MICHIGAN DEPARTMENT OF TRANSPORTATION
M•DOT

EVALUATION OF ICE DETECTION AND HIGHWAY WEATHER INFORMATION SERVICES

Final Report

MATERIALS and TECHNOLOGY DIVISION

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EVALUATION OF ICE DETECTION AND HIGHWAY WEATHER INFORMATION SERVICES
Final Report

J. H. DeFoe

FHWA Experimental Project No. 13 by the
Michigan Department of Transportation's
Maintenance and Materials and Technology Divisions
in Cooperation with the Federal Highway Administration

Research Laboratory Section
Materials and Technology Division
Research Project 89 G-274
Research Report No. R-1316

Lansing, March 1992

This report, authorized by the transportation director, has been prepared to provide technical information and guidance for personnel in the Michigan Department of Transportation, the FHWA, and other reciprocating agencies. The cost of publishing 100 copies of this report at $1.69 per copy is $169.84 and it is printed in accordance with Executive Directive 1991-6.

RECYCLED PAPER

ACTION PLAN

1. Engineering Operations Committee

   A. Approve report.

2. R. A. Welke

   A. Transmit to the Federal Highway Administration.

3. Maintenance Division

   A. Review the findings and implement where warranted, within budgetary restrictions.

4. Materials and Technology Division

   A. No further action.

ABSTRACT

The purpose of this project was to evaluate the usefulness and cost effectiveness of MDOT's pavement surface sensors and pavement forecasting system as part of a nationwide FHWA research project. The study was conducted over two winter seasons and involved six MDOT maintenance garages. Sensors in bridge decks and pavements were found to be dependable and cost effective. The pavement forecasting system is considered useful by some maintenance supervisors but more reliable and timely information can be obtained from local cable television weather broadcasts.

INTRODUCTION

The Michigan Department of Transportation (MDOT) began its use of bridge deck ice sensors in 1983, followed by subscription to a pavement forecasting service in 1986. Both the sensors and the forecasting service are products of Surface Systems Inc. (SSI) of St. Louis, Missouri and together comprise the Weather Information System (WIS) evaluated in this study.

The pavement sensors are devices about 6 in. in diameter which are placed in the surfaces of bridge decks or roadway pavements. The units contain several sensing elements that measure temperature, presence of moisture, humidity, and dew point and whether or not ice control chemicals are present on the surface. All this information is processed electronically and is continuously available to maintenance operations supervisors via personal computers (1).

The first sensors were installed in a bridge deck on I 496 over the Grand River in Lansing. Evaluation of this first set of sensors resulted in a recommendation that the Department expand their use (1). This early evaluation was concerned with the accuracy, reliability and durability of the sensors. The MDOT system of sensors was then expanded to the current eight locations shown in Figure 1. This research study deals with the usefulness and cost effectiveness of the WIS (sensors and Scancast) used in normal winter maintenance operations.

The Michigan Department of Transportation, along with a number of other state highway agencies, have installed and evaluated ice detection and weather forecasting systems in recent years. Most of these evaluations have addressed the performance of the equipment.

This evaluation was conducted at the request of the Engineer of Maintenance as part of Federal Highway Administration (FHWA) Experimental Project No. 13, "Ice Detection and Highway Weather Information Systems," initiated by the FHWA in 1988.

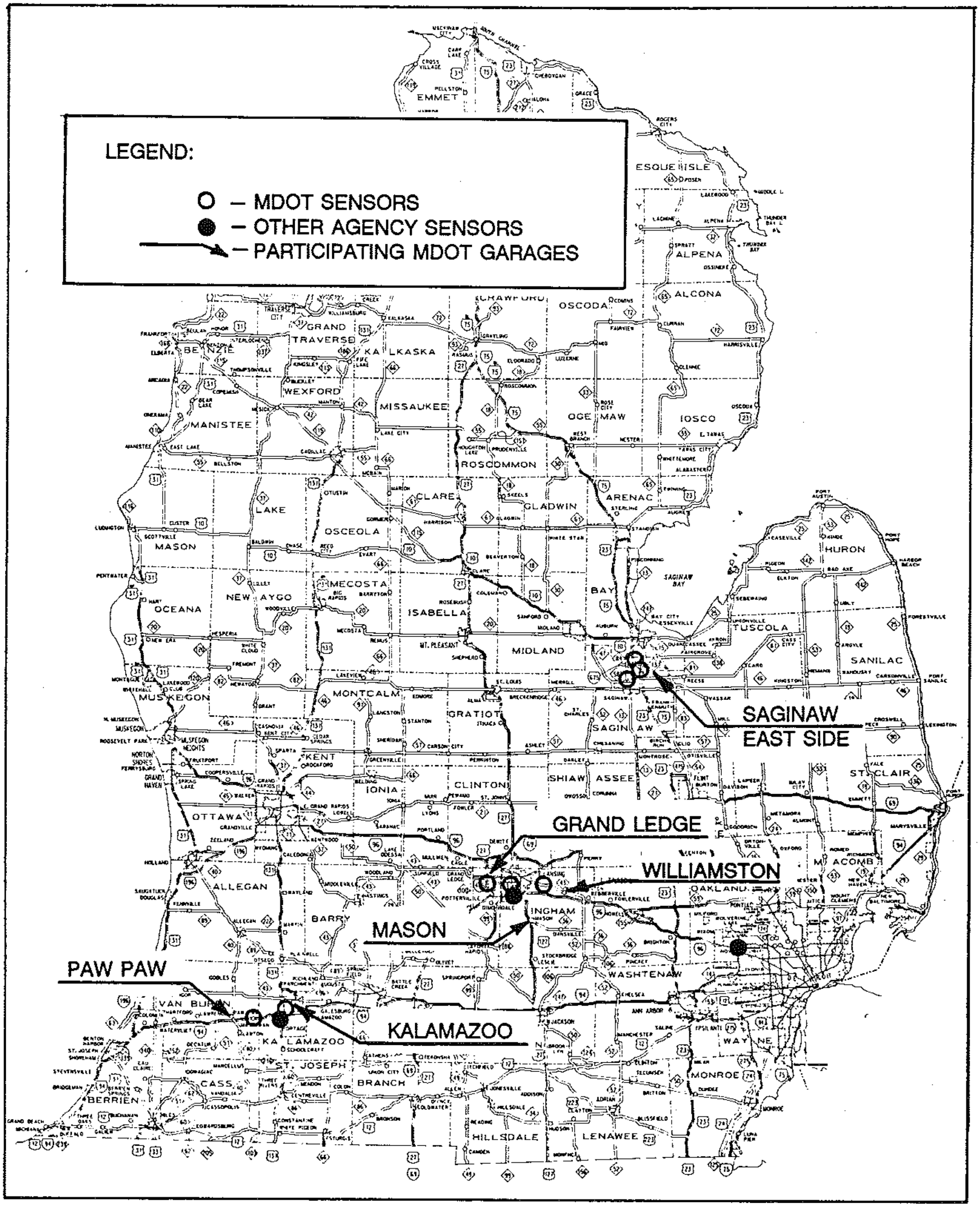

Figure 1. Location of weather information sensors and participating MDOT maintenance garages.

The Michigan Department of Transportation Winter Maintenance Program

Michigan's total highway network consists of approximately 117,400 miles of highways, streets, and roads. This includes approximately 9,500 miles of state highways, with the remaining miles under county and city jurisdiction. This network of state highways translates to approximately 13,825 miles of 24-foot wide road surfaces. Although only eight percent of Michigan's roads fall under state jurisdiction, these roads carry over 50 percent of the total vehicle miles traveled.

Winter Maintenance Operations - Winter maintenance operations for snow and ice control on the State Trunkline System are carried out by MDOT forces in 21 counties, while county road commissions perform maintenance operations by contract in the remaining 62 counties. Maintenance contracts are also in place with over 150 cities and villages, although not all perform winter maintenance (Fig. 2). With the contract agencies, the work crew and supervision, including foreman and superindendent, are staffed by the county or municipality. The overall contract administration, control of work item budgets, and conformance with Department policy and maintenance level guidelines are under the supervision of MDOT's District Operations Engineers. In a typical year, winter maintenance operations account for approximately 28 percent of the total $106,000,000 spent on road and bridge maintenance. Snow routes range in length from 20 to 45 lane miles. Winter road patrols, including second and third shifts, are scheduled in snow belt areas where past experience has shown it is necessary to provide adequate winter maintenance and for general economy of operations.

Decisions are made during winter storm operations by local garage foremen and/or the shift supervisors who review the available weather information along with road and weather conditions and schedule ice control operations. These are the individuals referred to later as "decision makers." A maintenance garage staff consists of between 10 and 25 equipment operators available for winter storm operations. The typical garage has one or more trucks assigned to each snow route and between five and twelve snow routes per garage. Snow trucks are equipped with underbody blades and salt/sand hopper boxes. Front-end plows are available for heavy snowstorms. Graders and loaders are used for pushing back banks, clearing ramps, parking lots, and emergencies.

Sand and salt/sand mixtures are the primary deicers used in Michigan. Calcium chloride is occasionally added. Calcium magnesium acetate (CMA) is used exclusively on twin concrete segmental bridges at Zilwaukee. Each bridge is over 8000 ft long.

Winter Maintenance Policy - In order to provide adequate winter maintenance services and still keep expenditures within or below budgeted funds, each state trunkline has been placed into one of three winter maintenance classifications. These classifications are based on traffic volumes with each classification being assigned a minimum level of maintenance service to be provided as a goal during winter storm conditions.

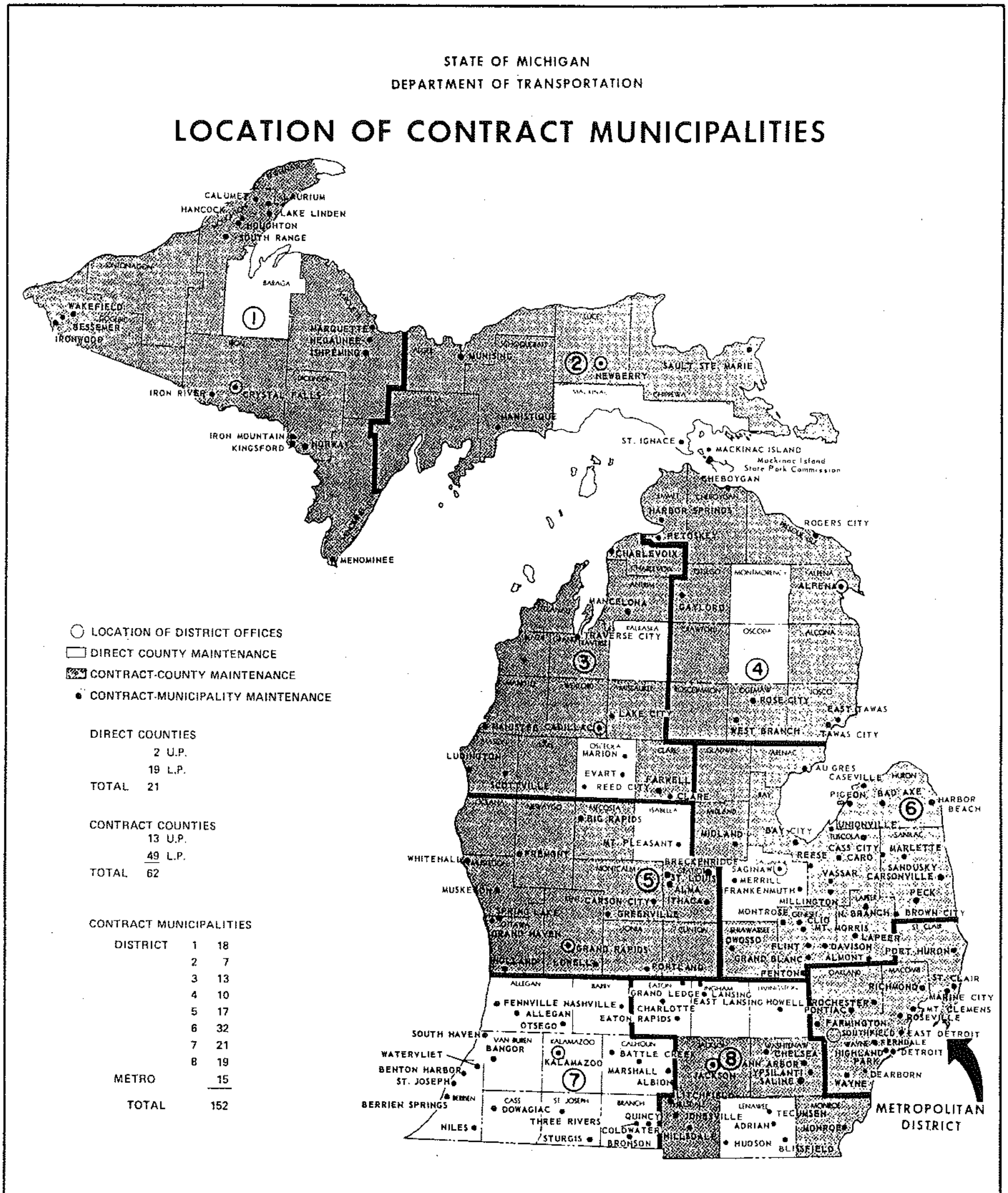

Figure 2. MDOT and contract winter maintenance locations.

As a general rule, winter maintenance operations begin as soon as hazardous road conditions develop and maintenance forces can be dispatched to respond. The first winter event usually occurs in late November or December with the last winter event usually occurring in April in the four areas of Michigan involved in this study.

MDOT's winter maintenance policy calls for the following classifications and levels of service:

1) Green, 5,000 and over winter Average Daily Traffic (ADT). Provide maintenance service as appropriate under prevailing weather conditions, with a goal of providing a pavement surface generally bare of ice and snow. This work will be accomplished using overtime labor as necessary.

2) Yellow, 2,500 to 5,000 ADT. Provide maintenance services as appropriate under prevailing weather conditions, with a goal of providing a pavement surface generally bare of ice and snow in the center portion wide enough for one-wheel track in each direction. Clearing the pavement bare of ice and snow over its entire width will be accomplished as soon as reasonably possible without working overtime.

3) Red, 0 to 2,500 winter ADT. Provide maintenance service as appropriate under prevailing weather conditions, with a goal of providing a pavement surface that is passable though snow covered. Clearing the pavement bare of ice and snow will be accomplished as soon as reasonably possible without working overtime.

During the winter season, maintenance employees in both direct maintenance and contract counties are subject to 24-hour call. As a general rule, winter operations start as soon as hazardous road conditions develop. Every effort is made to clear highways of ice and snow prior to peak traffic periods, especially early morning commuter traffic. Second and third shifts are scheduled in areas where past experience has shown this to be necessary to provide a desired level of winter maintenance service. This is also an effective way to minimize overtime costs.

Winter Maintenance Equipment - The standard truck is a single-axle unit with a 6.5 cu yd dump box and an underbody scraper. The trucks are also outfitted with a drop-in salt-hopper/spreader-box and a detachable quick-hitch for the snow plow attachment.

Front plows are normally not used until a storm's snow accumulation reaches 8 in. or more or severe drifting is encountered. Snow wings are normally used only on motor graders with the same detachable hitch used on trucks so the plows can be interchanged.

The Michigan Department of Transportation Weather Information System

Pavement Condition Sensors - The Department has sensors at eight locations and acquires information from sensors owned by other agencies at three other sites. Individual sensors are located on bridge decks, bridge approaches, and approach pavements (subsurface). Sensors are located in four geographic areas, eastern Saginaw County, the Lansing area, Oakland County, and the Kalamazoo area (Fig. 1). The pavement sensors give surface temperature, moisture, and chemical (chloride) concentration, thus allowing reliable predictions of the presence of frost or ice. Each of the four geographic areas also has at least one weather station that supplies air temperature, dew point temperature, humidity, precipitation (yes/no), wind direction, and wind speed. Each set of sensors has a remote processing unit (RPU) that transmits data by telephone or radio to one of four central processing units (CPU) for data storage and retrieval (one CPU for each geographic area). The Maintenance Division central office in Lansing can retrieve data from any CPU in the state by telephone. CPUs can also be called from any location by telephone using portable lap-top data terminals. These portable terminals are used by garage foremen at home or in the office and are a key part of this winter information system. The Kalamazoo CPU is located at the Kalamazoo airport and the data are shared with them.

Pavement Forecast Service - The Maintenance Division has a contract with Surface Systems Inc. to provide forecasts, called Scancasts, of pavement temperature, moisture, plus a weather forecast for each of the four geographic areas. The 24-hour Scancasts are obtained in the same way as the pavement sensor data by using portable data terminals. The pictorial line and bar graphs provided by the Scancasts are easy for the truck drivers to read and understand.

Weather Radar - The Capital City Airport in Lansing and the Maintenance Division share ownership of an X-band radar unit at the airport. Information from the radar, including an area map showing storm movement, color coded by precipitation intensity, can be accessed by personal computer via telephone at the Lansing area maintenance garages.

Cable Weather Channel - Television sets have been placed in three maintenance garages: Kalamazoo, Saginaw eastside, and Grand Ledge (just west of Lansing). The TVs have been locked onto the weather channel in order to provide additional weather information.

Weather Systems Costs - The capital investment by the Michigan Department of Transportation over the past decade in 1990 dollars is approximately $400,000. The installation of the weather channel information including the television and cable hook-up has cost about $1,000 per site. The total cost for the Scancast pavement forecast is about $9,000 per year. The maintenance of the pavement sensors and weather radar have run about $20,000 per year for parts and labor (including the consultant's repair technicians and in-house labor).

EVALUATION OF THE WEATHER INFORMATION SYSTEM

This evaluation was conducted in accordance with the FHWA's Evaluation Work Plan for Experimental Project No. 13. According to this work plan the evaluation was to be based on information from five sources.

1. A Winter Maintenance Event Form (WME)
2. Winter Maintenance Activity Cost Forms
3. Site Information Forms
4. Accident records
5. Newspaper, maintenance crew, or police reports on motorists delays

The two-year evaluation of MDOT weather information systems described in this report was conducted in conformance with the FHWA work plan requirements as nearly as possible.

Results After the First Winter (1989-1990)

Five MDOT maintenance garages were involved during the first winter season of the study, Grand Ledge, Kalamazoo, Mason, Paw Paw, and Saginaw eastside. The evaluation after the first winter was based on the information reported on the Winter Maintenance Forms (Appendix, Fig. A1) along with interviews with the decision makers and other key personnel in the winter maintenance areas using the Weather Information Systems.

WME forms were to be filled out and submitted by the decision makers for each event (i.e., storm) which required winter maintenance activities to correct hazardous road conditions. The WME form included entries that would show whether or not the various weather information sources were used in deciding what action to take.

A review of the WME forms indicated some problems in getting the forms filled out correctly. Information reported on these event forms also showed some problems with the reliability of the Weather Information System equipment (i.e., sensors, Scancast, and radar). The sensors and the radar required frequent maintenance during the first season of this evaluation.

The Weather Information System was used in decision making during storm events over the 1989-90 winter season and results are summarized in Table 1. Information in this table was taken from the Winter Maintenance Event Forms as submitted by the decision makers at the five participating garages.

Examination of Table 1 revealed some apparent discrepancies and suggested that some corrective actions were needed before the next winter. The first discrepancy involved the reliability of the Weather Information Service components. Of the 95 events reported, the equipment provided

TABLE 1
INFORMATION SOURCES REPORTED BY DECISION MAKERS
AS INFLUENCING WINTER STORM OPERATIONS

Garage	No. of Events Reported	Weather Information Systems Used				Traditional Methods*	Equipment Failures		Man-hours Saved	WIS Use, Percent of Events Reported
		Sensors	Scancast	Radar	More Than One		Sensors	Scancast		
Grand Ledge	21	1	1	0	1	18	2	1	—	4.7
Kalamazoo	32	12	22	0	12	17	6	0	612	68.8
Mason	24	12	1	1	0	18	0	0	4	58.3
Paw Paw	9	4	4	0	4	4	5	0	—	44.4
Saginaw	9	0	0	0	0	6	4	3	—	0

*Other observations, phone calls, radio/TV, police

information to the decision makers 58 times but were reported to be malfunctioning 21 times (22 percent). Usage reported by each garage ranged from 68.8 percent of events at Kalamazoo down to 0 percent at Saginaw eastside. Equipment failure plagued the Saginaw garage throughout the season. Early failures may have discouraged any further reporting by the decision makers.

Interviews, however, with personnel from the garage, indicate they are able to minimize the amount of CMA needed on the Zilwaukee Bridge because of sensor information. The Saginaw eastside garage maintains the Zilwaukee Bridge which opened in 1987 and has carried more than 27 million vehicles without any traffic tie-ups, closures or congestion. The two spans are kept free of ice and snow through the use of calcium magnesium acetate (no salt has ever been permitted on the bridges) along with appropriate mechanical removal equipment dedicated for that bridge.

A second concern involved the disparity in the number of storm events reported (WMEs submitted) with Kalamazoo reporting 32 events while Paw Paw (only 13 miles west of Kalamazoo) reported only nine events, the same as Saginaw. From past experience in evaluating ice control measures, the number of winter storm events usually ranges from 20 to 30 during a winter season. It might seem that WME forms were not submitted for every storm at some of the garages.

Finally, only two garages reported a savings in manpower, with one reporting 616 hours saved and the other four hours. No other savings were reported. It seemed advisable to relieve the burden of figuring these daily costs from the decision makers who, as a first priority, supervise the normal maintenance garage activities as well as direct ice control operations.

Use of the System - Decision makers use of the Weather Information System was apparently influenced by the reliability of the components of the system as well as by the attitude of the decision maker about the need for supplemental information. The degree to which decision makers rely on the systems varies with the individuals involved as well as each storm situation. At one garage, the foreman carried his lap-top data terminal wherever he went, bringing it home at night and on weekends. His decisions were greatly influenced by information obtained in advance of the storms. Other foremen, however, availed themselves of the system's information after they arrived on duty at the garage. The first approach can be quite beneficial in situations where application of chemicals prior to the storm is appropriate. Wet, heavy snowfall with predicted accumulations which could result in a snow pack of several inches would be one example. Experience at the Zilwaukee Bridge has shown that pre-storm application of calcium magnesium acetate is essential to effective and efficient use of this expensive deicing material.

Second Winter Results (1990-1991)

During the second winter the following four garages participated in the study, Grand Ledge, Kalamazoo, Saginaw eastside, and Williamston. These changes were made because of supervisory changes at several garages. The Winter Maintenance Event Forms were revised for this second winter in an attempt to make it easier to estimate savings and to provide more positive responses regarding the usefulness of the several information sources. The revised WME form is shown in the Appendix (Fig. A2).

Responses reported on the WME forms from each of the four garages are summarized in Table 2. Examination of Table 2 shows a wide disparity in the number of storms reported with Williamston reporting only five events, Grand Ledge eight, and Kalamazoo and Saginaw eastside each reporting 13 events. Of the 39 events reported by the four garages, only two were reported by all four garages while seven events were reported by two garages. Seventeen storms, however, were reported by individual garages, all on different days.

Information provided in Table 2 shows a significant savings in salt and working hours. Using the lesser value for each entry, the total savings in salt for the five garages was 302 tons (about $8,000). Total savings amounted to $99,800, including 385 manhours as well as operating costs for snow removal equipment. These savings are probably on the low side since there is an indication that not all storms resulted in WME forms being submitted. Snowfall records by the National Climatic Data Center show that there were 75 different days during the 1990-91 winter when a trace or more of snow was recorded for the areas of Michigan that included the four garages. Most of these snowfalls were reported for more than one garage area so that a total of 243 snowfall days occurred at the four garages. From these 243 snowfall days, a total of 39 WME forms were submitted as summarized in Table 3.

Decision makers' interest in participating in this study seemed to diminish significantly as shown in Table 3. During December 1990, a total of 20 WME forms were submitted covering 54 snowfall days (37 percent) while during February and March 1991 only 7 WME forms resulted from 100 snowfall days (7 percent). It is expected that not every snowfall day would require maintenance. The higher ratios, however, of WME forms

TABLE 2
SUMMARY OF RESPONSES FROM WINTER MAINTENANCE EVENT FORMS, 1990-1991

Garage Location	Beginning		Storm Duration, hrs	Weather Source	Weather Condition	Pavement Temperature		Air Temperature		Percipitation, in.	Money Saved By [Yes, No]			Salt Saved, tons	Working Hours Saved	Working Hours Shortened By [Yes, No]			Patrol Shift Start or End Altered By [Yes, No]			Crew Request For	
	Date	Time				Start	End	Start	End		Radar	Sensors	Scancast			Radar	Sensors	Scancast	Radar	Sensors	Scancast	Surface Temperature	Chemical Factor
Williamston	12-03-90	4:00a	43	1,2,3	Hv. Snow	30	28	28	24	3.0	N	Y	Y	16-20	6-10	Y	Y	Y	N	N	N	N	N
	01-02-91	4:00p	15	—	Snow Sq	24	11	22	14	0.5	N	Y	Y	1-5	11-15	Y	Y	Y	N	N	N	N	N
	01-05-91	8:00a	25	1	Hv. Snow	22	27	24	28	3.0	N	N	Y	16-20	16-20	Y	Y	Y	N	N	N	N	N
	01-11-91	3:00a	36	1,2	Rain/Slt	26	29	28	30	—	N	Y	Y	6-10	6-10	N	Y	Y	N	Y	Y	N	N
	01-20-91	4:00p	32	1	Rain/Slt	32	0	30	10	1.0	N	Y	Y	16-20	16-20	N	Y	Y	N	N	N	Y	N
Grand Ledge	12-03-90	4:30a	34	4	Hv. Snow	31	—	27	—	3.0	N	—	—	0	0	N	N	N	N	N	N	N	N
	12-23-90	12:0a	?	6	Hv. Snow	—	—	—	—	4-5	N	N	N	—	—	—	—	—	—	—	—	N	N
	12-25-90	12:0a	45	—	Hv. Snow	—	—	—	—	—	Y	Y	Y	—	—	—	—	—	—	—	—	—	—
	12-27-90	9:00p	6	—	Hv. Snow	—	—	—	—	—	Y	Y	Y	?	?	Y	Y	Y	—	—	N	N	N
	01-05-91	8:15a	26	None	Hv. Snow	—	—	—	—	—	N	N	N	40-50	0	N	N	N	N	N	N	N	N
	01-09-91	3:00a	21	N Shift	Lt. Snow	28	—	—	—	—	N	N	N	—	—	N	N	N	N	N	N	Y	N
	01-20-91	4:00p	19	6	Snow Sq	—	—	—	—	—	NA	NA	NA	—	—	N	N	N	N	N	N	N	N
	01-23-91	7:00a	17	None	Lt. Snow	28	?	26	?	—	NA	NA	NA	—	—	—	—	—	—	—	—	—	—
Kalamazoo	12-03-90	4:00a	18	6	Lt. Snow	32	35	30	34	3.0	NA	NA	NA	—	—	N	N	N	N	N	N	N	N
	12-14-90	1:00a	11	1,2,5	Lt. Snow	26	27	25	25	12.0	N	Y	N	16-20	1-5	N	Y	N	N	N	N	N	N
	12-15-90	12:3a	11	—	Rain/Slt	32	34	32	33	0.1	Y	Y	Y	16-20	11-15	N	N	N	Y	Y	Y	Y	N
	12-22-90	7:00p	80	4,6	Lt. Snow	35	10	31	9	4.0	Y	Y	Y	Other	16-20	Y	Y	Y	N	N	N	Y	Y
	12-27-90	7:00p	?	6	Lt. Snow	20	22	22	23	3.0	Y	Y	Y	16-20	6-10	Y	Y	Y	N	N	N	Y	Y
	12-29-90	10:0p	10	—	Rain/Slt	33	29	33	34	2.0	Y	Y	Y	16-20	16-20	N	N	N	N	N	N	N	N
	01-10-91	10:0p	14	6	R/S, Lt.Sn	27	35	23	27	7.0	N	N	N	—	—	N	N	N	N	N	N	Y	Y
	01-05-91	6:00a	18	1,2,5	R/S, Lt.Sn	22	29	23	28	4.0	Y	Y	Y	70	130	Y	Y	Y	Y	Y	Y	Y	Y
	01-12-91	?	?	4,6	Lt. Snow	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	02-14-91	2:30a	35	—	Lt. Snow	34	20	34	17	3.0	N	N	N	—	16-20	Y	N	N	N	N	N	Y	N
	02-15-91	3:00a	25	6	Lt. Snow	20	—	20	—	2.0	N	N	N	Other	None	N	N	N	N	N	N	N	N
	02-26-91	4:00p	15	6	Lt. Snow	26	20	28	22	3.0	N	N	N	None	None	N	N	N	N	N	N	N	N
	02-27-91	7:00a	15	6	Lt. Snow	23	27	22	38	1.0	Y	N	N	16-20	6-10	Y	N	N	Y	Y	Y	N	N
Saginaw East Side	12-03-90	7:00a	12	6	Rain/Slt	—	—	28	36	1-3	NA	NA	NA	1-5CMA	11-15	NA	NA	NA	—	—	—	—	—
	12-04-90	5:00a	12	6	Snow/Sq	—	—	21	38	—	NA	NA	NA	1-5	11-15	—	—	—	—	—	—	—	—
	12-22-90	4:00a	8	6	Hv. Snow	—	—	14	—	1-3	NA	NA	NA	6-10	16-20	—	—	—	—	—	—	—	—
	12-23-90	12:0a	12	—	Lt. Snow	—	—	16	—	—	—	—	—	6-10	16-20	—	—	—	—	—	—	—	—
	12-24-90	12:0a	12	—	Clean Up	—	—	14	—	—	—	—	—	—	16-20	—	—	—	—	—	—	—	—
	12-25-90	3:00a	9	—	Snow/Sq	—	—	—	—	—	—	—	—	16-20	16-20	—	—	—	—	—	—	—	—
	12-26-90	12:0a	—	—	—	—	—	16	—	1-3	—	—	—	6-10	16-20	—	—	—	—	—	—	—	—
	12-28-90	3:00a	21	—	R/S, Hv.Sn	—	—	5	00	—	—	—	—	1-5	11-15	—	—	—	—	—	—	—	—
	12-29-90	12:0a	17	—	—	—	—	14	—	—	—	—	—	1-5	11-15	—	—	—	—	—	—	—	—
	01-05-91	7:00a	31	4,6	Hv. Snow	15	28	22	28	4.0	Y	N	N	16-20	1-5	Y	N	N	Y	N	N	Y	Y
	02-15-91	5:00a	?	6	Lt. Snow	—	—	—	—	—	N	Y	N	1-5	1-5	N	N	N	—	—	—	Y	Y
	03-02-91	6:00p	25	2,6	R/Sl, Lt.Sn	33	—	29	—	—	Y	Y	Y	1-5	1-5	N	N	N	—	—	—	Y	Y
	03-09-91	8:00p	16	—	Rain/Slt	32	—	34	—	—	N	N	Y	1-5	1-5	N	Y	N	—	—	—	N	N

Note: Weather Source 1 = Ice Dectectors; 2 = Scancast; 3 = Radio Forcast; 4 = T.V. Forcast; 5 = Radar; 6 = Other
— No response entered
NA "Not Applicable" box was checked

TABLE 3
SUMMARY OF SNOWFALL DAYS AND WINTER MAINTENANCE EVENT REPORTS

Month	Grand Ledge		Kalamazoo		Saginaw eastside		Williamston	
	Snowfall Days	WME Days	Snowfall Days	WME Days	Snowfall Days	WME Days	Snowfall Days	WME Days
December 1990	14	4	14	6	12	9	14	1
January 1991	25	4	16	3	23	1	25	4
February 1991	14	0	12	4	13	1	14	0
March 1991	14	0	7	0	12	2	14	0

to snowfall days during December from Saginaw and Kalamazoo (75 and 43 percent respectively) probably indicate a realistic level of maintenance activity. Quite likely the weather information systems were used consistently throughout the winter by all garages even though not always reported by WME forms.

In addition to data obtained from the WME forms, decision makers were interviewed at each garage at the end of the second winter season. The interviews provided an opportunity for the users of the systems to state their opinions and experiences in an open and informal manner that could not be achieved with questionnaires or event forms. The opinions and experiences of the decision makers seemed to be similar for the four garages and are summarized as follows concerning the various components of the weather information and communications system used by MDOT.

Pavement and Bridge Deck Sensors - These sensors are felt to be the most useful of the weather information devices. Sensor information reduces or eliminates road patrols and the history page (which displays the last 15 significant changes in readings for each sensor) can thus indicate to the supervisor what his crews have been doing.

Scancast - There was no consensus on the usefulness of Scancast. At one garage it was felt to be as useful as the sensors while at others it was not used very much or was deemed to be inaccurate especially when compared with information from the local cable TV weather channel. Morning Scancast updates were often late, arriving at mid-day and too late to be helpful in planning the day's activities.

The radar installation at Kalamazoo never worked properly and was dismantled shortly after the project started. "Scrap it!" was the comment about the usefulness of the radar at Lansing. The local cable TV weather channel was usually cited as a more reliable source of information.

The interviews revealed the importance of cable TV weather channels along with a need for more sensors at certain locations.

Decision makers in each garage named several locations where additional pavement sensors could provide valuable and timely information. Several suggested locations are sections of highways known to ice-up or accumulate snow pack early in a storm. Major interchanges and extremities of areas of responsibility were also named as needing sensors.

The MDOT mobile radio system is also a vital part of winter storm operations. Drivers as well as supervisors can monitor a storm's progress and hear what actions work (or don't work) through the talk of drivers in other areas.

In summary, the interviews showed the sensors to be extremely valuable with a need for more to be installed. Scancast is of questionable value especially when a cable TV weather channel is available. The radar systems (those available at the start of this evaluation) were of little or no use.

Accident Information

Accident records for the garages and their individual routes are summarized in Table 4 with more detailed accident and traffic data included

TABLE 4
SUMMARIZED ACCIDENT DATA

	Garage	Total	Ice Related	Ice Related, percent of total
Summer 1989	Grand Ledge	526	2	0.4
	Kalamazoo	832	2	0.2
	Saginaw E.S.	492	0	0
	Williamston	478	2	0.4
Winter 1989-90	Grand Ledge	735	255	34.7
	Kalamazoo	636	331	52.0
	Saginaw E.S.	610	270	44.3
	Williamston	666	248	37.2
Summer 1990	Grand Ledge	589	2	0.3
	Kalamazoo	918	0	0
	Saginaw E.S.	516	0	0
	Williamston	432	0	0
Winter 1990-91	Grand Ledge	631	181	28.7
	Kalamazoo	915	243	26.6
	Saginaw E.S.	376	125	33.2
	Williamston	475	129	27.2

in the Appendix. The accident information is broken into two time intervals, November through April for the winter season and, May through October as a comparable non-icy season. This accident data was obtained from MDOT's Traffic and Safety Division and shows a decrease in the proportion of ice related accidents during the second season of the evaluation. Equipment problems seem to have been resolved by the second season and perhaps increased the effectiveness of both the sensors and Scancast.

CONCLUSIONS

Information obtained from the Winter Maintenance Event forms and from discussions with decision makers during this study justify the following conclusions regarding the weather information systems.

1) The pavement ice sensors are effective and provide information resulting in savings of deicing chemicals and labor. Supervisors at each garage provided a list of locations where additional sensors would be beneficial.

2) Scancast weather forecast information is also useful but not as effective as the pavement sensors which give actual current conditions. Scancast was not regularly used at all garages.

The pavement sensors provide information for decision making and are more reliable and timely than Scancast.

3) Weather radar at the local airports was unreliable and was not used by any of the garages.

4) Cable television weather channels are effective and useful in giving advance forecasts and are used by all garages where available.

REFERENCES

1. Spica, F. M., "SCAN 16 - Moisture, Frost, Ice Early Warning System (Final Report)," Michigan Department of Transportation, Research Report No. R-1252, October 1984.

APPENDIX

FHWA-EP-13

WINTER MAINTENANCE EVENT FORM

Location Code: Form Date:
Decisionmaker:

GENERAL EVENT INFORMATION

Beginning Date: Beginning Time:
Notification Method:

Type of weather or highway/bridge pavement conditions: (circle one)

Frost	Patchy Ice	Rain/Sleet	Snow Squall
Light Snow	Heavy Snow	Other:	

Ending Date: Ending Time:

Inches of precipitation:

Maintenance Response/Activities

Mobilization Start Time: Ending Time: No. of Units:	Patroling Start Time: Ending Time: No. of Units:
Spot Sanding Start Time: Ending Time: No. of Units: Tons of Sand:	Snow Plowing Start Time: Ending Time: No. of Units:
Spreading Chemicals & Abrasives Start Time: Ending Time: No. of Units: Material Used: Application Rate: Total No. of Applications:	Other Description: Start Time: Ending Time: No. of Units:
False Alarm Start Time: Ending Time: No. of Units:	Standby Start Time: Ending Time: No. of Units:

Effects of Ice/Weather Information System on Decisionmaking

Comments:	Hours Saved		
	Activity	Reg	Prem

Figure A1. Winter Maintenance Event Form used in the first season (1989-1990).

WINTER MAINTENANCE EVENT FORM

Garage:

Foreman or Shift Supervisor:

General Winter Event Information

Beginning Date: Beginning Time:

What weather information source alerted you of this winter event?

Type of weather or highway/bridge pavement conditions. (Circle one)

Frost Patchy Ice Rain/sleet Snow Squall

Light Snow Heavy Snow

At the start of the storm.

Pavement Temp. ________ Air Temp. ________

At the end of the storm.

Pavement Temp. ________ Air Temp. ________

Ending Date: Ending Time:

Inches of precipitation:

Maintenance Response/Activities

Did the weather radar _____, pavement sensors _____, or scancast pavement forecast _____ save any money in this storm?

Yes ___ No ___ Not Applicable ____

If you saved any money, how much salt did you save?

1-5 Tons ____ 6-10 Tons ____ 11-15 Tons ____

16-20 Tons ____ Other __________

How many working hours on winter operations did you save?

1-5 Hrs. ____ 6-10 Hrs. ____ 11-15 Hrs. ____

16-20 Hrs. ____ Other __________

Did you extend ____ or shorten ____ working hours as a result of information supplied by the weather radar ____, pavement sensors ____, or scancast pavement forecast ____?

Yes ___ No ___

Did you alter the start ____ or end ____ of the night patrolman's shift based on the weather radar ___, pavement sensors ____, or scancast ____?

Yes ___ No ___

Did you receive any request for surface temperature ____ or chemical factor ____ from your crews?

Yes ___ No ___

Were there any other benefits that the weather radar, pavement sensors, or that the scancast provided?

Mail this form biweekly to:

Materials and Technology Division
P.O. Box 30049
Lansing, Michigan 48909
Attn: Jack Defoe

Winter-F

Figure A2. Winter Maintenance Event Form used during the second season (1990-1991).

TRAFFIC AND SAFETY DIVISION
TECHNICAL SERVICES UNIT
ACCIDENT AND TRAFFIC DATA SUBUNIT
OCTOBER 11, 1991
ADR # 009

SAGINAW (EAST SIDE) TOTAL ACCIDENTS AND SNOWY-ICY RELATED ACCIDENTS

RTE #	C.S. #	MILEPOINTS	05/01/89 10/31/89		11/01/89 04/30/90		05/01/90 10/31/90		11/01/90 04/30/91		1989[1] RTE AVG ADT	1990[1] RTE AVG ADT
			TOT	ICY	TOT	ICY	TOT	ICY	TOT	ICY		
M-13	73051	0.0 - 14.9	31	0	36	10	33	0	41	3	7,595	8,516
	73091	4.0 - 7.5	3	0	4	2	3	0	3	0		
	09031	0.0 - 2.7	9	0	13	2	8	0	4	2		
M-46	73063	2.0 - 13.5	100	0	78	25	100	0	69	18	7,630	7,897
	79041	0.0 - 1.3	3	0	2	1	5	0	3	1		
M-81	73081	0.0 - 10.8	27	0	35	14	36	0	33	8	5,924	7,151
M-83	73121	0.0 - 2.1	46	0	28	4	34	0	17	2	7,574	6,841
	73131	1.9 - 14.5	73	0	95	34	48	0	14	10		
M-54	73131	0.0 - 1.9	3	0	0	0	3	0	3	2	6,548	5,882
I-75	73171	0.0 - 10.5	93	0	144	87	92	0	69	27	38,185	42,917
	73111	0.0 - 5.1	40	0	79	36	76	0	44	14		
	73112	0.0 - 4.1	34	0	34	19	36	0	23	14		
I-675	73101	0.0 - 7.9	30	0	62	36	42	0	53	24	20,659	20,614

[1] 1989 & 1990 ROUTE AVERAGE ADT was determined by averaging ADT's for individual control sections.

TRAFFIC AND SAFETY DIVISION
TECHNICAL SERVICES UNIT
ACCIDENT AND TRAFFIC DATA SUBUNIT
OCTOBER 11, 1991
ADR # 009

KALAMAZOO TOTAL ACCIDENTS AND SNOWY-ICY RELATED ACCIDENTS

RTE #	C.S. #	MILEPOINTS	05/01/89 10/31/89		11/01/89 04/30/90		05/01/90 10/31/90		11/01/90 04/30/91		1989[1] RTE AVG ADT	1990[1] RTE AVG ADT
			TOT	ICY	TOT	ICY	TOT	ICY	TOT	ICY		
M-43	39081	0.0 - 8.0	197	1	189	38	212	0	166	20	16,139	17,077
	39082	1.2 - 8.0	91	0	111	18	121	0	92	18		
M-96	39042	0.0 - 9.2	148	1	174	42	140	0	120	14	11,185	10,725
	39031	0.0 - 5.0	20	0	19	3	20	0	25	6		
US-131	39011	0.0 - 5.0	39	0	41	14	39	0	37	6	21,610	20,721
	39013	0.0 - 6.6	26	0	31	12	44	0	20	1		
	39014	0.0 - 6.8	49	1	92	35	71	0	82	27		
I-94	80024	9.5 - 10.5	11	0	15	4	6	0	4	2	32,990	36,732
	39024	0.0 - 9.3	99	0	113	51	104	0	113	35		
	39022	0.0 - 11.5	94	0	165	96	106	0	188	100		
I-94BL	39121	0.0 - 2.8	28	0	31	10	31	0	32	6	11,818	12,107
I-94BL (Stadium Dr.)	39041	0.0 - 0.6	30	0	33	8	24	0	36	8	22,645	22,810

[1] 1989 & 1990 ROUTE AVERAGE ADT was determined by averaging ADT's for individual control sections.

TRAFFIC AND SAFETY DIVISION
TECHNICAL SERVICES UNIT
ACCIDENT AND TRAFFIC DATA SUBUNIT
OCTOBER 11, 1991
ADR # 009

GRAND LEDGE TOTAL ACCIDENTS AND SNOWY-ICY RELATED ACCIDENTS

RTE #	C.S. #	MILEPOINTS	05/01/89 10/31/89		11/01/89 04/30/90		05/01/90 10/31/90		11/01/90 04/30/91		1989[1] RTE AVG ADT	1990[1] RTE AVG ADT
			TOT	ICY	TOT	ICY	TOT	ICY	TOT	ICY		
M-43	23052	0.0 - 1.3	0	0	3	0	2	0	5	0	21,160	17,427
	23041	0.0 - 16.1	52	0	55	26	48	0	29	6		
	23042	0.0 - 7.0	195	1	231	38	234	2	231	36		
	33061	0.0 - 1.2	52	0	47	9	44	0	49	10		
M-100	23071	0.0 - 8.1	24	0	42	18	21	0	42	19	7,381	7,715
	23072	0.0 - 2.3	44	0	46	12	48	0	35	6		
	19011	0.0 - 2.0	5	0	6	1	3	0	4	0		
I-96	19022	0.0 - 10.0	45	1	64	27	33	0	48	16	30,706	24,658
	23152	0.0 - 6.7	39	0	70	42	42	0	53	25		
	23151	0.0 - 2.8	9	0	29	17	21	0	17	8		
	33083	0.0 - 3.7	14	0	39	26	21	0	19	11		
	33084	0.0 - 2.1	13	0	32	16	27	0	19	10		
I-69	19043	0.0 - 9.6	18	0	53	23	24	0	63	29	15,503	18,401
I-96BL	19021	0.0 - 4.0	16	0	18	0	21	0	17	5	10,276	8,553

[1] 1989 & 1990 ROUTE AVERAGE ADT was determined by averaging ADT's for individual control sections.

TRAFFIC AND SAFETY DIVISION
TECHNICAL SERVICES UNIT
ACCIDENT AND TRAFFIC DATA SUBUNIT
OCTOBER 11, 1991
ADR # 009

WILLIAMSTON TOTAL ACCIDENTS AND SNOWY-ICY RELATED ACCIDENTS

RTE #	C.S. #	MILEPOINTS	05/01/89 10/31/89		11/01/89 04/30/90		05/01/90 10/31/90		11/01/90 04/30/91		1989[1] RTE AVG ADT	1990[1] RTE AVG ADT
			TOT	ICY	TOT	ICY	TOT	ICY	TOT	ICY		
M-43	33082	2.5 - 15.4	181	0	216	45	190	0	164	24	9,178	11,375
	33051	0.0 - 2.0	7	0	0	0	6	0	4	1		
M-52	33091	2.1 - 6.6	11	0	24	3	8	0	13	1	3,455	4,185
	33021	14.8 - 17.7	8	0	9	3	4	0	5	0		
	33092	0.0 - 7.3	11	0	5	0	7	0	10	0		
	33051	2.0 - 8.9	12	0	12	2	14	0	8	3		
M-36	33021	17.7 - 20.5	0	0	3	0	3	0	1	0	4,365	4,720
	47041	0.0 - 4.8	6	0	7	3	5	0	4	0		
M-106	33072	0.0 - 2.0	6	0	2	2	7	0	5	2	1,882	1,993
	47021	0.0 - 3.9	9	0	9	3	2	0	4	1		
I-69BL	33043	2.8 - 5.0	21	0	21	5	16	0	20	2	14,270	16,610
	19041	0.0 - 1.1	16	0	18	4	15	0	10	2		
I-69	19042	0.0 - 8.0	22	0	54	24	15	0	33	11	24,522	18.394
M-78 (Old Temp I-69)	19841	0.0 - 2.9	12	0	25	15	18	0	12	4	3,200	3,200
I-96	33084	2.1 - 17.6	81	2	161	97	67	0	117	56	35,190	36,189
	33085	0.0 - 2.7	15	0	21	9	4	0	7	4		
	47066	0.0 - 8.8	60	0	79	33	51	0	58	18		

[1] 1989 & 1990 ROUTE AVERAGE ADT was determined by averaging ADT's for individual control sections.