Highway Maintenance

January 1985

Program Evaluation Division
Office of the Legislative Auditor
State of Minnesota

Program Evaluation Division

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PREFACE

In May 1984, the Legislative Audit Commission directed the Program Evaluation Division to study highway maintenance by the Minnesota Department of Transportation. Our study focused on broad issues of management and decision making and did not directly address the productivity of the department's maintenance workers or the quality of their work. We think this report will be useful to the department and the Legislature in developing management tools to assist the department in the maintenance and preservation of Minnesota's state highway system.

We thank the staff of the Department of Transportation for their full cooperation. We were impressed by the professionalism, dedication, and openness of the department's central office and field managers. In particular, we found them concerned and knowledgeable about the importance of highways to the economic health of the state and its regions.

This report was written by Joel Alter, Allan Baumgarten (project manager), and Thomas Hiendlmayr.

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January 24, 1985

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Executive Summary

The Minnesota Department of Transportation (MnDOT) maintains the state's 12,100 mile trunk highway system. Our study examined how the department manages highway maintenance. We asked:

- Does the department manage its maintenance resources efficiently and effectively? Are its budgets, work plans, and staffing decisions based on a systematic analysis of maintenance needs?
- Are the department's decisions on certain improvements to highways based on adequate data and appropriate criteria?

A. BUDGET AND ORGANIZATION

In 1984, the department had a maintenance budget of $102 million. The department also spent $7.5 million on the Maintenance Preservation Program and another $35 million in state funds for highway resurfacing and reconditioning projects.

Highway maintenance is labor intensive: nearly two-thirds of the budget is spent on labor. The department employs nearly 2,300 maintenance workers, supervisors, and support staff.

Highway maintenance is highly decentralized and all but 100 employees work in field operations. The Department of Transportation organizes its field operations into nine districts, which are further divided into 15 maintenance areas and 75 sub-areas. Field supervisors have significant authority to budget resources and schedule work.

B. MANAGEMENT OF MAINTENANCE RESOURCES

The Minnesota Department of Transportation lags behind highway agencies in other states in its ability to effectively manage highway maintenance. Past efforts to implement maintenance standards and more systematic management methods in Minnesota have been unsuccessful.

Almost all states have implemented highway *maintenance management systems.* A maintenance management system is a systematic way to manage resources and establish a standard of service by planning work, performing it, and reporting accomplishments. It can be a powerful tool for analyzing work needs, developing budgets, allocating staff and funds, planning and scheduling work, and evaluating productivity and quality.

MnDOT does not have such a system and could benefit from better program and budget information.

1. COST ACCOUNTING

In order to budget its maintenance operations, MnDOT should know the full costs of maintenance activities, including labor, equipment, materials, and administrative overhead. However, we found:

- The department is unable to usefully calculate its costs of highway maintenance.

The department's cost accounting system does not report the full costs of maintenance in a useful way. For example, because the system does not relate hours of labor or quantities of materials to work accomplished, it cannot report unit costs for maintenance activities. Furthermore, the department's approach to managing its maintenance resources hinders its ability to understand the costs of maintenance. For example,

- Department managers usually view personnel expenditures--the largest item in the maintenance budget--as a fixed cost.

To calculate the cost of blacktop overlay, a maintenance manager will typically consider the cost of materials and the rented paving machine and operator, but not the maintenance crew's labor and preparation time. Similarly, districts are not required to budget for the full costs of acquiring and operating major pieces of equipment.

2. BUDGETING

Maintenance area budgets are largely based on past expenditures, adjusted for inflation and sometimes reflecting proposed special projects. We found that:

- Area maintenance budgets are generally not based on work plans, an analysis of maintenance needs, or anticipated repair work.

While area maintenance managers do prepare annual work plans for certain activities, their budget requests do not project the quantity of work that will be performed or detail the resources needed to perform those tasks.

Snow and ice control is the most unpredictable element in the maintenance budget. In 1981, a mild winter, only 16.7 percent of the state maintenance budget was spent for snow and ice control. The winter of 1982 was more severe and snow and ice control spending increased to 29.2 percent of budget. Despite the volatile nature of snow and ice control, maintenance budgets and work plans are developed around it.

We found that in practice:

- A maintenance area's operating budget for working on the roadway surface and shoulders is determined by how much money is left after spending for snow and ice control.

After a mild winter, a maintenance area has additional funds to spend. In recent years, however, many areas experienced severe winters. When budget lines for overtime, sand, and salt were depleted, area managers transferred funds from budget lines for roadway materials needed for spring work. These areas entered the spring with a full complement of maintenance workers but little money for materials, such as bituminous asphalt or gravel. Needed repairs to roadways were deferred. Instead, maintenance workers were assigned labor intensive tasks that might otherwise have a low priority, such as litter pickup or planting trees at the maintenance headquarters.

3. STAFFING

Since the early 1970s, the department has allocated most of its maintenance workers to maintenance areas on the basis of its snow and ice formula. The formula calculates the number of snow plows and operators that will be needed in each area to maintain a standard of snow plowing. We identified several problems with the department's reliance on this formula. First,

- The formula allocates the department's most important resource--maintenance workers--without consideration of the actual workload for snow removal or other maintenance activities.

The formula does not account for variations in winter activity from year to year and in different parts of the state. These differences result from variations in weather conditions, difficulty of snow removal, and staff productivity.

A second problem with the formula is that it results in a high level of staffing for a small number of peak periods during the winter. The formula calculates the number of plows and drivers needed during winter snow storms. However, there are only a few such storms in the average winter, and additional plowing is usually not urgent. Furthermore, the formula does not consider actual summer levels of activity. As a result, the two metro area districts receive more maintenance workers than they can fully use in the summer.

In other states and in some Minnesota cities, highway departments base their maintenance staffs on year-round average work loads. They meet peak winter needs by having permanent staff work overtime and by calling in additional drivers trained in snow plowing.

4. MAINTENANCE MANAGEMENT SYSTEMS

We conclude that MnDOT needs the budgeting and decision-making support that a well-designed and implemented maintenance management system can provide. With such a system, the department would have data about its costs and the results of maintenance. The data could be used to evaluate productivity, improve planning and scheduling of future work, and support investment decisions for highway improvements.

If the department were to implement such a system it would have to make a major commitment to collecting and organizing data on the physical features of the state's roads, and to tracking maintenance costs. A system would also require additional investment in data processing and analysis support within the department so that managers at all levels would use the information effectively.

C. WHO SHOULD PERFORM MAINTENANCE?

We looked at ways in which the department could smooth the fluctuations of its maintenance workload. One option is contracting with private firms or local governments to maintain state highways. A few states and Canadian provinces contract for a large portion of their maintenance. Even though state employees' unions and others oppose contracting for maintenance, we think it is important to understand the role contracting can play in maintaining highways.

MnDOT already uses maintenance contracts in limited ways. For example, 25 cities contract with the state to perform most routine maintenance on state highways within their borders. A private organization employing senior citizens maintains many highway rest areas. Some districts contract with private firms to stockpile gravel or to blacktop roads.

In 1982, the Legislature expressed an interest in hiring more private contractors for highway maintenance. To test the effectiveness of contracting, the department prepared four pilot projects and accepted bids. Three of the projects involved only one or two activities, such as snow and ice control or shoulder rehabilitation. The fourth project was for total maintenance of a section of highway. The department did not award the fourth contract because all bids were much higher than the department's estimate of costs.

The department's experience with these pilot projects, and in particular the total maintenance contract, led some to conclude that maintenance by contract is not a useful and cost-effective option. We reached much different conclusions. First,

- The pilot projects demonstrated the department's inability to calculate its own costs of maintenance.

The department had trouble in preparing bid specifications and in estimating an appropriate cost for the projects. It could not usefully compare its costs to a contractor's bid. Second,

- Evaluations showed that the contractors' quality of work was generally comparable with MnDOT crews' performance on nearby sections, although contractors sometimes used inefficient methods to achieve these results.

In fact, the performance standards and evaluation methods developed for the pilot projects were unique for the Department of Transportation. In general, the department does not formally evaluate the quality of its own maintenance work and the productivity of its own maintenance crews.

D. PAVEMENT MANAGEMENT

Accurate assessments of pavement condition are needed for good highway investment decisions. MnDOT uses a pavement condition rating based on two components: an objective, machine-measured rating of ride smoothness, and a subjective rating of visible pavement defects made by field observers in each district.

Although districts have collected condition ratings since 1966, it was only in 1982 that the department began to assess the uniformity and reliability of the ratings. In recent tests of rating reliability, the department found that different raters gave sample road sections a very wide range of ratings. The average range was 1.6 points on a 4.5 point scale.

The department's Program Management Division evaluates and approves highway improvement projects. The division divides these projects into eleven funding categories, including resurfacing and reconditioning. Condition ratings are heavily weighted in the department's ranking formulas for resurfacing and reconstruction projects.

In this report, we raise several questions about the department's project ranking formulas, particularly the use of condition ratings. In our view,

- The department relies too heavily on the condition rating in selecting resurfacing and reconditioning projects, which may lead to selecting projects which are not cost-effective.

Condition ratings may be unreliable and may give an incomplete picture of the structural soundness of a road. Also, by emphasizing condition ratings, the department favors the worst roads. This contradicts the preventive maintenance philosophy favored by the department and highway researchers: it is most effective to make investments in a road before it deteriorates significantly. Finally, some districts request resurfacing funds for a road with very low condition ratings that needs reconstruction but will not qualify under the criteria for that program.

We also found that the department project ranking formulas do not adequately measure the cost effectiveness of projects. Thus, we concluded that the Department of Transportation needs a better way to make decisions about how to invest in state roads.

Highway agencies in some other states have developed *pavement management systems* to assist in these decisions. A pavement management system may be thought of as a highway investment strategy. It includes a data base of information about road conditions and features. The system uses models to predict the future condition of the road and economic analysis to compare the effect of different investment decisions.

MnDOT has begun to develop a pavement management system. It has focused its efforts on developing a *network level* system which will help to determine the future needs of the pavement network as a whole. For example, the statewide budget needs for resurfacing in future years is a network level issue. The department's efforts to develop a network-level pavement management system are producing a well-coordinated, computerized data base from which to make decisions. We fully support MnDOT's efforts to develop a pavement management system and encourage the department to use this data to select resurfacing and reconditioning projects.

E. MAINTENANCE PRESERVATION PROGRAM

The department initiated the Maintenance Preservation Program in 1980 to help preserve roads to the end of their design life. For example, the department has identified repairs of joints in concrete highways as a high priority for the Maintenance Preservation Program. Such projects have preservation value because they help prevent future deterioration of the road and avoid the need to replace pavement sections before the road reaches the end of its design life.

In our review of the Maintenance Preservation Program, we found that it illustrates some of the department's problems in making sound investment decisions and in program management.

For example, oversight of the program by the central office has been weak. We found:

- Maintenance Preservation Program files are often inaccurate or incomplete, and the department has only a general idea of where and how funds are spent.

Without this information, the department cannot usefully evaluate whether activities funded through the program comply with the objectives of the program.

Moreover, the purpose of the program is not clear. We found:

- The department has not adequately distinguished the Maintenance Preservation Program from its routine maintenance and highway improvement programs.

As a result, Maintenance Preservation funds are sometimes used by districts to supplement the maintenance program. For example, program funds are used to rehabilitate gravel shoulders or to haul and stockpile gravel. These activities are part of the routine maintenance program.

In other cases, Maintenance Preservation funds are invested in roads which really need a major improvement, but which are not scheduled in the department's improvement programs. For example, districts use program funds to place a blacktop overlay on a seriously deteriorated highway in order to hold it together until it qualifies for an improvement program.

F. RECOMMENDATIONS

In this report, we have identified several areas in which the Department of Transportation needs to improve its management of highway maintenance. In general, we think the department needs to adopt a more systematic approach to maintenance management and highway improvement decisions. We regard the department's managers as competent and professional, and we think they are making important progress in some of these areas. This report offers a series of recommendations for department and legislative action.

We recommend:

- The Legislature should appropriate separate budgets for snow and ice control and for routine maintenance. This would make maintenance funding more stable and help managers to plan and schedule work. The department should maintain a contingency fund to help districts experiencing particularly difficult winters.

- The department should develop and implement a maintenance management system. This system should become the basis for budgeting, allocating staff, and planning work.

- The department should continue to examine the potential for contracting with private firms and local governments for maintenance and should develop additional maintenance by contract projects. It should use data from the maintenance management system to compare its costs with contractors' costs.

- The department should continue its efforts to develop a pavement management system. MnDOT should incorporate pavement management economic analyses into its project selection formula for resurfacing and reconditioning to improve the cost-effectiveness of the projects selected.

- The department should improve its management of the Maintenance Preservation Program and ensure that funds are used for preventive maintenance activities. It should also target funds to poor roads which need special maintenance to remain serviceable until rehabilitation funds become available.

Introduction

Minnesota's system of trunk highways is crucial to the economic vitality of the state. Highways are used by commuters traveling to their offices, farmers shipping grain to market, and tourists on their way to lake resorts. The Minnesota Department of Transportation (MnDOT) maintains the trunk highway system with an annual budget of more than $100 million and a staff of about 2,300 workers.

The Program Evaluation Division has completed a comprehensive evaluation of highway maintenance by the Minnesota Department of Transportation. We examined broad management and decision-making issues. We wanted to know if the department effectively manages its highway maintenance program. We also wanted to know how well the department makes decisions on certain preventive maintenance and improvement programs. During our study, we met with maintenance managers in eight of MnDOT's nine districts as well as administrators in the department's Saint Paul headquarters.

Chapter 1 of this report provides background information about Minnesota's highways, the organization of the Department of Transportation, and state expenditures for maintenance. Chapter 2 analyzes how MnDOT manages its maintenance resources and why it needs a highway maintenance management system. Chapter 3 examines recent efforts to use contractors to maintain roads and their implications for maintenance management. In Chapter 4, we review the objectives, management, and results of the Maintenance Preservation Program, a specially funded program for preventive maintenance work. Chapter 5 presents our review of how the department makes decisions on programming highway improvements and the possible benefits of a pavement management approach. Finally, Chapter 6 presents a discussion of two related issues: maintenance quality and maintenance standards. Several appendices are attached.

Trunk Highway Maintenance: Organization and Budget

Chapter 1

The Minnesota Department of Transportation (MnDOT) is responsible for maintaining Minnesota's 12,100 mile trunk highway system. In 1984, MnDOT spent nearly $102 million on routine maintenance for these highways. This chapter describes the trunk highway system, the Department of Transportation, and expenditures for trunk highway maintenance.

A. MINNESOTA'S HIGHWAYS

There are more than 130,000 miles of public streets and highways in the state of Minnesota. These roads are classified in nine major road systems and numerous smaller ones. Different units of government are responsible for maintaining and financing these systems. Table 1.1 shows the number of miles in each major road system, its use, and the unit of government responsible for maintenance.

The most important roadway systems are the trunk highways, the county state aid highways, and municipal state aid streets. While these systems contain only one-third of total highway miles, they carry 87 percent of the traffic.

1. THE TRUNK HIGHWAY SYSTEM

Our research focused on the state trunk highway system. About one-half of that system is created by the Minnesota Constitution, which provides for a trunk highway system of 70 routes. The location of the routes can be designated and changed by the Legislature. In addition, the Legislature can add routes to the trunk highway system, not to exceed 12,200 miles.

TABLE 1.1

MINNESOTA STREETS AND HIGHWAYS

Government	System	Mileage	% of Miles	% of Travel
State	Trunk Highway[1]	12,100	9	58
County	County State Aid	30,000	23	21
	County Road	15,300	12	2
Township	Township Road	55,100	42	2
City	Municipal State Aid Street	1,800	1	8
	City Street	13,500	11	8
Other	Forest Road, etc.	2,900	2	1
	TOTAL	130,700	100.0%	100.0%

Source: 1983-1985 Biennial Budget.

[1]State trunk highways include state routes, the interstate system, and designated U.S. routes.

The size of the trunk highway system is usually described in two ways. *Centerline miles* measure the length of highways, irrespective of the number of driving lanes. *Lane miles* reflect the number of driving lanes in a segment of highway. For example, a one-mile long segment of a highway with four driving lanes equals four lane miles.

When measured in centerline miles, the trunk highway system has grown only slightly in the past 30 years. In 1957, there were 11,797 miles of trunk highway in Minnesota. Since then, more than 800 miles of interstate highways have been added to the system, often replacing trunk highway routes that were then removed from the state system. The number of lane miles in the system has increased somewhat more dramatically. In 1977, there were 25,168 lane miles in the system, while in 1985 there are about 28,860 lane miles.

About two-thirds of Minnesota's trunk highways were paved with bituminous asphalt, sometimes referred to as blacktop. Most of the other highways were constructed by pouring slabs of concrete, connected with joints. Southern Minnesota has many concrete roads, most of which were constructed about 50 years ago. Some other roads were built with bituminous asphalt over the original concrete surface.

2. CLASSIFICATION OF HIGHWAYS

To help it make decisions about maintenance and improvement expenditures, the Department of Transportation classifies trunk highways in many different ways. For example, the department's computerized Transportation Information System uses more than a dozen categories based on traffic volume and function within the state system. Table 1.2 condenses the categories into four and shows the number of centerline and lane miles in each.

TABLE 1.2

FUNCTIONAL CLASSIFICATION OF THE TRUNK HIGHWAY SYSTEM

Class	Centerline Miles	Lane Miles
Principal Arterial/Interstate	884.6	3,728.7
Principal Arterial/Other	3,924.4	10,059.9
Minor Arterial	5,684.6	11,795.0
Major Collector	1,572.8	3,163.4
Other	54.3	113.9
TOTAL	12,120.7	28,860.9

Source: Minnesota Department of Transportation, Transportation Information System, June 11, 1984.

The department uses other classification schemes as well. For example, the department's snow and ice control formula for allocating maintenance personnel and equipment among different areas of the state uses a road classification scheme based on average counts of traffic.

During the early 1970s, the department described a two-tiered system of trunk highways for the state. Under this system, the interstate highways and certain key stretches of state highway would form a "backbone" for state transportation and commerce. The backbone included highway segments that had relatively high traffic volume, connected urban centers with the Twin Cities, or had important recreational functions. These segments would receive high priority in improvement and maintenance decisions, while the remaining highways would receive less investment. However, the department never formally adopted this system.

The issues of how large the trunk highway system should be and what levels of government should be responsible for what roads have received a good deal of attention in the past few years. A 1982 report by the Twin Cities Citizens League recommended a state operated and maintained trunk highway system of about 6,900 miles.[1] That report generally followed the criteria developed in describing the backbone system. In 1983, the Legislature created a study commission to review the issues of highway jurisdiction and maintenance. That commission is scheduled to report to the Legislature in January 1985.

A 1984 report by the Transportation Advisory Board of the Metropolitan Council recommended transferring several highways in the metropolitan area from the trunk highway system to the counties, and shifting many county roads to cities and townships.[2] The board also recommended adding some major county roads to the state trunk highway system.

B. THE IMPORTANCE OF MAINTENANCE

Highway maintenance is important for economic and other reasons. In this section, we discuss the economic rationale for effective highway maintenance and the importance of maintenance in various parts of the state.

1. ECONOMIC IMPORTANCE

Minnesota's 1984 total maintenance budget of $102 million represents a sizeable investment: $24.62 for every Minnesota resident, $46.67 for every licensed passenger vehicle, or $8,429 for every trunk highway mile. However, these expenditures do not fully reflect the impact maintenance has on the Minnesota economy, the state's fiscal outlays, and the individual driver. Deferred or inappropriate maintenance can significantly increase costs.

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[1]Citizens League, Use Road Revenue for the Roads That Are Used, March 1983.

[2]Transportation Advisory Board, Phase II Final Report of the Highway Jurisdiction Task Force, September 1984.

For individual drivers, rough roads increase tire wear and reduce the mechanical life of chassis parts. Also, fuel consumption is higher on roads that are rough or snow-packed. Furthermore, studies show that inadequately maintained roads slow driver speeds, producing time delays.[3]

Businesses are also affected by the level of maintenance, most notably by winter snow plowing. Snow-covered highways may increase absenteeism and tardiness, defer sales, increase spoilage of perishable goods, and reduce recreational spending.[4]

In many neighboring states, all trunk highways are designated as ten-ton routes, and large trucks can travel on them all year long. However, only portions of Minnesota's trunk highway system are classified as year-round ten-ton routes. During parts of the year, grain and lumber haulers need to drive heavily loaded trucks to shipping points. To accommodate the needs of those industries, the Commissioner of Transportation designates certain highways as temporary ten-ton routes on a seasonal basis. Heavy truck traffic causes additional stress on the roads. Increasingly, MnDOT maintenance crews are called on to repair those roads and to strengthen them for use by large trucks.

Traffic accidents are linked to levels of maintenance service and expose the state to possible financial liability. With the enactment of Minn. Stat. §3.736 in 1976, the state accepted tort liability for certain accidents. In general, a plaintiff must show that road conditions were the proximate cause of injury or death. Also, a plaintiff usually must show that the government with jurisdiction had notice of the road's condition and had sufficient time to correct it.[5] When the state does not exercise reasonable diligence to build and keep roads in a

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[3]Among other publications, see the following: "Zero Maintenance Pavements: Results of Field Studies on the Performance Requirements and Capabilities of Conventional Pavement Systems," Federal Highway Administration (April 1976), 240-254; M. Karan, R. Haas, and R. Kher, "Effects of Pavement Roughness on Vehicle Speeds," Transportation Research Record 602 (1976), 122-127; F. Ross, "Effect of Pavement Roughness on Vehicle Fuel Consumption," Transportation Research Record 846 (1982), 1-6.

[4]It is often difficult to separate the effect of bad weather from the effect of snowy roads. See B. Welch, W. Kennedy and R. Stewart, "Economic Impacts of Snow on Taffic Delays and Safety", Transportation Research Record 647 (1977), 40-47.

[5]J. Vance, "Liability of the State for Injury-Producing Defects in Highway Surface," Research Results Digest 135, Transportation Research Board (July 1982), 3-13.

reasonably safe condition, such a breach of duty may constitute common-law negligence.[6]

An increasing number of claims are filed against states for maintenance-related accidents. The number of maintenance-related claims in Minnesota tripled between 1976 and 1983. During that time, the percentage of total highway claims that were maintenance-related increased from 56.9 percent to 66.1 percent.[7] Accurate summary information on the financial outcomes of these suits is not presently available.

It is clear that state maintenance decisions have financial impacts beyond the scope of MnDOT's $102 million maintenance budget. As a result, maintenance decision-making is an important public policy issue in addition to being an internal management issue for MnDOT.

2. REGIONAL VARIATIONS

During our study, we learned of many special maintenance challenges in regions of the state. These challenges affect local priorities, and they affect the overall level of maintenance needed in each region.

Some of the variations are related to weather. Appendix A shows annual snowfall averages for Minnesota. The northwest corner of the state contends with the snowiest winters, averaging over 70 inches. However, southwest Minnesota, despite relatively low snowfalls, faces severe winter maintenance problems due to wind-drifted snow. Ice problems plague southeastern and south-central Minnesota. Although the Twin Cities receive moderate snowfall, meeting the demand for free, rapid traffic movement in the urban area requires a higher level of winter maintenance service than less populous areas receive.

Regional industries also affect the needs of roads in the state. Despite having lower traffic volumes than other regions, northern Minnesota contends with many heavy vehicles hauling timber and crops. The continuing abandonment of railroad lines in this part of the state increases reliance on the road system for commodity movement. Northern Minnesota also relies heavily on roads for its tourism industry.

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[6]39 AM. JUR. 2d, <u>Highways, Streets, and Bridges</u>, §372.

[7]Minnesota Department of Transportation Tort Claims Office. Cases are classified by their date of incidence occurrence, not the date filed. The estimates are rough, since some cases allege several areas of negligence.

Soil quality affects maintenance needs, particularly in southern and western Minnesota. Clay-like soils do not drain as well as granular soils, and trapped moisture may contribute to road deterioration. Also, the southern and western regions lack quality aggregate for road construction, resulting in premature cracking problems for many roads.

Finally, differences in access to roads affect the importance of maintenance in Minnesota's regions. Rural areas, particularly in the north, have fewer roads per square mile than urban areas. Thus, the lack of alternative routes of travel makes good highway maintenance doubly important in rural parts of the state.

C. ORGANIZATION OF MAINTENANCE IN MnDOT

The Operations Division of MnDOT is responsible for routine maintenance of the trunk highway system, including maintaining and repairing road surfaces and shoulders, snow and ice removal, roadside and drainage maintenance, bridge inspection and repair, and traffic control services, such as signs and lane stripes. The Office of Highway Programming is responsible for planning and programming highway improvements closely related to trunk highway maintenance, such as highway resurfacing and reconditioning.

1. CENTRAL OFFICE

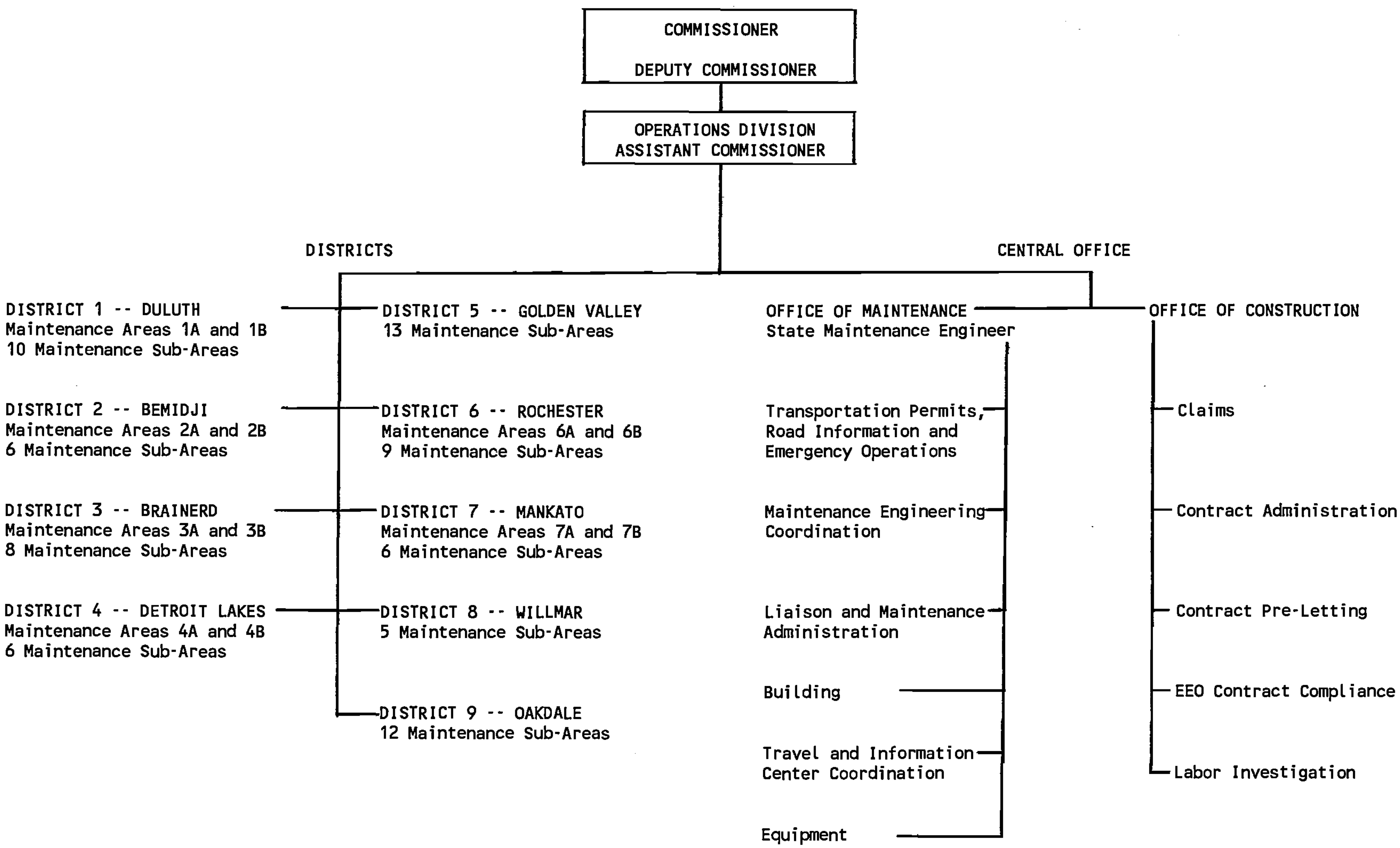
In 1984, the Operations Division had a staff complement of about 3,300, including about 2,300 working in maintenance activities. Most of the others work in highway design and construction. Certain statewide activities, such as procurement and contracting, are largely performed at the MnDOT central office in St. Paul, under the supervision of the state maintenance engineer. The central Maintenance Office manages six travel and information centers near major entrances to the state. The department also operates a central shop in Saint Paul.

2. DISTRICTS AND MAINTENANCE AREAS

Most of the Operations Division's work is carried out by personnel throughout the state. As shown in Figure 1.1, the division is organized into nine construction districts. Six of those districts are further divided into two maintenance areas, for a total of 15 units. Figure 1.2 is a map of MnDOT's districts and maintenance areas, showing the headquarters of each area.

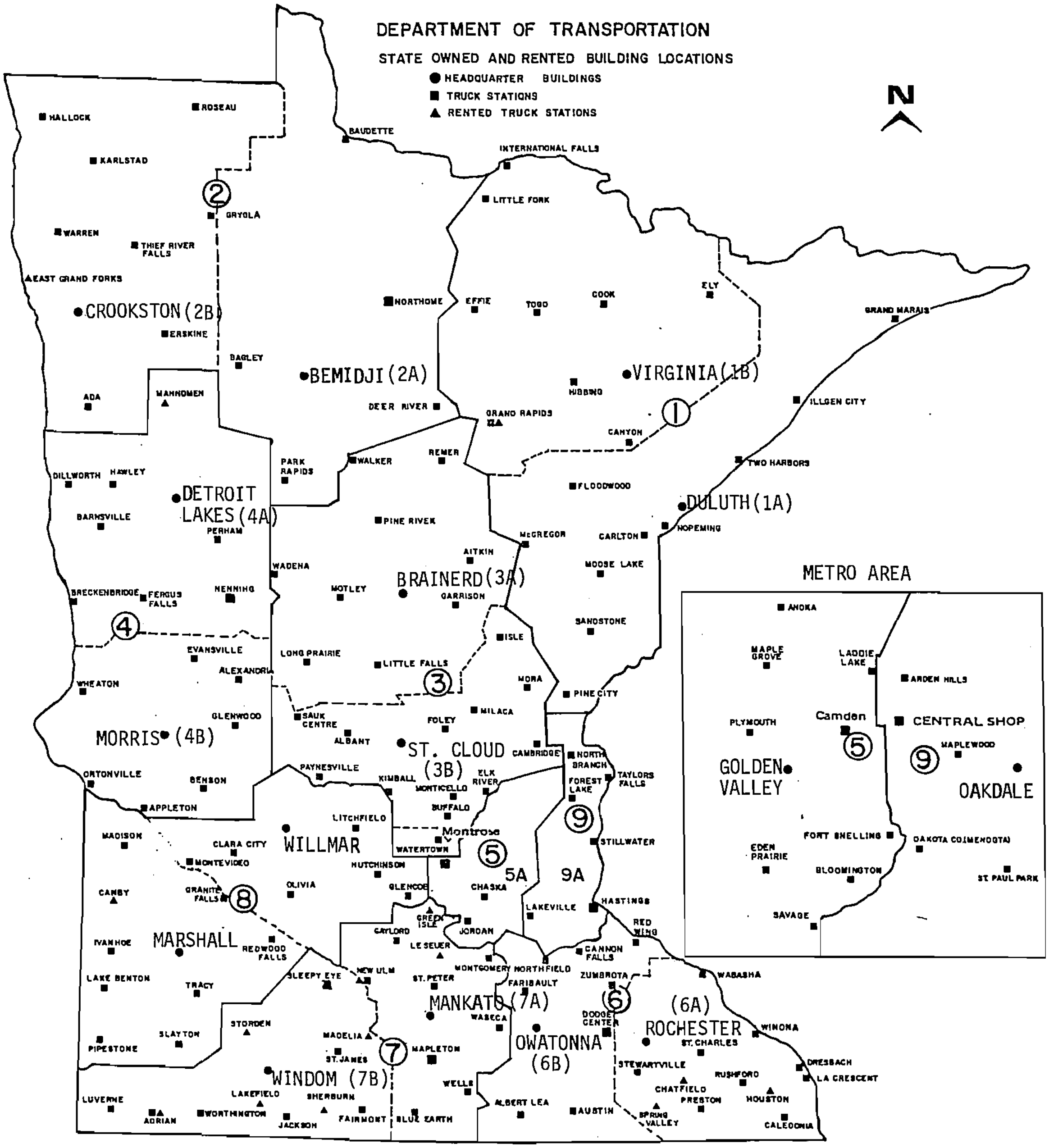
FIGURE 1.1

MINNESOTA DEPARTMENT OF TRANSPORTATION
ORGANIZATION CHART



Source: Program Evaluation Division.

FIGURE 1.2



Source: Minnesota Department of Transportation, 1984.

In 1983, the Department of Transportation considered consolidating offices in the north central part of the state and reducing the number of construction districts to eight. This proposal aroused strong opposition, particularly in cities which would have lost MnDOT operations and jobs. During the 1984 session, the Legislature directed the commissioner of transportation not to "alter the current nine district departmental structure prior to June 30, 1985."[8]

Although many operations are conducted in district and area headquarters, MnDOT has rest areas, truck stations, garages, and other installations throughout the state. Since 1980, the department has reduced the number of field locations, largely by eliminating local stations with two-person crews and consolidating those crews with other stations. In 1984, the department operated in 163 field locations, 11 of which were leased. MnDOT still operates four truck stations with two-person crews and three stations with three-person crews. In general, these small crews are located on remote snow plowing routes. To perform summer maintenance, the small crews are usually combined with crews from other stations.

A district engineer directs the operations of each MnDOT district and reports directly to the assistant commissioner of the operations division. Each maintenance area also has a maintenance engineer who reports to the district engineer. It is important to note that area maintenance engineers report to the district engineer and not to the state maintenance engineer. The maintenance areas are further divided into 75 maintenance sub-areas, each under the supervision of a sub-area foreman.

Two districts have organized their maintenance operations in innovative ways. District 8 (Willmar), in west central Minnesota, consolidated its two maintenance areas into one in 1982. According to managers in that district, that change was made to absorb budget cuts. The change was possible because of the relatively small area of the district (it is the smallest outstate district) and because of the retirement of an area maintenance engineer.

District 2 (Bemidji) continues to operate two maintenance areas. However, it has recently consolidated most business and inventory functions in the district headquarters.

3. STAFF COMPLEMENT

Table 1.3 shows the actual staff complement for maintenance and other activities in each maintenance area. MnDOT's authorized maintenance complement has decreased slowly during the last ten

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[8]Laws 1984, Chap. 654, Art. 3, Sec. 1(g).

TABLE 1.3

DEPARTMENT OF TRANSPORTATION OPERATIONS DIVISION
STAFF COMPLEMENT BY MAINTENANCE AREA

December 1984

Maintenance Area		Maintenance	Support	Construction	Total
1A	Duluth	137.00	19.00	155.0	311.0
1B	Virginia	91.15	5.85		97.0
2A	Bemidji	67.50	4.50	56.0	128.0
2B	Crookston	72.30	6.70		79.0
3A	Brainerd	78.13	11.87	66.0	156.0
3B	St. Cloud	131.50	8.50		140.0
4A	Detroit Lakes	100.00	16.00	59.0	175.0
4B	Morris	70.00	6.00		76.0
5	Golden Valley	320.00	47.00	233.0	600.0
6A	Rochester	119.25	15.75	102.0	237.0
6B	Owatonna	116.50	8.50		125.0
7A	Mankato	95.90	15.10	76.0	187.0
7B	Windom	99.00	9.00		108.0
8	Willmar	138.30	8.70	56.0	203.0
9	Oakdale	322.00	26.00	236.0	584.0
Subtotal		1,958.53	208.47	1,039.0	3,206.0
Central Office		63.0		35.0	98.0
Central Shop		26.0			26.0
TOTAL		2,047.53	208.47	1,074.0	3,330.0

Source: Maintenance Standards Engineer, Minnesota Department of Transportation, December 4, 1984.

Notes: Maintenance includes all maintenance workers and supervisors, shop and inventory staffs, and district engineers. For budgeting purposes, MnDOT assigns district engineers and support staff, such as clerks and business staff, to the maintenance complement, even if they have design and construction responsibilities.

years from 2,585 positions in 1975 to 2,316 in 1984. The department also employs a large number of seasonal and temporary workers, mostly to assist with summer maintenance and construction activities.

About 1,500 maintenance workers are allocated to the 15 maintenance areas on the basis of the department's snow and ice formula. Since the early 1970s, the department has used that formula to determine how many workers and trucks each maintenance area needs to maintain a standard of highway snow removal. In Chapter 2, we analyze the snow and ice formula and the other methods used by MnDOT to allocate staff and budgets among maintenance areas.

D. BUDGET

1. HIGHWAY MAINTENANCE FUNDING AND SPENDING

Trunk highway maintenance is funded largely by the state Trunk Highway Fund, which in turn, is a beneficiary of the Highway Users Tax Distribution Fund. Under a constitutional formula, 62 percent of the proceeds from motor vehicle registrations and the state gasoline tax are distributed to support maintenance and construction on state trunk highways.

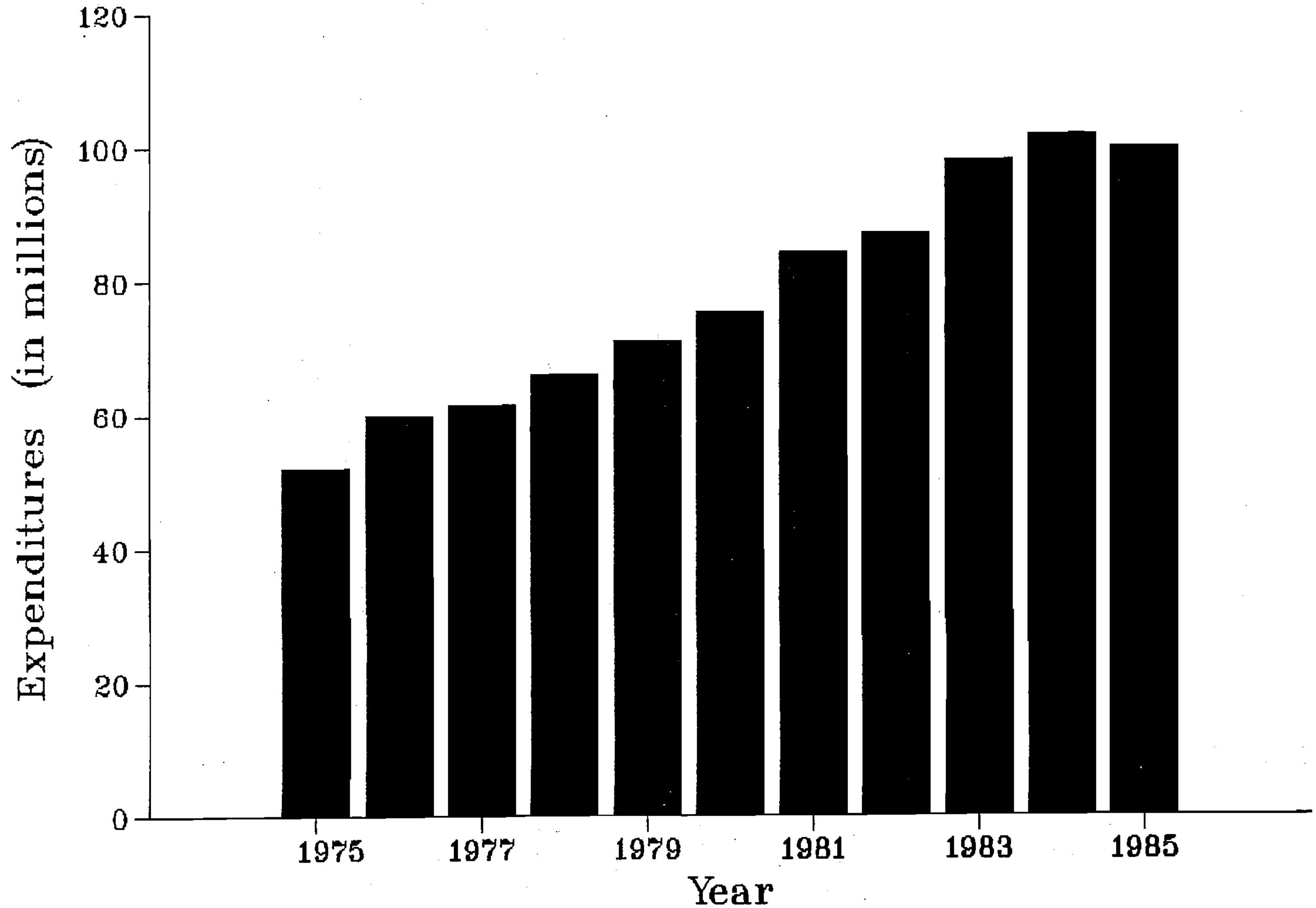
Counties receive 29 percent of the funds to support construction and maintenance of designated state aid routes and municipalities receive 9 percent for their state aid streets. For the 1983-1985 biennium, the Legislature appropriated $318.3 million for county state aid highways and $105.6 million for municipal state aid streets.

As shown in Figure 1.3, state expenditures for trunk highway maintenance have nearly doubled in the past ten years. In 1975, the state spent $52.2 million for highway maintenance, while just over $100 million is budgeted in 1985.

Highway maintenance is labor intensive. Nearly two-thirds of the budget is spent for personnel costs. The rest is spent on supplies, equipment, and other expenses. Most maintenance work is carried out by MnDOT employees. However, the department contracts with 25 cities to carry out routine maintenance on trunk highways that are also city streets. In Chapter 3, we review these contracts and other potential uses for maintenance by contract.

FIGURE 1.3

TRUNK HIGHWAY MAINTENANCE EXPENDITURES 1975–1985



Source: Biennial Budgets 1977–79, 1979–81, 1981–83, 1983–85

2. DISTRICT EXPENDITURE PATTERNS

Table 1.4 shows 1983 maintenance expenditures for each maintenance area. Districts 5 (Golden Valley) and 9 (Oakdale) in the metropolitan area account for nearly one-third of all state expenditures. Districts 2 (Bemidji) and 8 (Willmar) have the smallest budgets.

TABLE 1.4

1984 MAINTENANCE EXPENDITURES BY AREA

(Dollars in Thousands)

Maintenance Area		Labor	Other	Total
1A	Duluth	$ 4,721.8	$ 2,948.3	$ 7,670.1
1B	Virginia	2,823.7	1,640.7	4,464.4
2A	Bemidji	2,149.4	1,113.4	3,262.8
2B	Crookston	2,130.8	952.5	3,083.3
3A	Brainerd	2,585.8	1,185.4	3,771.2
3B	St. Cloud	3,838.8	1,483.9	5,322.7
4A	Detroit Lakes	3,164.7	1,421.1	4,585.8
4B	Morris	2,178.5	1,021.8	3,200.3
5	Golden Valley	10,259.3	4,368.8	14,628.1
6A	Rochester	3,891.3	2,107.4	5,998.7
6B	Owatonna	3,465.3	1,924.3	5,389.6
7A	Mankato	3,133.4	1,604.1	4,737.5
7B	Windom	2,947.3	1,545.1	4,492.4
8	Willmar	4,193.6	2,484.7	6,678.3
9	Oakdale	9,846.6	4,750.6	14,597.2
TOTAL		$61,330.3	$30,552.1	$91,972.4

Source: Budget-Expenditure-Encumbrance Report, Statewide Accounting System, September 2, 1984. Does not include amount encumbered but not liquidated as of that date.

In 1983, snow and ice control accounted for one-fourth of the maintenance budget, while maintenance of roadway surfaces and shoulders accounted for about one-third. Table 1.5 shows the percentage of the state maintenance budget spent in each of six activity categories between 1980 and 1984.

TABLE 1.5

PERCENTAGE OF ROUTINE MAINTENANCE BUDGET SPENT BY CATEGORY

1980-1984
(Dollars in Millions)

	1980 ($70.6)	1981 ($75.9)	1982 ($91.2)	1983 ($94.3)	1984[a] ($93.4)	Average
Roadway Surface	22.1%	22.5%	22.8%	24.3%	20.5%	22.4%
Shoulders and Approaches	7.8	10.9	8.5	8.6	7.4	8.6
Roadside and Drainage	25.3	28.9	22.0	23.3	21.7	24.2
Traffic Control	16.7	17.0	14.2	15.3	14.1	15.5
Snow and Ice Control	23.8	16.7	29.2	25.1	33.0	25.6
Structures	4.2	4.1	3.3	3.4	3.3	3.7
TOTAL	99.9%	100.1%	100.0%	100.0%	100.0%	100.0%

Source: Minnesota Department of Transportation, Cost Accounting System.

[a]Note that the 1984 expenditures are slightly different from those in Table 1.4. This is due to differences in the two accounting systems and because some maintenance expenditures are through the central maintenance office.

It is interesting to note the wide fluctuations in spending for snow and ice control. The department spent only 16.7 percent of the maintenance budget for snow and ice control in 1981 because of a mild winter. The winter of 1984 was more severe, particularly in the metro area, and the department spent one-third of the routine maintenance budget for snow and ice control. As a result, the percentage of budget spent to maintain the roadway surface and shoulders decreased that year. In Chapter 2, we discuss the department's approach to budgeting for snow and ice control.

Several factors affect expenditures by districts including the number of highway miles, the construction and condition of the highways, local weather conditions, and local economic activities. Table 1.6 examines how MnDOT districts spend their budgets in six major activity groups. Three activities--snow and ice control, roadway surface, and roadside and drainage--account for more than 70 percent of total expenditures. We saw some important variations among districts. For example, the two metropolitan area districts spend larger than average portions of their budgets on traffic service, which includes the cost of traffic signs, highway lights, and pavement striping. Conversely, the two metropolitan districts spend relatively small portions of their budgets on maintaining shoulders and approaches. This is probably due to the fact that most highway shoulders in these areas are paved and require less maintenance than gravel shoulders.

Snow and ice control accounts for an average of 23 percent of maintenance expenditures by districts. However, it is difficult to know what work has been performed and to compare the performance of different districts. The department's cost accounting system does not divide snow and ice control into separate activities, such as plowing, spreading sand and salt, or erecting snow fences.

Table 1.7 shows that maintenance areas spend nearly two-thirds of their budgets for personnel.[9] While areas differ somewhat in this measure, they vary significantly in two measures of personnel costs. First, maintenance areas vary in the extent to which they incur overtime costs. Overtime is typically used to respond to severe snow storms, although it may be used at other times. The proportion of personnel costs spent on overtime pay ranged from 1.3 percent in maintenance area 2A (Bemidji) to 5.5 percent in area 9 (Oakdale).

Similarly, maintenance areas vary widely in their use of part-time or seasonal workers. Maintenance areas typically employ seasonal workers to round out crews during the summer months. Seasonal workers often serve as flag persons, directing traffic in work areas. The proportion of the personnel budget spent on part-time or seasonal workers was as low as 0.4 percent in area 7B (Windom) and 0.7 percent in area 5 (Golden Valley), and as high as 9.6 percent in area 3A (Brainerd).

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[9] This analysis is based on data from the Statewide Accounting System. As we discuss in Chapter 2, we found that the data and reports that were readily available from the department's cost accounting system were inadequate for the analysis we wanted to perform.

TABLE 1.6

EXPENDITURES BY ACTIVITY BY DISTRICT

1981 and 1982

District	Roadway Surface	Shoulders Approaches	Roadside/ Drainage	Traffic Service	Snow & Ice	Structures	Total
1 Duluth	23.6%	10.2%	21.8%	14.4%	26.8%	3.5%	100.1%
2 Bemidji	25.1	14.8	21.9	14.2	22.0	2.1	100.0
3 Brainerd	21.8	13.8	25.7	12.8	22.2	3.9	100.0
4 Detroit Lakes	33.5	11.5	25.6	10.0	16.7	2.8	100.0
5 Golden Valley	13.2	3.9	28.2	24.9	25.1	4.8	100.0
6 Rochester	22.5	8.9	28.4	11.6	24.7	4.2	100.1
7 Mankato	21.5	12.5	30.1	11.9	21.1	3.0	100.0
8 Willmar	29.4	15.5	17.4	12.3	20.8	4.7	100.1
9 Oakdale	22.1	6.0	25.3	19.6	23.3	3.7	100.0
Statewide	22.7%	9.7%	25.5%	15.6%	23.0%	3.7%	100.1%
District Avg.	23.6%	10.8%	24.9%	14.6%	22.5%	3.6%	100.0%

Source: Minnesota Department of Transportation, Cost Accounting System.

Note: Based on an average of expenditures for 1981 and 1982.

TABLE 1.7

PERSONNEL EXPENDITURES FOR MAINTENANCE[a]

1983-1984

Maintenance Area		Percent of Personnel Costs In: Overtime	Percent of Personnel Costs In: Part Time/ Seasonal	Percent of Personnel Costs in Total Budget
1A	Duluth	2.4%	7.9%	59.2%
1B	Virginia	2.2	6.6	63.6
2A	Bemidji	1.3	7.0	66.5
2B	Crookston	2.0	3.4	66.4
3A	Brainerd	1.5	9.6	66.8
3B	St. Cloud	2.3	1.2	70.7
4A	Detroit Lakes	1.2	2.4	66.4
4B	Morris	2.3	2.1	64.7
5	Golden Valley	2.8	0.7	68.9
6A	Rochester	2.8	3.0	62.5
6B	Owatonna	4.3	2.1	63.5
7A	Mankato	2.4	2.7	65.1
7B	Windom	3.1	0.4	63.9
8	Willmar	2.8	2.3	62.1
9	Oakdale	5.5	1.6	66.2
	Statewide	3.0%	3.0%	65.3%
	Area Average	2.6%	3.5%	65.1%

Source: Statewide Accounting System, 1983-1984.

[a]Based on the average of 1983 and 1984 expenditures.

Table 1.8 compares maintenance areas on staff complement, expenditures, and lane miles. We calculated the ratio of lane miles to maintenance workers in each maintenance area. The range is quite wide. In the two metropolitan area districts, there are about six lane miles of highway for every maintenance worker. By comparison, there are about 28 lane miles of highway for every maintenance worker in District 2 (Bemidji). The ratio in most of the other areas is closer to the statewide ratio of 15 lane miles per maintenance worker.

We also examined the ratio of maintenance area expenditures to lane miles. As might be expected, this ratio reflects the level of staffing in each area. Thus, the total cost per lane mile for the state in 1984 was just over $3,000. The range was from $1,487 in area 2A (Crookston) to $7,368 in area 9 (Oakdale).

TABLE 1.8

MAINTENANCE COSTS AND STAFF PER MILE BY AREA

1984

Maintenance Area		Maintenance Complement	Lane Miles	Personnel Costs	Total Costs	Lane Miles Per Worker	Total Cost Per Lane Mile	Personnel Cost Per Lane Mile	Total Cost Per Worker
1A	Duluth	137.0	2,001.2	$4,721,755	$7,670,112	14.6	$3,833	$2,359	$55,986
1B	Virginia	91.2	1,754.2	2,823,651	4,464,413	19.2	2,545	1,610	48,979
2A	Bemidji	67.5	1,808.4	2,149,395	3,262,795	26.8	1,804	1,189	48,338
2B	Crookston	72.3	2,073.8	2,130,876	3,083,381	28.7	1,487	1,027	42,647
3A	Brainerd	78.1	1,737.5	2,585,766	3,771,243	22.2	2,171	1,488	48,269
3B	St. Cloud	131.5	1,945.9	3,838,846	5,322,652	14.8	2,735	1,973	40,476
4A	Detroit Lakes	100.0	2,037.2	3,164,707	4,585,793	20.4	2,251	1,553	45,858
4B	Morris	70.0	1,667.8	2,178,524	3,200,287	23.8	1,919	1,306	45,718
5	Golden Valley	320.0	2,017.0	10,259,333	14,628,153	6.3	7,252	5,086	45,713
6A	Rochester	119.3	1,954.0	3,891,300	5,998,740	16.4	3,070	1,991	50,304
6B	Owatonna	116.5	1,718.3	3,465,344	5,389,576	14.7	3,137	2,017	46,262
7A	Mankato	95.9	1,584.2	3,133,421	4,737,460	16.5	2,990	1,978	49,400
7B	Windom	99.0	1,640.2	2,947,290	4,492,447	16.6	2,739	1,797	45,378
8	Willmar	138.3	2,940.1	4,193,608	6,768,273	21.3	2,302	1,426	48,939
9	Oakdale	322.0	1,981.2	9,846,589	14,597,250	6.2	7,368	4,970	45,333
	Statewide	1,958.5	28,861.0	$61,330,405	$91,972,575	14.7	$3,187	$2,125	$46,960

Sources: Statewide Accounting System, 1984; Transportation Information System, May 23, 1984; Operations Division, Department of Transportation, November 1984.

3. RESURFACING AND RECONDITIONING

Highway resurfacing and reconditioning are closely related to highway maintenance, although they are funded and administered separately in MnDOT. As shown in Table 1.9, state spending for these projects varies significantly from year to year. The level of funding depends on a number of factors, including the total budget available for highway improvement and the relative priority given to different categories of projects. Private contractors carry out virtually all improvement projects. MnDOT construction engineers and technicians plan, monitor, and coordinate the projects.

TABLE 1.9

HIGHWAY RESURFACING AND RECONDITIONING PROJECTS

	1979	1980	1981	1982	1983	1984	1985
Expenditures	$21.7	$17.6	$40.6	$46.8	$50.3	$34.8	$40.0
Project Miles[a]	296	220	520	500	548	380	434

Source: Biennial Budgets, 1979-1981, 1981-1983, 1983-1985.

[a]Includes total mileage in project areas. Actual mileage receiving treatment may be less.

4. MAINTENANCE PRESERVATION PROGRAM

In 1980, MnDOT initiated the Maintenance Preservation Program. The program was intended to perform preventive maintenance activities such as bituminous overlays and concrete pavement joint renovation. About 80 percent of the work in the program is completed by private contractors. As shown in Table 1.10, MnDOT will spend about $7.5 million on maintenance preservation projects in 1984. Chapter 4 of this report presents our analysis of the Maintenance Preservation Program.

TABLE 1.10

EXPENDITURES FOR THE MAINTENANCE PRESERVATION PROGRAM

	1980	1981	1982	1983	1984	1985
Expenditures (in millions)	$2.9	$4.7	$7.5	$7.5	$7.5	$7.5
Projects	55	79	91	90	85	N/A
Miles[a]	356	395	450	500	N/A	N/A

Source: Biennial Budgets, 1981-1983, 1983-1985.

[a]Includes total mileage in project areas. Actual mileage receiving treatment may be less.

Management of MnDOT'S Maintenance Resources

Chapter 2

Highway maintenance in the Minnesota Department of Transportation is highly decentralized. Managers and supervisors in the maintenance areas make key decisions about where money should be spent, on which roads, and for which activities.

The department spends more than 90 percent of its $102 million annual maintenance budget in the 15 maintenance areas. It uses a formula to allocate about two-thirds of its maintenance workers among the maintenance areas. Budgets for supplies, materials, and support staff are largely based on historical experience with adjustments for inflation and some adjustments for future plans.

In this chapter, we present our analysis of how the department manages its maintenance resources. We asked:

- How does the department project its budgetary needs? Are they based on an objective and systematic analysis of maintenance needs?
- Is the department's snow and ice formula an appropriate way to establish staff complements for maintenance areas?
- How do other states use highway maintenance management systems, and how might such a system benefit Minnesota?

This chapter presents our evaluation of maintenance management in the department. Others, both inside and outside the department, have examined related issues. A series of critical WCCO-TV reports on highway maintenance in 1982 led to a number of initiatives by the department and a management study by the Management Analysis Division of the Department of Administration. In our research, we benefited from the work of the Department of Administration and the Maintenance Action Committee of the Department of Transportation.

A. BUDGETING FOR MAINTENANCE

1. BUDGET DEVELOPMENT

State funding for highway maintenance comes from the highway user tax distribution fund. In past biennial budget requests for highway improvement and maintenance, the Department of Transportation has described maintenance as a fixed cost. After setting the maintenance budget, the remaining amount of highway user tax receipts was combined with available federal funds to establish the highway improvement budget. If user tax receipts or federal aids were less than anticipated, the improvement budget was reduced, but not the maintenance budget.

The maintenance budgeting process is similar to the process followed in other state agencies. The maintenance areas submit proposed budgets to the department's Operations Division. Using current spending as a base, these budgets are adjusted for inflation, and show requested changes in spending.

We found:

- Area maintenance budgets are generally not based on work plans or an analysis of maintenance needs.

Each maintenance area's request includes a written justification of requests for line item budget increases which exceed inflationary adjustments. In order to support their requests, some maintenance areas present a list of significant activities, such as spot overlays, planned for the biennium. However, these requests do not generally project the amount of work that will be performed or detail the resources needed to perform those tasks. While each of the maintenance areas which we visited did develop annual work plans for pavement patching, shoulder maintenance, and other activities, these work plans do not form the basis for budget requests.

The department makes only limited use of road condition ratings in developing its statewide budgets. For 1984-85, however, the department recommended increases in the materials budgets of three districts because of the poor condition of their roads. Nevertheless, based on the department's condition ratings, one of the districts receiving an increase has few poor roads. Another district with the highest percentage of poor roads received no increase in its materials budget.

In contrast, the California Department of Transportation develops its maintenance budget in a more systematic way. California adopted a zero-based budget approach and uses a series of methods to calculate needs for labor as well as materials, equipment, and other operating needs. For example, certain activities occur in response to uncontrollable situations, such as a traffic signal failure or damage to drainage facilities. Using the historical data on workloads and productivity in its maintenance management system, the department projects the annual demand for these activities and its labor needs. Labor needs for other activities may be based on a frequency calculation (how often to collect litter) or may be related to a condition evaluation (when will a culvert need replacement).

2. IMPORTANCE OF SNOW AND ICE CONTROL

A maintenance area's budget is established well in advance of the beginning of the fiscal year and should provide a basis for an annual work plan. However, we found:

- In practice, a maintenance area's operating budget for working on roadway surfaces and shoulders is determined by how much money is left after spending for snow and ice control.

If the winter is mild, a district may have additional maintenance funds to spend. In recent years, however, Minnesota experienced severe winters. When budget lines for overtime and winter sand and salt were depleted, districts transferred funds from budget lines for roadway materials needed for spring work. In some cases, the central Maintenance Office has reallocated funds to districts facing shortages.

This approach to budgeting creates several problems. First,

- The practice of letting snow and ice expenditures determine the budget for other important activities makes it difficult for maintenance managers to plan their work and to best utilize their staff.

After a severe winter, a district entered the spring with a full complement of maintenance workers but little money for materials, such as bituminous asphalt or gravel. Because roadway surface work tends to be material intensive, districts sometimes deferred roadway repairs. Maintenance workers were assigned labor intensive tasks such as litter pickup. In other cases, districts selected a labor intensive approach to road repair, even when this approach was relatively inefficient or ineffective. For example, crews would patch individual potholes or cracks rather than applying an overlay on a larger area.

Workers also performed labor intensive tasks that might otherwise have a low priority. For example, in one maintenance area, workers spent part of the spring of 1984 planting trees at the maintenance headquarters. Needed repairs to roadway surfaces were deferred.

Thus, we concluded that the uncertainty of maintenance area budgets for materials means that roadway surface repairs are deferred. Given the state's large investment in its roads, it is particularly important that they be maintained in a consistent, systematic manner.

We also found that:

- The department's approach to maintenance budgeting leads to uneven spending by maintenance areas.

A maintenance area facing a surplus has an obvious incentive to spend the money before the end of the fiscal year. We found that June--the last month of the state fiscal year--was the peak month for Department of Transportation maintenance expenditures. For 1982, June expenditures were about 13.6 percent of the total. This seems to reflect a trend in the department. June expenditures in 1975 were only 7.2 percent, while June spending in 1980 was 11.2 percent of the total. In contrast, May and July tended to have substantially lower expenditures.

Such spending patterns are not unusual for state agencies, which typically rush to liquidate their budgets before the close of a fiscal year. Many of the MnDOT maintenance managers that we interviewed said that they spent their budgets cautiously in the first nine months of the fiscal year, in order to ensure that there would be adequate funds for snow and ice control. When they knew how much money was left in the spring, they worked to spend it before the end of the year. Thus, a district may have money for low priority activities in June even though it had no money for necessary repairs earlier in the year.

3. COSTS OF MAINTENANCE

In order to budget its maintenance operations, the Department of Transportation needs to know the full costs of maintenance activities, including labor, equipment, materials, administrative overhead and so on. However, we found:

- The department is unable to usefully calculate its costs for highway maintenance.

As we discuss later in this chapter, the department's cost accounting system does not adequately present the full costs of maintenance in a manner that is useful to the department's managers.

The department's approach to managing certain resources is a separate problem. Accepted practices hinder the department's ability to understand the costs of maintenance. Two important examples are the department's approach to personnel and equipment costs.

a. Personnel

Since personnel costs are the largest expense of highway maintenance, the department needs to make the most efficient use of its workers. However, we found:

- The department views its personnel expenditures as a fixed cost of maintenance.

When maintenance managers develop their work plans and budgets, they attempt to establish their cost for certain activities. In our interviews with managers, we found that they invariably calculate only the cost of additional materials or equipment, but not the cost of their permanent staff. For example, a MnDOT maintenance manager calculates the costs of a spot overlay as the costs of the bituminous asphalt and the rented paving machine and operator. The cost of the maintenance crew's labor and preparation time is not included in the calculation. This is one reason why the department cannot usefully compare its costs with those of private contractors or evaluate the productivity of its workers.

b. Equipment

Maintenance areas do not budget for the cost of acquiring or depreciating major operating equipment. A separate appropriation to the central Maintenance Office budget is used to purchase major pieces of equipment. A maintenance area pays for the cost of fuel and parts, but is not charged for depreciation of the asset. On the other hand, an area maintenance engineer who wants to rent equipment which is used infrequently must find money for the rental in the maintenance area's budget.

We see two problems with the department's accounting for equipment costs. First, the department does not hold maintenance areas responsible for the full cost of acquiring and operating equipment. Second, a maintenance area may be encouraged to request new equipment purchased through the department's central equipment budget rather than rent equipment at its own expense.

B. ORGANIZATION

1. OVERSIGHT AND SUPPORT

In our visits to eight of the nine districts, we were impressed by the department personnel we talked with. We found maintenance managers intelligent, committed, and sensitive to the needs of their regions. We gained respect for the difficulty of highway maintenance work, which is often subject to unfair criticism because of its visibility.

Because maintenance in the Department of Transportation is so decentralized, district managers and area supervisors have wide discretion in scheduling work and allocating resources. This give managers a good deal of latitude to try innovative approaches to maintenance activities and management. However,

- There is no significant pressure from the central office to encourage district managers to innovate, or to adopt new methods piloted in other districts.

For example, the central office has supported administrative reorganizations in Districts 2 (Bemidji) and 8 (Willmar), but has not adopted these approaches for use by other districts. While districts may complain about requirements imposed on them by the central office, we found that the central office actually plays a small role in important district decisions.

Such a decentralized organization increases the need for centralized management support and oversight. The department does not dedicate staff or other resources to management analysis of the highway maintenance program. Analysts should help districts to review their staffing and organization, help engineers to improve their managerial skills, and examine worker productivity. With a budget of $100 million and a large staff, it is appropriate that some resources be devoted to providing additional management support.

The department benefits from the involvement of area maintenance engineers and other managers in peer review teams. These persons take time from their regular duties to visit maintenance areas to observe specific practices and discuss different ways to perform highway maintenance. For example, peer groups examined how mowing was performed around the state and offered recommendations on equipment and practices. We think these peer groups are useful to the department. We also think that the department would benefit from additional management analysis support for highway maintenance.

2. RESEARCH

Most of the department's research efforts are devoted to technical issues about materials and methods for highway maintenance and construction. The department's Office of Research and Development has conducted important studies since the 1920s. Unfortunately, the department has neglected management research to support highway maintenance. There is a good deal of work needed in the area of maintenance management. The department could be researching the cost effectiveness of preventive maintenance, the relationship between maintenance costs and road condition ratings, and user costs in highway maintenance. Such research would strengthen the department's decision-making abilities. As we describe in Chapter 5, the department's efforts to develop a pavement management system should make an important contribution in this area.

C. STAFFING

In the early 1970s, MnDOT began to use a snow and ice formula to set staffing and service standards for winter snow and ice control. The importance of the formula increased as the department came to rely on it as a tool to allocate maintenance workers and vehicles to maintenance areas.

1. HOW THE SNOW AND ICE FORMULA IS USED

The formula is based on two assumptions: First, the need for maintenance staff is lowest in the winter. Second, the number of workers and trucks needed to handle snow and ice control according to MnDOT's standards constitutes a basic core maintenance staff. The core staff can be supplemented by seasonal workers in the summer, when maintenance needs are greater. Figure 2.1 describes how the formula is applied.

Currently, the formula affects 1,496 workers in four job classes: highway maintenance worker, highway maintenance worker senior, heavy equipment operator, and bridge worker. Foremen and other supervisors involved in snow plowing are not included in the formula. Neither are shop workers, office staff, or other support workers. The department has no formula for allocating those positions to maintenance areas. In 1984, it developed guidelines for bridge workers, inventory staff, and shop workers. However, those guidelines are not binding on the maintenance areas, nor are they used to reassign staff.

The department undertook a major review of the snow and ice formula in 1983. Such a review was needed for several reasons. First, the old formula allocated 50 more trucks and 250 more maintenance workers than were actually available in 1983. Furthermore, the department faced significant changes in the trunk highway system, including more miles of high volume urban freeways and more interchanges. On the other hand, the department has realized significant efficiencies in recent years, such as the use of only one worker in most snow plow trucks, more reliable performance from the department's fleet of diesel trucks, and increases in truck speed.

As a result of the 1983 review, the department made significant adjustments in the formula. The two metro area districts each lost more than 60 formula positions. However, District 9 (Oakdale) actually gained seven positions, since it was operating

FIGURE 2.1

APPLICATION OF THE SNOW AND ICE FORMULA

1. SIZE OF TRUCK FLEET

The formula first calculates the number of large trucks needed in each area. This will then become the basis for the number of workers assigned under the formula.

Truck requirements are based on the number of lane miles of highways in each road classification and the number of interchanges. The classifications used for the formula are:

- Super Commuter: Average Daily Traffic (ADT) more than 30,000 vehicles.
- Urban Commuter: ADT between 10,000 and 30,000.
- Rural Commuter: ADT between 2,000 and 10,000.
- Primary: ADT between 800 and 2,000.
- Secondary: ADT less than 800

The formula does not count frontage roads, rest areas or turn lanes in the lane miles for each maintenance area.

SPEED: The formula assumes that trucks plowing high volume roads (10,000 or more ADT) cover an average of 15 miles an hour while trucks plowing lower volume roads travel at an average speed of 19 miles per hour.

CYCLE TIME: The formula also assumes a cycle time for each road classification, which is the number of hours needed to complete a snow plow route and return to the starting point. The following calculation is made:

$$\text{trucks} = \frac{\text{lane miles in each classification}}{\text{assumed speed X cycle time for classsification}}$$

INTERCHANGES: The formula adds trucks on the basis of the number and complexity of the interchanges within each area, again based on assumptions of speed.

2. STAFF: Allocations of maintenance workers are tied to the number of trucks provided by the formula. For example, the formula calls for 2.2 workers for each truck attributed to super commuter routes. This is intended to provide up to 24-hour coverage. On the other hand, trucks on secondary routes receive one worker per truck, and provide up to 12-hour coverage.

3. ADDITIONS: Each maintenance area receives a minimum of three spare trucks. Each area also receives a few additional workers to account for absenteeism. Some areas receive additional formula positions for intermittent foremen.

far below the old formula complement. District 5 (Golden Valley) lost 16 workers. These changes were not made immediately, since the department has waited for attrition to occur. Table 2.1 shows that some maintenance areas are still waiting for the new positions received under the revised formula.

2. PROBLEMS WITH THE SNOW AND ICE FORMULA

a. Staffing Standards

We analyzed the snow and ice formula and have several criticisms about its use. In our view,

- The most serious problem with the snow and ice formula is that it distributes MnDOT's most important maintenance resource--maintenance workers--without consideration of the actual workload for snow removal or any other maintenance activity.

Using data from the department's cost accounting systems for 1982 and 1984, we calculated the number of hours spent on snow and ice control in each district and related that number to the staff complement provided under the snow and ice control formula. As shown in Table 2.2, the number of hours spent on snow and ice control by complement position varies widely among the districts. Based on each district's snow and ice formula staff complement, each complement position in District 1 (Duluth) worked an average of 591 hours on snow and ice control, while each complement position in District 2 (Bemidji) worked only 397 hours on snow and ice control.

Obviously, a maintenance area's actual winter workload will vary because of several factors, including amount of snowfall, difficulty of snow removal, and staff productivity. Some of these factors vary significantly by region of the state. Average annual snowfalls vary from 35 inches in southwestern Minnesota to 70 in the northeastern part of the state. However, the formula does not reflect these regional differences.

Furthermore, by using the snow and ice formula to set staff levels, the department treats the most volatile and unpredictable part of its maintenance budget, snow and ice control, as a given. As we noted in Chapter 1, expenditures for snow and ice control vary significantly from year to year and among districts.

TABLE 2.1

DISTRIBUTION OF STAFF UNDER SNOW AND ICE CONTROL FORMULA

Maintenance Area		Snow and Ice Complement: Old Formula	Snow and Ice Complement: New Formula	Change	Actual in 1984	Difference Actual vs. New Formula
1A	Duluth	112	93	-19	96	+3
1B	Virginia	68	66	- 2	66	0
2A	Bemidji	50	42	- 8	46	+4
2B	Crookston	64	53	-11	54	+1
3A	Brainerd	63	61	- 2	55	-6
3B	St. Cloud	117	106	-11	103	-3
4A	Detroit Lakes	81	78	- 3	76	-2
4B	Morris	55	47	- 4	51	+4
5	Golden Valley	315	252	-63	252	0
6A	Rochester	105	94	-11	89	-5
6B	Owatonna	126	100	-26	92	-8
7A	Mankato	72	69	- 3	71	+2
7B	Windom	86	79	- 7	79	0
8	Willmar	102	104	+ 2	104	0
9	Oakdale	333	252	-81	252	0
	Total	1,749	1,496	-253	1,486	

Source: Department of Transportation, Maintenance Complement Status Report, December 4, 1984; Maintenance Standards Snow and Ice Committee Report, October 1983.

TABLE 2.2

SNOW AND ICE FORMULA RELATED TO ACTUAL HOURS OF WORK

1982, 1984

District		Formula Complement	Average[a] Hours Per Year	Hours Per Worker
1	Duluth	159	93,996	591
2	Bemidji	95	37,746	397
3	Brainerd	167	75,463	452
4	Detroit Lakes	125	56,294	450
5	Golden Valley	252	142,146	564
6	Rochester	194	95,478	492
7	Mankato	148	81,337	550
8	Willmar	104	52,704	507
9	Oakdale	252	114,582	455
	Average	1,496		495

[a]Average hours calculated as follows: For 1984 by taking hours reported in new cost accounting system by each maintenance area for snow and ice control activities. For 1982 by calculating labor costs for snow and ice activity by district and dividing that by an average hourly wage for maintenance workers as reported by the Accounting and Finance Section, Department of Transportation.

We do not agree with the assumption underlying the formula that the winter is a period of low maintenance activity. Indeed, the department's cost accounting systems show that the winter months are peak months for maintenance expenditures. Even if the assumption was correct, however,

- The snow and ice formula results in a high level of staffing for a small number of peak periods during the winter.

The formula calculates the number of snow plow trucks and operators needed to meet a standard of snow plowing during storms. However, there are only a few major storms in any winter. In most parts of the state, there are an average of three or four snowfalls a year that are four inches or more. Additional plowing may not be particularly urgent and can often be completed within the normal working day. It should be noted that cleanup plowing on certain busy routes or freezing rain may also create a heavy demand for service in some parts of the state.

Other jurisdictions take a different approach to staffing for winter peak needs. For example, the public works departments in Minneapolis and Saint Paul base their street maintenance staff complement on year-round work levels. Peaks in the winter are met by having permanent staff work overtime and by calling in additional drivers who are trained plow operators. As we describe in Chapter 3, certain states and Canadian provinces use contractors for snow and ice control.

Even though winter conditions preclude certain tasks, managers said that their crews had enough other winter work to keep busy when they were not plowing snow. During the winter, workers also use the compensatory time earned from snow plowing. However, we are concerned that the current system may not make the most efficient use of maintenance workers. Because different snow and ice activities are not reported separately in the department's cost accounting system, we were unable to determine whether maintenance workers are efficiently used in the winter.

During its 1983 review of the snow and ice formula, the department examined the standard of snow plowing service. It concluded that the level of service should be held at the current level or slightly below. The decision was partly based on the results of a survey of licensed drivers. The survey, conducted by a research office in the department, found that most respondents thought that winter maintenance was very satisfactory and that state highways received a satisfactory amount of plowing.[1]

Because of the formula standard for 24-hour coverage of commuter freeways, the two metro area districts receive many maintenance workers. However, we found that:

- Because of the formula, the two metro area districts have more people in the summer than they can fully use in maintenance.

These districts loan some maintenance workers for summer construction work and take on added responsibilities for building maintenance. In 1984, District 5 (Golden Valley) reported loaning 20 maintenance workers to design and construction, and District 9 (Oakdale) loaned 24 workers to construction. However, like almost all districts, the two metro area districts

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[1]However, nearly one-third of the respondents thought that highways received too much sanding and salting.

also hired seasonal workers to round out maintenance crews and to work on traffic control.

Some districts now supplement their regular plow operators with construction technicians or office workers. However, participation is strictly voluntary, and workers may not be available in remote areas.

Loaning maintenance workers to design duties in the summer is a relatively new practice. It is voluntary, and has been negotiated by the department and the workers' union. It is a step in what we view as a necessary evolution in MnDOT's staffing practices.

There is considerable interest in the department for creating a class of employee called "transportation worker." Such an employee would be trained in both maintenance and construction duties and would be assigned to either based on work demand. We think the idea has considerable merit and could improve the department's flexibility in hiring and deploying its workers.

b. Plowing Standards

A second issue is whether the snow and ice formula establishes an appropriate service standard for plowing. The formula is based on a high standard of plowing. For example, the formula calls for trucks and drivers to be available 24 hours a day on heavily traveled commuter routes. Even on lightly traveled secondary routes, trucks and drivers are supposed to be available for a twelve-hour day. We concluded:

- The department's high standards for plowing may be excessive.

In our interviews with maintenance managers, we were told that not all districts provide the levels of service called for in the formula. For example, even though the formula establishes a minimum standard of twelve hours of plowing a day, rural districts do not always plow a twelve-hour day. At least one district's practice is to plow for an eight-hour day and stop. Plowing is resumed the next day.

During the winter of 1984-85, District 2 (Bemidji) is experimenting with reduced winter maintenance on sections of two secondary highways in northwestern Minnesota. MnDOT workers will plow these roads only once per day and not on weekends, except in emergencies. Sand and salt will be applied only in hazardous areas. District managers felt the experiment could succeed because residents in the area have accepted similar levels of service on county roads for many years. Preliminary responses to the changes have been strongly negative, largely because of the hazardous conditions resulting from one storm in December 1984.

D. MAINTENANCE MANAGEMENT SYSTEMS

Our analysis of expenditure patterns, budgeting practices, and staff allocations in the Minnesota Department of Transportation has led to an important conclusion:

- The department needs more systematic methods to allocate and manage its maintenance resources, particularly workers. It also needs sophisticated tools to help it in that task.

In this section, we describe how some state highway agencies use maintenance management systems to meet these needs and the lessons Minnesota can learn from those states.

1. FEATURES OF MAINTENANCE MANAGEMENT SYSTEMS

As defined by the national Transportation Research Board, maintenance management is a means of:

> Controlling resources to accomplish a predetermined level of service through: *Planning* of work requirements; *Budgeting* to meet work requirements; *Scheduling* to achieve budget objectives; *Reporting* of accomplishments and resources used; and *Evaluation* of accomplishments compared to work objectives.[2] (emphasis in original)

State highway departments have worked to develop and use maintenance management systems for more than 20 years. In 1984, 41 of the 50 states operate some form of maintenance management system. Minnesota is one of the few states that does not. While the capabilities and quality of these systems vary considerably from state to state, some common features include:

- An inventory of the highway features, such as the pavement, shoulders, and fences, to be maintained and a system for referencing those features;
- Standards for the quality of maintenance, such as when certain roadway defects should be corrected, or how often roadsides on certain types of highways should be mowed;

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[2]National Research Council, Transportation Research Board, Maintenance Management Systems (Uncorrected draft, March 1984). The report is the source for much of the descriptive material in this section.

- Standards for the quantity of work and resources needed to meet the quality standard, that is, how many worker hours and how much material is needed;
- Performance standards to describe the appropriate crew sizes, equipment, and material to be used in performing a task;
- Planning, budgeting, and work control procedures;
- An information gathering and reporting system; and
- A work force.

These elements constitute a system for planning work, performing it, and comparing accomplishments to plans.

States with maintenance management systems are typically able to report unit costs for each activity. Many states have established quantity standards and use these standards to calculate labor and equipment needs. As we mentioned above, California is an example of a state which uses elements of its maintenance management system as the basis and support for its maintenance budget proposal.

2. BENEFITS OF MAINTENANCE MANAGEMENT SYSTEMS

Our review of the relevant literature indicates that states with effective maintenance management systems have realized benefits. A well-designed and properly implemented maintenance management system should enable the Minnesota Department of Transportation to better plan and schedule work. Improved historical data about workload and costs will help to improve plans for future work and will also support investment decisions for highway improvements. The maintenance management system will help to identify areas of high-cost maintenance which would benefit from improvements. The system will also help the department to analyze investment choices in programming highway improvements.

A maintenance management system would enable the department to evaluate the productivity and quality of different crews and districts. These evaluations should help the department to identify the most effective crew sizes and methods for performing maintenance activities and to implement those methods around the state.

Finally, the new generation of maintenance management systems capitalize on recent innovations in information technology to make information more accessible to managers and supervisors throughout the department. In the past, systems typically operated on large, mainframe computers at a central location.

Now, the wide availability of microcomputers makes it easier to analyze data and develop reports for field supervisors.

3. POTENTIAL DIFFICULTIES

Implementation of a maintenance management system is not a simple solution to the department's problems. Minnesota will benefit from reviewing the experiences of other states in designing and using maintenance management systems. For example, implementation of a maintenance management system does not, by itself, guarantee the adoption of uniform, standard methods which make the optimal use of workers and equipment. The system requires constant attention and evaluation.

The key to a maintenance management system is assembling data on operations and expenditures which enable managers to direct a highway maintenance program. Some states collect maintenance management data separately from their cost accounting systems, resulting in duplication of effort. Furthermore, the added data collection responsibility may impose a burden on field staff. This may result in worker resentment and unreliable data, particularly if workers see the maintenance management system as an instrument to control their activities rather than as a tool to make their work more efficient.

4. MnDOT's APPROACH TO MAINTENANCE MANAGEMENT

a. Field Maintenance Standards

During the 1960s, the department worked with the consulting firm of Booz, Allen and Hamilton to develop maintenance work standards. The standards were based on time-study observations of MnDOT maintenance crews and were published in a MnDOT manual. The department developed two types of standards: *Quality* standards which determine when certain operations should take place and what procedures should be followed. For example, a hole of a certain size on a busy highway should be patched within 24 hours after it is noticed. *Productivity* standards set forth the crew size and how long should be needed to complete a given work unit.

The department rescinded the standards in 1978 with a statement that they no longer contained current department policy. At that time, the department was concerned that the quality standards might expose the department to tort liability and had reduced the staff responsible for updating the standards. However, the department has never replaced the productivity standards.

b. FIRMS

During the 1970s, the Department of Transportation made a major attempt to improve its capability to manage highway maintenance. In 1973, the department initiated an ambitious project to develop a cost accounting and management information system. The system was known as the Financial Information Resource Management System, or FIRMS.

The system had several objectives. First, it would replace the department's old construction and maintenance cost accounting systems, which were generally regarded as outdated and inadequate. In particular, it was hoped that a new construction cost accounting system would increase federal reimbursement by as much as $670,000 a year because of improved allocation of indirect costs of construction projects. Second, the system would improve the timeliness and quality of information on the cost of the department's activities and would allow the department's top managers to hold middle managers more accountable.

The system was designed by consultants from a certified public accounting firm, department staff, and analysts from the Information Services Bureau of the Department of Administration. As designed, the system was complex and included numerous subsystems to control inventory, meet federal reporting requirements, and interface with the statewide accounting system and the state's payroll system.

The system was specifically intended to improve the department's maintenance management capability in several ways. It would have reported total road maintenance costs for the state, maintenance areas, and sub-areas by activity and by unit cost of the work accomplished. FIRMS would have collected information through bi-weekly time sheets and would provide periodic reports back to the area maintenance engineers and sub-area supervisors. These reports would have provided year-to-date and previous year comparisons and would show units of work accomplished and resources used. Costs and activities would also have been compared to current budgets.

The department originally scheduled completion of FIRMS in July 1977. Instead, the department encountered significant problems with the system's design and major overruns of schedule and budget. In 1979, the department halted work on the project.[3]

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[3]In 1980, the Program Evaluation Division published its Evaluation of the Information Services Bureau. That report analyzed problems faced by the state's central computer operation, particularly in developing computer systems. The FIRMS project and its problems are discussed in detail in the report.

The department reexamined its cost accounting needs and began to design a new system. It decided to develop the new system in stages, in order of the department's priorities. It gave highest priority to developing a system that would satisfy the cost accounting and reporting needs of the Federal Highway Administration. In 1981, the Legislature appropriated money to develop a new cost accounting system. The first components of that system were implemented in March 1983, and the system completed its first full year in June 1984. We understand that the Federal Highway Administration is generally satisfied with the new cost accounting system.

According to the department, the system was designed to accomodate the data collection and reporting needs of a maintenance management system. However, development of these subsystems received a lower priority, and they have not been implemented yet. In its 1986-1987 budget request, the department sought funds for a performance accounting subsystem. That subsystem would collect data on work units and associate that information with cost data to produce reports on achievements and productivity.

Until these capabilities are added,

- The new system currently does little to improve maintenance management in the department and offers little useful management information for maintenance operations.

For example, the new system reports hours worked on certain activities. (The old system did not record hours, only expenditures by work category.) However, it does not relate those hours to specific tasks or work accomplished. Similarly, the system reports materials expenditures by work category, but it does not relate amounts of materials used to work accomplished. Because the system does not relate quantities of labor or materials to measures of accomplishments, it cannot report unit costs for maintenance activities. Since the department is unable to record unit costs, the new system does not help a manager to evaluate worker productivity or to compare the productivity of MnDOT crews or maintenance areas. Furthermore, only a little progress has been made in developing periodic or ad hoc reports for maintenance managers.

Maintenance managers have the option of collecting and reporting cost data by area level, sub-area, or highway section. As a result, managers can select the information they feel is most useful. However, this means that statewide data on a sub-area or highway section level are not uniformly available.

c. <u>Current Efforts</u>

In 1982, the Department of Transportation completed four pilot projects in contracting for highway maintenance. Based on those projects, which we discuss in Chapter III, the department realized it lacked adequate information about its costs for maintenance. In 1982, it began a project designed to supplement Cost Accounting System data with additional information.

In this project, the department designated ten broadly representative segments of highway throughout the state. For twelve months, sub-area supervisors used special forms to collect data on 24 types of work performed on those road segments. The supervisors reported the data to the Office of Maintenance on a bi-weekly basis.[4]

The department has not completed its analysis of the cost data reported on the representative segments. It has completed a preliminary report reviewing the issues involved and listing some preliminary findings. For example, the data do indicate some significant variations in productivity and costs between maintenance areas. The data also seem to indicate wide variations in how districts record and report certain costs. This calls into question the reliability of the data collected.

E. RECOMMENDATIONS

The Department of Transportation needs to improve its management of highway maintenance. We believe that the department would benefit from implementing more systematic approaches to assessing work needs, budgeting, and using available resources. Therefore, we recommend:

- The Department should develop and implement a highway maintenance management system.
- The Department should develop the features inventory and other supporting data needed to support a maintenance management system.

In developing a maintenance management system, the department should seek to use existing systems and data to the extent possible and not significantly increase the reporting burden on maintenance staff. Furthermore, the department should explore methods of making management data and reports easily accessible to field supervisors.

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[4]District 3 (Brainerd) has continued to collect the supplementary data on certain highways within its borders as part of its effort to develop a small-scale maintenance management system.

We also recommend:

- The Department of Transportation should base its staffing decisions on the maintenance management system and not on the snow and ice formula.

The department needs to allocate additional resources for data processing support and management assistance. Given the size of the maintenance budget, complement, and equipment inventory, it is not unreasonable to spend additional funds for these purposes. Therefore, we recommend:

- The department should allocate funds for data processing support to improve the maintenance management information capabilities of the Cost Accounting System.

- The department should allocate additional staff resources to the Office of Maintenance to provide oversight and management assistance to districts.

Implementing a maintenance management approach requires stable funding, not subject to wide swings because of the weather. Therefore, we recommend:

- The Legislature should appropriate two separate budgets for highway maintenance: one for snow and ice control and the second for all other routine maintenance activities.

These budgets should be based on the work plans and resource needs developed through the maintenance management system. As is done now, the department would shift show and ice funds from districts experiencing mild winters to those where the workload is heavier than usual. It is important that the department receive an additional contingency appropriation so that a district which experienced a severe winter could seek a special allotment. If the winter was mild, a district would retain a portion of its snow and ice budget surplus for discretionary projects while depositing the rest in the contingency fund.

- The department should reexamine its approach to staffing for snow and ice control.

In particular, we think the department should review ways to smooth the fluctuations in its labor needs for winter activity. Obviously, the state needs capable and reliable snowplow operators during the winter. The department may be able to better staff for winter peaks by expanding its use of overtime and contractors and by hiring seasonal operators. In the next chapter, we review the use of contractors for maintenance activities. The department could also pursue the transportation worker concept and hire workers whose assignments would vary with seasonal workloads.

Furthermore,

- The department should continue to reexamine its high standards for snow and ice control.

Although safety and convenience dictate a certain minimum standard, experience suggests that this minimum may often be exceeded.

Contracting for Routine Maintenance

Chapter 3

The issue of who provides routine maintenance services is important to a variety of people. Private contractors want the state's business. State employee unions are concerned that private maintenance contracts would eliminate state jobs. The Minnesota Department of Transportation is ultimately responsible for the effective delivery of maintenance, and the department makes final decisions regarding who will provide services. In examining the difficult issue of maintenance-by-contract, we asked:

- To what extent do Minnesota and other states contract for highway maintenance?
- How reliable were MnDOT's findings from its four 1982 contracting pilot projects?
- What implications do the pilot projects have for MnDOT's own operations?

A. ROUTINE MAINTENANCE CONTRACTING IN MINNESOTA

Private companies do most of Minnesota's trunk highway construction work, while Minnesota Department of Transportation employees perform most of the trunk highway routine maintenance. However, the state spends significant sums of money for maintenance contracts.

In 1982, $6.57 million of MnDOT's routine maintenance outlays went for contracts with non-state service providers (7.2 percent of total expenditures). In 1984, state contracts totalled $3.25 million (3.3 percent of total expenditures).[1] A breakdown of

[1]Minnesota Department of Transportation Cost Accounting System.

1982 and 1984 agreements by district appears in Table 3.1. We learned of several examples of contracts in our discussions with district personnel. For example, District 3 (Brainerd) hires a private snowplow and driver for some of its winter work. On a larger scale, District 9 (Oakdale) contracted for $1 million in crack and joint repair from its maintenance budget in 1982.

TABLE 3.1

PERCENTAGE OF DISTRICT ROUTINE MAINTENANCE WORK DONE BY CONTRACT

1982 and 1984

		Percentage of Work Contracted	
	District	1982	1984
1	Duluth	5.5%	6.4%
2	Bemidji	5.0	2.1
3	Brainerd	6.0	1.8
4	Detroit Lakes	14.1	2.2
5	Golden Valley	7.0	3.0
6	Rochester	5.2	3.3
7	Mankato	0.0	2.7
8	Willmar	1.9	0.0
9	Oakdale	14.1	5.5
	State	7.2	3.3

Source: Minnesota Department of Transportation Cost Accounting System.

Table 3.2 shows the percentage of costs in broad maintenance categories represented by contract agreements in 1982. Nearly half of that year's contracts were for work on road surfaces.

The department's use of routine maintenance agreements with cities explains the large number of contracts in the traffic services category. The 25 affected cities provide all routine maintenance on certain stretches of trunk highways within the cities' corporate limits.[2] About two percent of the state's

[2]In addition, the department has several *limited* agreements with cities (e.g., for snow removal only).

trunk highway lane miles are maintained through local maintenance agreements. Expenditures for these agreements totalled $1.4 million in 1984.

TABLE 3.2

PERCENTAGE OF MINNESOTA ROUTINE MAINTENANCE WORK DONE BY CONTRACT

1982

Category of Routine Maintenance	Statewide Percentage Done by Contract	Highest Percentage of Contracting Among the Nine Districts[a]
Roadway Surface	19.7%	37.6%
Traffic Service	8.7	16.3
Structures	8.0	25.5
Roadside/Drainage	4.3	11.9
Shoulders/Approaches	3.4	8.5
Snow/Ice Control[b]	0.0	0.0

Source: Minnesota Department of Transportation Maintenance Cost Accounting System.

[a]For each category, this column represents the percentage of work done by contract in the district doing the most contract work. Note that District 9 (Oakdale) contracted for $1 million in roadway surface work in 1982.

[b]Although districts sometimes rent equipment for snow and ice control, the maintenance cost accounting system does not report these as contract expenditures.

Cities receive an annual sum based on the number of trunk highway miles or lane miles they maintain. The negotiated rates paid to cities vary, as seen in Table 3.3. Municipalities are responsible for most necessary maintenance on these road segments, even if the state funding does not fully reimburse the segment costs in a given year. Cities are not required to submit maintenance expenditure data for their agreements, so it is difficult to tell how closely the state's payment corresponds to city spending. The department enters most of the agreements because city crews can maintain certain roads in a more timely and convenient fashion than state crews. Any savings to the state resulting from these agreements are incidental; they are usually not explicitly considered when the state negotiates agreements. Maintenance agreements are renegotiated every two years.

TABLE 3.3

STATE RATES FOR ROUTINE MAINTENANCE AGREEMENTS

Maintenance Area	City	Miles or Lane Miles Maintained	Negotiated Payment Rate
1B	Grand Rapids	6.8 miles	$1,598/mile
1B	Hibbing	2.3 miles	1,598/mile
1B	Chisholm	1.3 miles	1,598/mile
1B	Virginia	2.5 miles	1,598/mile
1B	International Falls	3.1 miles	1,598/mile
1B	So. Int'l. Falls	2.2 miles	1,598/mile
1B	Biwabik	0.6 miles	1,598/mile
1B	Gilbert	0.9 miles	1,598/mile
1B	Buhl	0.5 miles	1,598/mile
4A	Fergus Falls	3.8 miles	1,918/mile
4A	Breckenridge	1.9 miles	1,918/mile
6B	Austin	2.4 miles	1,918/mile
6B	Albert Lea	7.1 miles	1,918/mile
6B	Faribault	4.9 miles	1,918/mile
6B	Northfield	2.8 miles	1,918/mile
6B	Red Wing	2.5 miles	1,918/mile
1A	Cloquet	1.4 miles	2,269/mile
6A	Rochester	3.9 miles	2,269/mile
4A	Moorhead	24.6 lane miles	959/lane mile
7A	Mankato	14.1 lane miles	959/lane mile
9	South St. Paul	21.6 lane miles	1,119/lane mile
9	West St. Paul	6.6 lane miles	1,119/lane mile
1A	Duluth	120.1 lane miles	1,981/lane mile
5	Minneapolis	197.6 lane miles	1,981/lane mile
9	St. Paul	175.3 lane miles	1,981/lane mile

Source: Minnesota Department of Transportation.

The department does not actively solicit new total maintenance agreements, and the number of cities with agreements remained fairly constant over the past decade. Seven of the state's fifteen maintenance areas have no cities with agreements. While small cities like Buhl and South International Falls maintain trunk highway segments for the state, larger cities like Bemidji, Brainerd, and St. Cloud do not maintain any trunk highways.

B. MAINTENANCE CONTRACTING IN OTHER STATES

For several reasons, it is difficult to compare the scope of Minnesota's maintenance contracting with that of other states. First, states define maintenance differently. For example, some states include resurfacing projects in their maintenance budgets, while Minnesota generally does not. Second, some data on the contracting efforts of states may not be reliable. For example, a 1983 national study suggested that Minnesota contracts no maintenance work, which is clearly incorrect.[3] Estimates of the percentage of maintenance done by contract in other states sometimes vary, depending on the source of information. A third problem is that even reliable estimates of a state's use of contracting rarely disclose who the contractors are (private firms or local governments) or what activities the contractors perform.

Recognizing these data problems, it is nevertheless useful to consider some summary data and some individual cases. In 1981, the national Transportation Research Board surveyed state maintenance engineers to obtain data specifically related to maintenance budgets. Of 37 states replying, 15 contract less than 10 percent of their maintenance, 12 contract 10 to 25 percent of their maintenance, and 10 contract more than 25 percent of their maintenance work.[4] Specific data on individual states were not available from this study. However, Appendix B includes percentages of contract work in various states, based on information we obtained from a variety of sources.

Among the governments that have tried the most extensive contracting are the following:

- <u>Michigan</u>: The state contracts with 62 counties and 154 municipalities. Most of these contracts cover a broad range of maintenance functions. Contract agencies maintain 74 percent of the state's trunk highway system. The local governments own their equipment and bill the state for equipment costs at an hourly rate.[5]

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[3] Council of State Governments, <u>State Highway Programs and Innovations: Midwestern Region</u>, April 1983, p. 35. MnDOT supplied the Minnesota data for this report.

[4] James F. Kelley, <u>Formulating and Justifying Highway Maintenance Budgets</u>, National Cooperative Highway Research Program, Synthesis of Highway Practice 80, October 1981, p. 24.

[5] Letter from Michigan Department of Transportation, June 28, 1984.

- Wisconsin: Seventy-two counties perform all routine trunk highway maintenance under the supervision of district transportation offices. Counties may not subcontract work. The state owns equipment only for sign maintenance and pavement striping.[6]

- New York: Towns and counties perform 58 percent of all state snow and ice control by contract.[7]

- Ontario: Private contractors perform 20 percent of all maintenance. The province trained private snowplow operators and now contracts one-fourth of its plowing. Also, the province does most winter highway salting by contract. Increasingly, Ontario uses private contractors in the summer for patching, stockpiling materials, drainage work, and ditching.[8]

To assess the potential of maintenance contracts with counties, we talked with representatives of several Minnesota county highway departments. We also visited Wisconsin, the state that uses county contracts the most. We conclude:

- There are no particular advantages to Wisconsin's structuring of maintenance service delivery over Minnesota's system.

Counties are the sole service providers in Wisconsin because of historical precedent, not because of efficiency studies comparing counties and other service providers. We found no evidence of inherent efficiency in Wisconsin's practice of having counties provide all trunk highway maintenance within their borders. In neither Wisconsin nor Minnesota do private companies compete with public employees for trunk highway maintenance work.

C. 1982-83 MINNESOTA PILOT PROJECTS

Legislative interest in the possibility of maintenance by contract led to two studies of the issue in the past four years. In 1981, the Legislative Highway Policy Study Commission

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[6]Interview with the head of Wisconsin's maintenance operations.

[7]Kelley, op. cit., p. 47.

[8]J. Hugh Blaine, "Contract Maintenance in Ontario," Maintenance Management Systems in Evolution, Transportation Research Board, 1984, pp. 297-312.

examined the feasibility of contracts with counties for trunk highway maintenance. Although no report was issued, the commission concluded that there is little interest and little promise in county contracting. However, the commission saw greater promise in private contracting for maintenance.

Based on the recommendations of the study commission, a Minnesota Department of Transportation committee selected four pilot projects for maintenance by private contract in 1982. The department let each project for bids in a different maintenance area, and each project was unique in the range of work activities it included. Figure 3.1 provides a brief description of each proposed project and its results. The projects are also summarized in a December 1983 report, "Maintenance By Contract," by the department's Maintenance Office.

D. CRITIQUE OF T.H. 55 PROJECT

Although we evaluated all four pilot projects, we focused our efforts on the T.H. 55 project (which was never awarded) for several reasons. First, MnDOT did not award the contract because the bids were much higher than the department's estimate of reasonable costs. However, the T.H. 55 project clearly illustrated the department's difficulties in writing contracts for the pilot projects and estimating maintenance costs. Second, this project's scope was much wider than the other projects. The contract would have had a longer duration (two years) and included more work activities than any of the other three projects. The project's range of work activities most closely resembled the ongoing tasks of a MnDOT maintenance crew. Because of the project's broad scope, MnDOT invested a significant amount of staff time the preparation of the contract and engineer's estimate. Finally, this project clearly had more impact in shaping opinions about contracting than any of the other projects. During the course of our study, we heard many people mention the T.H. 55 results as evidence that contracting for maintenance is not cost-effective.

1. METHODOLOGY OF THE ENGINEER'S ESTIMATE

a. Description

The Minnesota Department of Transportation's Technical Services Division makes engineer's estimates for all construction contracts. The purpose of these estimates is to determine a reasonable bid for a work proposal.

The department uses a variety of techniques to compute engineer's estimates. Annual MnDOT surveys of contractors yield

FIGURE 3.1

SUMMARY OF 1982-83 PILOT PROJECTS

	TOTAL MAINTENANCE: TRUNK HIGHWAY 55	SNOW AND ICE CONTROL: INTERSTATE 94	SHOULDER MAINTENANCE: TRUNK HIGHWAY 4	STOCKPILING: DISTRICT 8
LOCATION	23 miles of T.H. 55, located west of Minneapolis.	14 miles of Interstate 94, located south of St. Cloud.	19 miles of T.H. 4, located near Windom.	Eleven sites in MnDOT District 8 (Willmar).
CONTRACT ACTIVITIES	All highway maintenance, except for highway lighting and traffic signal maintenance.	Snow plowing, chemical application, bridge clearing, sign cleaning, other winter maintenance.	Construction and maintenance of gravel shoulders. Eliminate dangerous shoulder drop-offs, and provide shoulder slopes appropriate for good drainage.	Purchase sand and salt; haul materials to stockpile site; mix nine parts sand with one part salt.
CONTRACT LENGTH	Two years.	One winter (October through May).	One year.	Contractors were given about two months to stockpile sand for a single winter.
WHO DETERMINED UNIT QUANTITIES REQUIRED BY CONTRACT	Mainly a committee of District 5 workers; MnDOT's Maintenance Office helped.	MnDOT's St. Cloud Office (District 3).	MnDOT's Windom Office (Area 7B).	MnDOT's Willmar Office (District 8).
WHO ESTIMATED UNIT PRICES FOR THE DEPARTMENT	Technical Services Division of MnDOT developed an engineer's estimate.	Technical Services developed an engineer's estimate.	Technical Services developed an engineer's estimate.	MnDOT's Maintenance Office estimated the department's own costs of stockpiling.
RANGE OF CONTRACTOR BIDS	$944,647 to $1,081,643.	$53,215 to $157,550.	$63,850 to $87,360.	Varied by site. Average bid at 11 awarded site was $14.09 per cubic yard of winter sand.
MnDOT's COST ESTIMATE	Originally, MnDOT's engineer's estimate was $625,384. After bids came in, MnDOT revised the estimate to $688,994.	Originally $45,450, the department later increased the engineer's estimate to $49,203.	$63,171.	Varied by site. MnDOT's estimated costs at the 4 rejected sites was $11.86.
RESULTS OF CONTRACT	Not awarded.	Awarded to low bidder. Contractor had problems with the first storm but improved afterwards. MnDOT estimated its costs on a control section that winter were $46,605, while actual contractor costs were $63,622.	Awarded to low bidder. MnDOT found the contractor had slightly lower costs than state crews on a control section. The department called the contractor's work "generally acceptable."	Three contractors won bids at 11 of 15 sites proposed; MnDOT maintained the other four. Quality of work at all sites was good, but MnDOT concluded (based on costs at its four sites) that state stockpiling is more cost-effective than contractor stockpiling.

hourly costs for certain types of equipment. The department contacts materials suppliers for regional cost information. In addition, the department keeps computerized records of all bids received on various types of construction work. MnDOT uses this information to develop cost estimates that consider a contractor's profits, overhead, and fringe benefits. In general, contracts are awarded to the lowest bidder, provided the low bid is not more than 10 percent over or 25 percent under the engineer's estimate.

b. Problems with the Estimate

In examining the department's maintenance contract cost estimates, we found that:

- The department encountered serious problems in its efforts to develop engineer's estimates for the pilot projects.

The Technical Services Division estimated three of the four maintenance pilot projects using the methodology described above. One of the problems encountered was the lack of maintenance experience on the part of the estimators. Estimating prices on the T.H. 55 project required numerous assumptions regarding crew size, crew productivity and frequency of work. The division's two estimators received help in making some of these assumptions from a District 5 (Golden Valley) employee. However, the estimators also made many of the assumptions and estimates intuitively, without outside help. Although both estimators had experience pricing Maintenance Preservation Program projects, the items in the T.H. 55 contract bore little resemblance to previously estimated items.

A second problem with the estimate was the occasional use of District 5's (Golden Valley) work assumptions. For example, District 5 provided approximate crew productivity rates based on district experience. By applying estimated contractor costs to District 5 work assumptions, the department produced an engineer's estimate that mixed a contractor's perspective with District 5's perspective. This is different from MnDOT's usual practice with construction engineer's estimates, which are primarily computed from the contractor's perspective. The engineer's estimate could not fully reflect a contractor's perspective since the District 5 work assumptions were never disclosed to contractors.

While the engineer's estimates were made in good faith and probably reflected the best information available at the time, we conclude that:

- The MnDOT engineer's estimates were artificial and far inferior to a better measure against which bids might be compared: MnDOT's own maintenance costs.

Unfortunately, the department does not have adequate cost data to make comparisons between state costs and contractor costs, as discussed in Chapter 2. The use of engineer's estimates for *construction* projects is appropriate. Department forces generally do not perform construction work, so estimates of reasonable costs for proposed projects are needed. However, in the pilot maintenance projects, MnDOT was deciding whether its own forces or contract forces would deliver given services. Historical state maintenance costs offer a unique resource for bid comparison that MnDOT should use.

As noted earlier, the department currently contracts for several million dollars of maintenance work each year. As a general rule, districts contract for items they cannot do or choose not to do themselves. Thus, we found that:

- Explicit cost comparisons of state and contract crews often do not occur before districts enter contracts. Because of this, the department cannot determine the cost-effectiveness of current contract work.

In the case of private contracting, MnDOT compares bids from private companies to each other, but not always to the department's cost for the same task. In the case of contracts with municipalities, the department generally renegotiates the agreements without explicit comparison of state and city maintenance costs.

The department currently has no plans to develop additional pilot projects in which it would award contracts based on comparisons between state costs and private bids. This may be due to the governor's opposition to such contracts, expressed to the commissioner of transportation.

2. CLARITY OF SPECIFICATIONS

Through interviews with contractors and department personnel, we found:

- The T.H. 55 contract proposal was imprecise and incomplete. This hindered the bidding process.

The contract proposal included no historical data on expenditures, hours of work, methods, or staffing levels. At least two contractors sought this information from MnDOT and were unable to obtain it. The department held a "pre-letting conference" for potential bidders, designed to resolve contract questions and ambiguities. We learned that both contractors and MnDOT personnel remained unclear about parts of the contract after the conference.

One example of the lack of contract clarity was the use of several lump sums in the specifications. Work items bid by lump sums require the contractor to estimate a total work item cost without knowing the specific number of resource units needed. For example, T.H. 55 bidders had to estimate the total cost of traffic cones they would need for two years of maintenance work.[9] The contract proposal gave no indication of the number of cones needed, producing wide variation in the estimates. One bid for cones was eight times the engineer's estimate.

Contractors often perceived work items differently than the department because of ambiguity in bid items. One example involved roadside seeding. The contract stated that topsoil was an incidental item, meaning it would be included in the seeding pay item. However, the contract gave no indication of the need for topsoil on T.H. 55. Thus, the contractor assumed the seeding site might require the delivery of topsoil. The department made no such assumption. As a result, MnDOT estimated a cost of $150 per acre for roadside seeding, while one contractor bid $6,000 per acre.

Why did the contract proposals lack clarity and specificity? First, the department did not have the detailed historical information that might have helped bidders and MnDOT estimators. Second, specific road maintenance needs are hard to predict, especially without good historical data. Since the T.H. 55 contract was designed as a total maintenance contract, the department wrote the contract specifications broadly to leave room for unforeseen contingencies.

Contractors responded to the lack of clarity and the lack of MnDOT historical data with cautious bidding. They added cushion to their bids as a protective measure in case they won the contract and experienced unexpected costs. Both contractors and department personnel claim that this sort of response is not unusual with vague contract proposals. The lack of contract clarity also hindered the Technical Services Division's estimators. However, since MnDOT crews were not held to the department's estimate when the contract was not awarded, the Technical Services Division did not have the financial stake in the contract which the bidders had. Thus, the division did not have an incentive to exercise the degree of cautious price estimation shown by the contractors.

3. UNIT QUANTITY ESTIMATES

Contracts are awarded on the basis of total bid prices, not on the basis of individual bid items. For each bid item, MnDOT determines the number of units required (such as hours of work

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[9]Traffic cones are used to divert traffic away from highway work.

or tons of material), and this estimate of quantity becomes a given for bidders. Bids vary in price, not in quantity.

Even though all bidders use the same quantity estimates, assumptions made regarding unit quantities may determine who wins or loses a contract. The relative importance of each contract work item is affected by the quantity of each item that is set in the specifications. Quantity estimates of individual items are especially important in a contract proposal with many bid items, like the T.H. 55 proposal.

We found:

- The department has little information on which to base accurate estimates of unit quantities for maintenance activities, and this may affect the awarding of contracts.

In general, district offices estimated quantities for all four pilot projects. For T.H. 55, a committee of District 5 workers estimated the amounts of work needed over a two year period. Although the district had information on the number of days per year spent in certain activities, most of the quantity estimates were ballpark figures and were not based on actual experience on T.H. 55.

The Minnesota Department of Transportation's Cost Accounting System does not include information on the quantities of materials used for various maintenance tasks. The system reports overall materials costs for work categories, but it does not report information such as tons of asphalt mix used.

It is difficult for us to determine conclusively what impact questionable quantity estimates had on the contractors' bids. Nevertheless, the following example illustrates our doubts about the accuracy of T.H. 55's quantity estimates and the possible impact of errors in these estimates.

Because 1984 was the hardest winter in recent years, snow and ice control accounted for 33 percent of the year's routine maintenance expenditures. However, in the T.H. 55 engineer's estimate, snow and ice control accounted for 42 percent of costs. This extremely high estimate raises questions about its validity. Further doubts about the estimate arise when comparing the estimated T.H. 55 snow and ice quantities with the estimated quantities for the Interstate 94 winter maintenance pilot project. Level of winter service on these roads is comparable, although T.H. 55 may need somewhat more attention due to frequent intersections and certain high-traffic areas. Table 3.4 compares quantity estimates for these highway sections, with corrections made for mileage differences between the two:

TABLE 3.4

COMPARISON OF QUANTITY ESTIMATES

	Interstate 94*	T.H. 55
Sand	1408 tons	2200 tons
Salt	580 tons	1650 tons
Equipment	2552 hours	4000 hours

*I-94's mileage is equated to T.H. 55's mileage

The estimates suggest that T.H. 55 needs twice as many materials and 57 percent more equipment than Interstate 94. While snow and ice control needs are hard to predict, the T.H. 55 contract specifications may have been excessive in their snow and ice quantity estimates. These high quantity estimates worked to the department's favor in the bidding process, since the engineer's estimate of snow and ice costs was lower than or equal to contractors' bids in all cases. The high quantities gave added weight to winter maintenance work items compared to others in the contract.

E. ISSUES IN OTHER PILOT PROJECTS

1. PERFORMANCE EVALUATION

At the outset of the projects, the state maintenance engineer said: "The most important part of these experimental projects is the evaluation of the result."[10] He noted that this evaluation is difficult and, to a certain extent, subjective. An evaluation committee measured project performance by collecting information on cost, productivity and quality of work. Among those who monitored the projects were MnDOT personnel, legislative staff, contractor representatives, and representatives from the American Federation of State, County, and Municipal Employees.

- In general, contractors in the pilot projects fared reasonably well on performance measures, although they sometimes used resources inefficiently to achieve quality results.

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[10]Memorandum, C. W. Christie to Evaluation Committee members, September 8, 1982.

Shouldering. The department concluded: "The contractor's quality of workmanship was generally acceptable with the exception of the shoulder maintenance in the areas of bituminous surfaced entrances or road approaches, where frequently a ridge of gravel or a low area was left by the contractor."[11] The monitoring team used work sampling and time study to measure productivity. The department concluded that the contractor, despite costing less than MnDOT crews, worked slightly slower.

Snow and ice. The monitoring team deemed productivity for snow and ice control a "meaningless indicator" and did not develop productivity measures. The team's quality measures included response times, work times, accidents and complaints, labor and equipment hours, salt and sand quantities, and signs damaged. The monitoring team used a control section for comparison. Over the entire winter, the control section received an average quality rating of 6.86 and the contract section was rated 6.63. However, the contractor used 31 percent more labor and equipment than MnDOT used in the control section. The contractor also used 22 percent more salt and 30 percent more sand than MnDOT.

Stockpiling. The department compared 11 sites stockpiled by contract to the four sites where bids were rejected. MnDOT drew no specific conclusions on quality and productivity in its final report on these projects. However, District 8 (Willmar) reported in its study of the projects: "The quality and quantity results by both MnDOT forces and the contractors were good."[12] Perhaps the most significant finding by District 8 was that the stockpiling methods used by contractors and the department differed. Department crews used a time-saving mixing technique that lowered costs.

We found that:

- MnDOT developed specific performance measures for routine maintenance work only to evaluate maintenance by contract pilot projects.

The work evaluations used in the pilot projects were unusual for the department. MnDOT developed the rating systems specifically to evaluate contractors for the 1982 projects and to compare the performance of MnDOT crews on control sections. However, no such measures are used now to regularly evaluate department work.

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[11]Maintenance by Contract, p. 15.

[12]District 8 Maintenance Office, Cost Comparison of Winter Sand Production, January 11, 1983, p. 3.

2. EQUIPMENT COSTS

To determine the sites at which stockpiling contracts were awarded, the Department of Transportation made estimates of its own stockpiling costs and compared the costs to bids received. Estimating these costs required the department to assign equipment costs to specific tasks. MnDOT did this by multiplying the amount of time stockpiling equipment was needed by the department's 1982 state-owned equipment rental rate. We conclude that:

- **The department's estimates of equipment costs were highly questionable.**

Equipment rates can vary significantly from year to year. The department sets hourly equipment rates by dividing the previous year's total equipment costs (depreciation, fuel, insurance, maintenance) by the total usage the equipment received in the year. The rate is not actually paid by districts when they use pieces of state-owned equipment since districts do not receive equipment budgets.

We looked at rates for eight pieces of equipment that one district used for stockpiling. Over a five year period, the maximum state equipment rate charged for these pieces of equipment averaged 139 percent over the minimum rate charged in that time.[13] An example of a drastic one-year rate change is motor graders, which went from a 1983 rate of $14.85 per hour to $1.85 per hour in 1984. Changes in equipment rates tend to reflect changes in usage rather than changes in costs faced by MnDOT. Using the widely varying equipment rates to make in-house cost estimates may lead to inaccuracies, and the department should consider this problem.

A second problem with the stockpiling equipment estimates was the department's assumption that equipment used at all 15 sites is identical. A 1982 survey of equipment used at one district's stockpiling sites showed that equipment varied significantly from one site to the next.[14] Details about equipment used in site-specific tasks are important and may help districts discover equipment efficiencies. It also will help the department produce more realistic estimates of its work activity costs. Historical information on task-specific or site-specific equipment usage is not kept by the department.

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[13]Minnesota Department of Transportation. Included in the comparison are equipment classes 33, 35, 62, 72, 75, 76, 77, and 121.

[14]District 6 submitted data on 16 stockpile sites to the department in November 1982.

3. OVERLOOKED COSTS

We found that the department neglected some important operating costs in its analysis of the pilot projects. Specifically:

- The department's estimate of its stockpiling costs prior to bidding did not consider *administrative overhead.*

The result was an understatement of estimated costs at the stockpiling sites. Overhead represents approximately one-fifth of MnDOT's routine maintenance costs and is routinely applied to labor, equipment and materials by the Cost Accounting System.

- *Overtime* was not considered by the department in its engineering estimates or its estimates of state crew costs.

In particular, overtime is a significant expense for winter maintenance activities and should be explicitly considered in the department's estimates of snow and ice costs.

- The department has no indication of the extent to which *down time* adds to maintenance costs.

Down time occurs when factors beyond the worker's control prevent the completion of tasks. Causes of down time may include bad weather, accidents on the road, broken or missing equipment, and lack of materials.[15] Some states keep separate accounts for down time. It is important to recognize that poorly utilized state crew time represents a cost to the state. However, when contractors poorly utilize time, they generally absorb this expense in the bid price.

F. CONTRACTING: BARRIERS AND ADVANTAGES

In this section, we review possible barriers to maintenance contracting and possible advantages of such contracts. The actual effect of these barriers and advantages can only be determined by contracting experiments.

1. POSSIBLE BARRIERS TO CONTRACTING

The cost of subcontracting. The contractors who bid on the T.H. 55 pilot project did not anticipate doing all maintenance

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[15] Utah Legislative Auditor General, Utah Department of Transportation's Contractual Maintenance, September 1984, p. 19.

work themselves. While the low bidder claimed that he planned little subcontracting, another bidder considered subcontracting even for major activities, such as road surface maintenance. Subcontracting clearly inflated some bids by adding an extra layer of profits. Thus, we believe that bids involving large amounts of subcontracting are less likely to win contracts than bids from "jack-of-all-trades" contractors. This may hinder contractors on projects like T.H. 55 that involve varied work activities. However, the bidding process tests the degree to which subcontracting acts as a barrier to cost-effective service delivery.

The cost of profit. The bids of private contractors include profits, a cost that government service providers do not have. However, as with subcontracting, the bidding process should test whether contractor profits prevent cost-effective work. In addition to being a cost, profits provide a cost-saving incentive.

Lack of proper equipment. Because contractors lacked experience in routine maintenance service, many did not have all the equipment needed for the pilot projects. Contractor expenses for new equipment inflated several bids. However, the contractors' annual equipment costs are, in part, determined by the length of the contract. Longer contracts produce lower equipment costs, as contractors amortize their investment at lower annual rates.

Regarding winter maintenance, we learned that contractors often lack the equipment needed for winter work. However, we were also told by some contractors that snowplowing work is a promising area for the normally slow winter work period.

Lack of contractor interest in certain items. Some people told us that contractors are not interested in small routine maintenance activities. We did find that contractors express greater interest in large activities, but they do not rule out smaller items if they are profitable. MnDOT staff claim that contractors will not bid on unpredictable work items. This can best be tested in future contract letting.

Lack of contractor experience. It is clear that private contractors often lack the valuable experience that state crews have gained from years of service delivery. The problems encountered in the first snowstorm of the 1982 St. Cloud pilot project exemplify this barrier to effective contracting. But the contractor's performance improved markedly after this initial experience.

Bid-rigging. In any contract letting, there is some threat of contractor bid collusion. An unsuccessful bidder on the shoulder maintenance pilot project was recently indicted for construction bid-rigging. The solution to this problem may be proper department monitoring rather than a refusal to contract.

Emergency response. It is difficult to account for every maintenance contingency when writing a contract. Situations may arise that require work not within the bounds of the contract. The state could handle emergencies in a variety of ways. Government crews could address emergencies, or the department might allow good faith negotiation on cost reimbursement after a contractor responds to the emergency.

Cyclical interest in maintenance contracts. Some people told us that contractors were interested in the 1982 pilot projects mainly because the construction economy was slow at the time. They said construction booms will weaken the market for maintenance contracting. However, our discussions with contractors indicated that interest in contracting still exists. Some contractors like the continuing nature of maintenance, which could smooth the unevenness of construction contracting. Also, the state's investment in new construction is not likely to expand in future years, and this may make routine maintenance more attractive to contractors.

Contracting's effect on the department's workforce. First, contracting may not prove cost-effective if the department does not reduce its workforce as contracts are awarded. MnDOT did defer some equipment purchases and held some positions vacant during the pilot projects. In two of the projects, however, the department's costs for labor were not significantly reduced. Second, if contracting *does* result in lower department staff levels, such staff reductions may be difficult to reverse in the future. If contracting efforts produce poor results, expertise lost in earlier staff reductions might not be regained.

Labor negotiations. Large numbers of contracts might result in layoffs. Minnesota courts have interpreted the Public Employee Labor Relations Act as requiring an agency to negotiate with its workers before entering layoff-producing contracts for agency-delivered services.[16]

Cost estimation. Many of the department's problems in estimating costs were caused by its lack of historical cost data. Even with such data, however, the department would face uncertainties in predicting maintenance needs. No one knows with much certainty when a given pothole will appear or when a major winter snowstorm will occur.

However, these cost estimation uncertainties are not insurmountable barriers to contracting. First, some maintenance activities are more predictable than others. Mowing and debris cleanup follow regular schedules. Second, while individual potholes are often hard to predict, maintenance needs for a long stretch

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[16] General Drivers Union Local 346 v. Independent School District No. 704, Proctor School Board, 283 N.W.2d, 524.

of road are easier to predict. Third, maintenance needs are determined largely by the condition of various roadway components (e.g., road surface, shoulders, culverts). Reliable condition ratings of these components help predict needs. Finally, uncertainties are less important when bidding is done on a unit price basis. Awarding contracts to the low unit price bidder assures cost-effectiveness even when quantities vary from original estimates. This is less true on a contract like T.H. 55, where the large number of work items increased the need for accurate quantity estimates.

2. POSSIBLE BENEFITS OF MAINTENANCE CONTRACTING

Mistakes cost less. Presently, the state pays for the costs of its maintenance crews' mistakes. If work is poorly done, corrections generally are made by state crews at state expense. If contractors do poor work, the state may require corrections without additional state costs.

MnDOT flexibility and workload levelling. We found that maintenance districts have many workload peaks and valleys during the year. Contracting may help minimize the effect of these varying demands on state employee workloads. Openness to contracting may also give the department a freer hand in seeking work efficiencies.

Lower resource costs. The department pays for state labor and equipment whether it is used efficiently or poorly. For example, idle equipment represents a cost to the state, even though district budgets are not hurt by such inefficiencies. However, when work is contracted, the state pays only for labor and equipment when they are in use.

Greater accountability. Serious consideration of maintenance contracting forces governments to better account for their own costs of doing business. These costs are presently seen as a given in many cases.

Schedule continuity for contractors. As noted earlier, some contractors view the continuing nature of maintenance as a good balance to the sometimes unpredictable nature of construction work. However, contractors should not view maintenance as secondary to construction work. Timely maintenance is important, and such work should not be dictated solely by a contractor's construction work schedule.

G. TWO UNIQUE CASES OF CONTRACT MAINTENANCE

1. ONTARIO

Private contractors perform over 20 percent of Ontario's maintenance. The use of contracting increased greatly in recent years, particularly in patching, surface repair and winter maintenance activities. Ontario awards contracts when cost savings will result or when private firms offer expertise lacking in the province highway department.

Until 1979, Ontario only used province staff and province-owned equipment for snow and ice control. In an effort to reduce costs, Ontario tested contract snowplowing five years ago. The government provided instruction for the private truck owners and also provided snowplowing equipment. Ontario encountered few problems, and contractors appeared interested in this work.

Private contractors currently perform 23 percent of the province's snowplowing. Contractor productivity is comparable to the government's, and most contractors now use their own equipment. The government still purchases equipment for contractors in cases where volume purchases produce lower prices. The government now mounts most of its salt spreaders on contractor trucks. The government facilitated this by purchasing self-contained spreaders that are easily attached and removed from vehicles. Contractor truck specifications, which once were less rigid than those of government trucks, now are comparable to government specifications. In addition, the government cut its equipment costs by contracting for 200 snowplows.

Ontario shifted gradually to contracting, without employee layoffs. Although it anticipates no total maintenance contracts (like T.H. 55), Ontario contracts for a wide variety of activities.

So far, Ontario has not had major problems with performance or with the financial viability of contractors. Two contractors terminated their winter contracts in 1982-83, but the government avoided service reductions by obtaining replacement equipment. However, agencies thinking of contracting for maintenance should consider the possible consequences of contract terminations.

We are impressed by the apparent success of Ontario's transition to contract maintenance. The changes are due, in part, to tight budgets. Still, the training and equipment initially given to contractors suggests more than minor interest in maintenance by contract. Instead of being discouraged by the contractors' lack of maintenance experience, Ontario addressed this problem to investigate possible improvements in service delivery. In addition, Ontario is improving its maintenance management system so that it can more closely compare costs of its own crews with contractor costs.[17]

2. UNITED KINGDOM

The United Kingdom does all its highway maintenance by contract. However, government organizations do most of the maintenance, not private contractors. Legislation in 1980 created direct labor organizations (DLO's) of public employees that operate as contractors with the public highway authority. Each county's DLO is separately accountable and competes with private contractors for certain maintenance activities. Counties award all jobs costing more than £50,000 on a competitive basis, and the counties also open 30 percent of all jobs below this threshold to competition.

Perhaps more interesting than the introduction of competition is the form of reimbursement used for DLO work. The basis of each DLO's income is the bids or quotations submitted before work is done. DLO income is not based on the actual cost of work done, and income is not provided in the form of a budget. Even when a DLO faces no competition for a given job, it must still bid for the planned work, and the county bases reimbursement on the bid price. Each DLO must earn a specified rate of return on capital, currently five percent. The transportation authority can close down all or part of any DLO that does not achieve the mandated rate of return.

The United Kingdom system confronts public agencies with the same responsibilities facing private contractors. DLO's are at risk to make appropriate bids and to recoup their costs. And since DLO's can accumulate profit and spend it in succeeding years, incentives for efficiency exist.

Early experience with the system shows that public employees still provide most of the United Kingdom's maintenance. But specification of routine maintenance costs and determination of appropriate rates is becoming simpler. Increasingly, DLO's make accurate cost predictions before bidding and quantify the results of their work.[18]

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[17]Blaine, "Contract Maintenance in Ontario," pp. 297-312.

[18]Brian E. Cox, "Contract Maintenance in the United Kingdom," <u>Maintenance Management Systems in Evolution</u>, Transportation Research Board, pp. 329-347.

H. CONCLUSIONS AND RECOMMENDATIONS

1. MEASUREMENT OF MAINTENANCE COSTS

The 1982 contracting pilot projects left many people with the impression that maintenance by private contract is not cost-effective. We do not believe the pilot projects justify this conclusion. Rather, we conclude that:

- **The department lacks sufficient information about the cost of its own maintenance work and the performance of its own crews.**

The recent improvements to the Cost Accounting System do not adequately address MnDOT's need for cost information, especially information needed to make appropriate decisions on maintenance contracts. The department's inattention to needed management information leads us to conclude that:

- **The Minnesota Department of Transportation has not sufficiently distinguished its role as a service provider from its role as a manager of public resources.**

The department views delivery of maintenance services by its own employees as a given, and it gives inadequate attention to the cost and productivity of the services it manages. Thus, the department lacks information on which to base good managerial decisions: decisions regarding how service is delivered and who the service providers should be.

For these reasons, we recommended development of a maintenance management system in Chapter 2. Even if MnDOT were never to let another maintenance contract, the department needs such a system to aid decision-making and internal work evaluations. Minnesota is behind many if not most states in its ability to estimate the cost of its maintenance work.

2. PERFORMANCE EVALUATION

Performance evaluation serves two primary purposes. It provides feedback for supervisors and managers so they may acknowledge quality work practices and correct inadequate ones. Evaluation also produces measures of productivity that the department can use to predict future maintenance resource needs. While the department makes some worthwhile evaluation efforts (particularly through its Peer Review reports of district activities), MnDOT needs additional performance appraisals. We recommend that:

- The department should develop an array of performance measures for major work activities similar to those developed for the 1982 pilot projects.

Districts could use these measures to spot-check crew performance or to develop ongoing crew comparisons. Managers can measure the process crews use to complete tasks and the final product of the crews' work. Pennsylvania does quality assurance evaluations for activities such as patching, crack filling, pipe replacements and surface treatments.

We also recommend that:

- As part of a maintenance management system, the department should develop standard units of productivity measurement for work items and appropriate methods for recording this data.

The department's comparative segment study is a good first step in this direction. Districts recorded productivity units such as tons of material used per worker hour. The department should refine this model based on lessons learned in the first study.

3. FUTURE PRIVATE CONTRACTING FOR MAINTENANCE

The first four contracting pilot projects were a good faith effort by the department. We found no evidence to substantiate some contractors' claims that the department intentionally manipulated project results to favor state crews. What we did find was that the Department of Transportation's ability to estimate its own costs is inadequate, and the department's willingness to investigate service delivery options is less than enthusiastic.

We recommend:

- The department should continue to examine additional ways of contracting highway maintenance activities.

MnDOT needs to understand if and when contracting is a cost-effective option for the state. It may not be useful to develop large scale pilot projects until the department implements a maintenance management system and can better compare its costs to a contractor's bid. However, the department could contract for certain activities where it would be easier to define the scope of the work and to estimate costs. Examples are mowing, litter pickup, and weed control.

There are several steps the department could take to ensure the success of future pilot projects and additional maintenance contracting.

We recommend:

- The department should take steps to facilitate contracting if such help will lead to more cost-effective service delivery. Actions might include technical assistance for contractors, the development of longer contracts, and the provision of historical maintenance costs to bidding contractors.

- Pilot projects should be ongoing rather than single, short-term efforts.

- The department should compare contractor bids to actual state crew costs whenever possible, rather than comparing bids to engineer's estimates of contractor costs.

- All estimates of MnDOT costs should consider overhead, overtime and, when appropriate, down time.

To improve the estimation of state equipment costs in future maintenance contracts, we recommend that:

- The department should estimate equipment costs with a method less sensitive to yearly variations in equipment usage.

The department could achieve this in different ways. First, it could estimate equipment costs using an average equipment rate over several years. Second, if the department wants to address its rate-setting structure, it might investigate use-related depreciation schedules as an alternative to straight-line schedules. Some states are implementing use-related depreciation. We also recommend that:

- The department should direct districts or sub-areas to document the types of equipment used for specific maintenance tasks.

This will help districts discover efficiencies in equipment use that some districts may already practice.

4. CONTRACTING WITH COUNTIES

We believe that any use of counties to deliver maintenance services in Minnesota should be selective and directed at efficiency improvements. MnDOT districts may find that county highway departments are more proximate to certain difficult roads (e.g., roads with serious snow problems). In such cases, county service delivery for particular stretches of trunk highway may produce efficiencies. However, we doubt that major efficiencies are possible by having counties maintain all roads within their borders. The department may wish to retain legal liability for maintenance, in order to ease counties' concerns about increased exposure to tort liability.

We recommend:

- The department should develop criteria (such as proximity, availability of equipment, etc.) to identify roads which counties could maintain. Each maintenance area should investigate the potential for cost savings that might arise from contracts with counties for certain stretches of road.

Maintenance Preservation Program

Chapter 4

In this chapter, we examine the Minnesota Department of Transportation's Maintenance Preservation Program (MPP). Through the program, the department uses a separate annual appropriation of $7.5 million for preventive maintenance activities throughout the state. The program attempts to address some roadway problems not adequately dealt with by routine maintenance activities or highway improvement programs.

Our evaluation of the MPP addressed the following questions:

- How well does the department manage the Maintenance Preservation Program? How has the department distributed the MPP funds among its districts, and what kinds of work did districts perform?

- Did MPP work comply with the purpose and objectives of the program? How different are MPP projects from routine maintenance and highway improvement? To what extent is MPP work performed by private contractors?

- Has the Maintenance Preservation Program been effective? To what extent does the program achieve its objectives?

This chapter presents our findings concerning these questions. It is organized in three sections. The first section gives an overview of the Maintenance Preservation Program and describes the types of work performed. The next section examines the operation of the program and presents our analysis of department management of the program. In the final section, we offer recommendations for improving the Maintenance Preservation Program.

A. PROGRAM OVERVIEW

1. APPROPRIATIONS

The Legislature first funded the Maintenance Preservation Program in 1980. The Legislature approved $2.9 million for 1980 and $4.7 million for 1981. The department's 1982-83 request for the program was based on a survey of districts' needs. The Legislature increased the appropriation to $7.5 million annually, where it has remained since. The department believes that current funding levels meet district needs for the foreseeable future.

2. PROGRAM OBJECTIVES AND ACTIVITIES

MnDOT has three distinct programs that perform various activities on the trunk highway system: routine maintenance, highway improvement, and maintenance preservation. Routine maintenance activities are ad hoc repairs of minor, recurring deficiencies in roadway conditions. Highway improvements are intended to significantly enhance the roadway's condition and to extend the useful life of the roadway beyond original design expectations.

In contrast, maintenance preservation activities involve non-routine repairs designed to guard against further deterioration, prevent more costly future repairs, and enable the road to reach its full design life. For example, a concrete road may be designed to last for 35 years. However, to reach the full 35 years requires both routine maintenance and maintenance preservation work, such as repairing the joints every eight to twelve years and performing other work at regular intervals. If these periodic treatments are not performed, the road will need major repairs well before reaching the end of its design life. Maintenance preservation activities are generally larger in scope, more costly, and take longer to perform than routine maintenance activities.

Figure 4.1 describes the various activities that qualify as maintenance preservation projects. The Department of Transportation cites three objectives for the Maintenance Preservation Program:

1. To extend the service life and operational safety of roadways;
2. To defer the need for capital improvements; and
3. To reduce ongoing maintenance expenditures.

The department says that it is necessary to use program funds for extraordinary repairs to roads in poor condition. Because funds for highway resurfacing and reconditioning are limited, some of these roads will not receive major rehabilitation for

FIGURE 4.1

TYPES OF MAINTENANCE PRESERVATION PROJECTS

1. Surface Treatments:

   a. full overlays - full width pavement overlays of bituminous material; may vary in depth from 1/4 to 2 inches, and may vary in lenth from 500 feet to less than 3 miles; used to improve the strength of the roadway and the quality of the ride.

   b. spot overlays - full width pavement overlays of bituminous material; less than 500 feet in length; used in spots where successive patching and deterioration have occurred.

   c. seal coats - road surface is sprayed with an asphalt material, then covered with sand or chip rock; used on sound roadways to protect the surface from weather and moisture damage.

2. Concrete Pavement Joint Renovation:

   Renovation of inplace joints between concrete panels by sawing out failed joint sealant, replacing it with new material, and hand-patching any deterioration.

3. Concrete Pavement Repair:

   Spot replacement of destroyed roadway panels and concrete joint repair which is beyond the scope of joint renovation; may include pavement planing or milling to bring adjacent panels level at the joints.

4. Shoulder Restoration:

   Building up low shoulders or replacing shoulder material (usually gravel) to prevent or correct excessive shoulder drop off; done to improve safety and drainage .

5. Stockpiling:

   Providing for ample, on-hand supplies of necessary maintenance materials such as gravel for shouldering, and sand and salt for snow and ice control.

6. Bridge Painting:

   Spot painting of bridges where the structures have 20 percent unsound paint or less; complete painting of bridges in severe cases.

7. Bridge Preservation:

   Provides a short term extension in the structural life when funding is unavailable in other programs to refurbish the structure.

8. Drainage Treatment:

   Provides or corrects drainage of roadway.

9. Base Corrections:

   Work done below the pavement of a roadway, such as culvert replacement, and the clearing and grading of ditch in-slopes and back-slopes to reduce the potential for snowdrift accumulation.

Source: A Summary Report on Maintenance Preservation - 1980, Minnesota Department of Transportation (Sept. 1980).

several years, if ever. As we discuss in this chapter, program funds are used to keep these roads serviceable, even though the department acknowledges that such expenditures may not be cost-effective.

In our analysis, we have defined appropriate activities and benefits for the Maintenance Preservation Program more narrowly than the department. Specifically, we have looked for activities which contribute to roads reaching their full design life, and we have measured the department's use of the program against this more narrow standard.

3. FUNDING AND PROJECT SELECTION PROCEDURES

During the first two years of the Maintenance Preservation Program, the department allocated an equal amount to each district. In 1982, MnDOT changed the funding allocation method and separated the appropriated funds into two categories:

- *Category I funds* (60 percent of the annual appropriation) are allocated to the districts at the rate of $157 per lane mile. These are discretionary funds which districts can spend on projects which they select.

- *Category II funds* (40 percent of the appropriation) are spent on projects selected by the department's central office based on a statewide priority system.

The 1982 change in allocation procedure was intended to expand central office control over the increased appropriation while maintaining district discretion over a portion of the program funds.

Each district designs its own MPP projects with the approval of the Maintenance Operations Section. In addition to restricting projects to the types of work described in the previous section, department criteria dictate that:

1. Money may be used for renting equipment, purchasing materials, hiring seasonal employees and letting contracts;

2. Projects should not conflict with planned projects in the highway improvement, bridge painting, and bridge replacement programs;

3. Projects must provide a longer extension of service life than can be obtained through routine maintenance;

4. Projects should have a maintenance preservation benefit; and

5. Projects should meet one of the following criteria:
    a. extend the useful life of the facility in lieu of making a capital improvement;
    b. reduce the routine maintenance cost of the facility; or
    c. be a necessary project which does not qualify in other programs.

To describe and substantiate the need for a Category I MPP project, districts provide itemized cost estimates, a description of the current condition of the worksite, and a statement of the anticipated benefits. A manager in the Maintenance Operations Section reviews Category I project requests for each district, and approves them if they meet the criteria.

The department distributes Category II funds on a project-by-project, statewide basis, and uses a more restrictive set of criteria to target projects to activities producing preservation benefits. Districts initiate requests for Category II funds. The requests are reviewed together, which means that each proposal competes against all others for funding, regardless of district.

The department established a priority scheme for Category II projects. Highest priority goes to medium sized projects ($50,000 to $350,000) which involve concrete pavement work. Bituminous overlays and shoulder restoration projects in this dollar range receive second priority. The department's rationale for first evaluating Category II projects by cost is that projects over $350,000 should be in an improvement program, such as resurfacing or reconditioning. Projects less than $50,000 can be managed within routine maintenance budgets and staff.

B. MnDOT MANAGEMENT OF THE MPP

1. PROGRAM DOCUMENTS AND RECORDS.

The Maintenance Preservation Program is managed by the Maintenance Operations Section in the department's Operations Division. Staff review and approve district requests for MPP project funding and monitor the progress of all projects.

The Maintenance Operations Section monitors district activity on MPP projects. It maintains records on all approved projects, transfers of funds to districts, and payments made to private contractors. Staff also prepare periodic program recap and district status reports. In 1981, staff began to enter pertinent project data in a computer file with the intention of eventually producing reports detailing where and how program funds were spent.

In 1980 and 1982 the department published summary reports on the projects completed in the first and third years of the Maintenance Preservation Program. In addition to presenting data on each project completed, the summaries attempted to analyze the benefits realized from the activities performed.

However, it was extremely difficult to obtain accurate and reliable data about many projects from the central Maintenance Office. We found that:

- Many MPP files and records are incomplete or inaccurate, and the department has only a very general idea of where and how funds are spent.

As a result, the department cannot determine the extent to which projects comply with the purpose and objectives of the Maintenance Preservation Program. For example, we found that the MPP Project files contained projects which were approved but later cancelled. We also found that the MPP Force Account File did not contain final cost figures for most of the projects performed by district maintenance forces. The 1980 and 1982 MPP Summary Reports were not reliable because summary tables showed figures that could not be reconciled with project cost figures contained elsewhere in the reports. Finally, the computer file contained complete project information for only two of five years.

The Maintenance Operations Section acknowledged that its records and files on the program are incomplete and that the program is not easy to evaluate. Staff explained that the problems resulted from lack of staff and the 1982 increase in the MPP budget. Though the computer file was intended to be a central source for all program data, keeping it updated received low priority. According to department staff, the department will soon commit the resources needed to make the computer file current.

2. DISTRIBUTION OF MPP FUNDS.

a. <u>Category I: District Discretionary Projects</u>

Table 4.1 shows the Category I dollars allocated to the districts between 1980 and 1984. In the first two years of the program, each of the nine districts received the same allocation. The table indicates that with the increase in the 1982 MPP appropriation, most districts currently receive more Category I funds. However, both metropolitan area districts do not fare as well under the per lane mile allocation formula and receive substantially less than they did in 1981.

Actual expenditures by districts have been different from their initial allocations. Table 4.1 shows the amount of each

TABLE 4.1

MAINTENANCE PRESERVATION PROGRAM
CATEGORY I DISTRICT ALLOCATIONS AND EXPENDITURES

District	1980		1981		1982		1983		1984	
	Allocate	Expend	Allocate	Expend	Allocate	Expend[a]	Allocate	Expend[a]	Allocate	Expend[a]
1 Duluth	$ 300,000	$ 130,316	$ 500,000	$ 655,958	$ 575,000	$ 426,051	$ 575,000	$ 315,733	$ 575,000	$ 196,072
2 Bemidji	300,000	383,467	500,000	479,360	615,000	513,905	615,000	576,889	615,000	0
3 Brainerd	300,000	304,085	500,000	485,937	584,000	696,205	584,000	888,559	584,000	218,613
4 Detroit Lakes	300,000	289,913	500,000	441,200	578,000	460,652	578,000	383,585	578,000	228,263
5 Golden Valley	300,000	306,899	500,000	531,249	294,000	333,861	294,000	230,434	294,000	189,799
6 Rochester	300,000	375,352	500,000	630,667	573,000	816,505	573,000	708,614	573,000	444,352
7 Mankato	300,000	298,131	500,000	501,460	516,000	553,803	516,000	481,895	516,000	424,305
8 Willmar	300,000	300,208	500,000	631,871	465,000	514,309	465,000	636,694	465,000	738,215
9 Oakdale	300,000	487,079	500,000	317,885	308,000	42,143	308,000	426,100	308,000	100,952
Overrun Reserve	195,000		210,000							
Totals	$2,895,000	$2,875,450	$4,710,000	$4,675,587	$4,508,000	$4,357,434	$4,508,000	$4,648,503	$4,508,000	$2,540,571

Source: PED analysis of Minnesota Department of Transportation records, September 1984

[a] Note that expenditure figures for several projects in 1982, 1983, and 1984 were not final at the time of our research.

district's annual allocation that was actually spent. Actual expenditures for 1983 and 1984 appear low for many districts because final payments have not been made on 34 percent of projects begun in 1983 and on 72 percent of 1984 projects. In addition, 13 percent of 1982 projects have not been finalized.

Some districts have been more successful than others at spending their full allocation. During the first three years of the program, Districts 5 (Golden Valley), 6 (Rochester) and 8 (Willmar) fully utilized their allocations and captured funds from other districts, notably Districts 1 (Duluth) and 4 (Detroit Lakes). Table 4.2 compares districts on the proportion of their allocations which they actually spent during the first four years of the program.

Some were able to spend more than their initial allocation. This may have happened for several reasons. First, a project may have received funding from another program, such as federal highway rehabilitation funds for concrete or overlay work. Second, funds may have been shifted among districts because of differences in estimated and actual costs on specific projects. If a district scales down or cancels an approved project and cannot get other projects approved in time, the department transfers unused and unencumbered Category I funds to a district with a project overrun or a project it can begin immediately.

Some districts may be less effective than others at designing preservation projects and less aggressive in securing other districts' unspent Category I funds. For example, in District 1 (Duluth), construction staff rather than maintenance operations staff design and plan MPP projects. Construction staff do not give priority to developing MPP projects. The district has not had projects ready on which to spend all of its allocation.

On balance, the benefits from shifting Category I allocations outweigh any disadvantages or unfairness resulting from relative gains or losses among districts. The system rewards good planning and preparedness. Since allocations occur annually, districts can try to gain funds in the succeeding year.

b. Category II: MnDOT Selection of MPP Projects

Table 4.3 shows the total dollar amounts allocated to each district for projects selected by the department's central maintenance office. Total allocations to districts between 1982 and 1984 ranged from a low of $100,000 to as much as $750,000. As in the case with Category I funds, however, actual spending by districts differed significantly from the amount originally allocated. Although final spending figures are unavailable for 1983 and 1984, it is clear that some districts have gained while others have lost project funding.

TABLE 4.2

MAINTENANCE PRESERVATION PROGRAM CATEGORY I FUNDS
COMPARISON OF DISTRICT ALLOCATIONS TO EXPENDITURES

BY DISTRICT
1980-1983

	Total Allocations		Total Expenditures		Expenditure/ Allocation Ratio	
District	Dollars	Rank	Dollars	Rank	Percent	Rank
1 Duluth	$1,950,000	4	$1,528,058	7	78%	9
2 Bemidji	2,030,000	1	1,953,621	4	96	6
3 Brainerd	1,968,000	2	2,373,786	2	121	3
4 Detroit Lakes	1,956,000	3	1,575,350	6	81	8
5 Golden Valley	1,388,000	9	1,402,443	8	101	4
6 Rochester	1,946,000	5	2,531,138	1	130	2
7 Mankato	1,832,000	6	1,835,589	5	100	5
8 Willmar	1,465,000	7	2,083,082	3	142	1
9 Oakdale	1,416,000	8	1,273,207	9	90	7

Source: PED analysis of Minnesota Department of Transportation Records.

TABLE 4.3

MAINTENANCE PRESERVATION PROGRAM
CATEGORY II FUNDING DISTRIBUTIONS

District	1982 Allocation	1982 Expend	1983 Allocation	1983 Expend[a]	1984 Allocation[a]
1 Duluth	$ 452,000	$ 352,110	$ 750,000	$ 750,000	$ 196,613
2 Bemidji	360,000	373,725	0	0	550,551
3 Brainerd	380,000	287,360	401,000	83,812	644,337
4 Detroit Lakes	150,000	227,073	275,000	146,902	278,852
5 Golden Valley	217,000	66,972	100,000	77,031	0
6 Rochester	746,000	687,938	625,000	618,840	234,698
7 Mankato	398,000	351,936	195,000	113,324	146,049
8 Willmar	0	0	225,000	175,695	293,411
9 Oakdale	289,000	651,947	250,000	439,006	697,037
Overrun Reserve			171,000		
Totals	$2,922,000	$3,009,061	$2,821,000	$2,403,610	$3,041,548

Source: PED analysis of Minnesota Department of Transportation Records.

[a]Data on 1983 and 1984 expenditures are incomplete.

3. PROJECTS FUNDED BY THE MPP.

Table 4.4 presents a summary of Maintenance Preservation Program activity in each maintenance area for 1980 to 1984. The table indicates differences in the way districts design MPP projects and utilize program funds. Districts 1 (Duluth), 5 (Golden Valley) and 9 (Oakdale), containing Minnesota's major urban areas, have a few large MPP projects each year. Districts 3 (Brainerd), 6 (Rochester) and 7 (Mankato) perform a large number of small projects.

These differences in size of projects depend on who designs MPP projects at the district level. Maintenance engineers tend to design numerous small projects with specific maintenance needs in mind, while construction engineers with a large scale highway improvement perspective tend to design projects involving more miles of highway and more systemic maintenance problems.

We also analyzed how much of each type of work was done. Table 4.5 shows expenditures for five major types of MPP activity. The table indicates that the greatest commitment over the five-year period has been to bituminous surface treatments and shoulder rehabilitation: 56 percent of expenditures. However, since 1982, when Category II funding began, the amount of funds devoted to bituminous and shoulder work has decreased. During this same period expenditures for concrete pavement work has increased.

a. <u>How Districts Spent Discretionary Funds</u>

In our analysis of Category I projects, we looked at how each district spent its allocation. From the data and from discussions with district administrators, we learned that the program's flexibility enables each district to address problems unique to its geographic area. Table 4.6 summarizes the extent to which each district performed five different kinds of MPP projects for the five-year period.

District 1 (Duluth) contains three major watersheds and has had serious and unexpected road washouts during spring thaws. Thus, 39 percent of its allocations were for base corrections, much more than any other district. It used the MPP as an emergency resource and to replace deteriorated metal drainage pipes with concrete culverts.

The trunk highways in District 2 (Bemidji) serve heavy commercial traffic associated with the agricultural industry in the Red River valley and the timber industry in Minnesota's north central forests. Much of the area is marsh and bog which provide a poor substructure for roadways. Table 4.6 shows that the district spent most of its allocation for thick bituminous overlays and shoulder restoration. Thick overlays provide additional strength to weak roadways, and they compensate for

TABLE 4.4

MAINTENANCE PRESERVATION PROGRAM SUMMARY
NUMBER OF PROJECTS FUNDED AND TOTAL EXPENDITURES
BY MAINTENANCE AREA AND BY DISTRICT

1980-1984

Maintenance Area/District	1980 Number of Projects Funded	1980 Total Expenditures	1981 Number of Projects Funded	1981 Total Expenditures	1982 Number of Projects Funded	1982 Total Expenditures	1983 Number of Projects Funded	1983 Total Expenditures	1984 Number of Projects Funded	1984 Total Expenditures	1984 Encumbered Unliquidated	1984 Estimated Total Expenditures	5 Year District Project Totals	5 Year District Expenditure Totals
1A Duluth	1	$ 130,316	1	$ 255,554	1	$ 91,954	3	$ 940,155	2	$ 30,467	$ 414,605	$ 445,072		
1B Virginia	0	0	3	400,404	4	686,207	2	125,578	7	256,014	111,211	367,225		
Subtotal	1	130,316	4	655,958	5	778,161	5	1,065,733	9	286,481	525,816	812,297	24	$ 3,442,465
2A Bemidji	2	263,944	4	280,162	6	503,770	6	396,198	3	0	462,499	462,499		
2B Crookston	1	119,523	4	199,198	5	383,860	4	180,691	5	0	753,177	753,177		
Subtotal	3	383,467	8	479,360	11	887,630	10	576,889	8	0	1,215,676	1,215,676	40	3,543,022
3A Brainerd	3	144,911	7	191,367	5	455,124	8	292,965	6	85,238	323,566	408,804		
3B St. Cloud	8	159,174	8	294,570	12	528,441	9	678,406	12	133,375	666,295	799,670		
Subtotal	11	304,085	15	485,937	17	983,565	17	971,371	18	218,613	989,861	1,208,474	78	3,953,432
4A Detroit Lakes	4	99,412	4	294,486	5	257,191	4	235,859	6	114,557	867,000	981,557		
4B Morris	4	190,501	3	146,714	5	430,534	6	294,628	4	113,706	63,704	177,410		
Subtotal	8	289,913	7	441,200	10	687,725	10	530,487	10	228,263	930,704	1,158,967	45	3,108,292
5 Golden Valley	1	306,899	5	531,249	5	400,833	3	307,465	2	189,799	18,546	208,345	16	1,754,791
6A Rochester	6	144,129	10	251,263	9	961,785	6	355,913	5	278,371	51,184	329,555		
6B Owatonna	9	231,223	8	379,404	9	542,658	14	971,541	7	165,981	189,975	355,956		
Subtotal	15	375,352	18	630,667	18	1,504,443	20	1,327,454	12	444,352	241,159	685,511	83	4,523,427
7A Mankato	5	124,308	1	247,727	7	441,394	11	316,897	4	354,624	3	354,627		
7B Windom	7	173,823	9	253,733	10	474,345	10	278,322	8	215,112	91,784	306,896		
Subtotal	12	298,131	10	501,460	17	915,739	21	595,219	12	569,736	91,787	661,523	72	2,972,072
8A Willmar	5	118,956	7	303,700	4	231,077	8	812,367	6	738,215	22,122	760,337		
8B Marshall	1	181,252	5	328,171	9	283,232	1	22	—	—	—	—		
Subtotal	6	300,208	12	631,871	13	514,309	9	812,389	6	738,215	22,122	760,337	46	3,019,114
9 Oakdale	3	487,079	1	317,885	4	694,090	6	865,106	8	100,952	880,273	981,225	22	3,345,385
TOTAL	60	$2,875,450	80	$4,675,587	100	$7,366,495	101	$7,052,113	85	$2,776,411	$4,915,944	$7,692,335	426	$29,662,000

Source: PED Analysis of Minnesota Department of Transportation Records.

settling. The table also indicates that District 2 had more stockpiling projects than any other district. This is because additional layers of bituminous on a roadway require building up aggregate shoulders to the same level. Ironically, the district's need for shoulder aggregate is combined with the absence of gravel pits in the region. Therefore, gravel must be hauled into the district.

TABLE 4.5

MAINTENANCE PRESERVATION PROGRAM
PERCENTAGE OF EXPENDITURES BY TYPE OF WORK[a]

Type of Project	1980	1981	1982	1983	1984	1980-84
Bituminous Surface Treatments and Shoulder Work	61%	62%	61%	46%	53%	56%
Concrete Joint Renovation and Pavement Repair	33	29	27	39	37	33
Base Corrections	0	4	4	9	7	6
Stockpiling	4	3	6	5	3	4
Bridge Painting and Repair	2	2	2	1	0	1

Source: PED analysis of Minnesota Department of Transportation records.

[a] Total expenditures 1980-1984=$29.7 million

District 3 (Brainerd) devoted most of its allocation to bituminous overlays, using the program as a resource for holding together roads which really need to be reconstructed. The district also spent a relatively large percentage of its MPP allocation for stockpiling.

District 4 (Detroit Lakes) spent most of its MPP allocation on bituminous overlays and shoulder restoration projects. Significantly, several recent projects covered long stretches of roadway that, if thicker, would not be distinguishable from resurfacing projects in the highway improvement program. The second greatest commitment of program funds in District 4 was for base corrections to snowslopes. Grading the strips of land adjacent to roads helps to prevent drifting of snow, a major problem in the district.

TABLE 4.6

MAINTENANCE PRESERVATION PROGRAM
SUMMARY OF CATEGORY I EXPENDITURES AND PROJECTS

1980-1984
By District and Type of Work

	Bituminous and Shoulder Work		Concrete Work		Stockpiling		Bridge Work		Base Corrections	
District	% of Dollars	% of Projects	% of Dollars	% of Projects	% of Dollars	% of Projects	% of Dollars	% of Projects	% of Dollars	% of Projects
1 Duluth	35%	24%	26%	19%	0%	5%	--	--	39%	52%
2 Bemidji	82	65	3	6	12	26	--	--	3	3
3 Brainerd	54	46	21	13	15	20	2	8	8	13
4 Detroit Lakes	75	60	3	2	3	5	1	2	18	31
5 Golden Valley	41	29	56	50	--	--	3	14	0	7
6 Rochester	67	60	25	25	1	3	6	12	--	--
7 Mankato	90	86	1	2	9	10	0	2	--	--
8 Willmar	88	85	6	2	1	7	2	4	3	2
9 Oakdale	29	50	71	50	--	--	--	--	--	--

Source: PED analysis of Minnesota Department of Transportation records.

The metro area districts spent most of their program funds on concrete work. District 9 (Oakdale) spent more of its MPP allocation on concrete pavement projects than any other area. The district ranks third in number of concrete lane miles in the state and has made the preservation of these roads a high priority. District 5 (Golden Valley) spent about 56 percent of its MPP allocation on concrete pavement projects. 30 percent of its roads are concrete.

District 6 (Rochester) used the program to place bituminous overlays on selected stretches of roadway. According to district administrators, the region has more old roads than other districts, and they need to be rebuilt. The district uses MPP projects to hold roads together until they can be reconstructed.

Districts 7 (Mankato) and 8 (Willmar) spent more of their MPP allocations on bituminous and shoulder restoration projects than any other district. According to staff, these districts have many old roads which are inadequate for serving the spring and fall agricultural transportation needs of the area. The roads need to be reconstructed, but because of low traffic counts they do not qualify for improvement programs. MPP bituminous and shoulder projects help to maintain minimum serviceability. Though District 7 ranks second in the state in total concrete lane miles, it spent the least on concrete pavement projects. District staff say that their concrete highways are beyond repair and that to spend program funds on them is to throw money away.

This summary demonstrates the flexibility of the Maintenance Preservation Program. While this is a very positive aspect of the program, we concluded:

- Several types of work currently performed with MPP funds are inconsistent with maintenance preservation goals.

In particular, bituminous overlays on roads needing major improvements, stockpiling projects and shoulder restoration activities do not provide any preservation benefits.

By our definition, maintenance preservation activities are those which result in avoidance of future, more costly maintenance repairs and which ensure only that roads remain in serviceable condition for as long as originally expected. Concrete pavement projects are the best example of activities that produce several preservation benefits. According to the department, timely replacement of joint material between concrete pavement panels prevents penetration of water to the subgrade where it would rust metal reinforcements and create soft spots. Prevention of these problems avoids potential cracking and breaking away of pavement and the eventual replacement of pavement sections.

However, the department spends program funds on activities without clear preservation purposes. In its 1980 and 1982 Summary Reports on the Maintenance Preservation Program, the department claimed that each activity reduced maintenance costs and extended the useful life of highways beyond the original lifespan. However, activities whose only benefits are maintenance cost reductions or extensions to service life do not serve preservation purposes.

Thus, we conclude:

- The department uses the program to supplement the highway improvement program and routine maintenance activities.

For example, many bituminous overlay projects performed with MPP funds do not serve preservation purposes. Rather, they supplement highway improvement programs.[1] In interviews, department managers said that the program is often used to quickly provide a surface treatment on roads needing extensive improvement. For a variety of reasons many roads do not qualify for highway improvement programs when they need improvements, and districts use the program to "hold the roadway together" in the meantime. Projects which extend the service life of roadways that need highway improvement do not serve a preservation goal. Department staff have defined the program broadly and feel that these activities are appropriate expenditures of program funds.

Other activities have little preservation benefit and seem to supplement the routine maintenance program. For example, stockpiling projects do not provide preservation benefits. Their only benefit is a one-time cost savings realized by the purchase of larger quantities of material at a lower unit cost. This benefit may be offset by the cost of holding the material in inventory until it is used.

Shoulder rehabilitation projects involving the distribution and grading of rock on aggregate shoulders are part of the routine maintenance program and do not have preservation benefits.[2] Shoulder rehabilitation primarily improves safety. It may produce a secondary benefit of improved drainage. Pavement width, traffic, and erosion dictate the frequency of shoulder restoration activities. It is difficult to see how shoulder work that does not address these three factors would reduce future shoulder maintenance.

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[1]Some bituminous overlays do serve preservation goals. Generally, bituminous overlays are appropriate as MPP projects when performed earlier in the life cycle of a roadway.

[2]For purposes of this discussion we do not include shoulder restoration activities performed in conjunction with appropriate bituminous overlays.

b. Analysis of MPP Category II Projects

Category II funding criteria give highest priority to projects valued between $50,000 and $350,000 and involving several different kinds of concrete pavement activities. Table 4.7 shows that most of the 1982 projects were bituminous pavement activities, which should have received lower priority under the department's criteria. However, since then the proportion of concrete pavement projects selected increased sharply, from 36 percent to 86 percent in 1984.

TABLE 4.7

MAINTENANCE PRESERVATION PROGRAM
CATEGORY II EXPENDITURES

	PERCENT OF PROJECTS			
	1982	1983	1984	Total
BY PROJECT DOLLAR AMOUNT				
$50,000 - $350,000	67%	83%	58%	68%
Less than $50,000	25	8	21	20
More than $350,000	8	8	21	12
BY PROJECT TYPE				
Concrete Pavement Work	36	92	86	63
Bituminous Pavement Work	56	8	14	33
Other	8	0	0	4

Source: PED analysis of Minnesota Department of Transportation records.

The table also shows the department moving away from its preference for projects in the $50,000 to $350,000 range. In 1984, 42 percent of projects selected were not in the department's top priority range of between $50,000 and $350,000.

c. Contracting MPP Projects

A district may contract out MPP projects or perform the work with its own maintenance forces. If a district elects to contract for a project, the Central Maintenance Office handles the advertising, bid letting and awarding of contracts. If a district uses its maintenance forces for MPP projects, the district charges the program account for incurred material costs and equipment rentals. Program funds do not pay for labor costs unless temporary workers are hired.

We examined the use of contractors for MPP projects. As shown in Table 4.8,

- Contracting has become the predominant method of accomplishing MPP projects.

The proportion of MPP expenditures for contractors has grown from 71 percent in 1980 to 92 percent in 1984. From 1980 through 1984, districts contracted 57 percent of all MPP projects (79 percent of program expenditures) to private firms.

- Some districts have performed MPP projects with MnDOT maintenance workers to a much greater extent than others.

For the five-year period, District 7 (Mankato) contracted for only 37 percent of its MPP funding. All other districts spent more than 50 percent of their program funds by contracting for the work. In 1984, only District 7 (Mankato) contracted for less than 75 percent of its programs funds.

Districts used their own maintenance forces to spend 21 percent of all MPP funds available from 1980 through 1984. Bituminous surface treatments and shoulder repairs were the types of work most often performed by MnDOT maintenance forces. In 1980 the department spent 25 percent of program funds on bituminous and shoulder repair projects performed by district maintenance crews, but by 1984 that had fallen to 6 percent of total expenditures.

In our discussions with district managers we learned that the decision to contract is closely related to how districts use their maintenance workers. For instance, Districts 5 and 9 (Golden Valley and Oakdale) loan maintenance workers to construction projects during the summer. If their remaining maintenance forces were performing MPP projects, regular maintenance work would not get done. Thus, District 5 (Golden Valley) contracted for 100 percent of its program funds, and District 9 (Oakdale) contracted for 95 percent of its MPP funds.

Managers in Districts 6 (Rochester) and 7 (Mankato) said that their staff complements permit the completion of regular maintenance activities and the performance of some MPP projects with maintenance workers. In addition, some districts own or can readily rent specialized equipment and obtain materials needed to perform some MPP projects. Several districts own bituminous pavers, enabling them to do overlay projects that other districts contract out.

TABLE 4.8

MAINTENANCE PRESERVATION PROGRAM
CONTRACTED PROJECTS

1980-1984

District	Percent of All MPP Projects[a]						Percent of All MPP Expenditures					
	1980	1981	1982	1983	1984	Total	1980	1981	1982	1983	1984[b]	Total
1 Duluth	100%	50%	80%	80%	67%	71%	100%	88%	97%	98%	81%	91%
2 Bemidji	100	75	55	100	100	83	100	86	76	100	100	92
3 Brainerd	64	40	76	88	89	73	87	61	87	99	99	90
4 Detroit Lakes	25	57	70	90	90	69	67	79	81	98	95	88
5 Golden Valley	100	100	100	100	100	100	100	100	100	100	100	100
6 Rochester	20	28	50	40	50	37	54	44	81	70	79	72
7 Mankato	8	0	35	19	50	23	21	0	37	39	72	37
8 Willmar	0	83	46	0	100	48	0	94	54	0	100	60
9 Oakdale	100	100	50	100	100	91	100	100	76	100	100	95
TOTAL	35%	49%	58%	58%	79%	57%	71%	72%	77%	77%	92%	79%

Source: PED analysis of Minnesota Department of Transportation records.

[a]Total projects 1980 to 1984 = 426. Overruns and supplements are counted as separate contracts.

[b]Percentages are based on actual expenditures plus unliquidated encumbrances.

4. PROGRAM EFFECTIVENESS

In 1980 the department reviewed the first year's operation of the MPP and concluded that the program successfully met its main objectives. However, we found that the department's analysis was superficial and, as the department's report admits, "subjective."

The department based its program benefit analysis on information and opinions obtained from the maintenance personnel directly involved with each project. Because the evaluation was done in the same year in which the projects were performed, it was based on anticipated benefits, and not on actual results. The department does not conduct any formal evaluation of MPP projects to measure their long term benefits to roads and has no evidence that the program is effective in producing expected results.

Since the department lacked valid measures of the MPP's effectiveness, we evaluated the program's objectives and the extent to which they were met.

a. Objectives

MnDOT proposed the MPP to provide funding for the performance of non-routine maintenance activities on highways not eligible for capital improvement programs. The department stated that the objectives of the program were to:

1. Extend the service life and operational safety of roadways;
2. Defer the need for capital improvements; and
3. Reduce ongoing maintenance expenditures.

The department established individual project criteria to help districts design projects that would qualify for MPP funding. These project criteria incorporated the objectives of the program.[3]

We found that:

- The criteria developed by the department to ensure that districts design projects which meet these objectives do not include specific outcome measures.

The project criteria are deficient because they do not specify the extent of the intended result. For example: What is the desired service life extension? What is the extent of deferral of capital improvements? What is the amount of reduction in maintenance expenditures sought?

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[3]The department MPP project criteria are set forth on pages 76 and 77 in the first section of this chapter. See items 5a and 5b.

Measurable outcomes are needed to determine whether and to what extent the objectives have been met. While the criteria may be appropriate for deciding whether to approve individual projects, they are insufficient for evaluating the success of the MPP as a program.

Furthermore,

- A main objective of the Maintenance Preservation Program--to extend roadway service life and operational safety--is inconsistent with a maintenance preservation concept.

As we stated earlier, we think it is inappropriate for a maintenance preservation program to extend the life of roads which have completed their design life and which need a major improvement. Districts use the program to extend the serviceability of old roads and view it as a source of "fast money" with which to supplement the highway improvement program.

We acknowledge that the department faces a major problem. There are more roads in need of improvement than there are funds available to do the work, and there is a large backlog of improvement projects. However, using maintenance preservation funds to "hold the road together" in the meantime is not the most effective use of the limited funds in that program. The department concedes that such projects are not an effective use of the program and are poor investments in the long term. As we discuss in Chapter V, the department needs to develop a coherent approach to roads which need attention until improvement funds are available.

b. <u>MPP Effectiveness</u>

We attempted to evaluate the success of the program as MnDOT designed and operated it. We developed several tests to measure the effectiveness of the MPP. First, we tried to determine whether performance of MPP projects reduced the maintenance costs for a sample of roadway sections. However, in trying obtain the necessary expenditure and activity data, we found:

- Reduction in maintenance costs for specific sections of roadway could not be determined because not all districts recorded their maintenance activities in the cost accounting system in a consistent way.

For example, some districts charged maintenance expenditures to maintenance sub-areas rather than control sections.

Second, we sought to measure whether the expected life extension was or would be realized. (When obtaining MPP project authorization, maintenance engineers project the number of years of added road life that will result from performing the work.)

We found that:

- We could not determine whether expected road life extensions were realized because the department's cost accounting and condition rating data were inconsistent across districts and could not be related to the actual sites of projects.

As a third test, we attempted to assess reductions in maintenance costs on all roads in two sample districts rather than particular sections of roads. The Maintenance Operations Section provided us with the total annual maintenance expenditures for road surface activities in Districts 1 (Duluth) and 6 (Rochester) from 1975 through 1984. Figure 4.2 depicts the increasing trend in maintenance expenditures in the two districts over the ten year period, and beginning in 1980, shows the yearly MPP investments in each district.

From 1982 to 1984 maintenance road surface expenditures increased dramatically in District 1 and somewhat less so in District 6. These increases occurred despite the investment of greater amounts of MPP funds on roads in each district. Thus, we found no clear, objective evidence that the MPP reduces maintenance costs.

C. RECOMMENDATIONS

The Department of Transportation needs to improve the operation and design of the Maintenance Preservation Program. The program illustrates some of the problems which the department faces in managing programs and making sound investment decisions.

1. PROGRAM DESIGN

In our view, the department has not clearly defined the purposes of the Maintenance Preservation Program and how it fits between the department's routine maintenance and improvement programs.

We recommend:

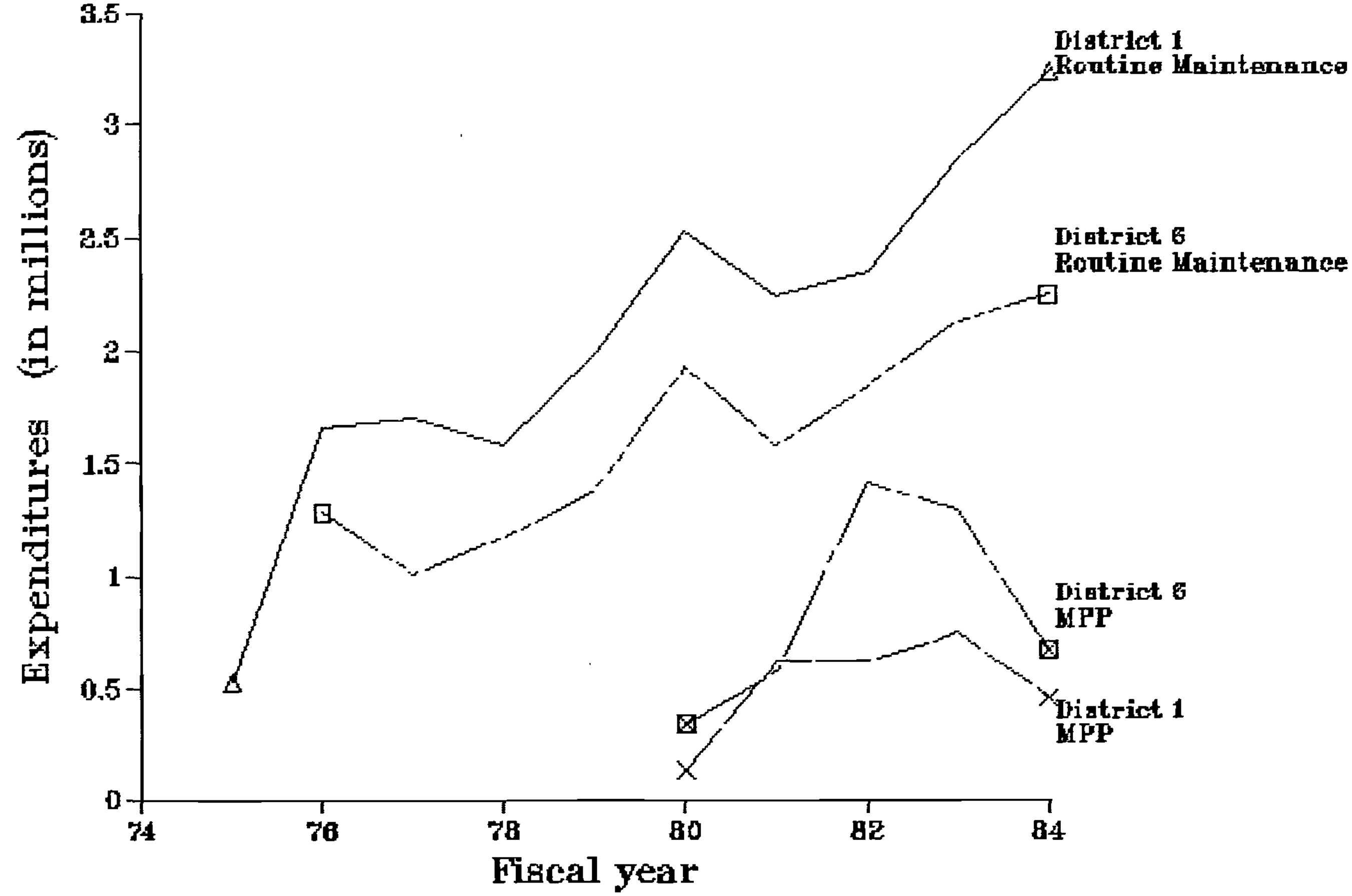
- The department should limit the activities eligible for Maintenance Preservation Program funding.

Specifically, stockpiling and shoulder rehabilitation do not provide preservation benefits, and should be performed in the routine maintenance program.

- The department should reemphasize the role of preventive maintenance in the program and ensure that all

FIGURE 4.2

MPP EFFECT ON ROUTINE MAINTENANCE EXPENDITURES



Source: MnDOT Cost Accounting System and MPP records districts use a significant portion of their discretionary funds for that purpose.

From our analysis, it is clear that some districts are using very little of their discretionary program funds for preventive maintenance activities.

It is also clear that some districts have many roads which are substantially deteriorated and which would not benefit from preventive maintenance. Indeed, these districts have received relatively small Category II allocations for preventive maintenance activities which meet statewide priorities. These districts have used much of their discretionary funds to hold deteriorated roads together.

We recommend:

- The department should continue to provide funds for the special needs of those districts.

For administrative convenience, the department should continue to allocate those funds through the Maintenance Preservation Program. It should designate a portion of the program's budget for this purpose. However, the department should direct these funds to the areas of greatest need. This will require additional central Maintenance Office oversight. The department should develop clear, measurable criteria for how these funds should be used and what results are expected. Furthermore, it needs to monitor closely district decisions about funding of extraordinary repairs so that they are coordinated with central office programming decisions affecting the same roads.

The Maintenance Preservation Program currently offers districts broad discretion, which has made the program popular in the districts. The cumulative result of these recommendations would be to reduce districts' discretion. However, we think these changes are necessary to narrow the scope of the program and to ensure that funds are spent effectively.

2. PROGRAM MANAGEMENT

We found several problems with the management of the program. First, the project files were inaccurate or incomplete. Second, the department lacks evidence that maintenance preservation activities produce the results expected. It has no methods for measuring the effectiveness of the program.

Thus, we recommend:

- The Department of Transportation should place a high priority on updating the Maintenance Preservation Program files and keeping them current in the Central Maintenance Office.

We also identified several problems with the design of the MPP, specifically the project selection and funding criteria of the program. First, the criteria do not set forth measurable outcomes. Second, if the program criteria included measurable outcomes and were appropriate, they would likely not be susceptible to measurement by the department. MnDOT cannot usefully measure the effectiveness of the program because its cost accounting and road condition information systems do not collect the necessary data in sufficient detail or with adequate consistency.

Therefore, we recommend:

- The department should develop a methodology for evaluating the effectiveness of the program as a whole and the unique activities funded by the program.
- The department should develop measurable criteria for project selection and evaluation.
- The department should ensure that district maintenance staff and special maintenance crews record information on maintenance activities and road conditions so that it can be correlated at a later time and used to evaluate the MPP.

Pavement Management

Chapter 5

Pavement management refers to the implicit and explicit highway investment strategies pursued by the Minnesota Department of Transportation. It is the process of deciding the needs of Minnesota's road system as a whole (network-level decisions) and deciding the specific needs of individual roads (project-level decisions). Pavement management helps determine whether roads need treatments (such as overlays) beyond the scope of routine maintenance.

In this chapter, we briefly discuss historical spending for these treatments. We then analyze Minnesota's road condition rating system, since it is the basis of many pavement management decisions. Finally and most important, the chapter focuses on the notion of pavement management *systems* as a means of making highway decisions. We asked:

- What techniques does the Minnesota Department of Transportation use to measure road conditions? How reliable are these measures?
- What progress has the department made on its proposed pavement management system, designed to help determine future road needs and budget allocations?
- Does the department have an adequate system for selecting individual resurfacing and reconditioning projects?

A. A BROADER DEFINITION OF MAINTENANCE

Minnesota Department of Transportation personnel often think of maintenance as those activities which the department performs with its own forces. This definition does not include resurfacing and reconditioning, two highway improvement activities a layperson might think of as maintenance. For purposes of this chapter, we chose a broad definition of maintenance, one that includes resurfacing and reconditioning. *Resurfacing* is a category of work that includes bituminous overlays, shoulder work, joint repair and maintenance emergencies. *Reconditioning* projects typically are more extensive than resurfacing projects, perhaps including road widening and drainage improvements. Both resurfacing and reconditioning maintain the in-place roadway without major changes in design or underlying structure.

Table 1.9 shows historical state budgets for the resurfacing and reconditioning programs. However, these budgets do not include similar surface treatments funded by other programs. For example, MnDOT districts finance many urban road projects with Federal Urban Aid money ($12 million in 1985). Federal funds also support interstate highway rehabilitation projects. In addition, many projects in the Maintenance Preservation Program involve resurfacing and reconditioning. We summarized state rehabilitation work in all funding categories. Table 5.1 represents the MnDOT Construction Office's best cost and mileage estimates for all 1981-84 projects (regardless of funding category) that are less intensive than reconstruction.

The Minnesota Department of Transportation has 11 categories of funding for highway improvements, two of which are resurfacing and reconditioning. Districts often strategically develop their funding requests to maximize the state dollars obtained from these various categories. Similarly, the department sometimes selects road projects that maximize federal funding. While these practices may represent good fund management, it is unclear what effect they have on the condition of state pavements. The implications of categorical funding may become clearer as the state implements its new system of pavement management, discussed later in this chapter.

B. EVALUATING THE CONDITION OF MINNESOTA'S PAVEMENTS

Accurate assessments of pavement condition are a foundation for good highway investment decisions. In this section, we will discuss Minnesota's system of pavement condition rating and the reliability of that system.

1. PAVEMENT CONDITION RATINGS

Each trunk highway in Minnesota has a *condition rating* between 0.0 and 4.5. The higher the rating, the better the road. This rating is made up of two equally-weighted components:

TABLE 5.1

TRUNK HIGHWAY REHABILITATION BY MINNESOTA DISTRICTS

1981-1984[a]

District	Expenditures	Miles	Dollars/Mile	Percentage of District Miles Rehabilitated
1 Duluth	$ 25,539,809	261.1	$97,778	16.1%
2 Bemidji	21,252,610	344.1	61,762	19.0
3 Brainerd	13,705,113	279.6	49,016	17.7
4 Detroit Lakes	25,310,208	414.5	61,062	25.3
5 Golden Valley	12,872,640	137.6	93,551	22.5
6 Rochester	15,183,275	276.7	54,872	19.1
7 Mankato	21,698,382	255.7	84,858	18.8
8 Willmar	26,549,167	354.7	74,849	24.8
9 Oakdale	8,642,141	93.1	92,826	14.8
State	$170,753,345	2,417.2	$70,640	20.0%

Source: Minnesota Department of Transportation Construction Office.

[a]These figures represent construction projects let for bid in fiscal years 1981-1984. Included are all projects which the Construction Office judged as less intensive than highway reconstruction. Projects represented in the table come from a variety of funding categories.

(a) *Ride rating*. This is an objective, machine-measured rating of road smoothness. It is one of the objective road testing measures described in Figure 5.1.

(b) *Surface rating*. This is a rating of visible pavement defects made by field observers.

Minnesota has a longer history of pavement condition rating than most states. When the Minnesota Department of Transportation began an accelerated program of resurfacing in 1965, the Research Section developed a system intended to uniformly evaluate roads in terms of their resurfacing needs. MnDOT trained district raters in 1966 to ensure uniform results.

Between 1967 and 1981, districts continued to collect road condition ratings. However, there was no coordination of these efforts by the central office. Districts apparently handed down rating procedures verbally during these years--there was no statewide training manual.

In 1981, the department realized that the condition rating system needed review. A study of the subjective surface rating led to changes in the weights given to various surface rating defects. In addition, the newly-organized Pavement Management Section of the Department of Transportation assumed responsibility for processing condition rating data in 1982. Staff in this office train raters, centrally process road data, and oversee the condition rating system's reliability.

Perhaps most important, the Pavement Management Section developed a manual for surface ratings in 1983. This manual provides detailed instructions for the eighteen district personnel who rate roads each year. Two people in each district spend approximately six weeks of the year rating roads. Each trunk highway receives a new condition rating once every two or three years.

Table 5.2 shows each district's 1983 condition rating for the three primary types of pavement. Minnesota's average condition rating is 3.2 on a scale of 4.0. The overall condition rating of state roads remained fairly constant over the past few years. Figure 5.2 shows the percentage of district roads in various ranges of condition ratings.

2. RELIABILITY OF CONDITION RATINGS

The reliability of Minnesota's condition ratings are important for several reasons. First, the Department of Transportation makes many significant road decisions based largely on condition ratings. The department approves projects for resurfacing and reconditioning using a formula based 70 percent on condition

FIGURE 5.1

TYPES OF ROAD TESTING

	RIDE RATINGS	DEFLECTION RATINGS	SKID RATINGS
EQUIPMENT USED	Each district has a trailer-mounted Mays meter that objectively measures ride. Minnesota also has a profilometer, used mainly in research.	Department has 3 machines: 1 road rater, 2 falling-weight deflectometers. meters. The latter are more useful because they accurately simulate the load of a moving truck.	Department has 2 skid-measuring trailers, operated by the Office of Materials Engineering.
WHAT IS MEASURED?	The smoothness of the pavement surface.	1) How much road bends downward under a heavy weight; 2) Degree to which load stresses are spread through the pavement; 3) How do various road layers interact under stress.	Tire friction on a wet surface.
RANGE OF RATINGS	0.0 (poor) to 5.0 (excellent). Generally, new bituminous roads rate higher than new concrete roads. Few roads rate over 4.0.	There are many ratings that deflection tests can produce, all with different ranges. Some states convert deflection ratings to a 0 to 5 scale.	0.0 (low friction) to 1.0 (high friction).
WHY IS THIS TESTING IMPORTANT?	Pavement smoothness affects vehicle operating costs and driver comfort. It is possible to conduct reliable tests of many roads in a short period of time. Ride tests account for 50 percent of a road's condition rating.	Provides insight into the structural problems of roads. Useful in helping the department determine weight restrictions on state roads. Many people see deflection as a leading indicator of pavement deterioration. It is possible to detect structural problems in roads that exhibit good surface condition ratings.	Important for safety reasons. Also, a low low skid rating may dictate corrective action, regardless of a road's other conditions. Provides insight into the adequacy of road-building materials. Parts of the state lack quality aggregate for construction.
WEAKNESSES OF THIS TESTING	Ride ratings can be superficial since they do not indicate a road's structural condition.	Deflection is not very useful on concrete pavements. Also, the amount of deflection testing tripled in the past three years, and districts now find it hard to get deflection machines when needed.	

TABLE 5.2

AVERAGE DISTRICT CONDITION RATINGS

1983[a]

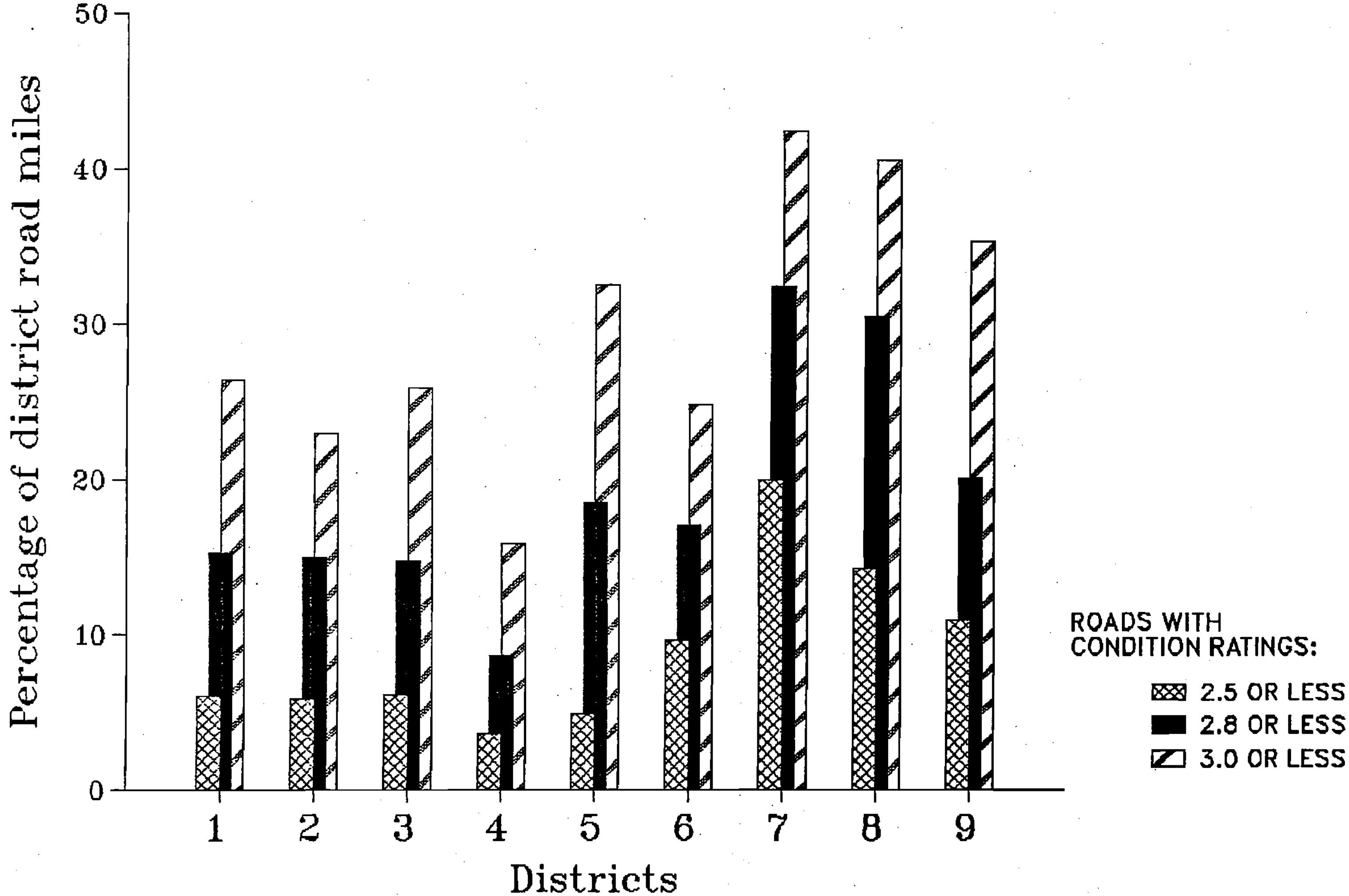
District	Type of Pavement	Miles	Average Rating
1 Duluth	Bituminous	1,356	3.3
	Jointed Concrete	280	3.3
	Bituminous Overlaid Concrete	178	2.8
	Total	1,819	3.3
2 Bemidji	Bituminous	1,535	3.3
	Jointed Concrete	231	3.1
	Bituminous Overlaid Concrete	171	3.4
	Total	1,937	3.3
3 Brainerd	Bituminous	1,397	3.4
	Jointed Concrete	320	3.2
	Bituminous Overlaid Concrete	127	2.6
	Total	1,843	3.3
4 Detroit Lakes	Bituminous	1,169	3.6
	Jointed Concrete	417	3.1
	Bituminous Overlaid Concrete	226	3.5
	Total	1,849	3.4
5 Golden Valley	Bituminous	445	3.3
	Jointed Concrete	234	3.1
	Bituminous Overlaid Concrete	162	3.2
	Total	868	3.2
6 Rochester	Bituminous	873	3.5
	Jointed Concrete	659	3.2
	Bituminous Overlaid Concrete	259	3.0
	Total	1,802	3.3
7 Mankato	Bituminous	628	3.3
	Jointed Concrete	586	3.1
	Bituminous Overlaid Concrete	334	2.8
	Total	1,597	3.1
8 Willmar	Bituminous	909	3.2
	Jointed Concrete	281	2.9
	Bituminous Overlaid Concrete	260	3.5
	Total	1,451	3.2
9 Oakdale	Bituminous	356	3.3
	Jointed Concrete	268	3.3
	Bituminous Overlaid Concrete	190	2.7
	Total	814	3.2
	Average state condition rating: 3.3		

Source: Minnesota Department of Transportation.

[a]Continuously reinforced concrete pavement (CRCP) is not shown here as a separate category of pavement because relatively few state miles are in this category. CRCP is reflected in each district's total miles and average condition rating.

FIGURE 5.2

PERCENTAGE OF DISTRICT MILES NEEDING REPAIR



Source: Minnesota Department of Transportation ratings. Condition ratings are also used to evaluate reconstruction projects and to determine budget allocations.

A second reason for the condition ratings' importance is their role in the department's proposed pavement management system. Such systems rely heavily on accurate road data for decision-making. According to the transportation department of Washington, one of the first states to implement a pavement management system: "The backbone of the Washington State Pavement Management System is a biennial pavement condition survey."[1]

In February 1984, MnDOT's Pavement Management Section conducted tests to evaluate the inter-rater reliability of *surface ratings*. The surface ratings, representing 50 percent of the condition rating, are far less objective than the machine-measured ride ratings. Raters estimate the extent of most surface defects while they drive along the road.

In its 1984 tests, the Pavement Management Section chose 18 road segments for rating. Central office engineers carefully measured surface defects on these segments to obtain the "true" surface rating against which the district raters' estimates were compared. The mean rating of these roads calculated by the central office was 2.34, well below the system average of 3.4. This indicates that MnDOT's sample of roads was probably not representative of the state's roads as a whole and included a disproportionate number of poor roads. For this reason, the Pavement Management Section says that results from the 1984 tests are inconclusive.

The department's findings on the 18-road sample were noteworthy. While the central office's average surface rating was 2.34, the district raters' average rating was 2.14. However, this relatively small difference masks more significant differences on individual segments. The average range among the 18 raters on each of the segments was 1.6 points. This difference in ratings is large enough so that road rehabilitation strategies might differ, depending on who does the rating. Some raters thought a given road was in good condition, while other raters thought it had serious surface problems. District personnel rated jointed concrete pavement more consistently than other types of pavement.

We conclude that:

- The 1984 surface rating tests raised significant questions about the reliability of road condition ratings in Minnesota.

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[1]Washington State Department of Transportation, Development and Implementation of Washington State's Pavement Management System: Executive Summary, February 1983, p. 3.

First, even though the department tested mostly poor roads, it is usually poor roads that are considered for rehabilitation. The department makes rehabilitation decisions for individual projects based largely on condition ratings. Given the wide rating variation for individual road segments in the department's surface rating test, there is cause for concern. Second, while department staff think that ratings on better roads are more reliable than ratings on poor roads, the scant evidence available from the 1984 tests does not confirm this. The five test segments rated by MnDOT at 2.8 or greater had, on average, a wider range of scores among the district raters than the segments below 2.8. A road rated 3.1 by the department had the widest range among the district raters of any test segment. A road which the department rated in essentially perfect condition (4.0) received a 1.6 rating from one person.

RECOMMENDATIONS

We recommend:

- The department should give high priority to ensuring condition rating reliability before implementing its pavement management system.

The department plans to analyze the reliability of the condition ratings again in 1985. We view this as a positive step.

- The department should seriously consider using central office raters if the 1985 tests indicate continuing problems in inter-rater reliability.

Since 1966, district personnel have rated Minnesota roads. Department managers say they do not have the staff to conduct road ratings from the central office. Further, these managers believe that districts better understand the importance of road ratings when they are part of the rating process. However, the department must be accountable for the reliability of its rating process. While some human error is inevitable, unreliable ratings should lead MnDOT to consider change.

Given the questions surrounding road rating reliability, we also recommend:

- The department should investigate the reliability of bridge condition ratings as it is doing with road condition ratings.

The federal government requires annual inspection and rating of all bridges. The Minnesota Department of Transportation lists over 400 of the state's trunk highway bridges as deficient. Some of these deficiencies are easily measurable and are not related to structural deterioration. For example, bridges that fail to meet federal width standards account for over half of Minnesota's deficient trunk highway bridges. However, the *structural* condition rating of bridges is highly subjective and involves many judgements. The department trains all of its bridge raters, but MnDOT does no tests of inter-rater reliability.

C. PAVEMENT MANAGEMENT SYSTEMS: AN INTRODUCTION

1. DEFINITION

In Chapters 2 and 3, we discussed the need for a maintenance management system within the Minnesota Department of Transportation. It is important to distinguish between maintenance management and pavement management. *Maintenance management* addresses the allocation of routine maintenance resources and the quality of maintenance performance. *Pavement management* is best thought of as a highway investment strategy. The Department of Transportation invests in roads through expenditures for routine maintenance, periodic life-cycle treatments, and improvements. Deciding how much to invest in each of these categories is difficult. A pavement management system improves the decision-making process, providing information on the road system and a model for estimating road needs.

To obtain sufficient funding for a road system, it is reasonable that a highway department should address itself to questions such as the following:

a. What is the current condition of the state road system?

b. What are the road system's needs during the programming period?

c. What are the costs of all work on pavement over the pavement's lifetime?

d. What rehabilitation options should be considered for particular road segments, and what is the cost of those options?

e. What are the costs of delaying a project?

f. What are the effects of maintenance on the rehabilitation option chosen?

g. What level of pavement improvement results from a given budget?

h. What level of budget brings about a given improvement in pavement condition?

i. Are state roads deteriorating faster than expected?[2]

A pavement management system (PMS) helps to answer these questions. It includes a data base that describes each road's characteristics in detail. A PMS also requires development of prediction models that forecast the pavement's future condition. Finally, a PMS employs a systematic method (generally an economic analysis) for determining appropriate rehabilitation strategies.

Potentially, pavement management systems provide two different types of information. First, a PMS may provide *network level* information. These data help decision-makers determine the needs of the pavement network as a whole. For example, the statewide budget needs of resurfacing work in coming years is a network level issue. Second, a PMS may provide *project level* information. It is possible to design a pavement management system that will determine the most cost-effective rehabilitation strategy for a road, including the optimum timing of this investment.

The most important part of a pavement management system is its economic analysis of alternative strategies, based on relevant, accurate data. Generally, a PMS suggests a variety of rehabilitation options for given road conditions. States calculate the cost of these options and their effect on pavement conditions. To determine the annual cost of each option, states find the total rehabilitation costs of various strategies over equal time periods (for example, 20 years). States then discount these costs to arrive at a present value for each strategy.

2. PAVEMENT PERFORMANCE

In Chapter 4, we discussed a preventive maintenance program justified partly on the basis of long-term cost savings. As we noted, the Minnesota Department of Transportation does not collect information that documents these savings, and the department admitted that not all projects funded under the Maintenance Preservation Program are cost-effective investments. Nevertheless, there is a strong feeling within the highway profession that deferring road investments increases long-term

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[2]M.A. Karan, T.V. Christison, A. Cheetham and G. Berdahl, "Development and Implementation of Alberta's Pavement Information and Needs System," Transportation Research Record 938, p. 11; Washington State Department of Transportation, Development and Implementation of Washington State's Pavement Management System: Summary, February 1983, p. 6.

highway costs. The case for early, preventive maintenance appears well-founded, if not conclusive. A brief discussion of this philosophy will help explain the rationale behind pavement management systems.

Most people in the transportation field today assume that a typical road's life looks something like Figure 5.3. A road's surface generally requires little or no maintenance during the first few years of its life. However, the deterioration of a road tends to accelerate over time. Because of this acceleration, roads may require less expensive improvements early in their life cycle than in later stages. A Utah report suggests that a highway whose structure has failed requires an overlay which is four times as thick as an overlay needed before the structure fails.[3] Minnesota's past bridge deck maintenance policy reflects a similar belief in preventive rehabilitation. MnDOT recommended giving first priority to restoration of bridges with critical problems. However, second priority went to bridges in good shape, and last priority went to bridges with moderate and severe problems.[4]

Figure 5.4 shows the effect an overlay has on the road life cycle. An overlay produces an immediate improvement in a road's condition rating, deferring the need for road reconstruction.

The actual shape of road performance curves is, at this time, more theoretical than empirical. However, states are beginning to explore differences in the performance of concrete and bituminous roads. Several states now record the historical and projected performance curve of each state road, using pavement management system data. The Minnesota Department of Transportation is presently studying the relationship between a road's age and its condition rating.

3. HISTORY OF PAVEMENT MANAGEMENT SYSTEMS

The term "pavement management" came into use in the late 1960's. Interest in pavement management followed two decades of large-scale investment in new road construction. During these decades, there was a growing recognition that pavement monitoring must accompany highway expenditures. For example, studies conducted on Illinois roads between 1958 and 1962 led to the country's first system of road condition rating.

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[3]Utah Department of Transportation, Pavement Rehabilitation Design Strategies, December 1980, p. 2.

[4]Minnesota Department of Highways, Bridge Deck Task Force, 1976 Report and Policy for Protection of Concrete Bridge Decks, January 15, 1976, p. 9.

FIGURE 5.3

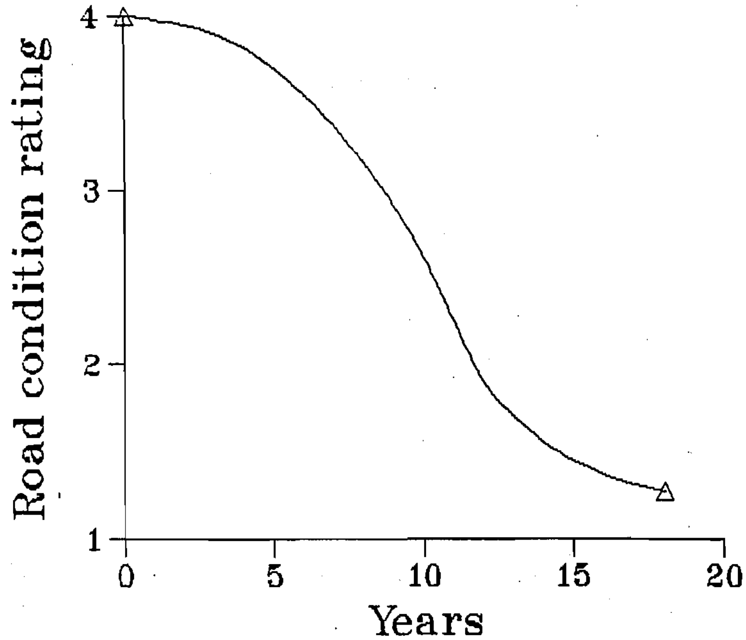
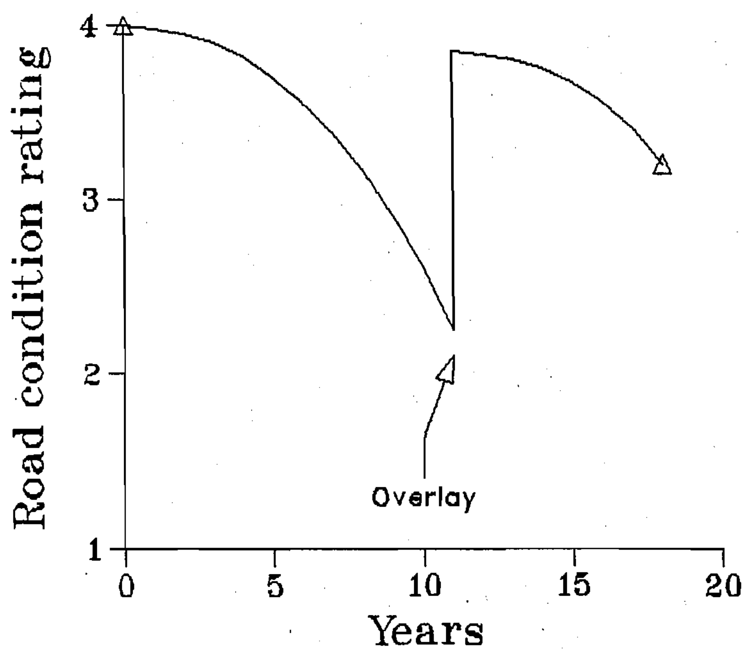


FIGURE 5.4



In the 1970's, new trends gave impetus to the pavement management movement. States began investing more money in rehabilitation and maintenance in an effort to preserve the road system, rather than expanding the system. Information technology improved, and many states implemented maintenance management systems. Energy crises, materials shortages and inflation contributed to higher highway costs at a time when government budgets were tight. Researchers began developing models that predicted road performance. There was also increased research on the relationship between road condition and vehicle operating costs.

The Federal Highway Administration started to emphasize pavement management in 1979. Since that time, many states have developed pavement management systems. States such as Washington, Idaho, Texas, Utah, and Arizona have implemented pavement management systems.[5]

4. BENEFITS OF PAVEMENT MANAGEMENT SYSTEMS

Pavement management systems can significantly improve state highway decision-making capability. First, a PMS can help highway decision-making at the district level. District managers and supervisors will have detailed information on all roads. This should lead to better project design, project timing, and maintenance scheduling.

Second, a PMS allows a state highway department to make more consistent, equitable statewide decisions. Condition rating data permit states to assess regional funding needs and to make better decisions on project funding. In addition, the PMS provides highway departments with justifications for legislative requests. Departments can calculate expected needs on state roads, and departments can show the results of past decisions. Also, use of PMS prediction models permits more timely rehabilitation of roads since states can program roads for work before the time the roads actually deteriorate.

Finally, a PMS offers benefits for state legislatures. Network-level pavement management systems can link funding decisions to specific legislative goals. For example, legislatures may choose to fund a highway system at a level that ensures a given statewide condition rating. On the other hand, legislatures may want to see the effect that alternative budgets have on the amount of highway work done. Pavement management systems provide either type of information. In addition, a PMS

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[5] W. Ronald Hudson and Ralph Haas, "Development, Issues, and Process of Pavement Management," Pavement Management: Proceedings of National Workshops, June 1981, pp. 26-30.

might tell a legislature the following: the effect of deferring work or lowering standards; the effect of increased load limits; the effects of less capital or maintenance funding.[6]

5. DEVELOPMENT OF A PAVEMENT MANAGEMENT SYSTEM IN MINNESOTA

The Federal Highway Administration met with Minnesota Department of Transportation officials in 1980 to encourage development of a PMS. The department agreed to organize a task force on pavement management issues. The task force made an important early decision that development of Minnesota's PMS should initially focus on the network level (helping to make statewide funding decisions), not the project level (helping MnDOT approve individual road projects). Nevertheless, the relationship of network- and project-level data has been a source of ongoing debate within the task force.

In April 1981, the department created a Pavement Management Section within the MnDOT Office of Research and Development. This section now employs four staff. The Pavement Management Section and the original task force devoted most of their time in the past three years to data needs. Establishment of centralized files on pavement condition and revision of the state condition rating formulas were among the key achievements during this period. Department employees also attended several national pavement management workshops, and they traveled to several states that have pavement management systems.

While the Pavement Management Section has made important progress in developing its data base, we found that:

- The weakest link in the department's pavement management data base is historical maintenance costs.

The department began collecting maintenance data usable in the PMS only in 1983. There is still a sense within MnDOT that current data is not detailed enough since, unlike some states, Minnesota does not collect data on a mile-by-mile basis. The department's Pavement Management staff believe that a good PMS is impossible without good maintenance cost data. However, they recognize that most states with pavement management systems have similar difficulties trying to document maintenance costs.

In the coming year, department staff foresee two major pavement management tasks. First, a consultant will help the department develop models that predict the performance of Minnesota pavements. Second, the department will develop a decision matrix that recommends rehabilitation strategies for particular pavement problems. During 1986, MnDOT expects to purchase

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[6] _Ibid._, p. 31.

computer software that will permit network-level economic analysis of highway needs.

6. OTHER HIGHWAY DEPARTMENTS' PAVEMENT MANAGEMENT SYSTEMS

We examined the decision-making processes of several highway departments that have implemented pavement management systems. The department's Pavement Management Section looked at many of these same models over the past two years. Figure 5.5 provides a brief summary of some PMS characteristics in other states.

D. MINNESOTA'S NETWORK-LEVEL PAVEMENT MANAGEMENT

Network-level decisions primarily address issues of efficiency. The proper budgetary mix of new construction, rehabilitation and maintenance dollars is a network decision as is the efficient level of expenditure in each of these categories over a long time span. In this section, we discuss several network-level issues as they relate to the Minnesota Department of Transportation's pavement management system.

1. DOES THE DEPARTMENT ADEQUATELY COORDINATE PAVEMENT DATA COLLECTION?

Prior to 1981, MnDOT's central office did not record the condition of Minnesota's highways in computerized files. Information on highway truck traffic loads was inadequate. Before 1983, the department did not collect usable information on the cost of road surface maintenance. The Pavement Management Section recognized these problems and acted to correct them. Thus, while work on the data base is not yet complete, the department's Pavement Management Section deserves praise for its efforts thus far.

However, there are still important data issues the department must resolve. Two of these concern maintenance costs. First, some people claim that cost data is not detailed enough to make good pavement management decisions. While a few states record maintenance costs on a mile-by-mile basis, Minnesota records these costs for segments up to 30 miles long. Second, the department has not yet determined the relationship between a pavement's condition and its maintenance costs, information required for an accurate pavement management system.

FIGURE 5.5

KEY FEATURES OF OTHER STATES' PAVEMENT MANAGEMENT SYSTEMS

Washington

- Develops performance curve for each state road. Each curve has a "should" and "must" level for rehabilitation.
- To estimate maintenance costs over a road's life, Washington studied the relationship between these costs and condition ratings.
- Considers two types of user costs: vehicle operating costs and traffic delay costs.
- Network analysis only.
- Transportation department does not share PMS information with districts.

Alberta

- Completed PMS in three years.
- Province estimates total capital and maintenance costs for rehab alternatives 25 years into future.
- PMS recommends alternatives that minimize cost or maximize road conditions over a 10-year period.
- Province does not share PMS information with districts since overlays are designed centrally.
- Found that good research exists on road performance prediction.

Idaho

- Predicts ride, surface and deflection ratings up to six years in advance.
- Keeps maintenance costs mile-by-mile.
- Project-level decisions made centrally, based on PMS economic analysis. Districts must provide justifications if they choose not to follow department recommendations.
- Finances rehab out of a single funding category, facilitating use of PMS.

Utah

- State ranks all roads on cracking, deflection and skid problems.
- Pavements fit into 16 condition groups, based on nature of defects. Each of these groups has specific rehab strategies.
- Studied relationship between maintenance costs and road condition.
- Economic analysis considers user costs and salvage values.

Arizona

- Unlike several other states, Arizona verified the reliability of its prediction models. Arizona found that its model predicts ride and cracking accurately over a five-year span.

2. DO THE DEPARTMENT'S SUMMARY MEASURES OF ROAD CONDITION MEET DECISION-MAKING NEEDS?

As stated earlier, the department bases its road condition ratings 50 percent on a machine-measured ride rating and 50 percent on a visual rating of surface defects. The Pavement Management Section, to its credit, revised the surface ratings two years ago. The section must still determine whether the surface rating system is reliable.

We have another concern: the condition ratings' components. District managers often told us about structurally unsound roads that ride well and have few cracks. Overlays frequently cover up structural problems rather than solving them. Thus, we question whether the condition ratings describe the road system with sufficient accuracy.

Several states address this problem by including structural ratings (as measured by deflection tests) in their condition ratings. Utah developed a 0.0 to 5.0 structural rating, a scale comparable to ride and surface ratings. Utah bases this rating on estimates of the years remaining in a road's life. Alberta and Idaho use similar ratings in their pavement management systems.

Network-level data should describe the status of Minnesota's road system in the most comprehensive manner possible. We believe broad measures of road condition will prove useful to legislators and MnDOT decision-makers. The department should consider the possible contributions that deflection data could make to network decisions. We are encouraged that the Pavement Management Steering Committee recently recommended development of a new road quality index that considers pavement structure, rideability, and surface defects.

3. IS THE DEPARTMENT PURSUING APPROPRIATE MEANS OF PREDICTING PAVEMENT PERFORMANCE?

Predicting pavement performance is an imperfect science. Certain roads last longer than expected, while some roads deteriorate faster than expected. Nevertheless, researchers continue to progress in their efforts to predict pavement wear. Several states now use prediction models with confidence, particularly for network-level decisions.

In general, the Minnesota Department of Transportation recognizes the importance of prediction models. Staff will begin developing these models in 1985, correlating road age with condition ratings to determine typical road performance curves. We have two concerns about this effort.

First, the department's correlation of road age and condition requires accurate condition ratings. As we noted earlier, it is not yet clear whether current condition ratings are reliable. We have even greater doubts about historical condition ratings the department's study will use.

Second, we believe the department may need more detailed predictors of road condition than it currently plans for. Clearly, age is a major factor (if not the prime factor) in the deterioration of a road. But accurate predictions may require more than this single variable. Many states with pavement management systems develop individual pavement performance curves for each road based on the road's unique history of deterioration. Some states look at the percentage change in road surface ratings from one year to the next, while others account for regional variations in road wear.

Some MnDOT staff would like to go beyond the planned correlation of age and condition rating, and we encourage them to do so. The experience of others states suggests that a network-level PMS requires more detailed prediction tools than those described by the department so far.

4. IS THE DEPARTMENT CORRECT IN FOCUSING ON A NETWORK-LEVEL PMS?

The department's Pavement Management Steering Committee decided in late 1981 that Minnesota's PMS should initially collect information for network-level decision-making (i.e., deciding future, statewide road funding needs) rather than project-level decision-making (i.e., selecting or designing individual road projects). There was considerable debate on this choice, and debate still continues on the relationship between network and project needs.

In our view, the department was justified in its decision to initially focus on network-level decisions. At a 1980 Federal Highway Administration workshop on pavement management, two leading researchers in the field noted the following:

> In the 1970's, it became clear that other aspects of pavement management were at least as important as improved pavement design. While consideration of budgeting and cost-benefit analysis at the project level were important, it became clear to many people that the real savings were to be gained by a kind of pavement management at the network level.[7]

The consensus of participants at this national workshop was that network systems produced a greater initial payoff than project-

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[7] Ibid., p. 26.

level systems. We should note that, despite this conclusion, several states with pavement management systems started at the project level.[8]

In the past, the Minnesota Department of Transportation developed biennial budget requests largely on the basis of rough estimates of road needs. Network-level pavement management should help the department develop more accurate, demand-based budgets. The department will have a stronger basis for dividing its highway budgets among different categories of improvements and maintenance. While we support the department's network-level efforts, we have some reservations about the department's current project-level decisions. The next section addresses these issues.

E. MINNESOTA'S PROJECT-LEVEL DECISION-MAKING

Each year, the Minnesota Department of Transportation decides which resurfacing and reconditioning projects it will fund. As in network-level decision-making, efficiency is a primary goal of project-level choices. However, equity is also a major issue in project decisions. In selecting projects to fund, the department weighs the requests of one district against the requests of another. The department's choices directly affect the transportation investments in Minnesota's various regions. In this section, we will evaluate Minnesota's current system for making project decisions.

1. DOES THE DEPARTMENT ADHERE TO ITS PROJECT SELECTION FORMULA?

In the late 1970's, the Minnesota Department of Transportation developed a formula for selecting resurfacing and reconditioning projects. The formula produces point totals for each project. The department bases 70 percent of the points on project condition ratings, 20 percent on cost-effectiveness, and 10 percent on the road's functional classification. We looked at project decisions for the past five fiscal years to determine how strictly the department follows its formula. Figure 5.6 presents our year-by-year findings.

From this historical review, we conclude that:

- The department uses its project selection formula quite strictly to approve resurfacing and reconditioning projects.

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[8]Federal Highway Administration, Pavement Management: Proceedings of National Workshops, June 1981, p. 9.

FIGURE 5.6

HISTORICAL USE OF RESURFACING AND RECONDITIONING FORMULA

<u>1982-83 Resurfacing</u>

The department approved 67 projects for this two-year span. The 45 projects with the highest number of formula points all made the program. Of the 70 requested projects with the highest point totals, 64 received department approval.

<u>1982-83 Reconditioning</u>

The department approved 28 projects. All of these were among the 29 requested projects with the highest point totals on the formula.

<u>1984 Resurfacing and Reconditioning</u>

The department approved $45 million in projects for 1984. It allocated $41 million strictly using the formula--the department selected only the projects with the highest point totals. The department approved the remaining $4 million in projects based on field reviews. The reviews favored projects that: (1) had high traffic counts; (2) would have serious consequences if delayed; (3) were beyond the scope of routine maintenance work.

<u>1985-86 Reconditioning</u>

The department produced its list of approved projects in an unusually short period of time. Although some sites had been visited in previous years, the department made no new site visits before approving this two-year program. As a result, the department selected 1985-86 reconditioning projects strictly according to formula, with only minor changes made after the initial selection.

<u>1985 Resurfacing</u>

As with 1985-86 reconditioning, the department developed its original 1985 resurfacing program in an extremely short time period. This resulted in a strict use of the project selection formula, with no exceptions. However, two districts received no allocations under this scheme. Thus, months later, the department reversed its original project choices and tried an experimental allocation. Districts received funding allocations based on their total lane miles and their average condition rating. The state gave districts freedom to choose their own resurfacing projects. Some problems resulted when districts could not find combinations of projects that precisely used up their district allocations.

<u>1986 Resurfacing</u>

The department used its formula fairly strictly, but not as strictly as in previous years. Of the 25 projects with the highest point totals, 22 received approval. However, the department also used field reviews to choose several other projects with low point totals.

We believe there must be room for exceptions to all project selection formulas. Indeed, despite its relatively strict use of resurfacing and reconditioning formulas, the department made many exceptions to the formulas over the past five years. Appendix C lists the reasons for these exceptions.

2. IS THE PROJECT SELECTION FORMULA ADEQUATE?

The department's relatively strict interpretation of the project selection formula is appropriate only if the formula is a good one. The department's 1985-89 Work Program suggests that the resurfacing and reconditioning criteria are "undergoing evaluation." While our discussions with decision-makers in MnDOT's Office of Highway Programs revealed general satisfaction with the present formula, the office will consider alternative formulas during this year's project selection process. The department has not decided yet whether to select resurfacing and reconditioning projects with the current formula or a new formula. In the following discussion, we review the elements comprising the current formula.

a. Condition Ratings Element

Condition ratings receive 70 percent of the weight in MnDOT's project ranking formula.[9] The formula gives poor roads more points than average roads. For example, a road with a 2.0 condition rating receives 700 points; a road with a 3.2 rating gets 140 points. Not surprisingly, those projects approved by the department tend to have low condition ratings.

We conclude that:

- Condition ratings receive too much weight in the selection formula, creating several problems with project choices.

The practice of favoring the worst roads directly contradicts the preventive maintenance philosophy articulated by transportation researchers and by MnDOT. If it is true that preventive work on roads saves money in the long run, favoring poor roads may increase state roadwork costs.

A second problem is that roads with very low condition ratings may need work beyond the scope of resurfacing and reconditioning. An overlay will not save a road in need of reconstruction. However, some districts request resurfacing money for very poor roads because the roads do not meet reconstruction criteria

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[9]Actually, condition ratings are about 75 percent of the formula, since they are part of the cost-effectiveness equation (see next section).

(perhaps because of low traffic counts). Reconstruction criteria only give 20 percent weight to condition ratings.

Third, the department approves projects based on their most recent condition rating, not on the road's condition at the time work will occur. For example, the department selected most projects for 1986-87 based on 1982 condition ratings. A road rated 2.4 in 1982 could easily rate below 2.0 by the time work begins. Although resurfacing was perhaps appropriate in 1982, it may be insufficient in 1987. This problem exemplifies the need for pavement prediction models in project selection.

b. <u>Cost-Effectiveness Element</u>

Cost-effectiveness accounts for 20 percent of the project selection formula. The department measures cost-effectiveness as follows:

$$\frac{\text{Average Daily Traffic (ADT)} \ \times \ \text{change in condition rating}}{\text{Project cost per mile (in thousands)}}$$

"Average Daily Traffic" is the total number of vehicles traveling on a road in one day. "Change in condition rating" represents the improvement in condition ratings that resurfacing brings to a highway. "Project cost per mile" is the district's cost estimate for the proposal submitted to the department.

We conclude that:

- The project selection formula inadequately measures the cost-effectiveness of proposed rehabilitation projects.

A first problem involves the estimated "change in condition rating." Presently, when using the formula, the department assumes that all rehabilitation produces condition ratings of 3.7. This assumption is not based on empirical study, and some department employees we spoke with said a resurfaced road's condition rating is quite variable. The effect of this equation element is an additional bias toward roads in the poorest condition.

The equation's notion of "project cost per mile" is a second problem. Cost per mile is a valid concern if the projects under consideration are all similar. However, projects within a single funding category often differ markedly from one another. Some resurfacing projects include shoulder work, widening, or pavement milling. Some reconditioning projects include drainage work and extensive landscaping. Thus, projects with high costs per mile may make cost-effective improvements, contrary to what the department's equation suggests.

There are also problems with the "traffic" element of the cost-effectiveness equation. Traffic is the equation's most important element because it is the most variable item in the equation. It is not unusual to find traffic on an urban road ten times greater than traffic on some rural highways. While traffic is an important consideration, we found no support in the literature for the notion that traffic is the main determinant of a road improvement's cost-effectiveness.

However,

- Our primary criticism of the department's cost-effectiveness criterion is that it neglects a critical factor: time.

The department's notion of cost-effectiveness only addresses initial capital costs. But capital decisions made today have cost implications for years to come, and the department needs to consider these. Two hypothetical examples illustrate the point:

Example 1: There are two roads in identical condition with identical traffic counts. One road gets a short-term treatment (a one-inch overlay). The other gets a longer-term treatment (a four-inch overlay). The second road is expected to last ten more years than the first road. Using MnDOT's current cost-effectiveness equation, the first road receives a higher score since its initial capital cost is lower. But is the short-term treatment really cost-effective, since it requires additional capital costs in just a few years?

Example 2: Two roads have 2.8 condition ratings and equivalent traffic counts. The first road is deteriorating gradually and predictably; the state spends relatively little time trying to address the road's many hairline cracks. The second road is falling apart fast. State crews spent lots of time patching the road last year, and they will probably do even more work on the road as its rapid deterioration continues. MnDOT's current cost-effectiveness equation does not consider routine maintenance costs or the rate of road decay, so the second option does not rank higher on state criteria. However, the cost of deferring resurfacing is clearly greater on the second road.

To conclude, the department's formula does not adequately measure cost-effectiveness. We believe there are models available for measuring cost-effectiveness in a better way. For example, it is possible to calculate the cost of a single surface treatment (such as a four-inch overlay) over the course of its life. This requires calculation of the initial capital cost, the stream of maintenance costs, and the road's salvage value at the time of its next surface treatment. These costs are then discounted over time to derive the present value of all costs. Another possible method requires calculating and discounting all expected road costs over a set period of time, such as 20 years. These methods require information that the department does not presently have: the life cycle of various rehabilitation techniques; the cost of these techniques; the relationship between maintenance costs and road condition.

These methods are consistent with the preventive maintenance philosophy. They recognize that targeting money cost-effectively differs from targeting money toward only the worst roads.

This kind of economic analysis is similar to the analysis described earlier in the section on network-level pavement management. This suggests a major issue: can MnDOT use its network-level pavement management economic analyses for project level decisions, too? The department hopes to produce economic analyses for individual roads in 1987. Assuming the availability of reliable economic analyses and having noted the inadequacy of the current formulas for project funding, we believe MnDOT can make better project selection decisions by replacing its current formula with the economic analyses.

3. SHOULD PROJECT SELECTION CRITERIA GIVE PREFERENCE TO CERTAIN ROADS?

a. Road Classification

In late 1982, the department's Pavement Management Steering Committee formed a Subcommittee on Trunk Highway Classification. The subcommittee's charge is: (1) to develop criteria for ranking the importance of Minnesota roads, and (2) to develop condition ratings for each class of road that will trigger rehabilitation. Underlying the committee's charge is the view that important roads should receive road improvements sooner than less important roads. There is also an assumption that a 2.8 condition rating presently triggers rehabilitation on Minnesota roads, regardless of their importance.

The Pavement Management Steering Committee appears to accept the classification concept. We think the notion of different "trigger values" for different roads is worth considering. However, the department still needs to answer two questions:

- Why should the state give priority to certain roads with high traffic volumes and high functional classification? What are the consequences of this priority system?

Among the possible reasons for giving preference to certain roads are the following:

(a) Some people claim that roads deteriorate at different rates, depending on traffic levels. If the department approves resurfacing for a high ADT road and a low ADT road when both reach the 2.8 condition rating, the high volume road will deteriorate more in the time before resurfacing begins. Thus, it may make sense to trigger work on the high volume road at an earlier time.

(b) The department says there is a backlog of roads needing resurfacing and reconditioning. If this is true, perhaps a classification system is a good way of allocating scarce resources. Regardless of the poor condition of many low volume roads, it perhaps is hard to justify investing money in them when heavily-traveled roads also have needs.

(c) Perhaps drivers on high traffic roads are less tolerant of rough roads than drivers on low volume roads.

(d) A classification scheme roughly reflects user costs. High traffic roads impose more vehicle operating costs and delay costs on drivers than equally worn low volume roads, simply because the primary roads affect more drivers. Higher trigger values for high volume roads are a means of considering user costs.

There are also many possible reasons for not giving preference to certain roads. Some of these reasons include:

(a) One of the key benefits of a pavement management system is that it helps determine the optimal timing of specific road treatments. A PMS may tell when it is most cost-effective to rehabilitate a road. Given this capability, the department should not try to *predetermine* this timing by developing a hierarchy of trigger values.

(b) A classification system may sacrifice long-term cost savings. The prevailing philosophy in the transportation field is that deferred maintenance costs more money than it saves. A tiered system of trigger values will institutionalize deferred maintenance on certain roads.

(c) The department's current formula already gives preference to roads with high traffic and high functional classification. For example, a principal arterial with 5,000 ADT and a 2.7 condition rating scores about the same number of points on Minnesota's current project ranking system as a collector with 500 ADT and a 2.2 condition rating.

(d) If the department wants smoother driving on high traffic roads, MnDOT could reflect this by considering user costs in its pavement management economic analysis (see the next section).

Several states use classification systems for highway improvement decisions. Not all of these states set different condition rating trigger values for different road classes. Some states merely limit the types of rehabilitation considered on low volume roads. For example, MnDOT could declare that low volume roads are only eligible for thin overlays, not major rehabilitation. While we make no specific recommendations on the system the department should adopt, the department should consider the wide range of issues outlined and should later use pavement management data to measure the consequences of its actions.

b. User Costs

Increasingly, states and researchers are recognizing the importance of user costs in maintenance and rehabilitation scheduling. User costs include vehicle operating costs, travel delay costs, accident costs and user comfort costs. The developers of Washington's pavement management system noted:

> User costs have a significant effect on the selection of an optimum maintenance strategy. The only incentive for keeping pavements in smooth condition is the reduction in user costs. If these costs are neglected, the optimum maintenance strategy would almost always be to do nothing until the pavement reaches a totally unsatisfactory condition.[10]

Participants at the Federal Highway Administration's 1980 workshop on pavement management said that user costs "exert a significant influence on the strategies for maintenance and rehabilitation obtained from the pavement management process." They said that lack of user cost data precludes effective pavement management systems.[11] Two hypothetical examples suggest how user costs can influence road strategies:

> *Example 1*: The state must defer resurfacing on either an urban road (15,000 ADT) or a rural road (1,000 ADT). The roads received identical scores on MnDOT's project selection criteria. Deferring work on either road will increase drivers' gas mileage and their vehicle maintenance costs. Since the urban road has 15 times as much traffic as the rural road, it is likely that the urban road has higher total user costs.

> *Example 2*: The pavement management system suggests that the most cost-effective rehabilitation of a busy urban road

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[10]R. Kulkarni, F.N. Finn, R. LeClerc and H. Sandahl, "Development of a Pavement Management System," Transportation Research Record 602, pp. 119-120.

[11]Federal Highway Administration, Proceedings, p. 20.

is a one-inch overlay each year for the next five years. However, such a schedule will disrupt traffic, causing driver delays. A thicker overlay might avert these user costs.

Some states (e.g., Washington and Utah) consider user costs in their pavement management economic analyses. However, quantification of user costs is difficult. Studies have quantified vehicle operating costs and travel time delays, but there is no methodology for measuring accident and discomfort costs.[12] We believe that user cost analysis is an alternative to the department's road classification plan, one worth considering sometime in the future.

4. CAN THE DEPARTMENT SHORTEN PROJECT LEAD TIME?

We found that:

- With most resurfacing and reconditioning projects, at least two years passes between the time of statewide project selection and the time work begins on the project.

This differs from Maintenance Preservation Program projects, which one official in MnDOT's Office of Highway Programs described as "fast money." Lead time on Maintenance Preservation projects is sometimes as short as one week.

Department officials insist that resurfacing and reconditioning projects could begin in a short period of time if the money was available. The process of designing these projects and letting them for bids is generally quite short.

In our view, lead time is only a problem if the department bases project selection on its *most recent* condition ratings, as it now does. The condition ratings that trigger project selection are usually one or two years old at the time of selection. Following selection, two or three years may pass before project work begins. As a result, a road deteriorates significantly between the time a rehabilitation-triggering rating is taken and the time rehabilitation occurs. During this time period, districts keep the road serviceable through maintenance work or through Maintenance Preservation work. In either case, the maintenance or MPP cost is directly caused by the department's time lag.

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[12]Ralph Haas and W. Ronald Hudson, Pavement Management Systems, 1978, p. 25.

F. RECOMMENDATIONS

The department's main pavement management efforts are presently directed at network-level pavement management, a system the department hopes to implement within two years. We believe that project-level decision-making for resurfacing and reconditioning can benefit from the network-level work now being done.

We recommend:

- When MnDOT develops reliable measures of rehabilitation life-cycles, rehabilitation costs, and maintenance costs, it should replace its current project selection criteria with its pavement management economic analyses.

These economic analyses (a) do not automatically favor roads in the poorest condition; (b) look at costs over a road's life in addition to initial costs; (c) can consider user costs in decision-making. The recommended change requires two elements already being investigated by the department: pavement prediction models and accurate estimates of pavement rehabilitation costs. A third necessary element is estimates of the relationship between maintenance costs and pavement condition. The Pavement Management Steering Committee recently voiced its approval of this element, although no research has yet been done. We recommend:

- The department should research the relationship between condition ratings and road surface maintenance costs (not including snow and ice control) during the next two years.

If it appears that reliable project economic analyses are several years away, the department should adopt interim project selection criteria. We recommend that:

- The department should develop a resurfacing and reconditioning formula more consistent with the preventive rehabilitation philosophy.

MnDOT needs a coherent strategy for investing in its system of roads. Currently, the project selection formula favors roads in very poor shape for resurfacing. The formula is contrary to the department's preference for preventive rehabilitation work, and it may allow roads needing reconstruction to receive inefficient surface treatments. Resurfacing and reconditioning projects should primarily be made on roads without major structural problems. The Office of Highway Programs is considering some formulas consistent with this recommendation. For example, the office is considering formulas which favor roads with condition ratings near 2.8, which is higher than ratings for most roads now programmed.

To make rehabilitation work more timely, we recommend:

- The department should consider using pavement performance prediction models for project selection as a means of lessening the impact of project time lags.

If the department can accurately make decisions based on a road's predicted condition rating at the time resurfacing work will occur, the lengthy project time lag described earlier harms no one. Moreover, the state can more effectively use maintenance and Maintenance Preservation Program money, rather than subsidizing the effects of the department's two-year lead time.

To more fully measure the impact of road funding decisions, we recommend:

- The department should study the extent to which road condition affects vehicle costs and the extent to which roadwork causes driver delays.

In our view, these recommendations will not lessen the role of districts in the project selection process. Districts will still design projects and they will still choose which projects to submit for improvement programming. Only the criteria by which the central office judges projects will change. As with the present formula, the central office should make exceptions to the formula when necessary. However, a pavement management system will allow the department to more accurately assess the cost implications of the exceptions made.

These recommendations may lead to deferral of work on certain roads with low condition ratings. While rehabilitation of such highways may not be cost-effective, the department should consider the public's safety and comfort on these roads. MnDOT might consider funding emergency resurfacing from a separate budget account, or it may wish to designate certain highways as "low maintenance roads" and to warn drivers of that status.

Discussion

Chapter 6

Throughout this report, we examine the Minnesota Department of Transportation's management of its trunk highway maintenance resources. Two issues are not directly discussed in previous chapters, but we address them in this chapter because of their relevance to the topic of highway maintenance.

A. IS MINNESOTA'S HIGHWAY MAINTENANCE OF HIGH QUALITY?

Most drivers make judgements about the condition of the roads they use. Many drivers also draw conclusions about the effectiveness and productivity of maintenance work based on observations of road crews and based on road conditions.

In our study, we did not examine technical measures of maintenance quality. We did not try to judge the propriety of maintenance procedures and materials, nor did we make time studies of highway workers. Nevertheless, some of our study's findings bear upon the issue of maintenance quality.

It is possible to focus on maintenance quality from two perspectives. We might ask:

(1) Is the quality of maintenance work good for the state as a whole?

(2) Is the quality of a particular maintenance crew's work good?

With regard to the first question, it is difficult to generalize about the quality of maintenance for the road system as a whole. Road condition ratings give a general idea about the quality of pavement surfaces in Minnesota. However, the state's condition ratings reflect original construction, later improvements, and routine maintenance. It is difficult to tell how much each activity contributes to road quality.

The second question is more easily answered, even though our study did not evaluate the quality of individual crews or their repairs. The choice of maintenance practices clearly affects the quality of Minnesota roadways. For example, pothole patches that are packed densely last longer than loosely packed patches. Concrete joints that are thoroughly cleaned before crews apply joint sealants have long lives, according to test results. Overall, it is far easier to assess the quality of maintenance work at the crew level than at a broader, statewide level.

We think the department can do more than it now does to assess maintenance quality at the crew level. Establishment of a maintenance management system will allow the department to measure and compare crew productivity. Further, the department should eventually develop quality inspection checklists for certain maintenance tasks. District supervisors could make discretionary inspections to measure work procedures and results.

Understandably, there is great legislative interest in the issue of maintenance quality, and many people would like a definitive statement on the quality of Minnesota maintenance practices. We believe that attempts at broad assessments of maintenance quality are less useful than small-scale, ongoing attention to quality issues. Questions of quality are technical in nature, and solutions to quality problems require changes at the crew level. The department should facilitate performance oversight by crew supervisors, and it should facilitate the sharing of innovative ideas among work units. While improved crew-level assessments of maintenance quality may someday permit generalizations for the state as a whole, we see little value in efforts to draw broad conclusions at this time.

B. CAN THE STATE LOWER ITS MAINTENANCE STANDARDS TO SAVE MONEY?

Under the assumption that there is insufficient money to fully maintain all Minnesota roads, some people recommend lowering state maintenance standards for certain low priority roads. In its 1984 hearings, the legislature's Highway Study Commission discussed this possibility.

We see several problems with a two-tiered system of maintenance standards. First, it is likely that districts already employ such a system informally. Many districts defer work on roads with low traffic in order to work on more heavily traveled roads. This suggests that an explicit hierarchy of maintenance standards might produce only minor savings.

Second, the Minnesota Department of Transportation does not have a rigid system of maintenance standards that dictate maintenance costs, contrary to the assumptions of some who advocate a two-tiered system. The department has standards for materials, procedures and, to some extent, work scheduling. Unlike several other states, Minnesota has no standards for crew sizes, equipment usage and productivity.

Third, lowering standards would not reduce maintenance costs significantly unless the department also made staff cuts. District staff levels affect maintenance costs more than maintenance standards do.

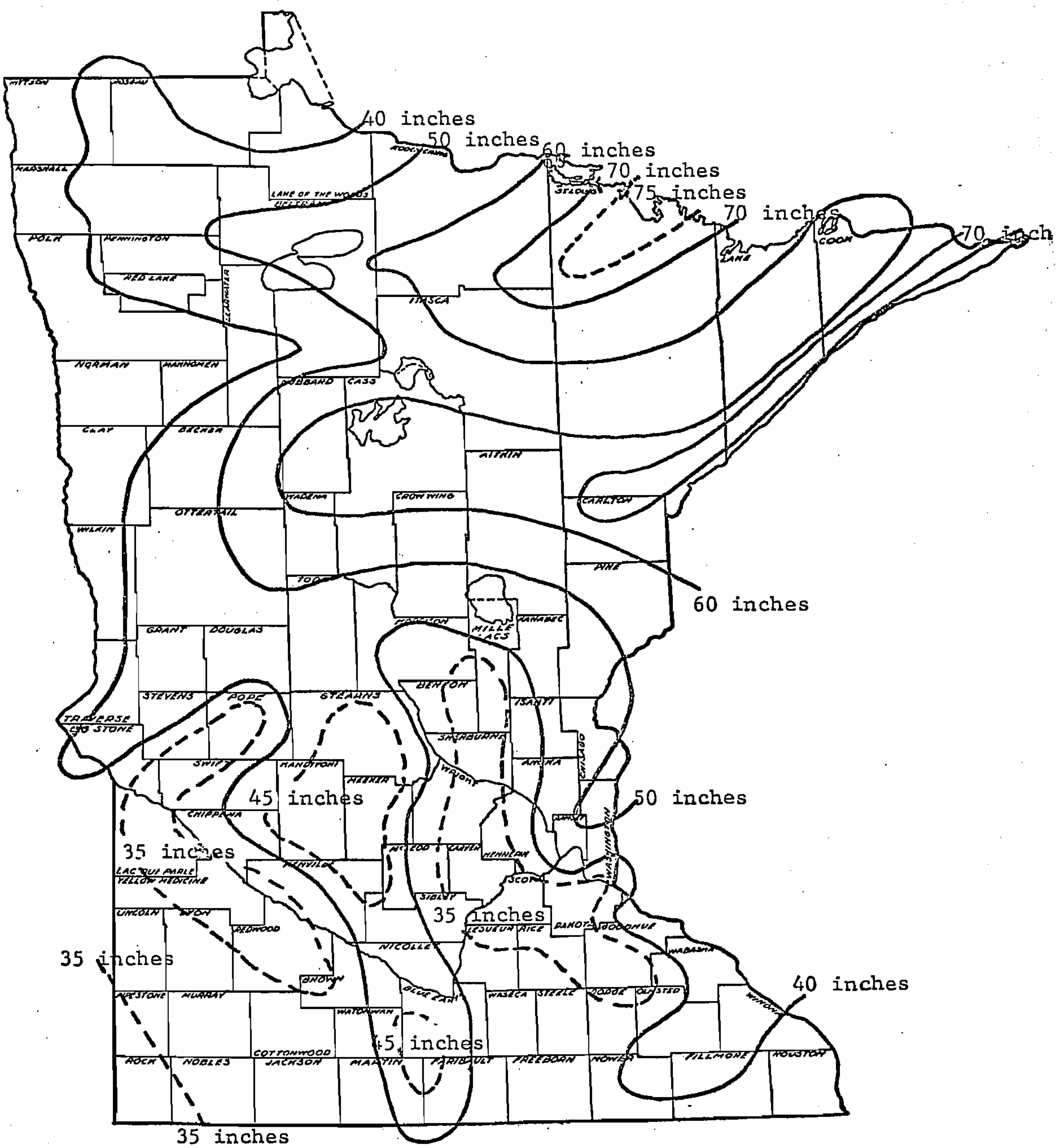
Finally, as we note in Chapter 5, we have some concern about institutionalizing a system of deferred maintenance on certain roads, especially road surface maintenance. We believe a pavement management system will help the department better understand the costs of deferring work.

Overall, we doubt that lower maintenance standards will produce lower budgetary outlays for Minnesota highways. On the other hand, it may be possible to lower state highway liability costs by formalizing a system of low maintenance standards on certain roads. Some states provide minimal maintenance to low priority roads and then warn drivers of this fact through highway signs. While this practice may not lower state operating budgets for routine maintenance, it would probably make the state less liable for road defects on low priority highways.

Appendices

APPENDIX A

AVERAGE SEASONAL SNOWFALL



Source: Office of State Climatology, based on 1950-1975 data.

APPENDIX B

CONTRACT MAINTENANCE IN OTHER STATES

State	% Work Done By State Employees: Maintenance	% Work Done By State Employees: Resurfacing
SOUTHERN REGION[1]		
Alabama	98	5
Arkansas	100	86
Florida	97	0
Georgia	100	17
Kentucky	91	1
Louisiana	100	0
Maryland	75	Minor
Mississippi	99	36
N. Carolina	95	0
Oklahoma	100	50
S. Carolina	100	20
Tennessee	94	5
Texas	90	5-10
Virgina	73	8
W. Virginia	99	0
WESTERN REGION[2]		
Alaska	90	10
Arizona	100	--
California	100	0
Colorado	100	50
Hawaii	93	0
Montana	100	0
New Mexico	84	66
Oregon	100	0
Utah	95	20
Washington	92	0
Wyoming	100	0
EASTERN REGION[3]		
Connecticut	100	0
Delaware	100	100
Maine	95	5
New Hampshire	90	10
New Jersey	81	69
New York	100	11
Pennsylvania	85	1
Vermont	98	53

State	% Work Done By State Employees: Maintenance	Resurfacing
MIDWESTERN REGION[4]		
Illinois	100	0
Indiana	80	0
Iowa	100	0
Kansas	97	0
Michigan	35	0
Missouri	100	--
Nebraska	100	0
North Dakota	100	0
Ohio	90	0
South Dakota	100	0
Wisconsin	0	0

[1]Council of State Governments, Comparative Data Report on State Highway Programs, Southern Legislative Conference, October 1983.

[2]Council of State Governments, State Highway Programs and Innovations, Western Region, April 1983.

[3]Council of State Governments, State Highway Programs and Innovations, Eastern Region, April 1983.

[4]Council of State Governments, State Highway Programs and Innovations, Midwestern Region, April 1983.

Other Sources' Reports of Contracting:

Illinois: Contracts out 12 percent of maintenance work.

New York: Contracts out 59 percent of snow and ice control work to towns and counties. Also has $4.4 million in contracts with cities for work on arterial highways within city limits.
(Source: Transportation Research Board, Formulating and Justifying Highway Maintenance Budgets, NCHRP Synthesis of Highway Practice, No. 80, October 1981.)

Nebraska: Contracts out 7 percent of maintenance.

New Mexico: Contracts out 9 percent of maintenance.

Washington: Contracts out 14 percent of maintenance.
(Source: Arizona Office of the Auditor General, Arizona Department of Transportation Staffing Relationships and Staffing Trends, February 1983.)

APPENDIX C

REASONS FOR EXCEPTIONS TO PROJECT SELECTION FORMULAS

The Minnesota Department of Transportation considers a variety of factors to select projects for its resurfacing and reconditioning program. When deciding whether to make exceptions to its project selection formulas, the department makes the following considerations:

- The department generally does not program work on parallel roads in the same year. Similarly, the department does not want to surround towns with major rehabilitation work.

- Some roads have load restrictions during spring months. Projects may get approved if they strengthen roads to meet traffic needs.

- The department tries, when possible, to approve projects that maximize the state's use of federal road funds.

- Old pavements may have extreme wear that does not show up in condition ratings. Thus, the department sometimes approves work on bituminous roads over 20 years old even though condition ratings are still good.

- The department tries to balance project allocations among districts. This minimizes the need to relocate district design and supervisory personnel.

- The department tries to tie projects together so that contractors can work on nearby projects simultaneously. Thus, a road scheduled for 1987 resurfacing might make the 1986 program in order to combine it with an adjacent 1986 contract.

- The department sometimes defers work on urban roads with low speed limits. A road's rideability is not as noticeable at low speeds.

STUDIES OF THE PROGRAM EVALUATION DIVISION

Final reports and staff papers from the following studies can be obtained from the Program Evaluation Division, 122 Veterans Service Building, Saint Paul, Minnesota 55155, 612/296-4708.

1977

1. Regulation and Control of Human Service Facilities
2. Minnesota Housing Finance Agency
3. Federal Aids Coordination

1978

4. Unemployment Compensation
5. State Board of Investment: Investment Performance
6. Department of Revenue: Assessment/Sales Ratio Studies
7. Department of Personnel

1979

8. State-sponsored Chemical Dependency Programs
9. Minnesota's Agricultural Commodities Promotion Councils
10. Liquor Control
11. Department of Public Service
12. Department of Economic Security, Preliminary Report
13. Nursing Home Rates
14. Department of Personnel, Follow-up Study

1980

15. Board of Electricity
16. Twin Cities Metropolitan Transit Commission
17. Information Services Bureau
18. Department of Economic Security
19. Statewide Bicycle Registration Program
20. State Arts Board: Individual Artists Grants Program

1981

21. Department of Human Rights
22. Hospital Regulation
23. Department of Public Welfare's Regulation of Residential Facilities for the Mentally Ill
24. State Designer Selection Board
25. Corporate Income Tax Processing

26. Computer Support for Tax Processing
27. State-sponsored Chemical Dependency Programs, Follow-up Study
28. Construction Cost Overrun at the Minnesota Correctional Facility - Oak Park Heights
29. Individual Income Tax Processing and Auditing
30. State Office Space Management and Leasing

1982

31. Procurement Set-Asides
32. State Timber Sales
33. *Department of Education Information System
34. State Purchasing
35. Fire Safety in Residential Facilities for Disabled Persons
36. State Mineral Leasing

1983

37. Direct Property Tax Relief Programs
38. *Post-Secondary Vocational Education at Minnesota's Area Vocational-Technical Institutes
39. *Community Residential Programs for Mentally Retarded Persons
40. State Land Acquisition and Disposal
41. The State Land Exchange Program
42. Department of Human Rights: Follow-up Study

1984

43. *Minnesota Braille and Sight-Saving School and Minnesota School for the Deaf
44. The Administration of Minnesota's Medical Assistance Program
45. *Special Education
46. *Sheltered Employment Programs
47. State Human Service Block Grants

1985

48. Energy Assistance and Weatherization
49. Highway Maintenance
50. Metropolitan Council (in progress)
51. Economic Development Programs (in progress)

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*These reports are also available through the U.S. Department of Education ERIC Clearinghouse.