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Evaluation of the Accuracy, Reliability, Effectiveness,
Expansibility, and Additional Potential Benefits of the SCAN 16 EF
Moisture, Frost and Ice Early Warning System

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16. Abstract The New Jersey Department of Transportation installed a SCAN 16 EF (SCAN) Moisture, Frost and Ice Early Warning System in the Fall of 1984. The system was not operational until the winter of 1985/86 due to problems in obtaining an FCC license. In the evaluation of the accuracy of the SCAN system, pavement and atmospheric data were collected from four sites in Region IV that contained SCAN remote processing units (RPU's), pavement sensors and various atmospheric gauges. A comparison of field collected data to the data supplied by the SCAN system showed that the data from the SCAN system was accurate (91% accurate overall). The system hardware, software and other appurtenant equipment was evaluated for reliability relative to breakdowns. The system was found to be highly reliable; however, phone line communications were not as reliable as radio communications. The only RPU communicating over a phone line was in communication failure nearly 50% of the time. The system is effective as an early warning system. It appears that utilization of the system should result in a reduction of snow and ice related accidents.			
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ABSTRACT (Cont'd)

Utilization of the system leads to reduced deicing chemical usage and a savings in manpower and equipment costs. By monitoring pavement temperatures, Region IV maintenance personnel were able to delay spreading deicing chemicals by up to three hours. In some cases, these delays resulted in the saving of up to one deicing chemical application per storm. These same delays, combined with delays in crew call-outs and early crew releases, resulted in a savings in manpower and equipment costs.

The system's greatest potential appears to be as a real time statewide roadway weather information system interactively shared with other agencies. Some of the possible benefits are 1) reduced deicing chemical usage (a savings of \$4,170 dollars for each spread saved statewide), 2) improved weather forecasts for the State of New Jersey, 3) reduced snow and ice related accidents, 4) other agency interaction (e.g. aeronautics could use the information to assist pilots in developing flight plans, data from the system could be used by the State Police to supplement their Emergency Management System, etc.), 5) savings in manpower and equipment usage. A savings (statewide) of 11,500 dollars per hour could be realized for each hour saved by delaying crew call-outs and expediting crew releases.

The SCAN 16 EF system works. It is in the best interest of the State of New Jersey and the general public to expand the system to provide statewide coverage.

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GLOSSARY OF TERMS

- Central Processing Unit (CPU): The Main Computer in the SCAN 16 EF System that controls the interpretation of data and execution of instructions.
- Mainframe Computer: A large computer containing a central processing unit that controls the interpretation and execution of instructions.
- Micro/Personal Computer: A compact computer consisting of a miniaturized integrated circuit that performs all the functions of a central processing unit.
- Modem: A device that enables microcomputers and terminals to communicate with other microcomputers and terminals over phone lines.
- Remote Processing Unit (RPU): A microprocessor based device that accumulates data from the SCAN 16 EF sensors/gauges and sends the data over phone lines or by radio signals to the system's Central Processing Unit.
- Significant Change: A user definable parameter in the SCAN 16 EF System Software that establishes the time interval at which the RPU will contact the CPU (e.g. if the air temperature decreases by two or more degrees).
- Terminal: A device equipped with an input and output device (keyboard and monitor/printer) that is connected to a computer system for input and/or output of data.
- TRI-METS Weather System: A computer that receives various types of non-real time weather data via satellite. Real time Radar maps are obtainable by phone line connection to national weather service radar stations throughout the country.

CONCLUSIONS AND RECOMMENDATIONS

The data supplied to the user by the SCAN 16 EF System is accurate. The system hardware, software and all appurtenances are reliable relative to breakdowns; however, phone line communications do not appear to be as reliable when compared to radio communications.

The system is effective as an early warning system. The system allows users to improve their decision making ability for snow and ice control operations through an improved awareness of actual pavement and atmospheric conditions. This improved decision making ability results in a savings in manpower, equipment and deicing chemical costs as can be seen in the findings of this report.

Since accident data is not yet available for the period from January 1986 to the end of the evaluation, a conclusion cannot be reached concerning whether the system results in a reduction in snow and ice related accidents; however, it appears that a significant reduction in snow and ice related accidents could be realized.

Although the system works exceptionally well as an early warning system at local sites (e.g. bridges), the system's greatest

potential seems to be as a real time statewide roadway weather information system that is interactively shared with other agencies. By expanding the system to provide for statewide coverage, there are many potential benefits that could be realized. Some examples are 1) a significant reduction in deicing chemical usage and an improved environmental impact, 2) maximization of available resources (labor, equipment, materials) for snow and ice removal operations, 3) reduced snow and ice related accidents, 4) improved forecasts for the State of New Jersey since the system provides real time data 5) information sharing (other agencies such as Aeronautics could use the information to assist pilots in developing flight plans, the State Police could use the information to supplement their Emergency Management System.

The most significant cost in the set up and operation of the SCAN 16 EF system is in the communication network required. The current network contains one RPU communicating by phone lines and three RPU's by single side band radio. If the system were expanded to provide for statewide coverage, it would probably not be cost effective unless the system was able to communicate using a communication system that is already in place and providing statewide coverage. The New Jersey State Police's 800 megahertz trunked radio system meets those requirements. The New Jersey State Police have offered to allow the New Jersey Department of Transportation to use their radio system in exchange for the weather related information provided by the system.

Information from the Central Processing Unit (CPU)* should be continuously downloaded and stored in a micro/personal* or mainframe computer. This will provide the user with the data for analysis and development of pavement prediction models and also the ability to "fine tune" operating procedures.

A terminal* should be placed in an area where the system can receive twenty four hour a day monitoring (e.g. the Trenton Security Office or the Engineering and Operations Building Security Station).

Information from the system should be made available to the Department's weather service vendor. The real time data from the system should result in improved forecasts for the area's currently delineated by the system's RPU'S.

The SCAN 16 EF system works. It is in the best interest of the State of New Jersey and the general public to expand the system to provide for statewide coverage.

INTRODUCTION

Background

New Jersey has the highest number of vehicles per capita in the nation and is also first in the number of vehicles per square mile and per mile of highway. New Jersey's geographical position as a corridor state and as a popular seaboard tourist and trade state provide for a densely traveled highway system.

New Jersey's economy and society relies on a highway system that is passable at all times. Because of this, New Jersey's Department of Transportation must maintain its highway system as free of snow and ice as possible. In order to accomplish that goal in the most economical way possible, research programs evaluating new materials, equipment and procedures must be continually undertaken. Previous research programs have included abrasives, pre-mixed calcium and sodium chloride, solid sodium chloride and liquid calcium chloride ('wetter salt'), open graded pavements, ground control spreaders, and calcium chloride impregnated bituminous concrete pavements (VERGLIMIT). This research, in conjunction with personnel training and an effective public relations program, have contributed significantly to attaining that goal.

Description of SCAN 16 EF System

The SCAN 16 EF system is a moisture, frost and ice early warning system. The system was developed by Surface Systems, Inc. of

St. Louis, Missouri. Each individual site (e.g. a bridge) consists of a network of pavement and atmospheric sensors/gauges. Data from the Pavement sensors and atmospheric sensors (located on or adjacent to the bridge) is sent to a Remote Processing Unit (RPU) at the site. The pavement and atmospheric sensors are hard wired to the RPU. A Central Processing Unit (CPU) prompts the RPU's (that utilize telephone line communications) for data at user defined intervals. The RPU's that utilize radio communications, transmit data to the CPU (without prompting from the CPU) any time there is a significant change from the previously obtained data. Significant change parameters are user definable. The CPU stores the last sixteen significant changes for each sensor. The CPU, utilizing custom software, analyzes the data and provides it to the user in various formats through a terminal connected to any one of its eight communication ports.

New Jersey currently has four systems installed (See Appendix B). There locations are as follows:

- 1) Atlantic City - Rt. 30 over Beach Thorofare (RPU #1)
- 2) Cherry Hill - I295 NB over Rt. 70 (RPU #2)
- 3) Logan Twp. - I-295 SB over Oldman's Creek (RPU#3)
- 4) Carney's Point - Rt. 140 (Plant St.) over I-295 (RPU#4).

The CPU is located in the Cherry Hill maintenance headquarters. RPU #2, 3 & 4 communicate to the CPU by radio. RPU#1 communicates by phone line.

A terminal is located at the Cherry Hill Headquarters. This terminal is directly connected to the CPU. A second terminal, located at the Trenton Emergency Control Center, accesses the CPU in Cherry Hill using phone lines and a modem. Any terminal or personal computer (PC) can access the CPU using a modem; however, when accessing remotely, the remote unit must enter the correct password when prompted by the CPU. Figure 1 illustrates how the various components of the system interact.

The following is a list of information that can be obtained directly from the CPU via a terminal or PC:

1. Date
2. Time
3. Surface Temperature
4. Air Temperature
5. Dew Point Temperature
6. Relative Humidity
7. Wind Direction
8. Wind Speed
9. Sensor number
10. Physical Location
11. Roadway Status (e.g. dry, wet, snow/ice alert)
12. Chemical Factor (indication of chemical presence, such as salt, in the moisture on the surface).

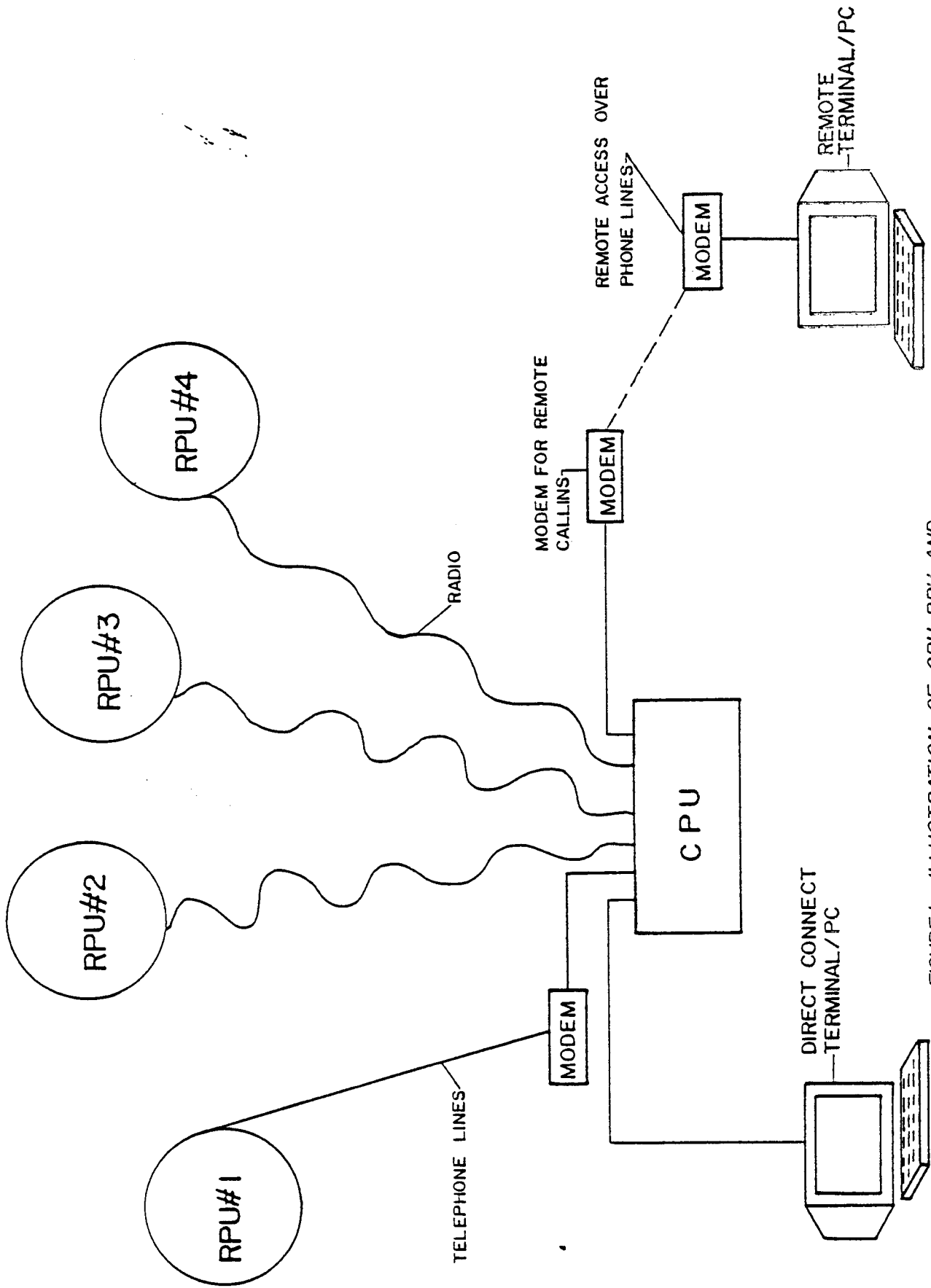


FIGURE 1: ILLUSTRATION OF CPU, RPU AND TERMINAL/PC INTERACTION.

There are several different conditions that are detected and displayed within the roadway status category. The various conditions detected (and their definitions) are as follows:

System Initializing: This status is displayed after power-up and before the CPU has made an attempt to call the RPU. It is only displayed upon system power-up.

Dry: An absence of precipitation or moisture on the surface sensor.

Wet: Precipitation/moisture present in liquid form on the surface and surface temperature above 32 degrees Fahrenheit (0 degrees Celsius).

*Dew: Moisture present on surface, the dewpoint has been reached and surface temperature above 32 degrees.

*Frost: Frost present on surface, the dewpoint has been reached and surface temperature below dewpoint.

*Frost Above Dew Point: Frost conditions have been reached and the surface temperature is no longer at or below dew point.

*Absorption: Moisture present on surface in an insufficient amount to present a hazard.

*Absorption @ Dew Point: Moisture present on surface in an insufficient amount to present a hazard and dew point has been reached.

Chemical Wet: Precipitation/moisture present in liquid form on the surface and surface temperature at or below 32 degrees Fahrenheit (0 degrees Celsius).

Snow/Ice Alert:

- A. Precipitation/moisture in liquid form on the surface starting to freeze.
- B. Precipitation/moisture on the surface which has frozen.

Sensor Down: An inoperative surface sensor.

Communication Failure: Disrupted communication between the RPU and CPU.

*A precipitation sensor is required for the display of these statuses.

The various report formats available from the CPU are 1) a summary of current conditions at all sensors, 2) current conditions at an individual sensor or site, 3) history of significant changes, 4) Significant change summary, 5) graphical representation of surface sensor data. Appendix A contains sample print outs of the various report formats. The maintenance manager/user uses the information from the CPU reports to initiate an appropriate maintenance response.

Installation of the SCAN 16 EF System

The SCAN 16 EF system was installed at four bridge locations in Region IV during the late summer and fall of 1984. Four pavement sensors were installed at each location. Two of the four sensors were installed in the approaches and two were installed in the bridge deck. Installation of the sensors was accomplished by Surface Systems Inc. (SSI) and a bridge maintenance crew from Region IV. Installation of the RPU's, CPU and radio relay antenna were installed by SSI personnel and our Division's radio shop. Electrical service was provided through a maintenance electrical contract. Telephone service was coordinated through the Department's Central Services section. The cost of the system (installed) is approximately 40,000 dollars per RPU. The cost includes the price of radios, antennas and other communication equipment.

The FCC license to operate the radio transmission equipment was not issued until October of 1985. Appendix B contains a map of Region IV showing the locations of the bridges and the sensors.

Method of Evaluation

During the winters of 1984/85, 1985/86 and 1986/87, pavement and atmospheric data were accumulated through on-site field measurements taken by evaluators. Measurements were taken in a random manner prior to, during and after a winter storm. The evaluators contacted either Cherry Hill Maintenance Headquarters or the Trenton Emergency Control Center (either by radio or phone) just prior to or immediately after taking the field measurements so that data from the CPU could be recorded for comparative analysis.

Surface thermometers were used for field measurement of pavement temperatures. A thermocouple was also used to measure surface temperature. Portable battery operated psychrometers were used to obtain data to calculate relative humidity. Visual observation by the evaluators was used to determine roadway status, precipitation and wind direction. Typical wall mounted type thermometers were used to measure air temperature.

The entire system was monitored daily, by accessing the CPU from the Trenton Emergency Control, to determine if any components of the system were not functioning.

Limitations of Evaluation

The FCC license for utilizing the radio equipped portions of the SCAN 16 EF system was not approved until October 1985; therefore, the only site available for data evaluation during the 1984/85 winter was the Route 30 bridge over Beach Thorofare in Atlantic City (the only site connected by phone lines).

The SCAN 16 EF's effectiveness as an early warning system was not monitored under non-winter storm conditions outside the normal working day (8:30 a.m. - 5:00 p.m.). Currently, no procedure has been established to monitor the SCAN 16 EF system twenty four hours per day at the Cherry Hill Maintenance Headquarters.

The evaluation was limited in some areas by the availability of measurement devices accurate enough for comparison to SCAN 16 EF sensors/gauges.

Purpose of Evaluation

The main purpose of this evaluation is to determine the accuracy, reliability and effectiveness of the SCAN 16 EF Moisture, Frost and Ice Early Warning System under actual field conditions. In addition, attempts will be made to determine if utilization of the system leads to 1) reduced snow and ice related accidents and 2) reduced manpower, equipment and deicing chemical usage in areas delineated by the system.

Scope

The major topics of this evaluation are as follows:

- 1) Evaluation of the accuracy of the data obtained from the SCAN 16 EF system CPU
- 2) Evaluation of the reliability of the system hardware, software, and all appurtenant equipment
- 3) Evaluation of the effectiveness of the system as a Moisture, Frost and Ice Early Warning System
- 4) Expansibility of the System and potential additional applications/benefits.

FINDINGS

Accuracy of Data from SCAN 16 EF System

The following table shows the total number of observations made and the degree of accuracy (field observations vs. system readings) for the areas evaluated:

Pavement/Atmospheric Category	Total Number of Observations	Tolerance	% Accurate
Roadway Status	287	0	90%
Precipitation	305	0	87%
Wind Direction	54	0	100%
Air Temp.	264	+4 degrees	94%
Surface Temperature	12	+1 degrees	92%
Overall weighted average % accurate			91%

The portable battery operated psychrometers that were used to obtain relative humidity were inaccurate. At temperatures near freezing, the distilled water used by the psychrometer to measure wet bulb temperature would begin to freeze; therefore, relative humidity accuracy was not evaluated.

Surface temperature was measured using circular disk shaped surface thermometers. These thermometers were highly inaccurate. Surface thermometers placed side by side on a surface showed a difference in readings by as much as ten degrees. Toward the end of the evaluation, a thermocouple was used to measure surface temperature. Only the data obtained using the thermocouple is reflected in the chart above.

Due to the probable inaccuracy of the wall mount type thermometers used to measure air temperature, a tolerance of ± 4 degrees was used for the purpose of this evaluation. This tolerance was selected based on comparisons made to the Department's TRI-METS Weather System. The TRI-METS Weather System provides "non-real time" weather information from the National Weather Service through Kavouras of Minneapolis, Minnesota. Information provided includes air temperature, dew point, relative humidity, visibility restriction (snow, sleet, rain, etc.), infrared images of cloud cover, and radar, etc.

The SCAN 16 EF precipitation gauges did not detect instances of extremely light precipitation. If instances of extremely light precipitation were eliminated from the data in the chart above, the precipitation gauge accuracy would be near 100%. Windspeed was not measured.

During monitoring of the system from the Trenton Emergency Control Center, data was compared to the Department's Triton Weather System. Atmospheric data from both systems compared favorably; however, the SCAN 16 EF system provided the data to the user at least one hour sooner than the Triton Weather System.

Reliability of Hardware, Software and Appurtenant Equipment

Other than working out the "bugs" that followed the initial set up of the the system, and normal routine maintenance, the hardware, software and all appurtenant equipment worked well with a limited amount of down time. Normal routine maintenance includes "pre-winter" calibration checks and cleaning of precipitation and pavement sensors. It is important to perform pre-winter maintenance to the system. If pre-winter maintenance is not performed, portions of the system may become unreliable (especially the precipitation sensors).

The relative humidity sensors have a life of approximately one to five years depending upon the environment they are exposed to (e.g. marine or industrial environments).

After three years, all of the relative humidity sensors in New Jersey's SCAN system have been replaced. Relative humidity sensors cost approximately one hundred dollars each.

Portions of the system went down as a result of

- 1) a tower at a remote unit being struck by lightning (one instance)
- 2) rodents chewing through wires in an RPU (one instance)
- 3) phone line problems between the CPU in Cherry Hill and RPU#1, Rt. 30 over Beach Thorofare in Atlantic City (ongoing problem throughout the evaluation).
- 4) a burned out power supply in a transceiver at the Cherry Hill Maintenance Headquarters.
- 5) a breakdown of the modem used for "call-in" remote access to the CPU

System downtime as a result of the above mentioned failures was minimal with the exception of items 3, 4 and 5.

Items 4 and 5 occurred during the summer of 1987; therefore, their repair was given a low priority by the Department's Electrical and Radio repair personnel. The system remained down from 06/87 through 08/87.

Item number 3 (phone line problems) has been an ongoing problem throughout the evaluation. Although, data was not accumulated for the actual number of hours of communication failure between the CPU and RPU#1, communication failure occurred between these units nearly 50% of the time.

The terminal to CPU configuration used during this evaluation did not allow for archiving data for future analysis (development of pavement prediction models, etc.).

Effectiveness as an Early Warning System

The Department currently does not monitor the system around the clock during non-storm conditions. During winter storm conditions, the system is monitored by maintenance personnel through a terminal connected to the CPU in Cherry Hill. Region IV maintenance personnel activate maintenance forces in reaction to the systems warning of potential hazardous conditions (e.g. icy bridge deck). If a hazard does occur, the system continually keeps the user aware of the

hazardous condition. Directions, as to what appropriate maintenance activity to utilize, were broadcast by radio to the relevant maintenance crews from the Cherry Hill maintenance headquarters.

The two report formats that were utilized the most by Region IV maintenance personnel were 1) the summary page report and 2) the status page report. Examples of both reports can be seen in Appendix A. The reports provide similar information: the status page report shows data from one RPU while the summary page report shows information from all the RPU'S. Decisions were made by Regional Maintenance Personnel based on the information provided in these reports.

The most common early warning conditions that prompted a maintenance response during the 1984 to 1987 evaluation period were 1) when the roadway status category indicated a snow/ice alert, freezing or frost, etc. and 2) during the period immediately following a deicing chemical application when a) pavement temperatures were at or below freezing, b) the pavement was wet and c) the chemical factor was decreasing into the 20 to 25 range. A reading of 95 is the highest possible chemical factor reading and normally occurs immediately after a deicing chemical application. The factor decreases at a rate consistent with the intensity of precipitation and the quantity of deicing chemical applied.

When precipitation was present or moisture existed on the pavement and the SCAN system indicated that the roadway/bridge pavement temperatures were falling (but were above 32 F and higher than the air temperature), the decision to spread deicing chemicals was delayed by up to three hours. This is compared to typical decisions that would have been made based on current operational procedures and forecasts from the Department's Weather Service Vendor. Currently, New Jersey (and most other states) spread deicing chemicals based on air temperature and the presence of precipitation or moisture on the pavement. By including pavement temperature as a factor in the decision making process, Region IV maintenance personnel believe that delays in applying deicing chemicals may have resulted in an average reduction of one deicing chemical application per storm.

During the final stages of a winter storm (clean up), the system was used to monitor for possible refreezing of wet pavement surfaces. Normally, monitoring is performed by highway road patrols. Region IV maintenance personnel were able to release snow and ice removal crews (for the relevant bridges and sections of roadway) two to three hours earlier than if they relied strictly on data from the Department's Weather Service Vendor. This was possible since regional maintenance personnel were able to monitor pavement temperatures. Pavement temperatures can rise above freezing even though the air temperature is below freezing. This often occurs toward the end of a storm when the sun comes out. The sun can heat the pavement to above freezing. If this condition occurred and the forecast was for air

temperatures to rise above freezing, an early release of snow and ice removal crews was possible. This type of decision could not have been made if pavement temperatures were not known.

New Jersey uses "wetter salt" (sodium chloride sprayed with liquid calcium chloride) as a deicing chemical. One ton of sodium chloride sprayed with eight gallons of liquid calcium chloride costs approximately thirty dollars per ton. Assuming an average spreading rate of 350 pounds per lane mile, the cost to spread one lane mile of roadway is \$5.25. Therefore, each time Region IV excluded spreading deicing chemicals on the roadway sections delineated by the SCAN 16 EF system, a total material savings of 1,077 dollars was realized. Those savings are only for the 205 lane miles in the evaluation section and are for materials only. Manpower and equipment savings are not included. If the SCAN 16 EF system provided statewide coverage a savings of 54,170 dollars in materials could be realized for each spread saved. Also, reduced deicing chemical usage will inevitably provide an improved environmental impact.

Region IV spends approximately 97 dollars per crew hour for labor and equipment during snow and ice removal operations; therefore, for every hour Region IV was able to delay calling a crew out at the start of a storm or expedite the release of a crew toward the end of a storm, 97 dollars for labor and equipment was saved for each crew. If the SCAN 16 EF system provided statewide coverage, every hour saved (all crews) would result in a savings of 11,500 dollars for labor and equipment.

All data used for the above analysis was obtained from the Department's Maintenance Management System and reflects data from the 1986/87 winter season.

Expansibility and Potential Additional Applications/Benefits

The SCAN 16 EF system, in addition to informing the maintenance manager of weather conditions at specific sites, could be used as a real time statewide weather information system. This could be accomplished by increasing the number of remote systems (RPU's & sensors) so as to give statewide coverage. A network could be created with other agencies in the state with similar systems. Each Agency would use the information from the network to meet their own individual needs.

The major additional applications/benefits that are possible from statewide coverage by the SCAN 16 EF system are

1. Probable reduced deicing chemical usage by varying application rate based on pavement condition (e.g. it may be snowing but roadway is well above freezing, residual salt on pavement from previous spreadings).
2. Probable elimination of highway road patrols since the network provides continuous monitoring.

;

3. Reduced highway system delay time since maintenance can react before hazardous conditions actually occur. Data from the network provides for improved decision support.
4. Utilization of the network to verify forecasts made by weather services.
5. Allow weather services to utilize the data from the network to improve forecasts for the system user.
6. Accumulation and storage of data reported by the stations in the network could lead to development of models to predict pavement conditions.

Possible Future Benefits

1. The system network with some modifications (speech synthesis) could be used as a public advisory service.
2. Other agency interaction (shared systems). Agencies such as the State Police and Aeronautics (airports) could use the data from the network to improve decision making.

New Jersey is currently in the developmental stages of creating a statewide Road and Atmospheric Weather Information System involving other agency interaction. A follow up report is planned for items 1 and 2 under "Possible Future Benefits" above.

The Department's TRI-MEIS Weather System receives much of its information from the National Weather Service through Kavouras of Minneapolis, Minnesota. There are no reporting National Weather Service observation stations in the north west quadrant of New Jersey. Expansion of the SCAN 16 EF system to that section of the state would provide atmospheric weather information to supplement the Triton Weather system.

APPENDIX A

Sensor No.	Sensor location	Status	Precip	Temperatures		Dew Pt.	CP		
				Surf	Air				
1	AC Rt. 30 EB Bridge	Communication Fail							
2	AC Rt. 30 EB Roadway	Communication Fail							
3	AC Rt. 30 WB Bridge	Communication Fail							
4	AC Rt. 30 WB Roadway	Communication Fail							
5	CH Rt. 295N/70 FL Rd	Wet	Y	✓	33	✓	29 *	27.4	✓08
6	CH Rt. 295N/70 FL Bg	Wet	Y	✓	33	✓	29 *	27.4	✓08
7	CH Rt. 295N/70 SL Bg	Chemical wet	Y	✓	32	✓	29 *	27.4	✓08
8	CH Rt. 295N/70 SL Rd	Snow/ice alert	Y	✓	32	✓	29 *	27.4	
9	OMC Rt. 295S SL Bg	Dry	N	✓	34	✓	31	24.8	
10	OMC Rt. 295S SL Rd	Dry	N	✓	35	✓	31	24.8	
11	OMC Rt. 295S FL Rd	Absorption	N	✓	34	✓	31	24.8	
12	OMC Rt. 295S FL Bg	Absorption	N	✓	33	✓	31	24.8	
13	CP Rt. 140E/295 Bg	Absorption	N	✓	34	✓	30	20.2	
14	CP Rt. 140E/295 Rd	Dry	N	✓	36	✓	30	20.2	
15	CP Rt. 140W/295 Bg	Dry	N	✓	35	✓	30	20.2	
16	CP Rt. 140W/295 Rd	Dry	N	✓	36	✓	30	20.2	

New Jersey DOT Region 4

History Page
FS

Time 02:30 January 25, 1987
Power on at: 14:31 on 01/22/87
CH Rt. 295N/70 FL Rd

Sensor # 5

Time Day	Status	Precip	Rel. Hum.		Temperatures		Dew Pt.	Wind/ MPH	
			Hum.	CF	Surf.	Air		Dir.	Vel.
01:38 26	Chemical wet	*N	96	95	25	21	20.2	E	/ 7
01:43 26	Chemical wet	Y	96	95	* 25	21	20.0	E	/ 6
01:29 26	Chemical wet	*Y	96	95	24	21	20.0	E	/ 6

New Jersey DOT Region 4

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FS

Time 02:32 January 25, 1987
Power on at: 14:31 on 01/22/87
CH Rt. 295N/70 FL 8g

Sensor # 5

Time Day	Status	Precip	Rel. Hum.		Temperatures		Dew Pt.	Wind/ MPH	
			Hum.	CF	Surf.	Air		Dir.	Vel.
02:51 26	Chemical wet	*Y	97	45	20	21	20.2	E	/ 7
01:38 26	Chemical wet	*N	96	45	20	21	20.0	E	/ 7
01:29 26	Chemical wet	*Y	96	45	20	21	20.0	E	/ 6
00:56 26	Chemical wet	N	96	45	20	* 21	20.0	E	/ 6

New Jersey DOT Region 4

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FS

Time 02:34 January 25, 1987
Power on at: 14:31 on 01/22/87
CH Rt. 295N/70 SL 3g

Sensor # 7

Time Day	Status	Precip	Rel. Hum.		Temperatures		Dew Pt.	Wind/ MPH	
			Hum.	CF	Surf.	Air		Dir.	Vel.
02:51 26	Chemical wet	*Y	97	30	21	21	20.2	E	/ 7
01:38 26	Chemical wet	*N	96	40	21	21	20.0	E	/ 7
01:48 26	Chemical wet	Y	96	40	* 21	21	20.0	NE	/ 6
01:29 26	Chemical wet	*Y	96	55	20	21	20.0	E	/ 6
02:56 26	Chemical wet	N	96	50	20	* 21	20.0	E	/ 6
00:48 26	Chemical wet	N	95	75	20	20	* 18.8	E	/ 7
03:31 26	Chemical wet	N	94	70	20	* 19			

New Jersey DOT Region 4 Changed Data Pg. Time 16:39 January 31, 1997
76 Power on at: 16:37 on 12/23/96

Sensor No.	Status	Precip	Temperatures		Dew Pt.	Wind / MPH Dir. / Vel.
18 *	Dry	Y	Surf. 37	Air 35	31.5	

New Jersey DOT Region 4 Changed Data Pg. Time 16:44 January 31, 1997
76 Power on at: 16:37 on 12/23/96

Sensor No.	Status	Precip	Temperatures		Dew Pt.	Wind / MPH Dir. / Vel.
18 *	Wet	Y	Surf. 37	Air 35	31.7	

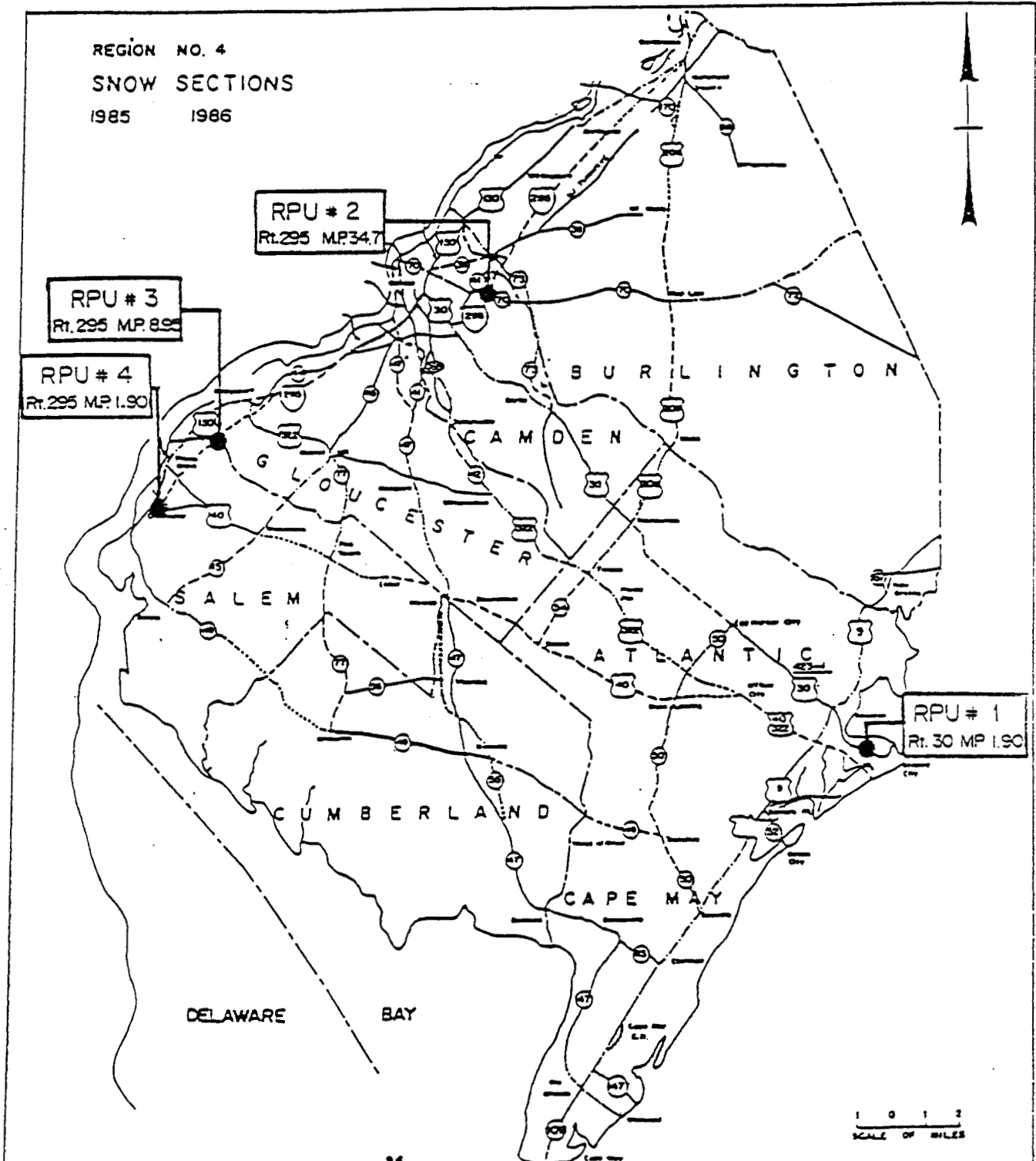
New Jersey DOT Region 4 Changed Data Pg. Time 16:52 January 31, 1997
76 Power on at: 16:37 on 12/23/96

Sensor No.	Status	Precip	Temperatures		Dew Pt.	Wind / MPH Dir. / Vel.
9	Wet	*Y	Surf. 38	Air 35	31.1	

APPENDIX B

ICE DETECTION SYSTEM

LOCATION OF REMOTE PROCESSING UNITS & SENSORS



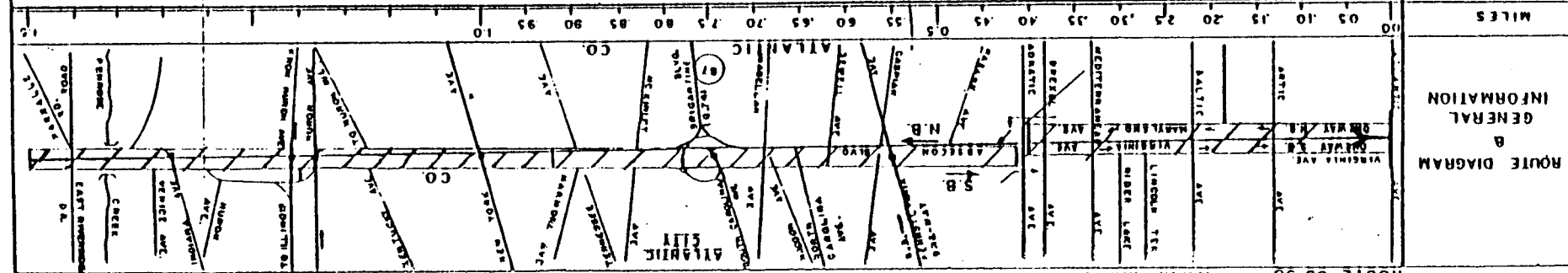
RPU # 1 Atlantic City
 Rt. 30 over Beach Thorofare
 SENSOR # 1. EB Bridge
 2. EB Roadway
 3. WB Bridge
 4. WB Roadway

RPU # 2 Cherry Hill
 Rt. 295 NB over Route 70
 SENSOR # 5. F.L. Roadway
 6. F.L. Bridge
 7. S.L. Bridge
 8. S.L. Roadway

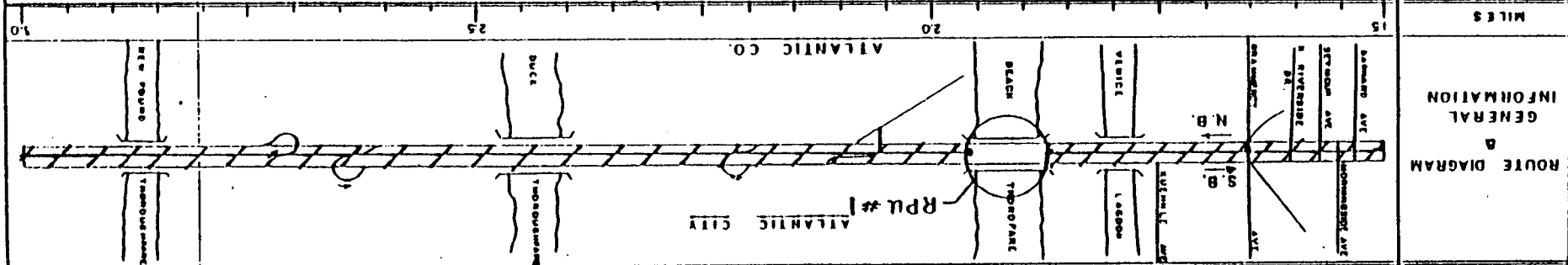
RPU # 3 Logan Twp.
 Rt. 295 SB over Oldman's Creek
 SENSOR # 9. S.L. Bridge
 10. S.L. Roadway
 11. F.L. Roadway
 12. F.L. Bridge

RPU # 4 Carney's Point
 Rt. 140 (Plant St.) over Rt. 295
 SENSOR # 13. EB Bridge
 14. EB Roadway
 15. WB Bridge
 16. WB Roadway

APPENDIX C



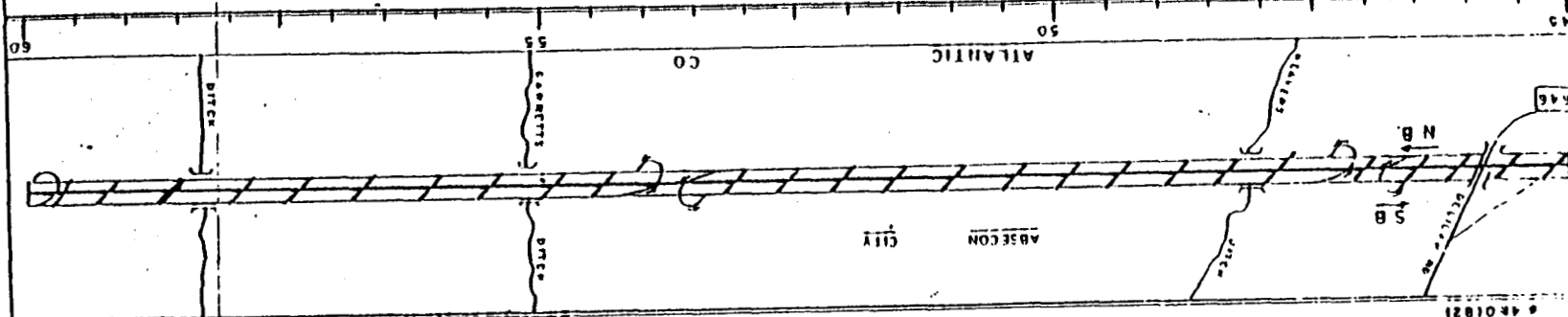
JURISDICTION		MILES		GENERAL INFORMATION	
MUNICIPAL	0.00 - 0.40	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
F.A. ROUTE NUMBER	30 B.C.	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
SHOULDER	30 B.C.	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
SB. & WB. PAVT.	30 B.C.	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
MEDIA	30 B.C.	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
NO. OF EB PAVT.	30 B.C.	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
SHOULDER	30 B.C.	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
NO. OF TRAFFIC LANES	30 B.C.	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
H.P.M.S. SECTION	000420	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
BRIDGE NO.	000420	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
CONTRACT & DATE	031021 04.10.01 03.10.01	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
SPEED LIMIT	35	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION
A.A.D.T.	35 40	0.00	0.40	ROUTE DIAGRAM	GENERAL INFORMATION



JURISDICTION		MILES		GENERAL INFORMATION	
MUNICIPAL	0.40 - 0.80	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
F.A. ROUTE NUMBER	30 B.C.	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
SHOULDER	30 B.C.	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
SB. & WB. PAVT.	30 B.C.	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
MEDIA	30 B.C.	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
NO. OF EB PAVT.	30 B.C.	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
SHOULDER	30 B.C.	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
NO. OF TRAFFIC LANES	30 B.C.	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
H.P.M.S. SECTION	0001590	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
BRIDGE NO.	0001590	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
CONTRACT & DATE	0331021 04.10.01	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
SPEED LIMIT	40 50	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION
A.A.D.T.	40 50	0.40	0.80	ROUTE DIAGRAM	GENERAL INFORMATION

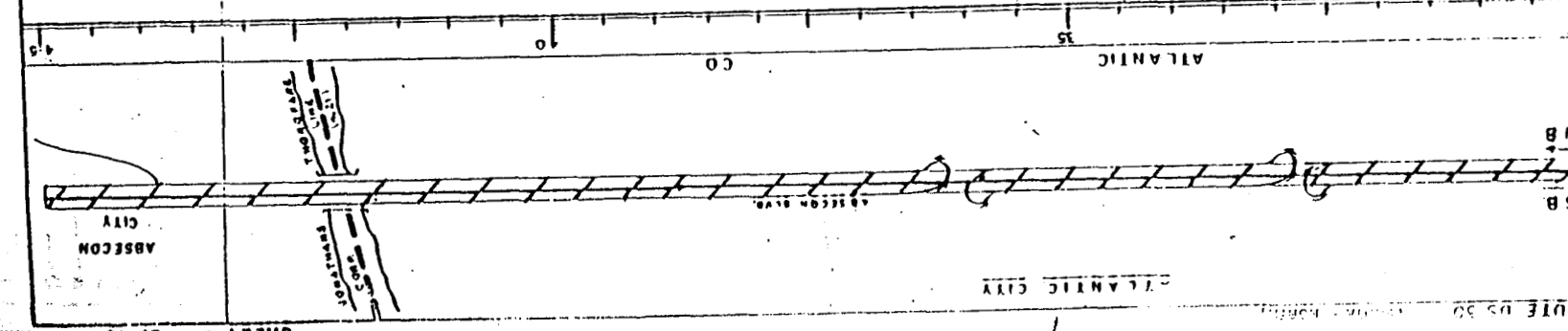
• 154 • 153

4
10' BC
24' BC
8" x 4" CONCRETE
24' BC
10' BC
FAE I S U B R A M I
CS 0103
N 101



B-1-10 35.21041

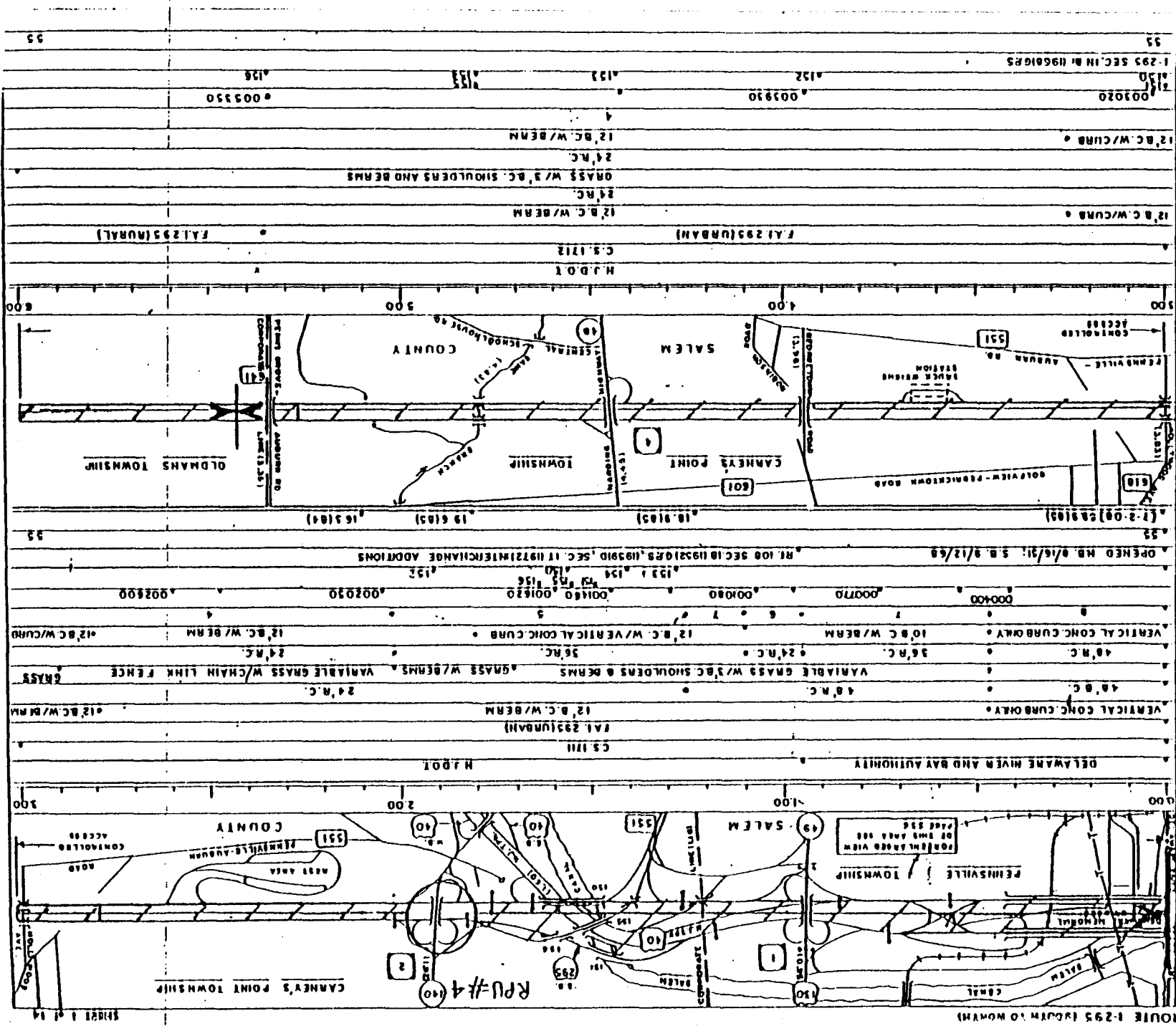
4
8' BC
25' BC
8" x 4" CONCRETE
25' BC
8' BC
FAE I S U B R A M I
CS 0103
N 101



• 152 (821) •

ADDT
SPEED LIMIT
CONTRACT & DATE
BRIDGE NO
IFMS SECTION
NO OF TRAFFIC LANES
SHOULDER
NO OF TRAFFIC LANES
SHOULDER
MEDIA
NO OF TRAFFIC LANES
SHOULDER
FA ROUTE NUMBER
CONTROL SECTION
JURISDICTION
MILES
GENERAL INFORMATION
ROUTE DIAGRAM
ADDT
SPEED LIMIT
CONTRACT & DATE
BRIDGE NO
IFMS SECTION
NO OF TRAFFIC LANES
SHOULDER
NO OF TRAFFIC LANES
SHOULDER
MEDIA
NO OF TRAFFIC LANES
SHOULDER
FA ROUTE NUMBER
CONTROL SECTION
JURISDICTION
MILES
GENERAL INFORMATION
ROUTE DIAGRAM

ROUTE DIAGRAM B GENERAL INFORMATION													
	MILES	6.0	6.5	7.0	7.5	8.0	8.5	9.0					
JURISDICTION	H J D T												
CONTROL SECTION	C.S. 0103					C.S. 0104							
F.A. ROUTE NUMBER	F.A.P. 16 (URBAN)												
UNDIV DIVIDED	SHOULDER	10' B.C.			9' B.C.			5' B.C.					
	SB or WB PAV'T	24' B.C.		27' B.C.									
	MEDIAN	CONCRETE											
	NB or EB PAV'T	24' B.C.		34' B.C.		38' B.C.		70' B.C.		42' B.C.		5' B.C.	
	SHOULDER	10' B.C.		6' B.C.					9' B.C.		5' B.C.		
No. OF TRAFF LANS	4												
HPMS SECTION	•008700												
BRIDGE NO.	150												
CONTRACT & DATE													
SPEED LIMIT	30		30 40		40 50				50				
AADT			•16.2(84) •17.0(84)		•16.5(82)		•19.4(82) •20.4(82)		•21.6(83)				
ROUTE DIAGRAM B GENERAL INFORMATION													
	MILES	9.0	9.5	10.0	10.5	11.0	11.5	12.0					
JURISDICTION	H J D T												
CONTROL SECTION	C.S. 0104												
F.A. ROUTE NUMBER	F.A.P. 16 (URBAN)												
UNDIV DIVIDED	SHOULDER	5' B.C.					8' B.C.						
	SB or WB PAV'T												
	MEDIAN												
	NB or EB PAV'T	42' B.C.					44' B.C.						
	SHOULDER	5' B.C.					5' B.C.						
No. OF TRAFF LANS	4												
HPMS SECTION													
BRIDGE NO.	151												
CONTRACT & DATE													
SPEED LIMIT	30												
AADT	•16.4(82)												

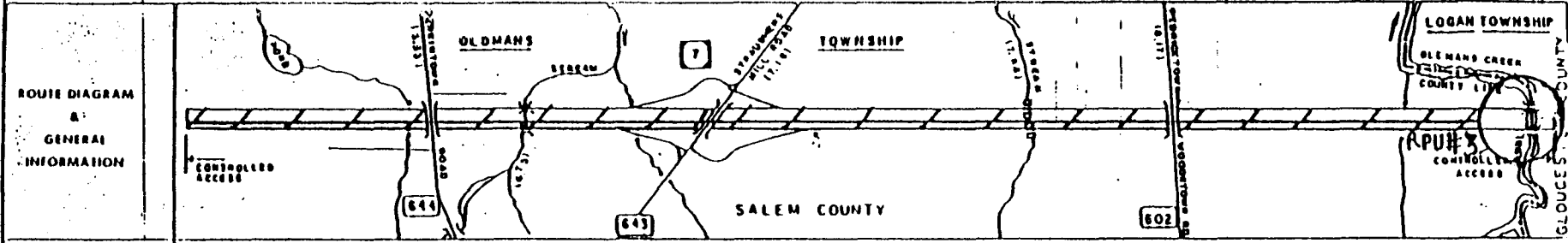


ROUTE 1-295 (DOWN TO NOWHERE)

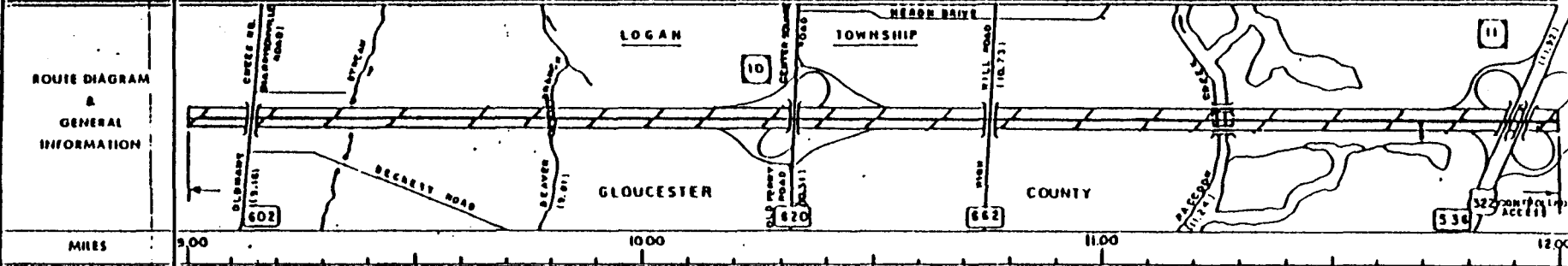
SHEET 1 OF 14

ROUTE DIAGRAM & GENERAL INFORMATION		MILES		JURISDICTION	CONTROL SECTION	F.A. ROUTE NUMBER	SHOULDER	58' W/ PAVT.	MEDIAN	NR. 18' PAVT.	SHOULDER	N.O. OF TRAFF. LANES	HPMS SECTION	BRIDGE NO.	CONTRACT & DATE	SPEED LIMIT	TRAFFIC VOLUME
ROUTE DIAGRAM & GENERAL INFORMATION		MILES		JURISDICTION	CONTROL SECTION	F.A. ROUTE NUMBER	SHOULDER	58' W/ PAVT.	MEDIAN	NR. 18' PAVT.	SHOULDER	N.O. OF TRAFF. LANES	HPMS SECTION	BRIDGE NO.	CONTRACT & DATE	SPEED LIMIT	TRAFFIC VOLUME
ROUTE DIAGRAM & GENERAL INFORMATION		MILES		JURISDICTION	CONTROL SECTION	F.A. ROUTE NUMBER	SHOULDER	58' W/ PAVT.	MEDIAN	NR. 18' PAVT.	SHOULDER	N.O. OF TRAFF. LANES	HPMS SECTION	BRIDGE NO.	CONTRACT & DATE	SPEED LIMIT	TRAFFIC VOLUME

ROUTE DIAGRAM & GENERAL INFORMATION		MILES		JURISDICTION	CONTROL SECTION	F.A. ROUTE NUMBER	SHOULDER	58' W/ PAVT.	MEDIAN	NR. 18' PAVT.	SHOULDER	N.O. OF TRAFF. LANES	HPMS SECTION	BRIDGE NO.	CONTRACT & DATE	SPEED LIMIT	TRAFFIC VOLUME
ROUTE DIAGRAM & GENERAL INFORMATION		MILES		JURISDICTION	CONTROL SECTION	F.A. ROUTE NUMBER	SHOULDER	58' W/ PAVT.	MEDIAN	NR. 18' PAVT.	SHOULDER	N.O. OF TRAFF. LANES	HPMS SECTION	BRIDGE NO.	CONTRACT & DATE	SPEED LIMIT	TRAFFIC VOLUME
ROUTE DIAGRAM & GENERAL INFORMATION		MILES		JURISDICTION	CONTROL SECTION	F.A. ROUTE NUMBER	SHOULDER	58' W/ PAVT.	MEDIAN	NR. 18' PAVT.	SHOULDER	N.O. OF TRAFF. LANES	HPMS SECTION	BRIDGE NO.	CONTRACT & DATE	SPEED LIMIT	TRAFFIC VOLUME

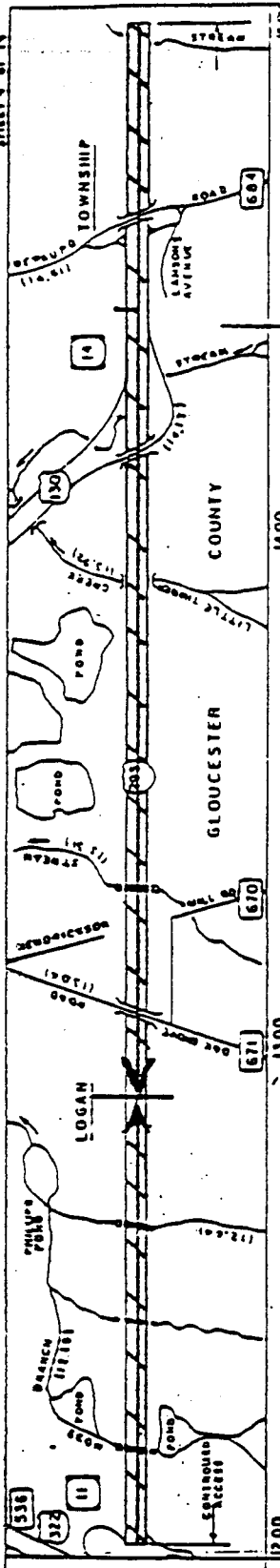


MILES	6.00	7.00	8.00	9.00
JURISDICTION	N.J.D.O.T.			
CONTROL SECTION	C.S.1112			
F.A. ROUTE NUMBER	F.A. 293 (RURAL)			
ROADWAY DIVIDED	SHOULDER	24' RC.		24' BC.
	SB or WB PAV'T.	60' GRASS W/ 3' SHOULDERS AND BERMS		
	MEDIAN			
	NB or EB PAV'T.	24' RC.		24' BC.
SHOULDER	12' BC. W/ BERM			
No. OF TRAFF. LANES	4			
HPMS SECTION	005350	007270		
BRIDGE NO.	157	158	159	160
CONTRACT & DATE	1-295 SEC. 14 & 15 (1968) P.S.			
SPEED LIMIT	35			
TRAFFIC VOLUME	21.3 (85)		23.1 (85)	

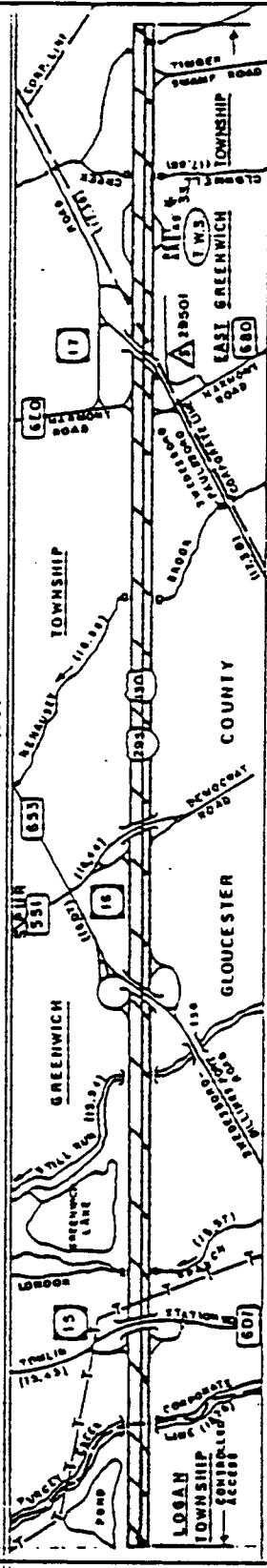


MILES	9.00	10.00	11.00	12.00
JURISDICTION	N.J.D.O.T.			
CONTROL SECTION	C.S.0820			
F.A. ROUTE NUMBER	F.A. 293 (RURAL)			
ROADWAY DIVIDED	SHOULDER	12' BC. W/ BERM		
	SB or WB PAV'T.	24' BC.		
	MEDIAN	GRASS W/ 3' SHOULDERS AND BERMS		
	NB or EB PAV'T.	24' BC.		
SHOULDER	12' BC. W/ BERM			
No. OF TRAFF. LANES	4			
HPMS SECTION	009150	010000	010750	
BRIDGE No.	130	131	132	133
CONTRACT & DATE	1-295 SEC. 15 (1968) P.S.			
SPEED LIMIT	35			
TRAFFIC VOLUME				

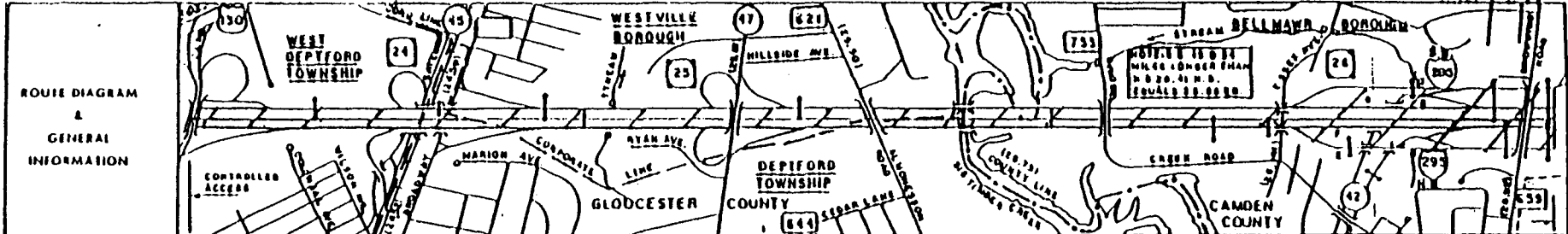
ROUTE 1-295 (SOUTH TO NORTH)



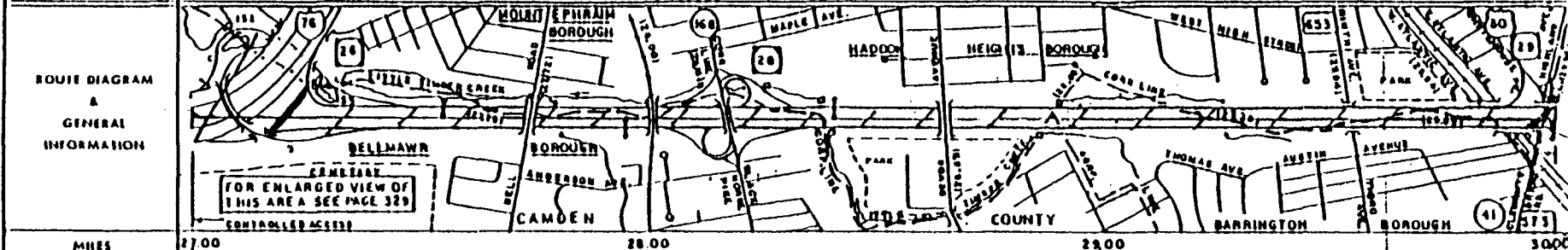
MILES	1200	1300	1400	1500
JURISDICTION	NJDOT			
CONTROL SECTION	C. 3. 0820			
F.A. ROUTE NUMBER	F.A. 1-295 (RURAL)			
SHOULDER	12' B.C. W/BERM			
SB or WB PAVT.	24' B.C.			
MEDIAH	4' GRASS			
NB or EB PAVT.	112' GRASS W/3 SHOULDERS AND BERMS			
SHOULDER	24' B.C.			
No. OF TRAF. LANES	4			
HPMS SECTION	013900			
BRIDGE NO.	187			
CONTRACT & DATE	1-295 SEC. 18 H868198.			
SPEED LIMIT	35			
TRAFFIC VOLUME	21,01631			



MILES	1300	1400	1500	1600
JURISDICTION	NJDOT			
CONTROL SECTION	C. 3. 0821			
F.A. ROUTE NUMBER	F.A. 1-295 (RURAL)			
SHOULDER	10' B.C.			
SB or WB PAVT.	24' B.C.			
MEDIAH	4' GRASS			
NB or EB PAVT.	24' B.C.			
SHOULDER	10' B.C.			
No. OF TRAF. LANES	4			
HPMS SECTION	013900			
BRIDGE NO.	187			
CONTRACT & DATE	U.S. 130 SEC. 18, 19, 20, 21, 22, 23, 24, 25			
SPEED LIMIT	35			
TRAFFIC VOLUME	21,01631			

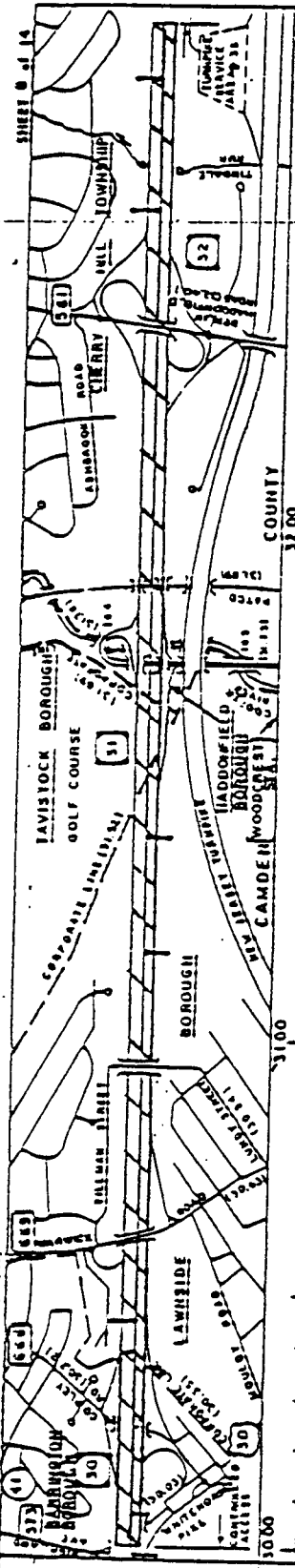


MILES	24.00	25.00	26.00	27.00
JURISDICTION	N.J.D.O.T.			
CONTROL SECTION	0822	C.S.0822	C.S.0427	
F.A. ROUTE NUMBER	F.A. 295(URBAN)			
DIVIDED	SHOULDER	12' B.C. W/BERM	12' B.C. W/BERM	
	SB or WB PAV'T	36' B.C.	24' B.C. (24' RC, 12' RC)	48' B.C. (24' RC, 12' RC)
	MEDIAN	VARIABLE GRASS	30' GRASS	VARIABLE
	NB or SB PAV'T	36' B.C.	24' B.C. (24' RC, 12' RC)	48' B.C. (24' RC, 12' RC)
SHOULDER	12' B.C. W/BERM		12' B.C. W/VERTICAL CONC. CURB	
No. OF TRAFF LINES	6	6	8	8
HPMS SECTION	021080	022280	022880	023880
BRIDGE NO.	150	151	152	153
CONTRACT & DATE	1-295 SEC. 1D (1960) P.S. (1966)W	1-295 SEC. 1C (1961) O.P.S. (1966)W	RT. 108 SEC. 1A & 2D (1958) O.P.S.	
SPEED LIMIT	35	35	35	35
TRAFFIC VOLUME	41,918(4)	37,818(5)	33	169,518(5)

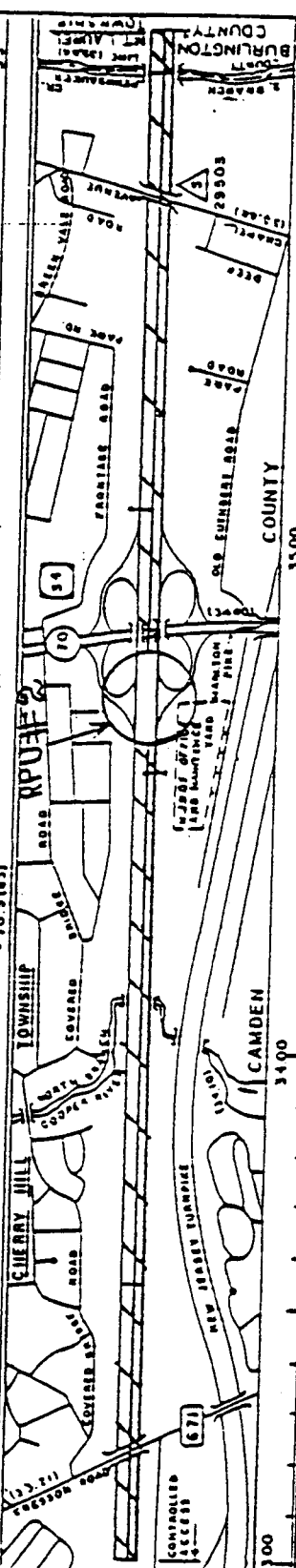


MILES	27.00	28.00	29.00	30.00
JURISDICTION	N.J.D.O.T.			
CONTROL SECTION	C.S.0428			
F.A. ROUTE NUMBER	F.A. 295(URBAN)			
DIVIDED	SHOULDER	12' B.C. W/BERM	12' B.C. W/VERTICAL CONCRETE CURB	12' B.C. W/BERM
	SB or WB PAV'T	48' R.C.	24' B.C.	36' B.C.
	MEDIAN	VARIABLE GRASS	VARIABLE GRASS	3' x 2' CONCRETE BARRIER
	NB or SB PAV'T	24' B.C.	36' B.C.	36' B.C.
SHOULDER	12' B.C. W/CURB	12' B.C. W/BERM	12' B.C. W/BERM	12' B.C. W/VERTICAL CONC. CURB
No. OF TRAFF LINES	6	6	6	6
HPMS SECTION	026880	027680	028280	029280
BRIDGE NO.	150	151	152	153
CONTRACT & DATE	RT. 108 SEC. 1A & 2D (1958) O.P.S.	1-295 SEC. 2A & 2B (1960) O.P.S. (1971)W		
SPEED LIMIT	35	35	35	35
TRAFFIC VOLUME		80,318(5)		35

ROUTE 1-2-3 IS QUOTE TO QUOTE



ROUTE DIAGRAM & GENERAL INFORMATION	
MILES	3000 3100 3200 3300
JURISDICTION	N.J.D.O.T.
CONTROL SECTION	C.S. 0428
F.A. ROUTE NUMBER	C.S. 0428
SHOULDER	F.A.I. 233 (URBAN)
SB OR WB PAVT	12' B.C. W/BERM
MEDIAN	35' B.C.
NB OR EB PAVT	35' B.C.
SHOULDER	50' GRASS W/3 SHOULDERS W/BERMS
No. OF TRAFF LANES	36' B.C.
HPMS SECTION	12' B.C. W/BERM
BRIDGE NO.	6
CONTRACT & DATE	030350
SPEED LIMIT	A 166 0150 0151
TRAFFIC VOLUME	1108 SEC. 2E 1196310PS A 1-223 SEC. 2E 1196310PS 110821R



ROUTE DIAGRAM & GENERAL INFORMATION	
MILES	3400 3500 3600
JURISDICTION	N.J.D.O.T.
CONTROL SECTION	C.S. 0429
F.A. ROUTE NUMBER	F.A.I. 293
SHOULDER	12' B.C. W/BERM
SB OR WB PAVT	36' B.C.
MEDIAN	30' GRASS W/3 SHOULDERS AND BERMS
NB OR EB PAVT	36' B.C.
SHOULDER	12' B.C. W/BERM
No. OF TRAFF LANES	6
HPMS SECTION	
BRIDGE NO.	
CONTRACT & DATE	0127 0158
SPEED LIMIT	1-223 SEC. 2E 1196310PS 110711W
TRAFFIC VOLUME	0161 0162 033010

REFERENCES

1. Ice Detection and Road Weather Information System: A State of the Art Report, December 1985. Operating Research Section, Transportation Department, Regional Municipality of Ottawa-Carleton.