RESEARCH REPORT DOCUMENTATION PAGE

1. Report No.	2. Report Date	3. Contract No.	4. Project No.
ND 92-03	September 1997	N/A	IR-094(102)352

5. Title and Subtitle

Road Condition-Weather Monitor
System To Determine Pavement Surface And Atmospheric Conditions

6. Report Type
Work Plan ☐
Construction ☐
Evaluation ☐
Final ☒

7. Project No.
8. Project No.
9. Project No.
10. Project No.

11. Author(s)/Principle Investigator(s)
Mike Marquart

12. Performing Organization Name and Address

NDDOT M+R ☒
NDDOT OTHER* ☐
NDSU ☐
UND ☐
UGPTI ☐
OTHER* ☐
*see supplementary notes

North Dakota DOT
Materials and Research Division
300 Airport Road
Bismarck ND 58504-6005

13. Sponsoring Agency Name and Address

North Dakota DOT
Materials and Research Division
300 Airport Road
Bismarck ND 58504-6005

14. Supplementary Notes

15. Abstract

Purpose and Need

This equipment should enable maintenance supervisors to evaluate the weather conditions at various locations. Supervisors could dispatch snow and ice removal equipment without sending an operator to check conditions on site. The Department of Transportation expects this system to reduce the incidence of ice related accidents occurring on the I-94 Red River structure. This would be accomplished by alerting maintenance forces to predicted icing conditions and by tracking and forecasting incoming weather systems. The ultimate goal is to provide safer roads for the traveling public and reduce maintenance costs.

Objective

The object of this experimental project was to install a road condition-weather monitoring system to provide data on pavement surface and atmospheric conditions. This equipment should enable maintenance supervisors to evaluate the weather conditions at various locations. Supervisors could dispatch snow and ice removal equipment without sending an operator to check conditions on site.

The Department of Transportation expects this system to reduce the incidence of ice related accidents occurring on the I-94 Red River structure. This would be accomplished by alerting maintenance forces to predicted icing conditions and by tracking and forecasting incoming weather systems. The ultimate goal is to provide safer roads for the traveling public and reduce maintenance costs.

Scope

The Road Condition - Weather Monitoring System is located on Interstate I-94 in the Fargo District and covers the area of the Red River Structure. The accuracy of the forecast and accident reports was used to evaluate the project annually for 3 years.

Summary

The North Dakota Department of Transportation contracts with Surface Systems, Inc. (SSI) to receive weather forecasts twice a day at the Fargo District during the winter months. The cost for six months of service during the winter of 1995/1996 was $2,750.00 or $458.50 a month. For the winter of 1996/1997 the cost was $3,270.00.

The Fargo District uses the forecasts and the system to plan their daily activities along with a snow and ice control plan. The access to this data improves the ability to plan the proper action. The Fargo District has experienced many SSI system breakdowns during the past year. The system has not been very reliable at peak times. The system accuracy during the past winter was about 50%.The Fargo District pays for another service that they find more useful than the SSI service. They do not plan on contracting with SSI in the upcoming winter season.

The SCAN system sensors are all located in the City of Fargo except for one, which is located west of town on Highway 38. The DOT receives data from some city-installed sensors in the city limits. It is rather hard to track an incoming storm using only two sensor locations.

The Fargo District reports that the SCAN weather system has saved the Department of Transportation $10,000 to $15,000 over a five year period. However, this is a tough figure to estimate. No one knows how many accidents were prevented or lives saved by using this system. The cost of constructing and installing the SCAN weather system was $131,216.26.

Recommendation

We recommended that the DOT not contract with SSI for their forecast service. We refer to the ever-increasing cost for the weather forecasting service and a decrease in system reliability. The DOT is using a less costly weather radar system that operators find easy to use and accurate. This system, along with the data from the SCAN sensors, should be used for our forecasting/monitoring program.

16. Key Words

Safety
Detection
Snow Ice Control
Scan System Equipment

17. Distribution Statement
No restrictions. This document is available to the public from:

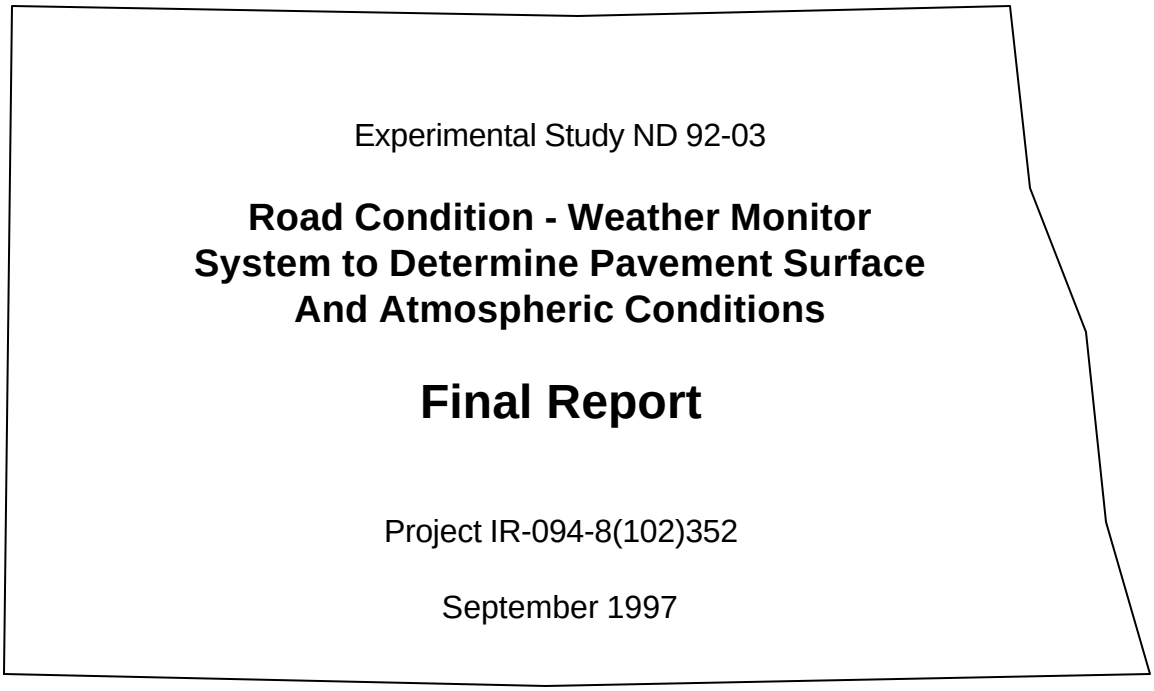
North Dakota Department of Transportation
Materials and Research Division:
300 Airport Road
Bismarck ND 58504-6005
Office: (701) 323-6900

18. No. of Pages
32

19. File type/Size
pdf/7.5 MB

NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION



Experimental Study ND 92-03

Road Condition - Weather Monitor System to Determine Pavement Surface And Atmospheric Conditions

Final Report

Project IR-094-8(102)352

September 1997

Prepared by

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
BISMARCK, NORTH DAKOTA
Website:http://www.discovernd.com/dot

DIRECTOR
Marshall W. Moore

MATERIALS AND RESEARCH DIVISION
Ron Horner

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO. [1]: STATE YEAR NUMBER SUF. — N D 9 2 - 0 3
CONSTRUCTION PROJ. NO. [8]: IR-094-8(102)352
LOCATION [28]: Fargo & Cass County

EVALUATION FUNDING [48]: 1 [X] HP&R; 2 [ ] CONSTRUCTION; 3 [ ] DEMONSTRATION; 4 [ ] IMPLEMENTATION
NEEP NO. [49]:
PROPRIETARY FEATURE? [51]: [X] YES [ ] NO

SHORT TITLE

TITLE [52]: Road Condition-Weather Monitor System to Determine Pavement Surface and Atmospheric Conditions

THIS FORM

DATE [140]: MO. 0 9 - YR. 9 7
REPORTING [144]: 1 [ ] INITIAL 2 [ ] ANNUAL 3 [X] FINAL

KEY WORDS

KEY WORD 1 [145]: SAFETY
KEY WORD 2 [167]: SNOWICE CONTROL
KEY WORD 3 [189]:
KEY WORD 4 [211]:
UNIQUE WORD [233]: Detection
PROPRIETARY FEATURE NAME [255]: SCAN System Equipment

CHRONOLOGY

Date Work Plan Approved: MO. YR. [277]	Date Feature Constructed: MO. YR. [281]	Evaluation Scheduled Until: MO. YR. [285]	Evaluation Extended Until: MO. YR. [289]	Date Evaluation Terminated: MO. YR. [293]
0 6 - 9 2	0 6 - 9 2	0 6 - 9 7		

QUANTITY AND COST

QUANTITY OF UNITS *(Rounded to whole numbers)* [297]: 2
UNITS [305]: 1 [ ] LIN. FT. 5 [ ] TON; 2 [ ] S.Y. 6 [ ] LBS.; 3 [ ] S.Y.-IN. 7 [ ] EACH; 4 [ ] C.Y. 8 [X] LUMP SUM
UNIT COST *(Dollars, Cents)* [306]: 1 3 1 2 1 7 0 0

AVAILABLE EVALUATION REPORTS

[315]: [X] CONSTRUCTION [X] PERFORMANCE [X] FINAL

EVALUATION

CONSTRUCTION PROBLEMS [318]: 1 [ ] NONE; 2 [X] SLIGHT; 3 [ ] MODERATE; 4 [ ] SIGNIFICANT; 5 [ ] SEVERE

PERFORMANCE [319]: 1 [ ] EXCELLENT; 2 [ ] GOOD; 3 [X] SATISFACTORY; 4 [ ] MARGINAL; 5 [ ] UNSATISFACTORY

APPLICATION

[320]: 1 [ ] ADOPTED AS PRIMARY STD.; 2 [ ] PERMITTED ALTERNATIVE; 3 [X] ADOPTED CONDITIONALLY; 4 [ ] PENDING; 5 [ ] REJECTED; 6 [ ] NOT CONSTRUCTED
(Explain in Remarks if 3, 4, 5, or 6 is checked)

REMARKS

[321] System not as reliable as expected. Surface sensors need regular checking and maintenance. During severe winter conditions, SSI forecasting was only 50% accurate. Subsurface sensors are very useful. The system is a valuable tool even with deficiencies. [700]

FORM FHWA 1461 (REV. 8-79) Previous Editions are Obsolete

Experimental Feature ND 92-03

ROAD CONDITION - Weather Monitor System To Determine Pavement Surface And Atmospheric Conditions

FINAL REPORT

Project IR-094-8(102)352

September 1997

By
Mike Marquart

Disclaimer

The contents of this report reflect the views of the author or authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views of the North Dakota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

TABLE OF CONTENTS

Road Condition - Weather Monitor System
To Determine Pavement Surface and
Atmospheric Conditions
Project IR-094-8(102)352

Final Report

Objective

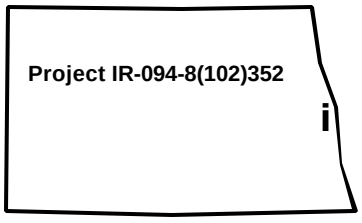
The object of this experimental project was to install a road condition-weather monitoring system to provide data on pavement surface and atmospheric conditions. This equipment should enable maintenance supervisors to evaluate the weather conditions at various locations. Supervisors could dispatch snow and ice removal equipment without sending an operator to check conditions on site.

The Department of Transportation expects this system to reduce the incidence of ice related accidents occurring on the I-94 Red River structure. This would be accomplished by alerting maintenance forces to predicted icing conditions and by tracking and forecasting incoming weather systems. The ultimate goal is to provide safer roads for the traveling public and reduce maintenance costs.

Location

The Road Condition - Weather Monitoring System is located on Interstate I-94 in the Fargo District and covers the area of the Red River Structure.

Remote processing units (RPUs) were installed at two locations. Site one is located on ND Highway 38 ten miles north of the Buffalo Interchange. Site two is located on Interstate 94 at the Red River Bridge in Fargo. See Appendix A.



Traffic

Year	Cars	Trucks	Total ADT	Rigid Pvmn't ESAL's
1997	41,610	3,770	45,380	5,055
2017	62,420	5,660	68,080	7,585
This is daily traffic for both directions				

Design

The Scan (surface condition analyzer) System was selected for this project based on equipment reliability, long-term stability of the provider, progressive technology, and qualified expertise necessary to install, maintain and upgrade the system. The Fargo District Engineer and a Surface Systems, Inc. (SSI) representative selected the RPU locations.

SSI of St. Louis, Missouri supplied and guided the installation of the system. The system includes RPUs with associated sensors for monitoring remote roadway conditions. Each RPU is a microprocessor based weather station powered by commercial 110 VAC (Volts Alternating Current). See Appendix B for plan details and drawings. A full complement of atmospheric sensors are mounted at each RPU for collection of environmental weather data (see Appendix C).

Construction

Construction work began on the project during the fall of 1991 and resumed in the 1992 construction season. The entire east and west bound lanes were reconstructed from Highway 81 to Minnesota 75. Most of the SCAN equipment was installed by state personnel. The DOT contracted the conduit trenching, base work, concrete foundation, and other necessary work to ready the sites for tower erection.

The central monitoring equipment is located at the Fargo District and includes the Data Handler. The brain of the Data Handler is the SCAN Plus Central Processing Unit (CPU). It is microprocessor based and used for collection, storage and presentation of all sensor data. All wiring and hookups took place during the construction phase.

The RPUs receive data from the pavement sensors by way of cables inside conduit in the pavement. The RPUs send data to the CPUs by utilizing radio waves. Data collected from these stations include pavement and air temperature, wind speed, dew point, visibility, chemical concentration, and whether the pavement is wet or dry. Sensors in the roadway can detect the presence of ice, snow or frost.

Cost

The cost of the SCAN Weather System was $131,216.26. This included all construction and installation costs. A price breakdown is shown below.

1.	SCAN equipment system and services	$98,224.00
2.	WIVIS sensor upgrade	7,773.00
3.	NDDOT radio services	10,148.00
4.	Allstate Tower Services, Inc.	710.00
5.	Traffic counter shop services	1,561.26
6.	(contracted) Tower foundation, conduit, and power supply (each tower $6,400.00) x (2)	12,800.00

Evaluation

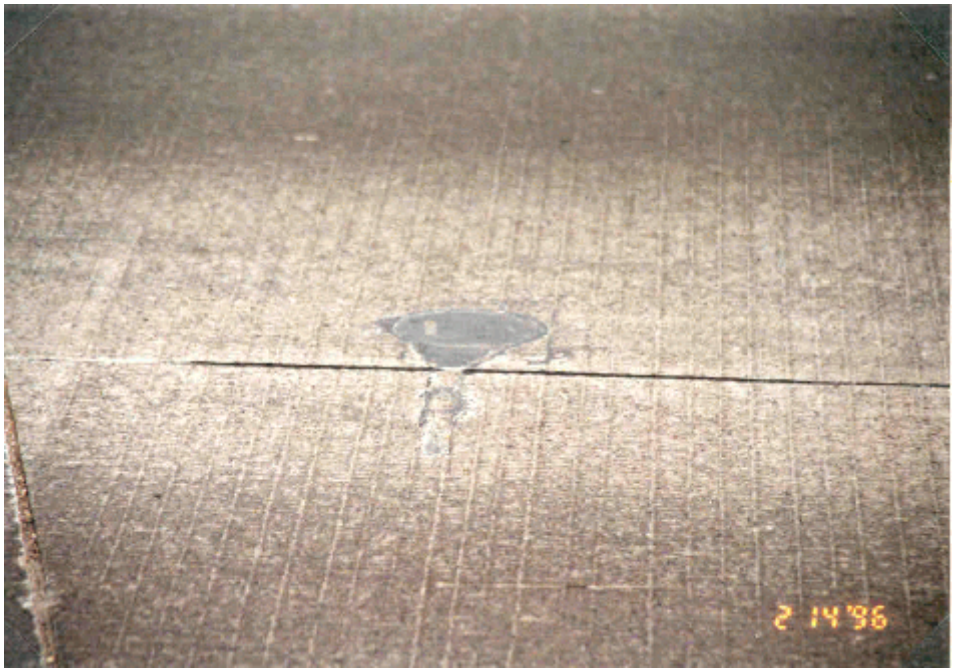
The DOT contracts with SSI to receive forecasts twice a day at the Fargo District. This service is obtained for the winter months only. It usually covers from October 15 to April 15. The last contract was for $3,270.00. Forecasts are received at 3:00 AM and updated at 3:30 PM. The department responds to these forecasts in a manner that will provide the safest driving conditions for the public.

SSI notifies the Fargo District of any severe incoming weather that develops between regular reporting times. A snow and ice control plan is developed from the data stored in the CPU. The main forecast conditions a manager looks at are wind speed, air and pavement temperature, dew point, and visibility. It takes a few winter seasons to become fully comfortable in relying on the SCAN weather forecasts.

The Fargo District has used the SSI system to track the winds in the Red River Valley. They wanted to use this data to see if they should have employees start sanding the roads early in the morning. The SSI forecast predictions include when snow will occur, time and speed of the wind, and the pavement temperature on the Red River Bridge. The Fargo District reports the following accuracy of the items mentioned above.

FORECAST ACCURACY			
YEAR	SNOW	WIND	PAVEMENT TEMPERATURE ON RED RIVER BRIDGE
95/96	55%	65%	70%
96/97	35%	40%	60%

These percentages are estimates by the Fargo District and not based on recorded data. Photo 1 shows a surface sensor on the Red River Bridge.



Appendix A Project location----weather sites

The Precipitation and Pavement Condition Forecast for the Red River Bridge was not

always on track. The river plays a big part in the ever changing conditions on the bridge. Two things come into play here. One is that the sensor is on a bridge and second, there is usually open water under the bridge. Temperature inversion and changing air currents under the bridge cause changes in relative humidity, air temperature, and due points. These can cause rapid changes in the surface condition of the bridge.

Most weather comes into the Fargo area from the west or northwest. With only one remote processing unit to the west of Fargo, the Fargo District and SSI find it difficult to forecast and track a storm coming in from the west. Additional sensors scattered to the west of Fargo would provide a time reference that would increase forecast accuracy. Although the NDDOT has installed RPUs in other districts, the Fargo District is too far away from other districts weather sensors to be very useful.

The Fargo District reports that the SSI system forecasts are not always reliable and updated. In referring to the "forecast accuracy" table on the previous page, one can see that the accuracy has dropped significantly. The Fargo District also reports that the SCAN Weather System failed many times and was not useable. Some system failures are shown below.

SCAN WEATHER SYSTEM FAILURES	
Date	**Remarks**
January 16,1997	COM FAILURE----------system failed at 4:00 AM
January 21,1997	COM FAILURE--------system failed again at 3:00 PM
January 22,1997	COM FAILURE--------system failed again at 7:00 AM
February 13,1997	COM FAILURE----------failed again
February 14,1997	COM FAILURE----------still fail
March 27,1997	COM FAILURE----------system failed
April 6,1997	COM FAILURE-----Highway 38 --- Buffalo site failed
May 21,1997	COM FAILURE----------system failed
July 7,1997	COM FAILURE----------system failed half of the time

A "com failure" is when two or more computers can not make the connection. This connection was from SSI in Saint Louis, Missouri to Fargo, or the Fargo office to the I-94 or Buffalo site.

The Fargo District does not plan on obtaining services from SSI in 1998. They state cost and reliability as reasons for their decision. Another less costly system will be used along with the present SCAN weather and roadway sensors.

Accident data was obtained from the department's traffic safety records. Computer records begin in January of 1989 and end in March of 1997. The data covers I-94 from mile 349.000 to 352.000. See the table below.

Vehicle Accidents -----I-94 Mile 349 to 352 Red River Bridge	
Date	**Total Accidents**
1990 - 1991	52
1992 - 1996	40
1996 - 1997	62

After the reconstruction of the roadway in 1992, the accident numbers decreased. In one year, March 1996 to March 1997, the accident number increased from 40 to 62. This is most likely due to the severe winter we had in 1996/1997. The "ACCIDENT DATA" table on the next page shows the influencing factors that caused or have contributed to the accidents. It shows 61% of the collisions were vehicles in transport. The weather was clear only 30% of the time that accidents occurred. Ice/snow was present at 51% of the accidents. Of the vehicles involved in an accident, 33% were driving too fast for conditions. This relates to the surface conditions of the roadway. Visibility and road conditions, along with excess speed for conditions, are the reasons for the jump in accident numbers for 1996/1997 winter season.

ACCIDENT DATA--I-94 MILE 349.0000 TO 352.0000					
COVERAGE PERIOD	**TYPE OF COLLISION**	**LIGHT**	**WEATHER**	**SURFACE CONDITION**	**CONTRIBUTING FACTOR**
Jan 89 to March 96	39% rear end	70% daylight	60% clear	52% dry	50% no clear contributing factor 23% speed -- driving to fast
March 96 to March 97	61% non collision (veh-in-trnsprt)	62% daylight	30% clear	22% dry 51% Ice/Snow	33%-- speed too fast for conditions 24% --no clear contributing factor

The SCAN weather system contributes to reducing the chance of an accident occurring. Just how great a part this weather system plays in reducing accidents is difficult to determine. Many other variables come into play from the roadway improvements. A few are:

The roadway was completely reconstructed

More lanes to carry traffic after construction

Better sight distance and lighting

Better skid resistant surface

Better turn lanes and off/on ramps

Another thing to keep in mind is that traffic increases each year. This creates more situations for accidents to happen. Speed plays a part in this also. People tend to drive faster on improved roads. The SCAN weather system is just a tool to help in planning maintenance activities and is not a guarantee to reduce the number of accidents.

Summary

The North Dakota Department of Transportation contracts with Surface Systems, Inc. (SSI) to receive weather forecasts twice a day at the Fargo District during the winter months. The cost for six months of service during the winter of 1995/1996 was $2,750.00 or $458.50 a month. For the winter of 1996/1997 the cost was $3,270.00.

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The cost of constructing and installing the SCAN weather system was $131,216.26.

The subsurface sensors may be a tool used to help determine when load restrictions should be applied. This use of soil temperature will increase in value as more sensors are installed in the state roadway system.

The North Dakota Department of Transportation continues to use the technologies available in this and other weather systems to help accomplish the objective of achieving a timely and effective method for snow and ice control. And also provide the safest driving conditions to the public.

Recommendations

We recommended that the DOT not contract with SSI for their forecast service. We refer to the ever increasing cost for the weather forecasting service and a decrease in system reliability. The DOT is using a less costly weather radar system that operators find easy to use and accurate. This system, along with the data from the SCAN sensors, should be used for our forecasting/monitoring program.

Appendix A

JOB# 1

FHWA REGION	STATE	PROJECT	SHEET NO.
8	N.D.	IR-094-8(124)351 F IR-094-8(102)352	1

DESIGN DATA

Traffic		Average Daily		Est. 30th Max. Hr.
Current (1985)	13,400 Pass.	1600 Trucks	15,000 Total	1600
Forecast (2005)	21,976 Pass.	2900 Trucks	24,875 Total	2488

Design Speed 70 MPH
Traffic Classification "M"
Minimum Sight Distance (Stopping) 625'
Minimum Sight Distance (Safe Passing)
Minimum Passing Sight Distance for Marking
Bridges Hs 25

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

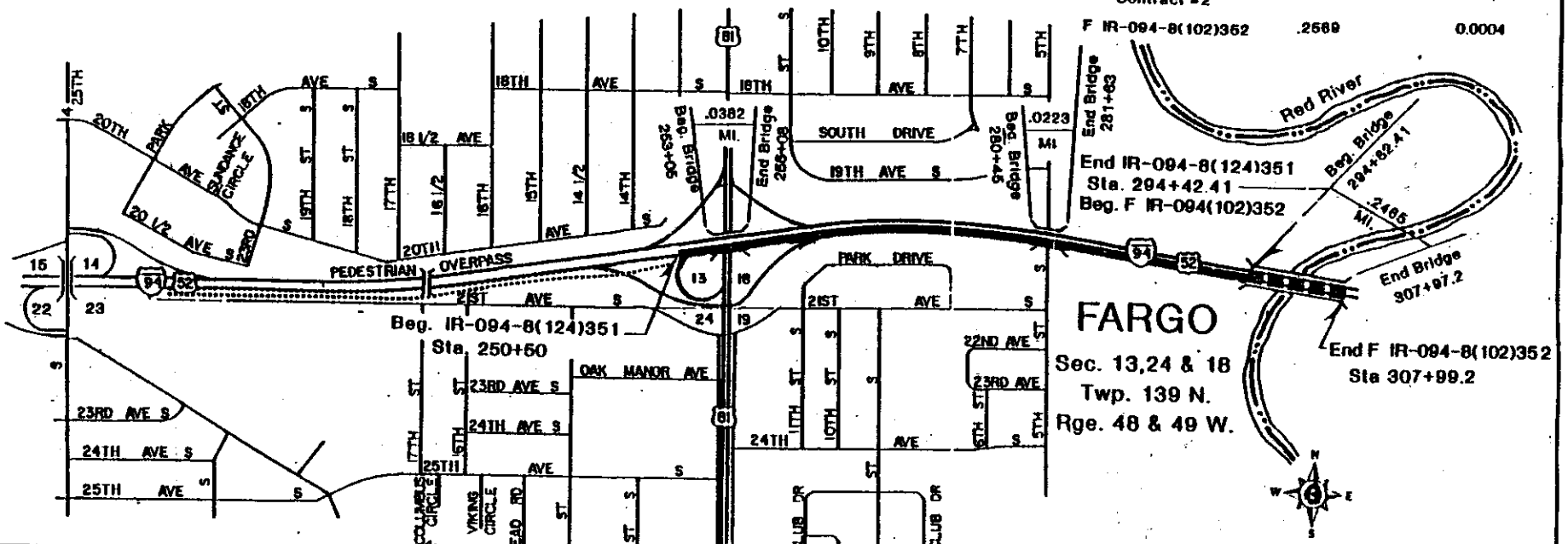
Cass County
IR-094-8(124)351
Contract 2
F IR-094-8(102)352
Grading, Surfacing, Sewer, Structural, Signing, Marking & Incidentals.

GOVERNING SPECIFICATIONS:

Standard Specifications for Road and Bridge Construction, adopted by the North Dakota State Highway Department, November 1986, shall apply to all North Dakota Department of Transportation contracts, standard drawings currently in effect, and other contract provisions submitted herein.

LENGTH OF PROJECT

Project	Miles-Gross	Miles-Net
IR-094-8(124)351 Contract #2	0.6318	0.7712
F IR-094-8(102)352	.2569	0.0004



U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED

DIVISION ADMINISTRATOR DATE

APPROVED DATE 9/20/91

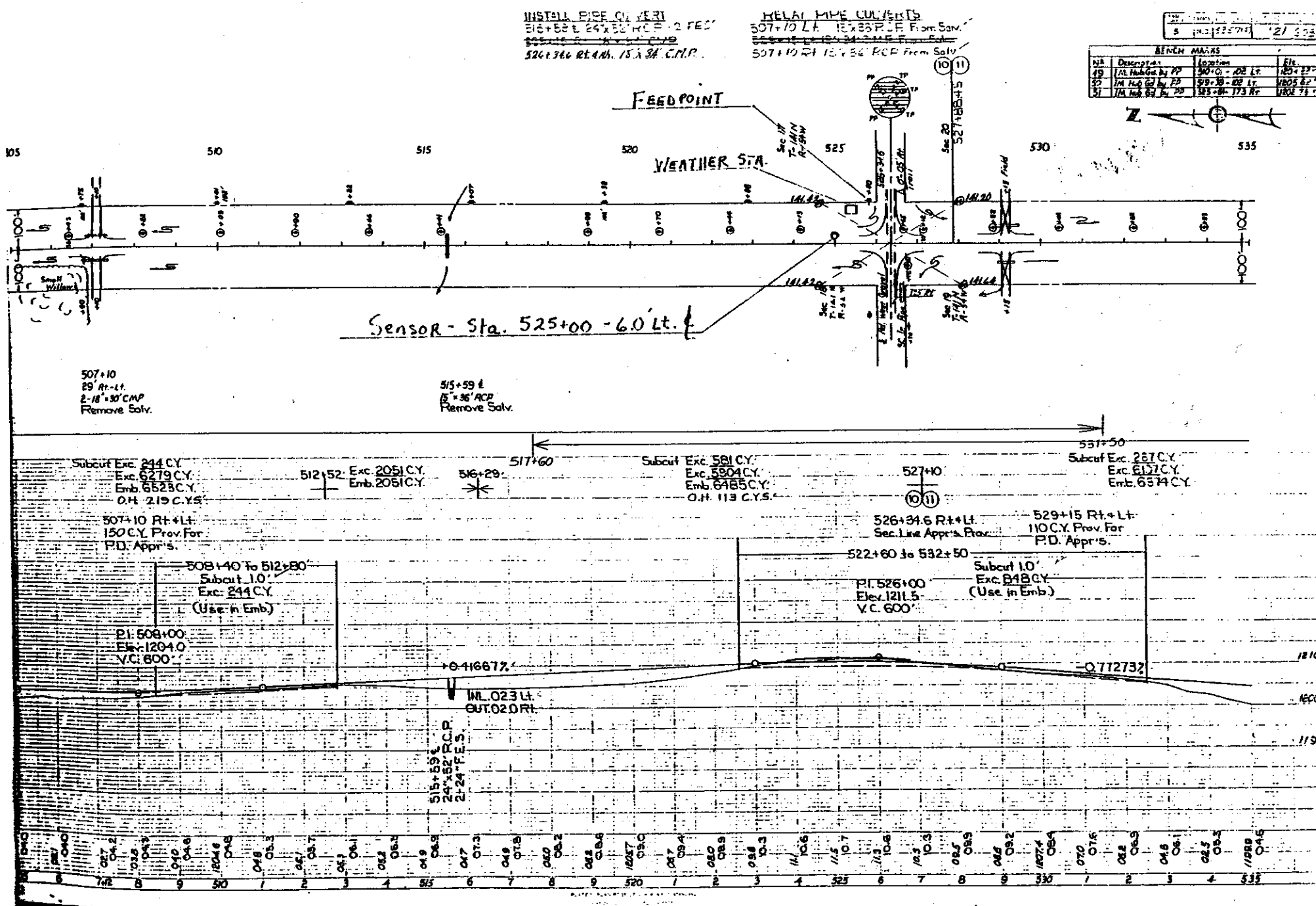
Ray Zink

DIRECTOR OF HIGHWAYS AND ENGINEERING
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

RAY ZINK REGISTERED PROFESSIONAL P.E. 972 ENGINEER NORTH DAKOTA

A-1

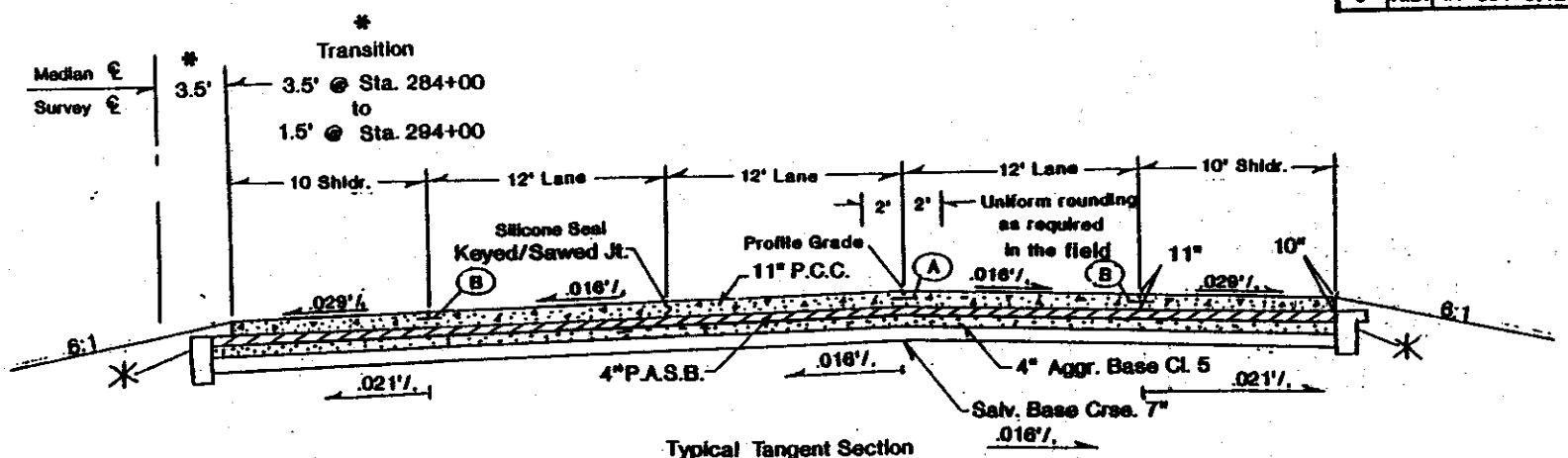
Highway 38 - Sensor Location.



A-2

Appendix B

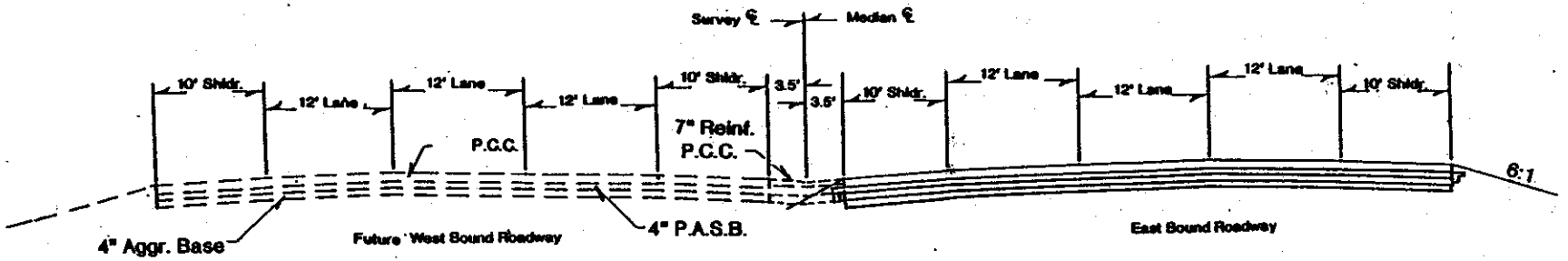
FHWA REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	N.D.	IR-094-6(124)351	23



Typical Tangent Section
East Bound Roadway
Sta. 281+63 to 284+00

✳ See Typ. Perm. Base & Drain Detail

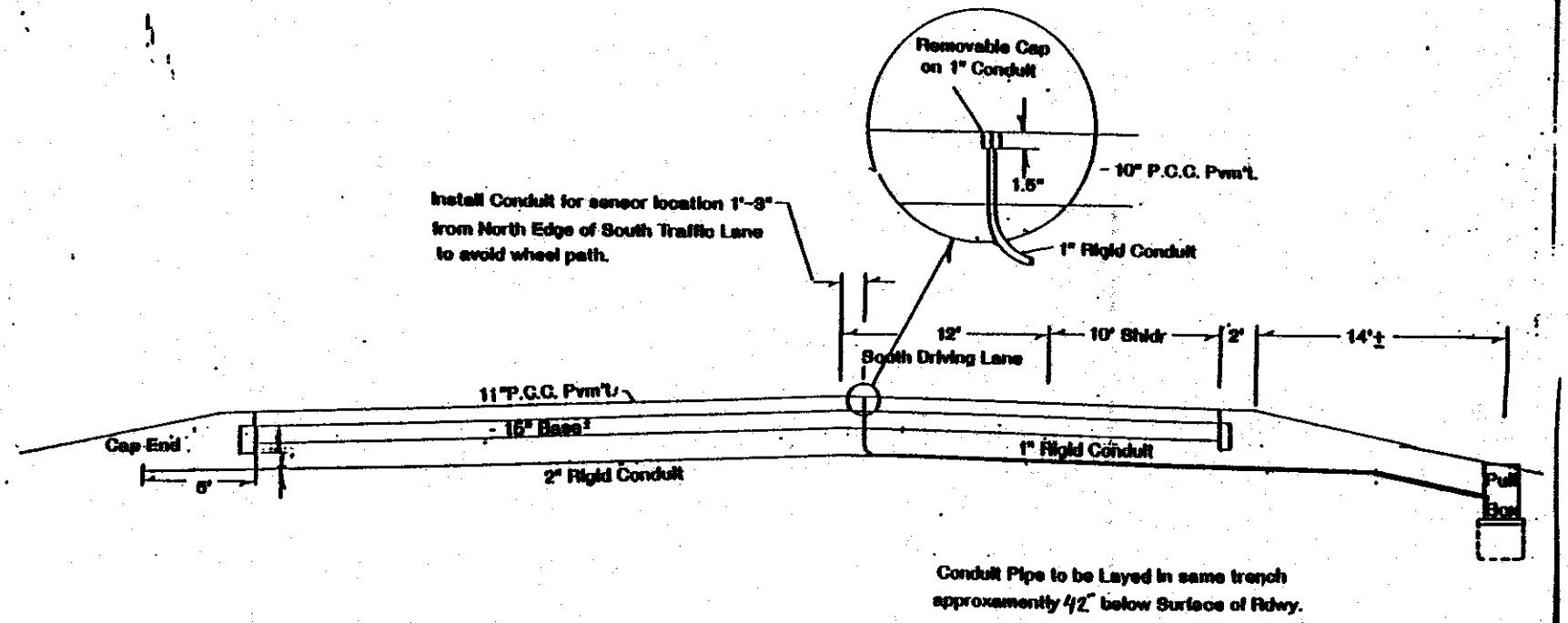
A - #4 Tie Bars spaced @ 2' - 6" C-C
B - #4 Tie Bars spaced @ 3' C-C.



Future Typical Tangent Section

B-1

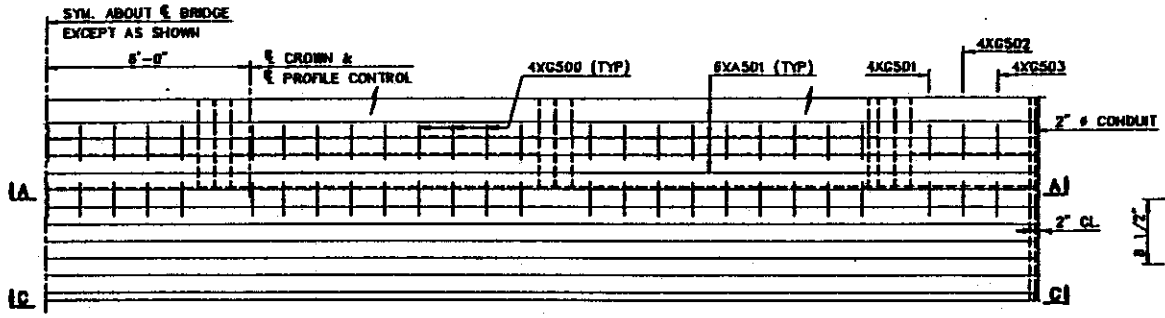
8	N.D.	IR-094-8(124)35	72



Conduit Pipe to be Layed in same trench approxamently 42" below Surface of Ridwy.

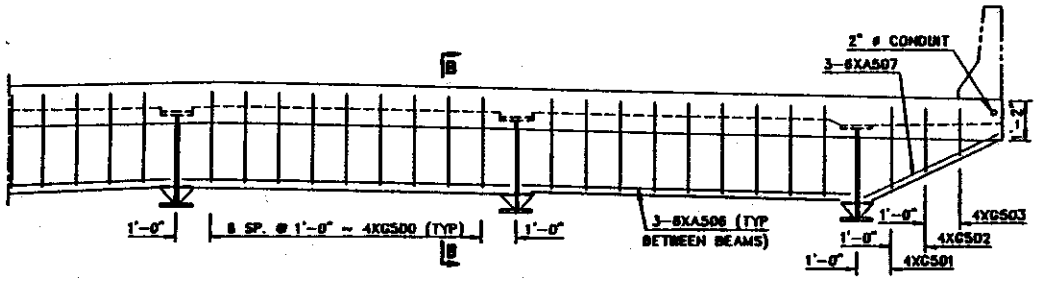
Conduit X-ing Detail
Sta. 293+00

8	N.D.	IR-094-8(102)352	380

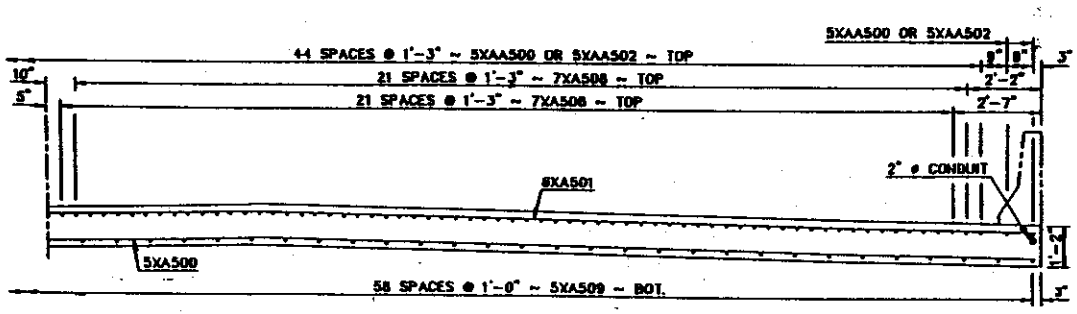


(LONGITUDINAL REINFORCING NOT SHOWN)

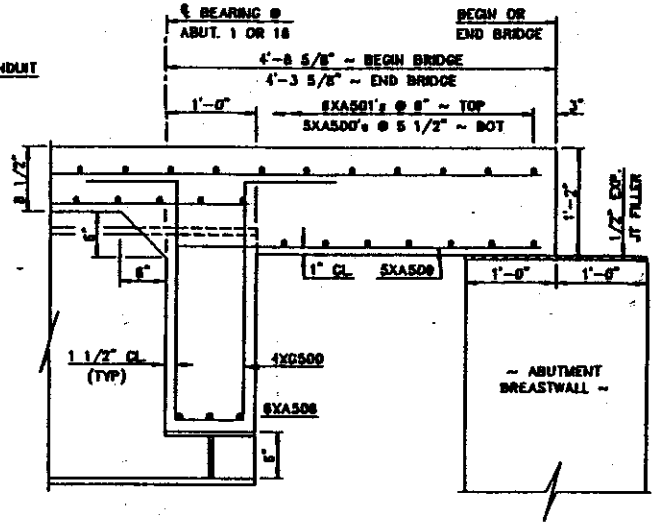
HALF END BEAM PLAN



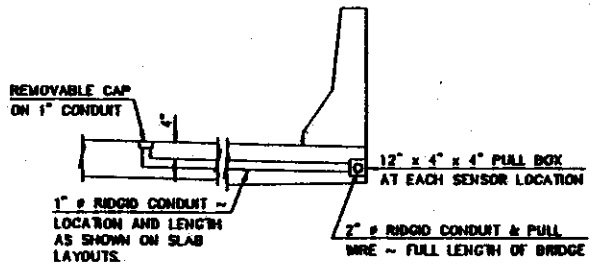
A–A



C–C



B–B



CONDUIT DETAIL

NOTE:

PULL WIRE: THE PULL WIRE SHALL CONSIST OF NO. 10 GAGE GALVANIZED BIRMINGHAM WIRE SINGLE STRAND STEEL. THERE SHALL BE 8 FEET ADDITIONAL PULL WIRE AT EACH PULL BOX.

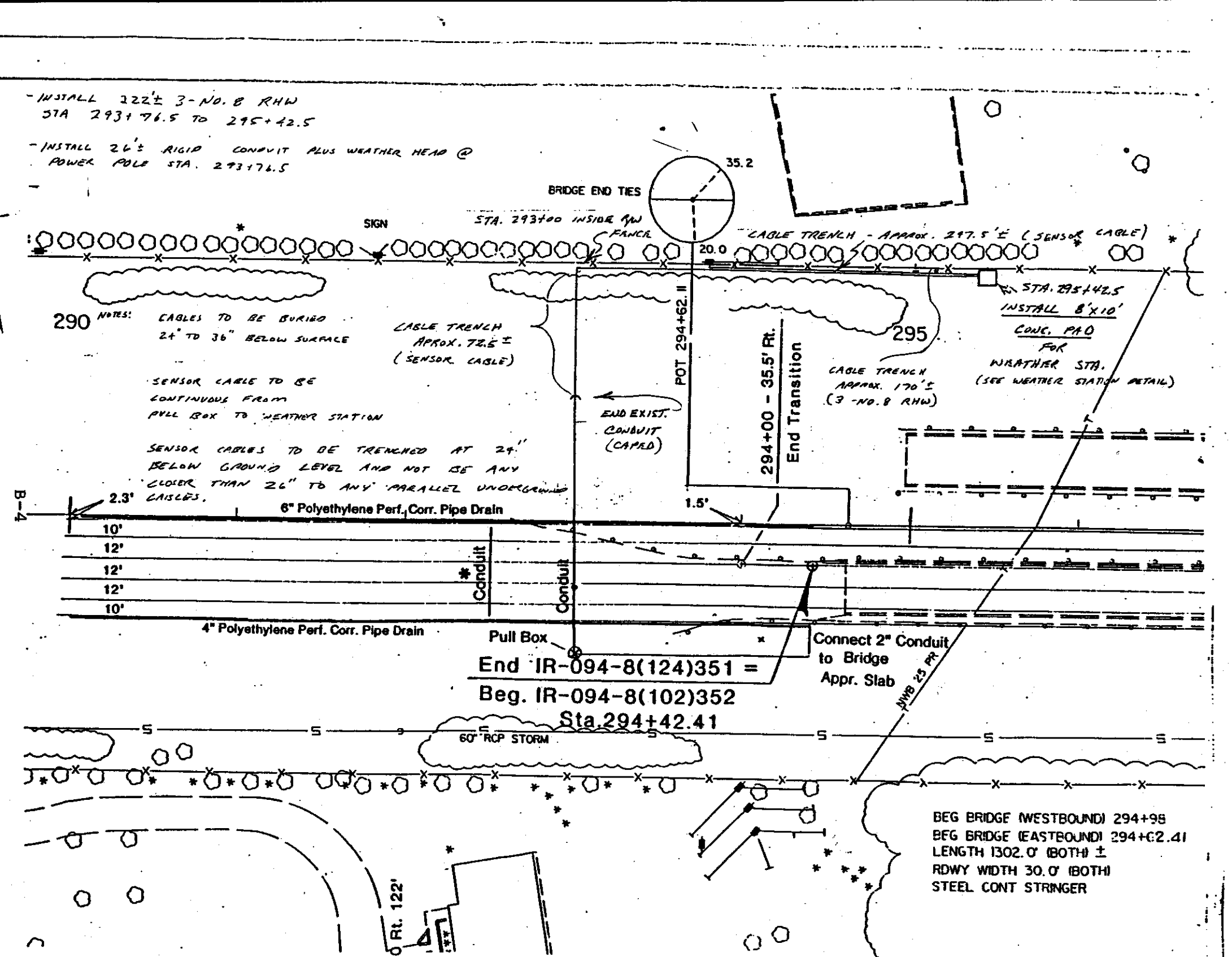
ALL MATERIAL SHALL MEET THE REQUIREMENTS OF SECTION 700 OF THE NORTH DAKOTA STANDARD SPECIFICATIONS.

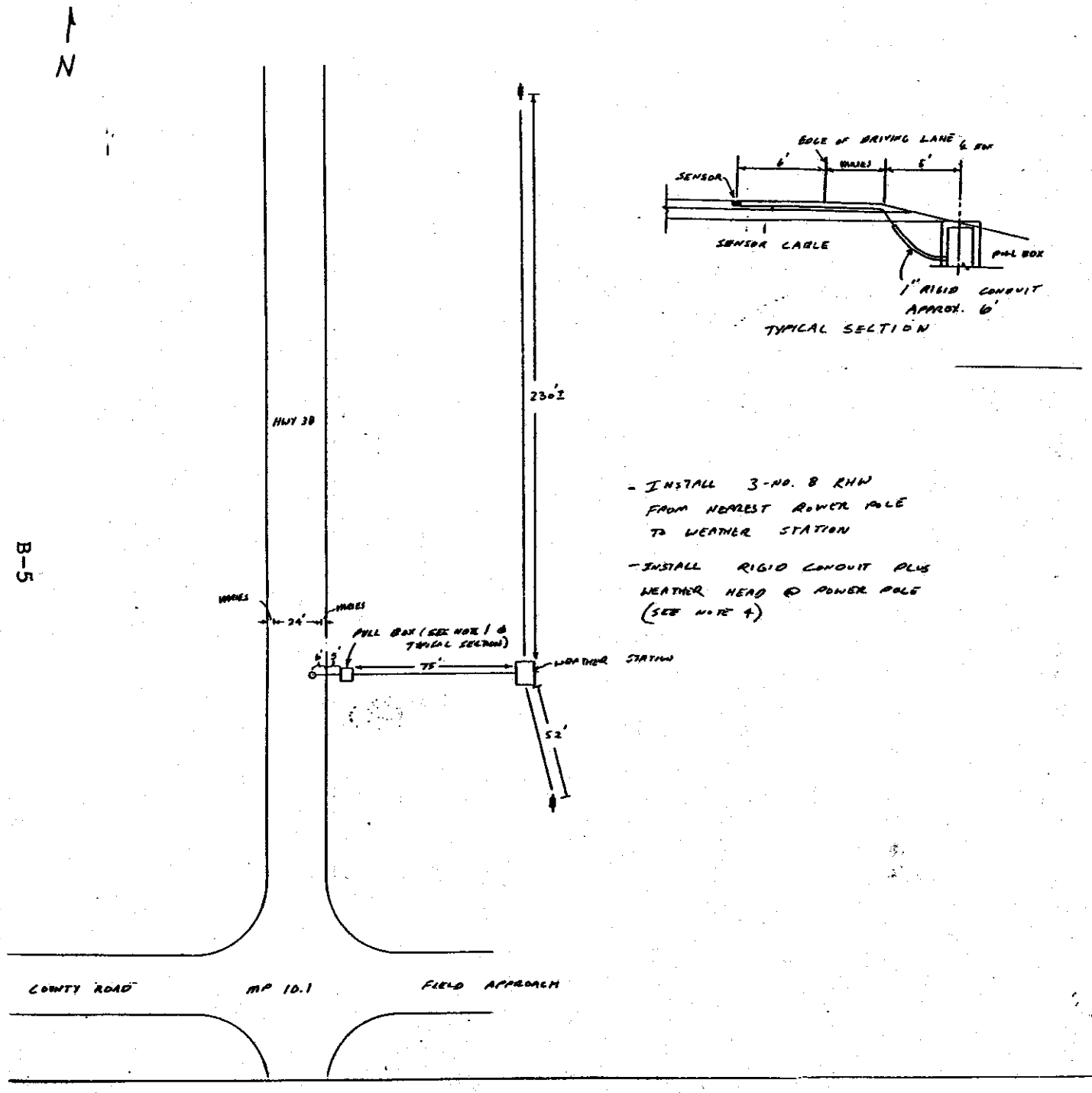
QUANTITIES

SEE DWG. 94-352.453-70

I-94 ~ RED RIVER
FARGO ~ MOORHEAD

SLAB END BEAM DETAILS


- INSTALL 222'± 3-NO. 8 RHW
STA 293+76.5 TO 295+42.5
- INSTALL 26'± RIGID CONDUIT PLUS WEATHER HEAD @
POWER POLE STA. 293+76.5
35.2
BRIDGE END TIES
SIGN
STA. 293+00 INSIDE R/W FENCE
20.0
CABLE TRENCH - APPROX. 297.5'± (SENSOR CABLE)
STA. 295+42.5
INSTALL 8'X10' CONC. PAD FOR WEATHER STA. (SEE WEATHER STATION DETAIL)
290
295
NOTES:
CABLES TO BE BURIED 24" TO 36" BELOW SURFACE
SENSOR CABLE TO BE CONTINUOUS FROM PULL BOX TO WEATHER STATION
SENSOR CABLES TO BE TRENCHED AT 24" BELOW GROUND LEVEL AND NOT BE ANY CLOSER THAN 26" TO ANY PARALLEL UNDERGROUND CABLES.
CABLE TRENCH APPROX. 72.5'± (SENSOR CABLE)
POT 294+62.11
294+00 - 35.5' Rt.
End Transition
CABLE TRENCH APPROX. 170'± (3 -NO.8 RHW)
END EXIST. CONDUIT (CAPPED)
B-4
2.3'
6" Polyethylene Perf. Corr. Pipe Drain
1.5'
10'
12'
12'
12'
10'
Conduit
Conduit
4" Polyethylene Perf. Corr. Pipe Drain
Pull Box
Connect 2" Conduit to Bridge Appr. Slab
End IR-094-8(124)351 =
Beg. IR-094-8(102)352
Sta 294+42.41
60" RCP STORM
NWB 25 PR
Rt. 122'
BEG BRIDGE (WESTBOUND) 294+98
BEG BRIDGE (EASTBOUND) 294+62.41
LENGTH 1302.0' (BOTH) ±
RDWY WIDTH 30.0' (BOTH)
STEEL CONT STRINGER



TYPICAL SECTION

- INSTALL 3-NO. 8 RHW FROM NEAREST POWER POLE TO WEATHER STATION
- INSTALL RIGID CONDUIT PLUS WEATHER HEAD @ POWER POLE (SEE NOTE 4)

NOTES:

1. SEE STANDARD DRAWING D-77B-5 SAW SLOT TO PULL BOX DETAILS RURAL SECTION.
2. CABLES TO BE BURIED 24" TO 36" BELOW SURFACE
3. SENSOR CABLE TO BE CONTINUOUS FROM PULL BOX TO WEATHER STATION.
4. SEE SERVICE CONNECTION DETAIL

CONCRETE FOUNDATIONS
(TRAFFIC SIGNALS & HIGHWAY LIGHTING)

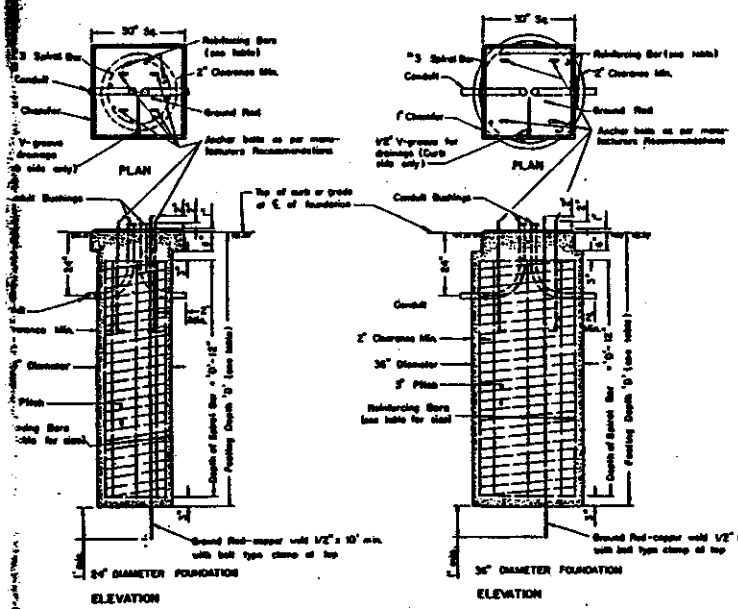
D-770-1

LIGHT & SIGNAL STANDARD FOUNDATION SELECTION TABLE				
Description	Reinforcing Bars Required	Footing Depth "D" 24" Diameter	Reinforcing Bars Required	Footing Depth "D" 36" Diameter
Light Standard				
30' Mounting Height	#3 - 5	6'	#4 - 4	5'
40' Mounting Height	#3 - 5	8'	#4 - 4	7'
50' Mounting Height	#3 - 5	8'	#4 - 4	7'
Combination 30' Mounting Height				
0-25' Signal Mast Arm	#3 - 5	11'	#4 - 5	9'
26'-44' Signal Mast Arm	#3 - 6	11'	#4 - 5	9'
45'-50' Signal Mast Arm	#3 - 8	11'	#4 - 5	9'
Combination 40' Mounting Height				
0-25' Signal Mast Arm	#3 - 6	12'	#4 - 5	9'
26'-44' Signal Mast Arm	#3 - 7	12'	#4 - 6	9'
45'-50' Signal Mast Arm	#3 - 8	12'	#4 - 7	11'
Combination 50' Mounting Height				
0-25' Signal Mast Arm	#3 - 8	15'	#4 - 8	12'
26'-44' Signal Mast Arm	#3 - 8	15'	#4 - 7	11'
45'-50' Signal Mast Arm	#3 - 8	15'	#4 - 7	11'
Type IV Signal Standard	#3 - 7	10'	#4 - 6	9'
Type I, II, III, VI, X, XI, & XII Signal Std.	#3 - ①	4'	#4 - ①	3'

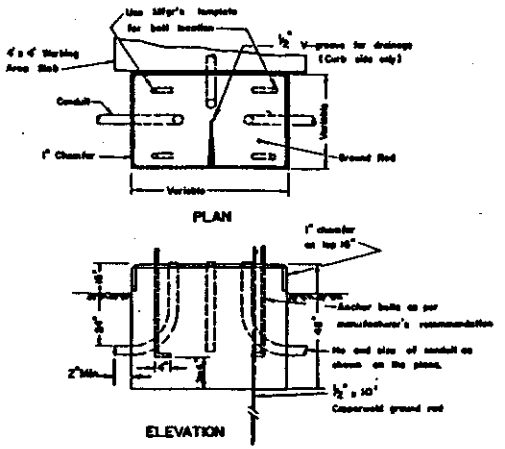
① No reinforcement is required if the anchor bolts extend to within 3" to 4" above the bottom of the foundation.

All reinforcing steel to be Grade 40 or 60.

If the Contractor elects to use a 24" square foundation, the next size smaller reinforcement bars may be substituted for those shown in the table. No substitutions may be made for a 36" square foundation. #4 tie bars on 12" c-c may be substituted for the spiral when a 24" square foundation is used. #4 round tie bars on 12" c-c may be substituted for the spiral when a 24" or 36" round foundation is used. Round tie bars shall have a min. of 12" lap.

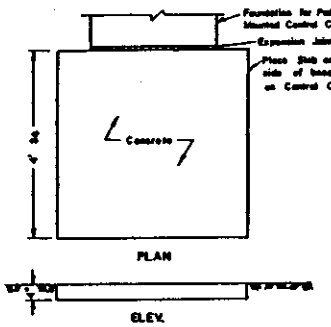


LIGHT & SIGNAL STANDARD FOUNDATION



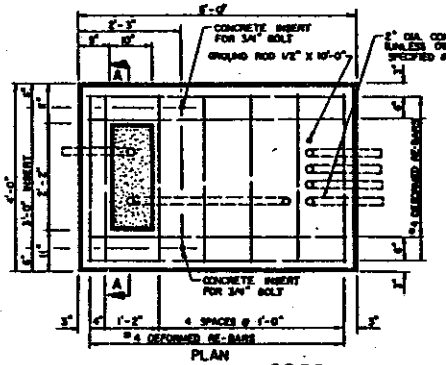
CONTROLLER CABINET FOUNDATION PAD MOUNT

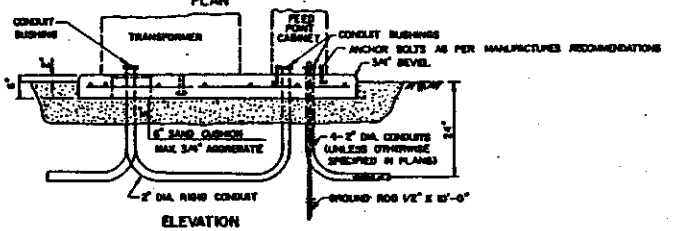
The Controller Cabinet Foundation shall be bid as Concrete Foundations-Traffic Signals.



WORKING AREA SLAB

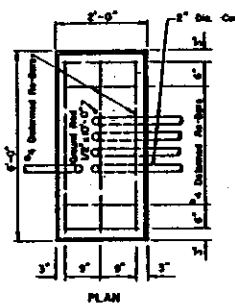
The Working Area Slab shall be installed where shown on the plans, and shall not be bid separately but shall be included in the price bid for Concrete Foundations-Traffic Signals.

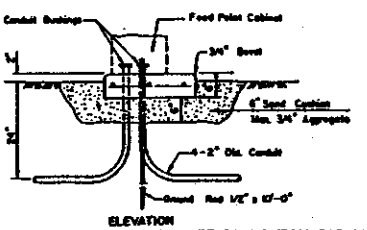




TRANSFORMER & FEED POINT CABINET FOUNDATION PAD MOUNT

The Transformer & Feed Point Cabinet Foundation Pad Mount shall be bid as Concrete Foundations-Feed Point Pad-Type A





FEED POINT CABINET FOUNDATION PAD MOUNT

The Feed Point Cabinet Foundation Pad Mount shall be bid as Concrete Foundations-Feed Point Pad-Type B

NOTES:

Light & Signal Standard Foundations:

See plans for conduit size, number of bends and correct positioning for each fou dation.

When conduit does not continue beyond the foundation, conduit with a 105° bend and bushings on both ends may be substituted for the 90° bends shown.

See plans for correct location of foundations. The grade and exact location shall be established by the Engineer in the field.

Maximum anchor bolt circle for the 24" foundation shall not exceed 15". Maximum anchor bolt circle for the 36" foundation shall not exceed 30".

Pad Mounted Signal Control Cabinet Foundations

See plans for the number of 90° bends per foundation and correct positioning.

Foundation for Pad Mounted Signal Control Cabinets shall be of sufficient size that there is a minimum of 3" of clearance from the outside edge of cabinet to outside edge of the foundation on any side. The Contractor shall insure a watertight seal between the control cabinet and the foundation by caulking, except for V gro

Working Area Slab:

The materials and preparation of this slab shall be as approved by the Engi in the field.

Transformer & Feed Point Cabinet Foundation Pad Mounted:

Foundation shall have a wood float finish.

All conduits shown shall be installed. Conduit that is not used at this time sha be plugged.

Feed Point Cabinet Foundation Pad Mounted:

Foundation shall have wood float finish.

All conduits shown shall be installed. Conduit that is not used at this time shall be plugged.

10-1-86 REVISIONS	
DATE	CHANGES

NORTH DAKOTA STATE HIGHWAY DEPARTMENT

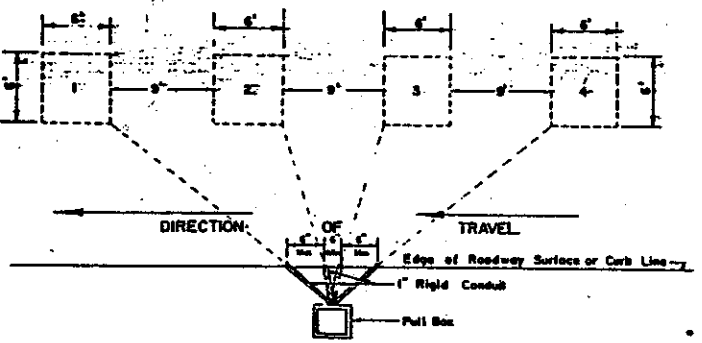
APPROVED: David B. Evans
DIRECTOR

B-6

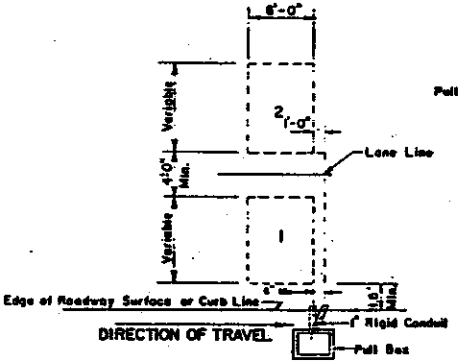
LOOP DETECTORS
DETAILS

FHWA REVISION	STATE	FED. AID PROJ. NO.
8	N.D.	

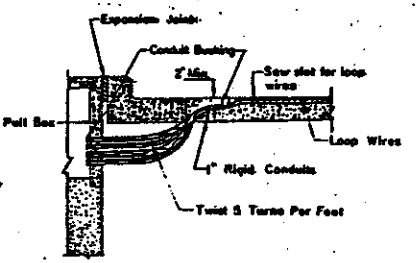
D-772-5



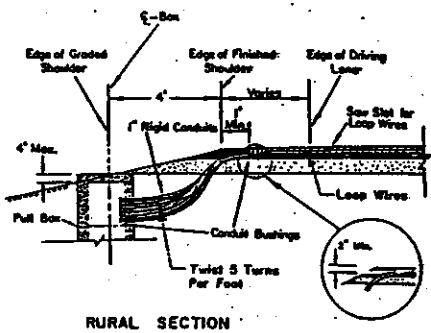
MULTIPLE LOOP DETECTOR DETAIL
(PRESENCE LOOPS)



LOOP DETECTOR DETAIL
(PASSAGE OR CALLING)
(Number of Loops and Number of Turns as shown in the Plans)

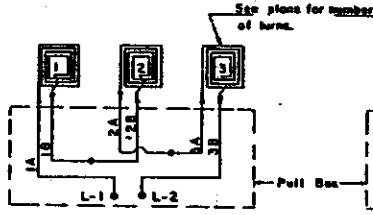


CURB SECTION



RURAL SECTION

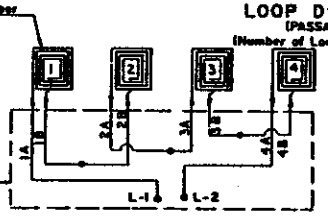
SAW SLOT TO PULL BOX
DETAILS



MULTIPLE LOOP CONNECTION

All conductors shall be labeled in the pull box as shown. (1A, 1B, 2A, etc.)

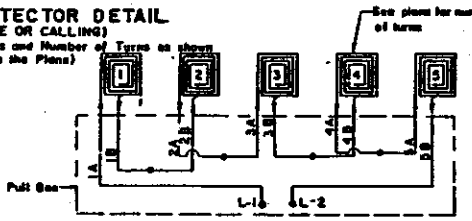
The loop connections shall be spliced in the pull box: 1A to L-1, 1B to 2B, 2A to 3A, and 3B to L-2



MULTIPLE LOOP CONNECTION

All conductors shall be labeled in the pull box as shown. (1A, 1B, 2A, etc.)

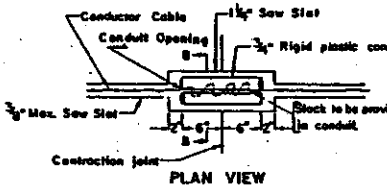
The loop connections shall be spliced in the pull box: 1A to L-1, 1B to 2B, 2A to 3A, 3B to 4B, and 4A to L-2



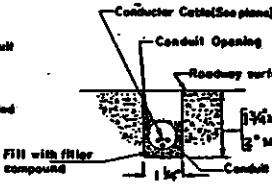
MULTIPLE LOOP CONNECTION

All conductors shall be labeled in the pull box as shown. (1A, 1B, 2A, etc.)

The loop connections shall be spliced in the pull box: 1A to L-1, 1B to 2B, 2A to 3A, 3B to 4B, 4A to 5A, and 5B to L-2

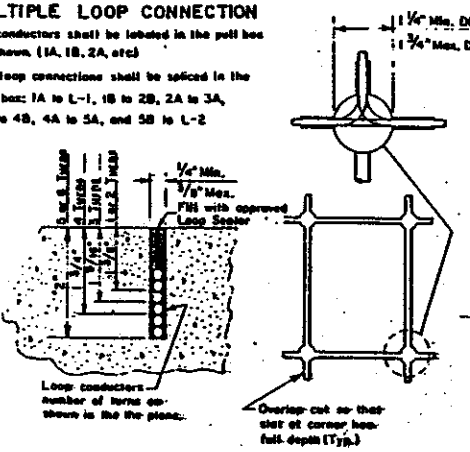


PLAN VIEW



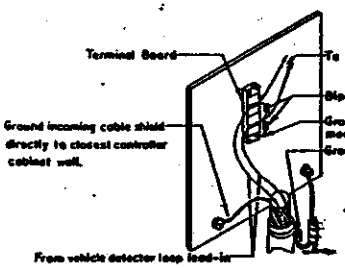
SECTION BB

CONTRACTION JOINT DETAIL
(This detail shall also be used whenever a crack in the roadway is encountered.)

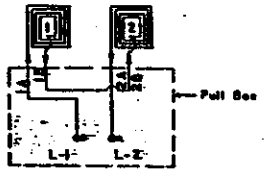


SAW SLOT DETAILS

Drill detector loop corners 2" deep. Then saw pavement slots to form loops. Dimensions and location shall be as shown in plans.



LOOP LEAD-IN CONDUCTOR LIGHTNING PROTECTI



MULTIPLE LOOP CONNECTION

All conductors shall be labeled in the pull box as shown. (1A, 1B, 2A, etc.)

The loop connections shall be spliced in the pull box: 1A to L-1, 1B to 2B, and 2A to L-2.

NOTES:

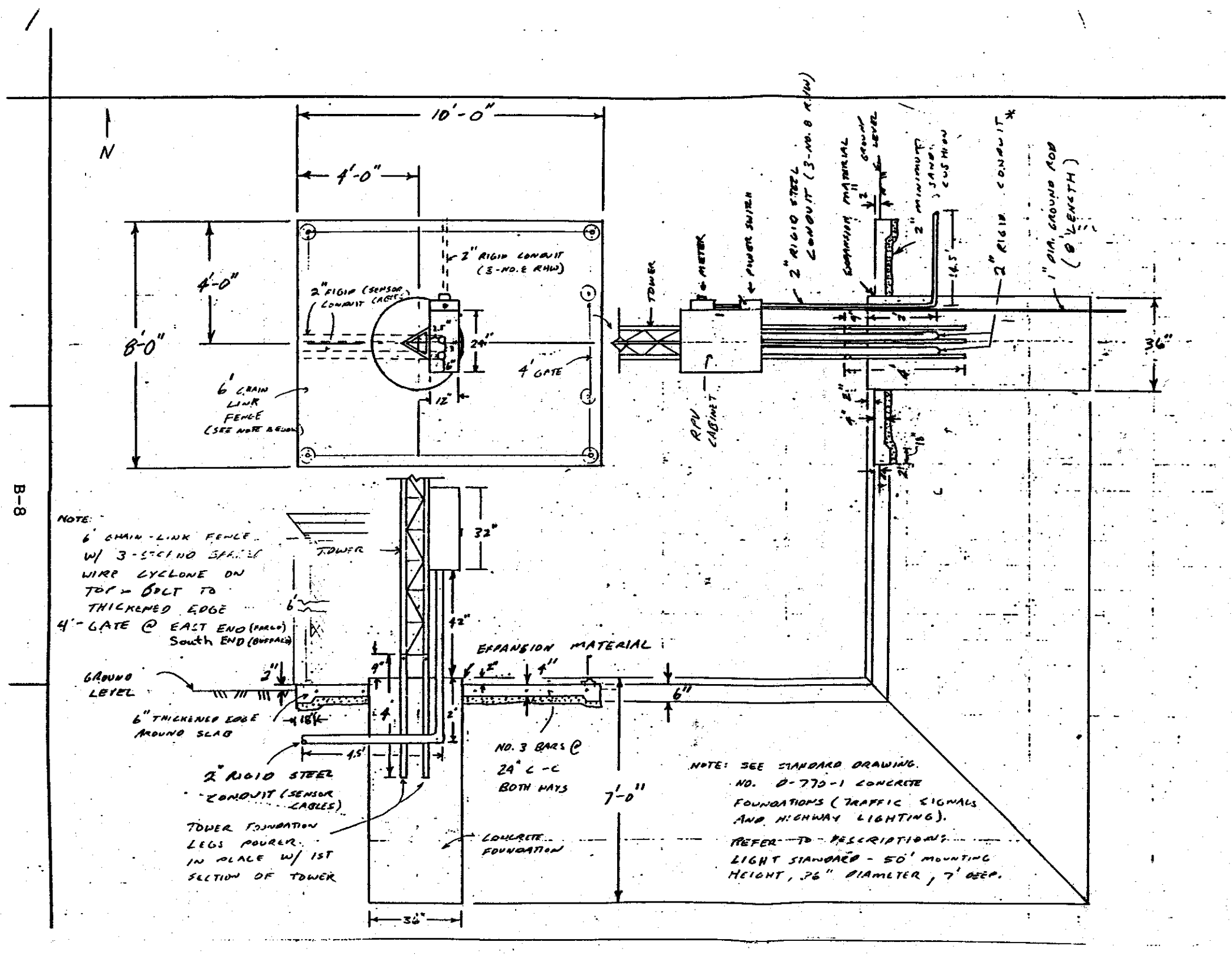
1. Each loop shall be saw cut in the roadway.
2. The number of turns, size of loop and size of conductor shall be as shown on the plans. The first loop dimension figure is the length in the direction of travel and the second dimension is the width across the traffic lane.
3. The lead routing shall be in separate slots to conduit leading to pull box to minimize interaction.

10-1-86 REVISIONS	
DATE	CHANGES
6-3-97	NOTE
11-30-00	RIGID CONDUIT AT CURB OPENING
12-6-00	MULTIPLE LOOP CONNECTION

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

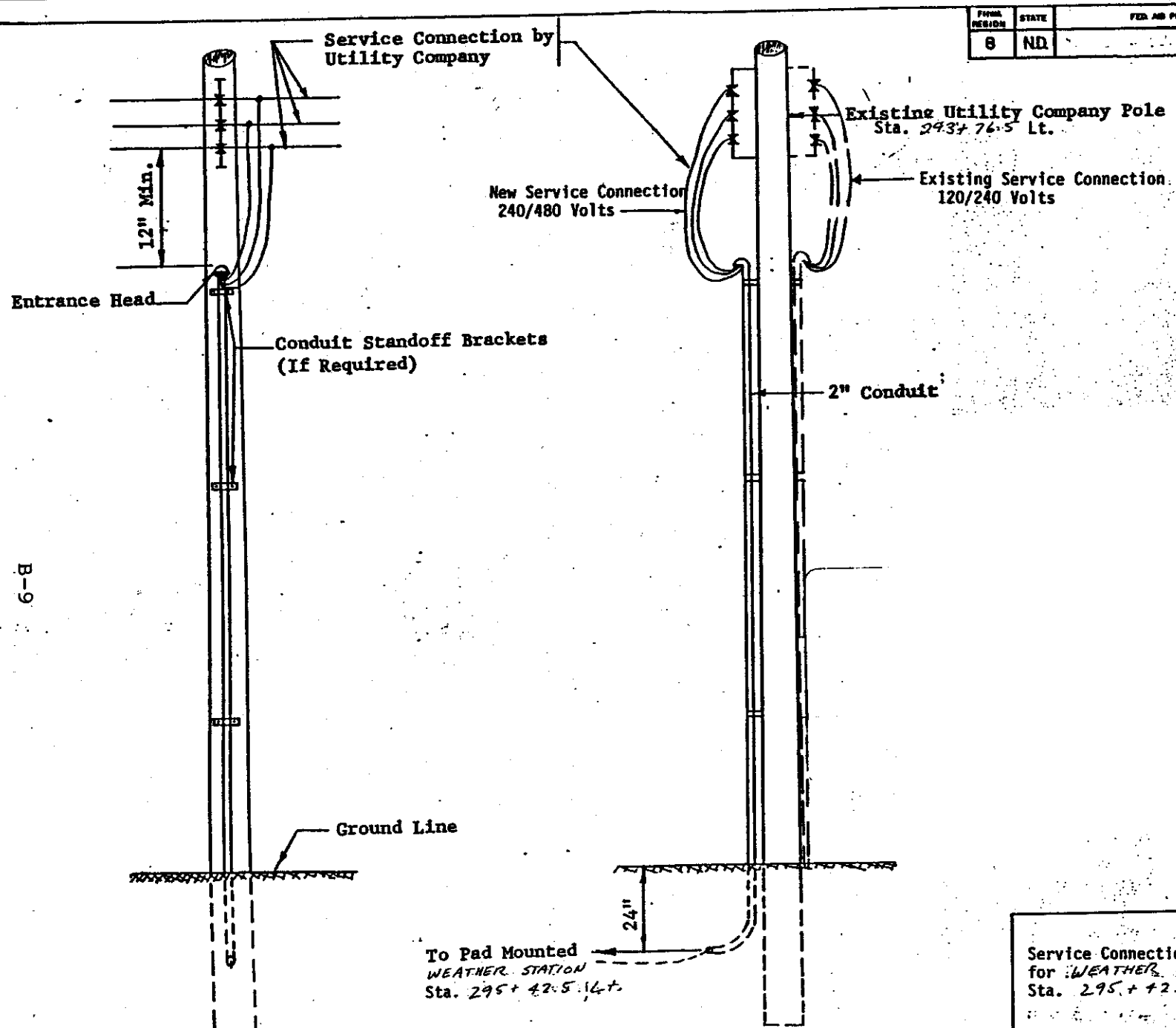
APPROVED David K.A. Sorenson
ENGINEER

B-7


N
10'-0"
4'-0"
4'-0"
8'-0"
2" RIGID (SENSOR) CONDUIT (CABLE)
2" RIGID CONDUIT (3-NO. 8 RHW)
24"
16"
12"
4' GATE
6' CHAIN LINK FENCE (SEE NOTE BELOW)
TOWER
METER
POWER SWITCH
2" RIGID STEEL CONDUIT (3-NO. 8 RHW)
EXPANSION MATERIAL
GROUND LEVEL
2" MINIMUM SAND CUSHION
14.5'
2" RIGID CONDUIT *
1" DIA. GROUND ROD (8' LENGTH)
36"
RPV CABINET
4" E"
18"
2"
NOTE:
6' CHAIN-LINK FENCE W/ 3-STRAND BARBED WIRE CYCLONE ON TOP - BOLT TO THICKENED EDGE
4'-GATE @ EAST END (FARGO) South END (BUFFALO)
32"
TOWER
6'
42"
EXPANSION MATERIAL
GROUND LEVEL
2"
9"
4"
2"
4"
6"
6" THICKENED EDGE AROUND SLAB
18"
4'
2'
4.5'
NO. 3 BARS @ 24" C-C BOTH WAYS
2" RIGID STEEL CONDUIT (SENSOR CABLES)
TOWER FOUNDATION LEGS POURED IN PLACE W/ 1ST SECTION OF TOWER
CONCRETE FOUNDATION
7'-0"
36"
NOTE: SEE STANDARD DRAWING NO. D-770-1 CONCRETE FOUNDATIONS (TRAFFIC SIGNALS AND HIGHWAY LIGHTING).
REFER TO DESCRIPTIONS: LIGHT STANDARD - 50' MOUNTING HEIGHT, 26" DIAMETER, 7' DEEP.

B-8

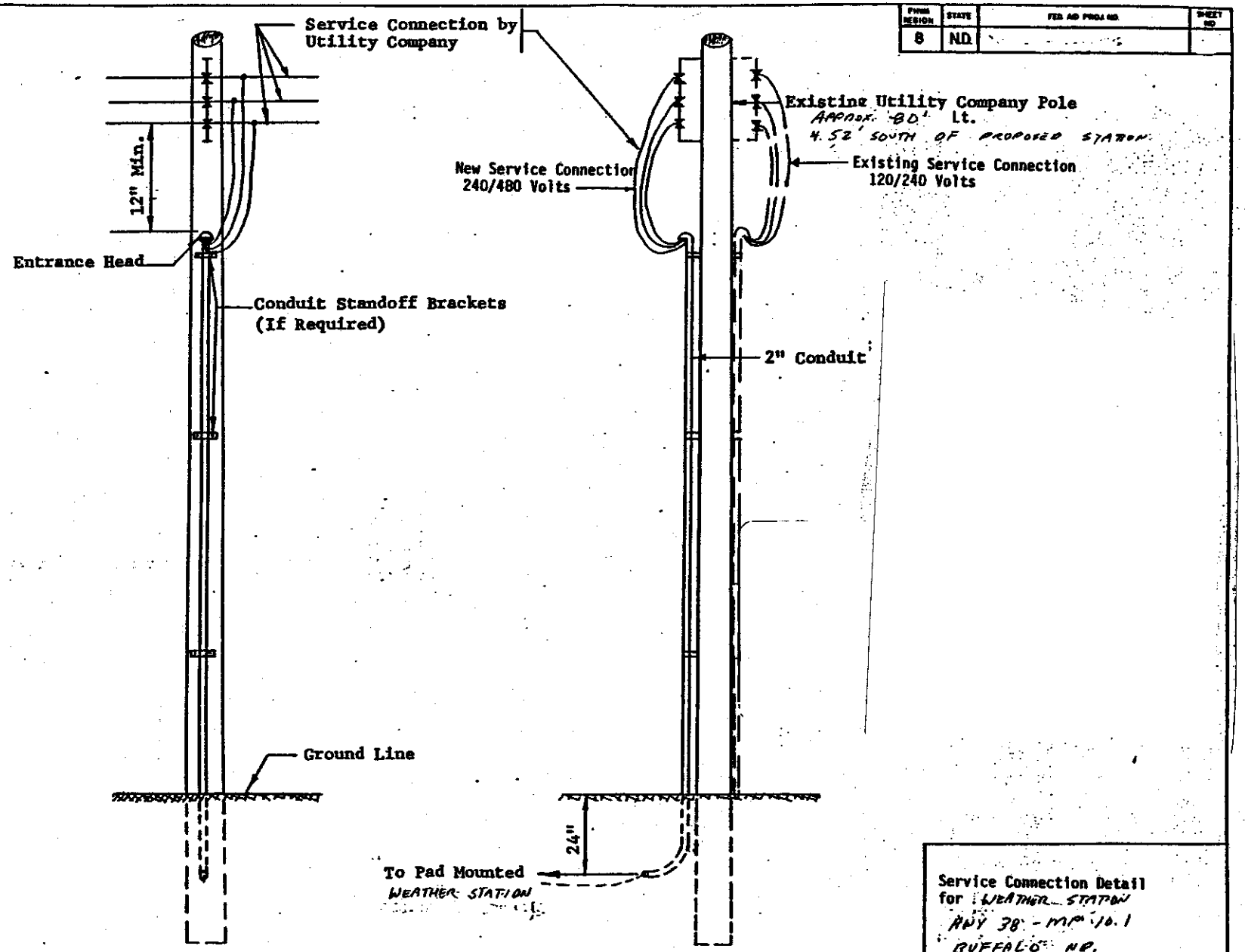
FHWA REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	N.D.		



Service Connection Detail
for WEATHER STATION
Sta. 295+42.5 Lt.

Fargo, ND

FHWA REGION	STATE	FED AID PROJ NO.	SHEET NO
8	N.D.		

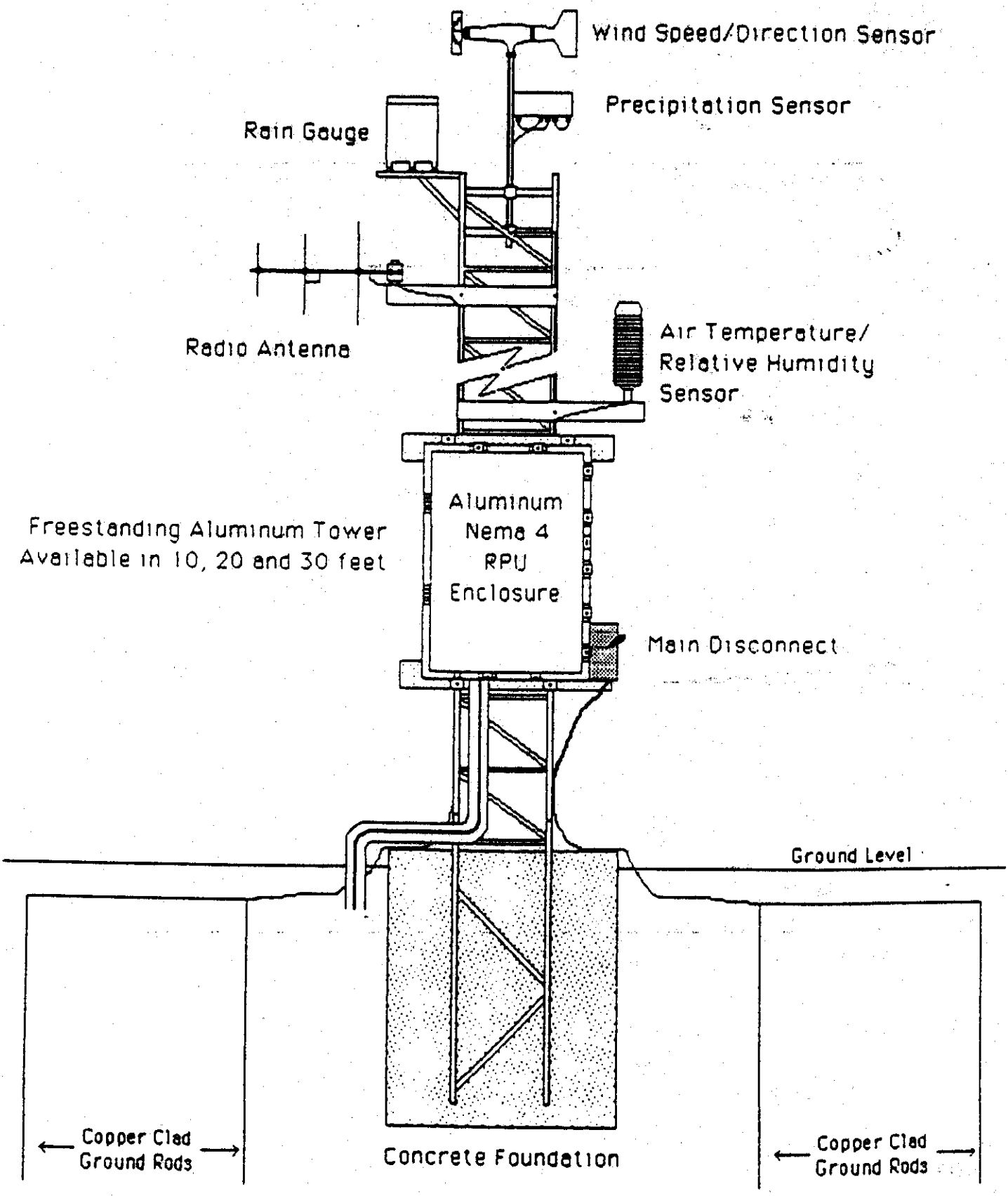


Service Connection Detail for Weather Station
Hwy 38 - MP 10.1
Buffalo, N.D.

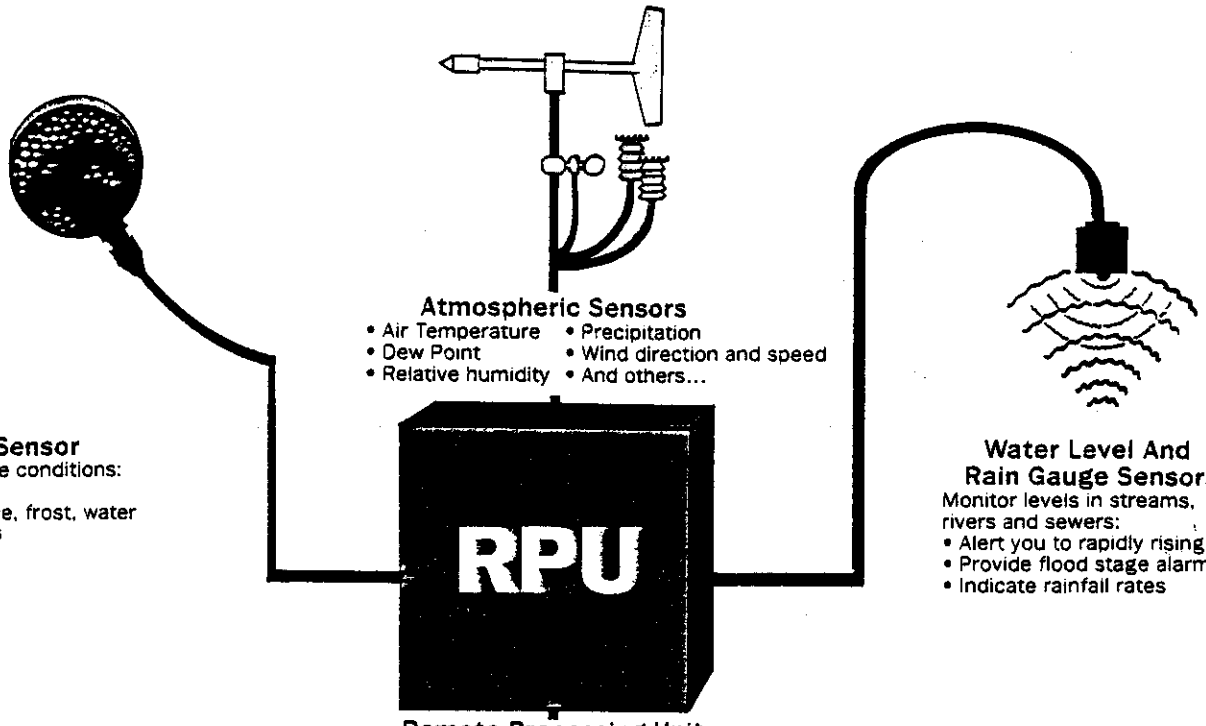
Appendix C

Typical Highway Remote Processing Unit (RPU)

Showing Radio Communications



SCAN® SYSTEMS

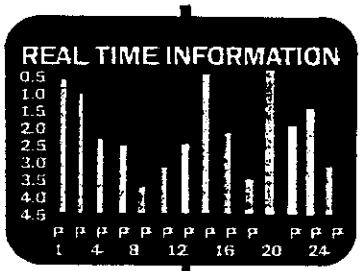


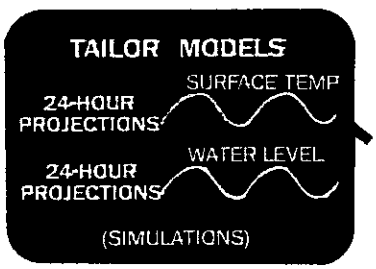
Atmospheric Sensors
- Air Temperature
- Dew Point
- Relative humidity
- Precipitation
- Wind direction and speed
- And others...

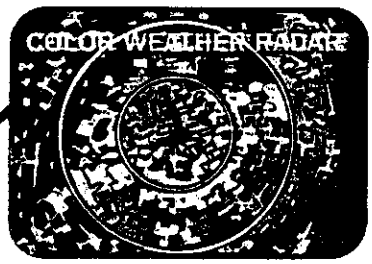
Surface Sensor
Monitors surface conditions:
- Temperature
- Presence of ice, frost, water and chemicals

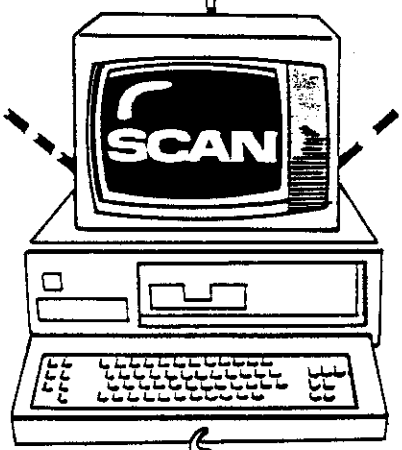
Water Level And Rain Gauge Sensors
Monitor levels in streams, rivers and sewers:
- Alert you to rapidly rising levels
- Provide flood stage alarms
- Indicate rainfall rates

Remote Processing Unit
Collects and transmits sensor data





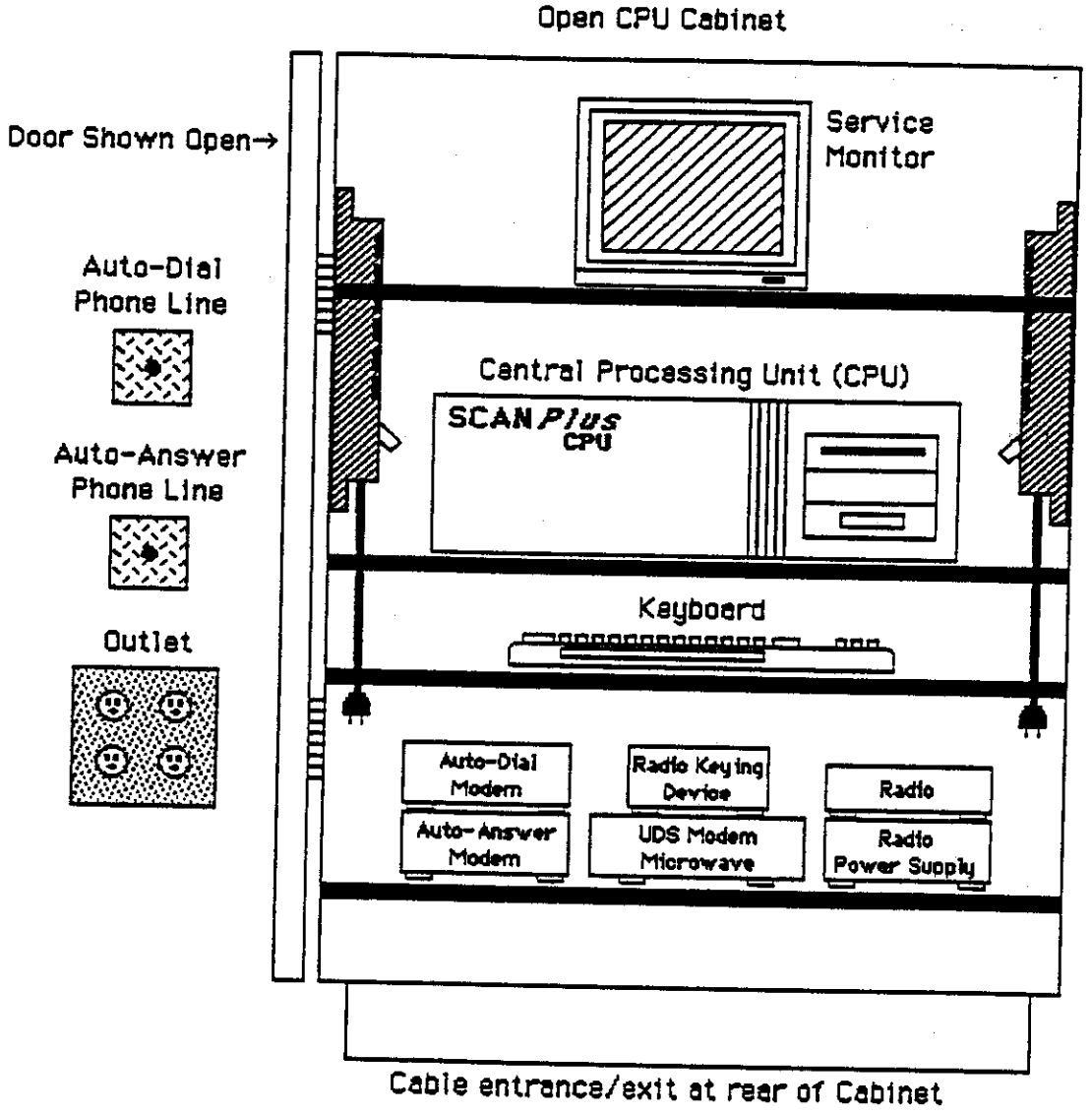


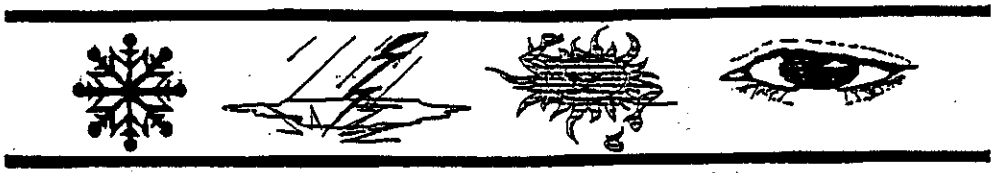


Access Weather Information From Nationwide Computer Data Base
- Snow and ice warnings
- Severe storm warnings
- Weather maps
- Public and pilot weather

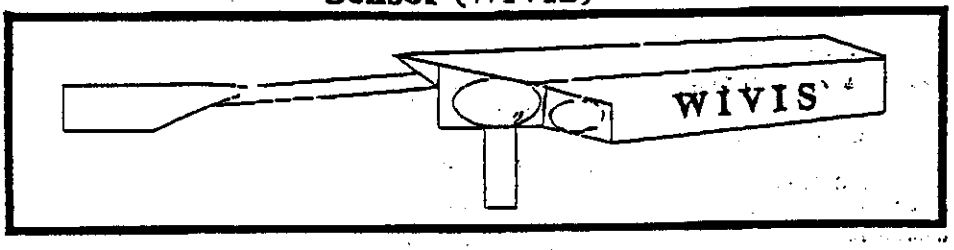
SSI® surface systems, inc.
2605 s. hanley rd.
st. louis, missouri 63144
[314] 781-5320
[800] 325-7226

Data Handler with Central Processing Unit





Weather Identifier and VISibility Sensor (WIVIS)



- **Type of precipitation detection**
- **Intensity of precipitation (rain and snow)**
- **Measurement of precipitation**
- **Measurement of visibility**

SCAN® Road Weather Information System (RWIS) Features

- Automatic Identification of precipitation types: Rain, Snow, Drizzle, and Mixture (Rain/Snow)
- Measures true dynamic precipitation rate range
- Fast resolution rate, even in light precipitation
- Highly accurate for all Intensities of precipitation
- Positive Indentification Of Precipitation State (Yes/No)
- Measures snowfall intensity
- Insensitive to background light, evaporation & splash
- Completely automatic/unattended operation
- Rugged modular design and very reliable
- No moving part - all solid state - long life
- Eye safe long life LED source

Available To Surface Transportation Agencies ONLY From SURFACE SYSTEMS, INC. (SSI)