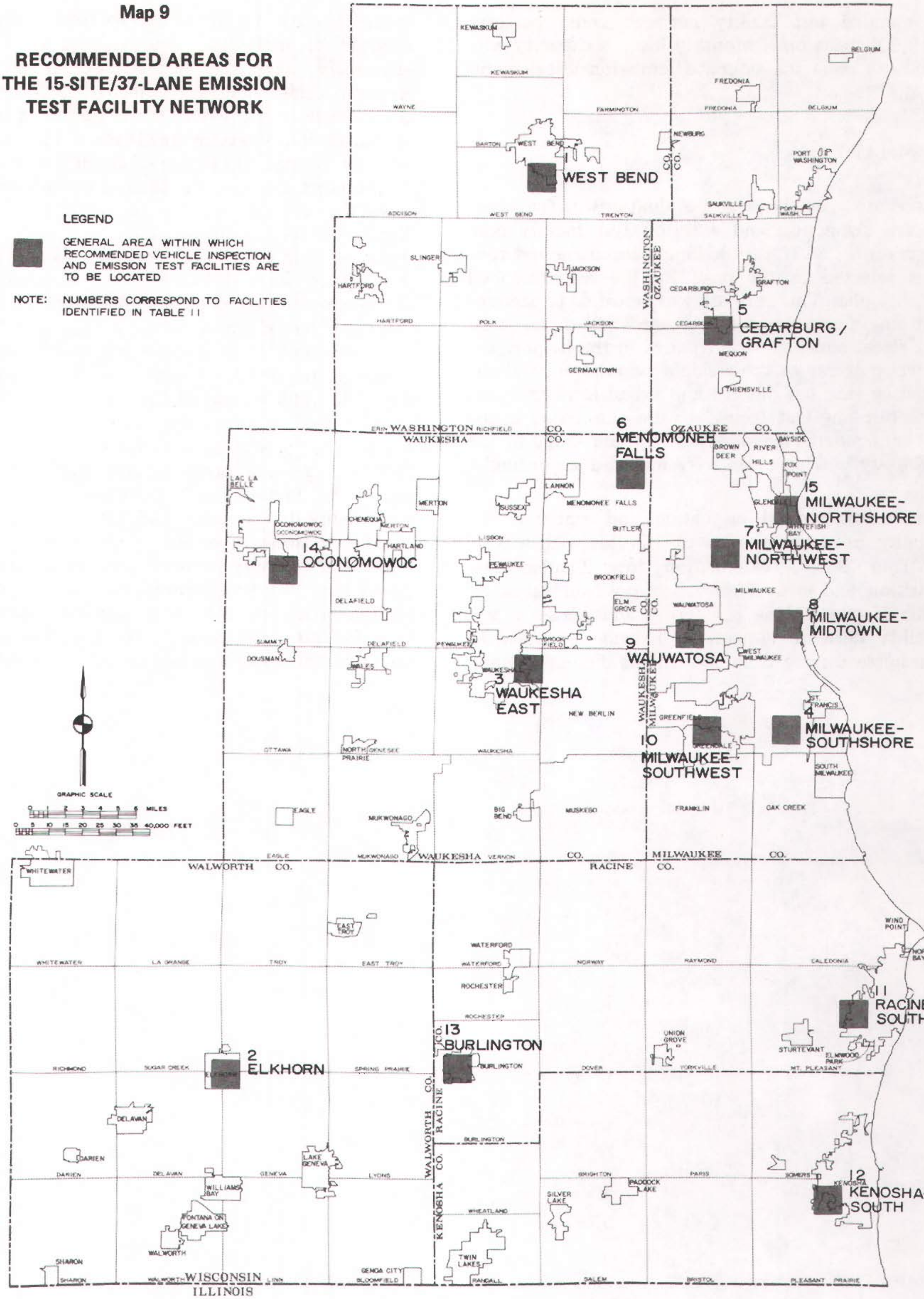
Based upon analyses and evaluations of five alternative inspection and emission test facility configurations, a 13-site/36-lane alternative network was selected as the basis for the recommended facility plan. This network was modified to account for such factors as the characteristics of the existing street and highway network in the Region, the travel patterns of the resident population, and the existing land use pattern and urban infrastructure. All four-lane test facilities were eliminated in the recommended plan and the size and shape of the tributary service areas were adjusted accordingly.

The recommended inspection and emission test facility network consists of 15 sites with a total of four 2-lane, two-position, four 2-lane, three-position, and seven 3-lane, three-position test lanes. This 15-site/37-lane inspection and emission test facility network appears to balance the need to minimize driving time and driving distance to and from the test facilities and to reduce the total number of individual test facilities required to efficiently serve the vehicle population of the Region. Under the recommended network plan, the average over-the-road travel time to a test site within a tribuary service area is about 11.2 minutes, with an average trip length of about 5.4 miles. The 11.2-minute average trip time is considerably less than the average journey to work time in the Region of 17.9 minutes, and the average driving distance of 5.4 miles is the same as the average journey to work distance in the Region. Under the recommended plan, an estimated 6.5 million vehicle miles of travel to the emission test facilities, including trips to retesting, will be required annually, requiring, in turn, the consumption of about 459,000 gallons of fuel.

Rather than specifying sites for each of the 15 test facilities, general areas within which the sites should be located were designated. These areas were delineated as nine U. S. Public Land Survey quarter sections. A review of the existing arterial street and highway network and existing and proposed land use development for the nine quarter section areas indicated that adequate transportation facilities are available to meet the requirements of the inspection and emission test facilities.

Map 9

RECOMMENDED AREAS FOR THE 15-SITE/37-LANE EMISSION TEST FACILITY NETWORK



Source: SEWRPC.

Table 14

ARTERIAL AND HIGHWAY SERVICE TO INSPECTION AND EMISSION TEST FACILITY SITE AREAS

Site	Facilities Serving Site
1. West Bend Located in the southern area of the City of West Bend	USH 45, CTH I (Decorah Street, City of West Bend) Indiana Drive, City of West Bend Paradise Drive, City of West Bend 7th Avenue, City of West Bend 18th Avenue, City of West Bend
2. Elkhorn Located in the southeast area of the City of Elkhorn	USH 12 (through its interchanges with STH 15 and CTH NN) STH 15 (through its interchange with STH 67) STH 11, STH 67 CTH H, CTH NN Lincoln Street, City of Elkhorn
3. Waukesha East Located in the eastern area of the City of Waukesha	CTH A CTH D (Sunset Drive and Cleveland Avenue) CTH Y (Racine Avenue) College Avenue, City of Waukesha Perkins/Genesee/Frederick Streets, City of Waukesha Sunset Drive, City of Waukesha
4. South Shore Located due west of General Mitchell Field in the City of Milwaukee	IH 94 (through its interchanges with Layton Avenue and W. College Avenue) STH 38 (Howell Avenue) College Avenue, City of Milwaukee Grange Avenue, City of Milwaukee Layton Avenue, City of Milwaukee S. 13th Street, City of Milwaukee
5. Cedarburg/Grafton Located in the north central area of the City of Mequon	STH 57 CTH C (Pioneer Road) CTH N (Wauwatosa Road) Green Bay Road, City of Mequon Hamilton Road, City of Mequon Boniwell Road, City of Mequon
6. Menomonee Falls Located in the eastern part of the Village of Menomonee Falls	STH 175 Fond du Lac Avenue, Village of Menomonee Falls Good Hope Road, Village of Menomonee Falls Menomonee Avenue, Village of Menomonee Falls Pilgrim Road, Village of Menomonee Falls Sunny Slope Road, Village of Menomonee Falls
7. Milwaukee Northwest Located in northwestern Milwaukee County	USH 41, STH 41, STH 190 Hampton Avenue, City of Milwaukee Fond du Lac Avenue, City of Milwaukee N. 43rd Street (Sherman Boulevard), City of Milwaukee N. 60th Street, City of Milwaukee W. Congress Street, City of Milwaukee W. Keefe Avenue, City of Milwaukee N. 68th Street, City of Milwaukee
8. Milwaukee Midtown Located in the Milwaukee central business district	IH 43, IH, 94, IH 794 1st Street, City of Milwaukee 2nd Street, City of Milwaukee 6th Street, City of Milwaukee St. Paul Avenue, City of Milwaukee Clybourn Street, City of Milwaukee Wisconsin Avenue, City of Milwaukee Wells Street, City of Milwaukee State Street, City of Milwaukee Highland Boulevard, City of Milwaukee 12th Street, City of Milwaukee 13th Street, City of Milwaukee 3rd Street, City of Milwaukee Water Street, City of Milwaukee Milwaukee Street, City of Milwaukee Broadway Street, City of Milwaukee Jackson Drive, City of Milwaukee Van Buren Street, City of Milwaukee Prospect Avenue, City of Milwaukee Astor Street, City of Milwaukee Harbor Drive, City of Milwaukee
9. Wauwatosa Located in the western portion of Milwaukee County	IH 94 (at its interchange with S. 84th Street) IH 894 (at its interchange with Greenfield Avenue) USH 45 (at its interchange with Bluemound Road and Wisconsin Avenue) USH 18 STH 59, STH 181 76th Street, Cities of West Allis, Wauwatosa, Milwaukee 92nd Street, Cities of West Allis, Milwaukee
10. Milwaukee Southwest Located in the Southridge area of Milwaukee County	IH 894 (at its interchanges with 84th, 76th, and 60th Streets) STH 24 Layton Avenue, City of Greenfield Grange Avenue, Village of Greendale STH 36 60th Street, City of Greenfield, Village of Greendale 76th Street, City of Greenfield, Village of Greendale 84th Street, City of Greenfield, Village of Greendale
11. Racine South Located in the western portion of the City of Racine	STH 20, STH 31 Lathrop Street, City of Racine Ohio Street, City of Racine Emmertson Road, City of Racine Graceland Boulevard, City of Racine 16th Street, City of Racine 21st Street, City of Racine
12. Kenosha South Located in the southwestern portion of the City of Kenosha	STH 31, STH 50 CTH EZ 39th Avenue, City of Kenosha 52nd Avenue, City of Kenosha 80th Street, City of Kenosha 85th Street, City of Kenosha
13. Racine West Located in the southern part of the City of Burlington	STH 11, STH 36, STH 83, STH 142 CTH P, CTH W
14. Oconomowoc Located in the southeastern part of the City of Oconomowoc	IH 94 (at its interchange with STH 67) STH 67 CTH B
15. Milwaukee North Shore Located in the area surrounding the Bay Shore Shopping Center	IH 43 STH 32 Silver Spring Drive, City of Glendale, Village of Whitefish Bay Bender Road, City of Glendale Port Washington Road, City of Glendale

Source: SEWRPC.

(This page intentionally left blank)

Chapter V

SUMMARY

INTRODUCTION

The objective of this study, undertaken at the request of the Wisconsin Departments of Natural Resources and Transportation, was to design and recommend the configuration and general location of the test facilities network required to implement a motor vehicle air pollution control equipment inspection and emission test program in the seven-county Southeastern Wisconsin Region. The motor vehicle inspection and maintenance (I/M) program is intended to aid in attaining and maintaining the ambient air quality standards for carbon monoxide and ozone in the Region by identifying and adjusting or repairing, as necessary, the air pollutant emission control devices on those motor vehicles that are found by the test program to exceed established tailpipe exhaust emission limitations.

A critical factor in the efficiency and public acceptance of an I/M program is a properly designed inspection and emission test facility network which has sufficient test sites and adequate test lane capacity to meet the anticipated test demand, and which is located in such a manner so as to produce a minimum of user inconvenience. The inspection and emission test facility network recommended in this study is designed to meet these objectives.

DESIGN OF THE STUDY

The basic design of a centralized program of conveniently located emission test facilities includes such considerations as the number and the spatial and temporal distribution of testable vehicles subject to the I/M program, and the ability of strategically located test facilities to accommodate the anticipated vehicle test demand.

Two basic test lane configurations were considered for the program: a two-position lane requiring three minutes at each position in the lane, and a three-position lane requiring two minutes at each position. Based on an operating schedule of 40 hours per week for 52 weeks per year at an operating efficiency of 67 percent, a two-station lane has an annual test capacity of approximately 27,900 vehicles and a three-lane station an annual test capacity of approximately 41,800 vehicles.

The testable vehicle fleet estimated for the program design is based on estimates attendant to the 1985 stage of the "no build" regional transportation system plan. All registered light-duty gasoline vehicles—that is, automobiles and light-duty trucks with a gross weight of 8,000 pounds or less—in the seven-county Southeastern Wisconsin Region, with certain exceptions, are to be subject to the annual inspection and emission test. Accordingly, the 1985 forecast of vehicles available for use within the Region on an average weekday was factored upward by 1.11 for automobiles and 1.06 for light-duty trucks to represent the number of registered vehicles in the Region.

The forecast number of registered automobiles in 1985 is about 975,000, and the number of light-duty trucks is approximately 81,600. These totals were adjusted to remove those vehicles not subject to the emission test—specifically, those vehicles more than 15 years old and those using diesel fuel. Based on these adjustments, the forecast of testable vehicles in the Region in 1985 is approximately 922,700 automobiles and 73,500 trucks. When this forecast population of testable vehicles is adjusted to account for an assumed test failure rate of 20 percent, the resulting vehicle emission test demand is approximately 1,235,000 annually. Assuming the use of three-position test lanes in the program design, 34 test lanes will be required to meet the 1985 annual inspection and emission test demand in the Region. Inspection and emission test facilities must be designed not only to meet the total annual test demand, but also to meet the capacity of any peak monthly test demand. Vehicle registration files for 1979, provided to the Commission by the Wisconsin Department of Transportation, indicated that the peak automobile registration occurred in May, and that about 70 percent of the light-duty truck registrations occurred in January. Because this significant peak in registrations in January would require a total of 47 test lanes, 13 more lanes than required to meet the total annual test demand, it is recommended that an alternative procedure to testing all light-duty trucks during the month of January be developed.

The spatial distribution of the vehicle emission test demand was established using the vehicle distribution and utilization pattern attendant to the 1985 stage of the "no build" regional transportation system plan. The vehicle population forecast attendant to that plan was assigned to 375 spatial units based on the Commission's planning analysis areas (PAA) and traffic analysis zones (TAZ). Having established that 34 test lanes would be necessary to meet the regional emission test demand, and having determined the spatial distribution pattern of vehicles in the Region, a computer location-allocation program (LAP) was used to aggregate the test lanes into test facilities of two or more lanes, and to determine the spatial location of those test facilities in order to minimize user travel in terms of both time and distance.

Additional considerations in the system design included the use of single-lane facilities only under unusual circumstances, compliance with the legislated restriction that no test facility be located within one-half mile of a carbon monoxide ambient air quality monitor which had recorded a violation of the established standards between 1976 and 1979, and the determination that all recommended facility site locations are adequately served by arterial street and highway facilities, and that all facilities are in compliance with local land use plans and zoning ordinances of land use and arterial and highway networks associated with the recommended facility site locations.

RECOMMENDED PLAN

Using the design objectives and criteria to develop an optimal lane capacity and location for the vehicle inspection and emissions test facility network, five computer-generated network alternatives were developed using the location-allocation program. The three initial test network designs were developed using 34 test lanes at 34, 19, and 13 sites. Because each of these three alternatives contained at least one single-lane test facility, an additional network configuration, a 13-site/36-lane network, was produced which eliminated all one-lane test facilities. The fifth test network design further reduced the number of test facilities to 11 sites with 34 lanes, but a trend of increasing travel time and distance with the reduction in the number of test sites was indicated, and thus no further reduction in the number of test facilities was attempted.

The recommended configuration and location plan for the motor vehicle inspection and emission test facilities network, as shown on Map 9 and described in Table 11, was developed based on refinements and modifications to the 13-site/36-lane test facility design. Adjustments to the computer-generated site solutions were made so as to better account for the street and highway network, land use, and urban infrastructure characteristics of the Region. The recommended test facility locations identified in this report are defined as general areas rather than as specific sites. The actual location of the test facilities within the recommended areas—each approximately 2.25 miles in areal extent—will be significantly influenced by local zoning regulations.

The recommended inspection and emission test facility network contains eight 2-position and 29 three-position test lanes distributed at 15 individually and strategically located emission test sites. This test facility network design is characterized by an average one-way trip length of 5.4 miles requiring an average of 11.2 minutes driving time. The 5.4-mile average one-way trip length is the same as the average journey to work distance in the Region, and the 11.2-minute average driving time is considerably less than the 17.9-mile average journey to work driving time, and even less than the average shopping trip driving time of 11.6 minutes. Based on these two measures of user inconvenience—plus the range in average travel time and distance and total vehicle miles traveled—the recommended 15-site/37-lane facility plan appears to represent an efficient test facility network capable of serving the peak monthly demand of approximately 118,500 emission tests while meeting the other objectives of the study design.

CONCLUSION

An important element of an efficient and publically acceptable I/M program is an inspection and emission test facility network that is designed so as to make optimum use of individual test facilities and yet result in a minimum of inconvenience for the vehicle owner. This plan recommends a 15-site test network consisting of 37 test lanes that is capable of meeting the peak monthly demand of approximately 118,500 emission tests while producing a minimum of user inconvenience as measured by average travel distance and travel time.