COMMONWEALTH OF PENNSYLVANIA
Department of Transportation

RESEARCH PROJECT NO. 90-056

ICE DETECTON SYSTEMS FOR
THE CITY OF PHILADELPHIA

CONSTRUCTION REPORT
OCTOBER 1997

Prepared by:
L. J. Bender, Jr.
City of Philadelphia, Department of Streets

PENNSYLLVANIA DEPARTMENT OF TRANSPORTATION
BUREAU OF CONSTRUCTION AND MATERIALS
ENGINEERING TECHNOLOGY & INFORMATION DIVISION

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. PB98-137664	2. Report Date: October 1997	3. Report Type and Dates Covered: Construction Report Jan. 1992 to April 1992

4. Title and Subtitle
RP 90-056 ICE DETECTION SYSTEM FOR THE CITY OF PHILADELPHIA

5. Funding Numbers
RP 90-056

6. Author(s)
L. J. Bender, Jr., P.E.

7. Performing Organization Name(s) and Address(es)
City of Philadelphia
Department of Streets
7th Floor – Municipal Services Building
1401 JFK Boulvard
Phildelphia, PA 19102-1900

8. Performing Organization Report No.
RP 90-056

9. Sponsoring/Monitoring Agency Name(s) and Address(es)
U.S. Dept of Transportation
FHWA
400 – 7th Street, SW
Washington DC 20590

Pennsylvania Department of Transportation
Bureau of Planning and Research
Division of Research
555 Walnut Street - 6th Floor Forum Place
Harrisburg PA 17101-1900

10. Sponsoring/Monitoring Agency Report Number
FHWA-PA-97-006+90-056

11. Supplementary Notes
Program Manager: Gerald Malasheskie P.E. Organization: Engineering Technology & Information Div.
Project Manager: John J. Hughes Engineering Technology Section

12a. Distribution / Availability Statement
Available from National Technical Information Service,
Springfield, VA

12b. Distribution Code

13. Abstract (Maximum 200 words)
This report evaluates the performance of an ice detection system installed on three bridge structures in the City of Philadelphia, Pennsylvania. The bridges are located on Bells Mill Road over Wissahickon Creek, Penrose Avenue (Platt) Bridge over Schuylkill River, and Pine Road Bridge over Pennypack Creek. This Construction Report describes the instruments, material and installation procedures used for the SCAN System 16, Marketed by Surface Systems, Inc., St Louis, MO.

14. Subject Terms	15. No. of Pages: 33
	16. Price Code

17. Security Classification of Report	18. Security classification of this Page	19. Security Classification of Abstract	20. Limitation of Abstract
None	None	None	

BLANK PAGE

RESEARCH PROJECT No. 90-056

ICE DETECTION SYSTEM FOR THE CITY OF PHILADELPHIA

CONSTRUCTION REPORT FEBRUARY 1994

CONDUCTED

BY

L. J. BENDER Jr.

CITY OF PHILADELPHIA DEPARTMENT OF STREETS
HIGHWAY DIVISION, CONSTRUCTION UNIT

This work was sponsored by the City of Philadelphia and the Federal Highway Administration. The contents of this report reflect the views of the author who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or the policies of the state or federal highway administration. This report does not constitute a standard, specification, or regulation. The Pennsylvania Department of Transportation and the Federal Highway Administration do not endorse products, equipment, processes, or manufacturers. Trademarks or manufacturers names appear herein only because they are considered essential to the object of this report.

BLANK PAGE

Metric Conversion Factors*

To Convert From:	To:	Multiply By:
Length		
foot (ft)	meter (m)	0.3048
inch (in)	millimeter (mm)	25.4
yard (yd)	meter (m)	0.9144
mile (statute)	kilometer (km)	1.609
Area		
square foot (ft^2)	square meter (m^2)	0.0929
square inch (in^2)	square centimeter (cm^2)	6.451
square yard (yd^2)	square meter (m^2)	0.8361
Volume		
cubic foot (ft^3)	cubic meter (m^3)	0.02832
cubic yard (yd^3)	cubic meter (m^3)	0.00315
gallon (U.S. liquid)	cubic meter (m^3)	0.004546
ounce (U.S. liquid)	cubic centimeter (cm^3)	29.57
Mass		
ounce-mass (avdp)	gram (g)	28.35
pound-mass (avdp)	kilogram (kg)	0.4536
ton (metric)	kilogram (kg)	1000
ton (short, 2000 lbm)	kilogram (kg)	907.2
Density		
pound-mass/cubic foot	kilogram/cubic meter (kg/m^3)	16.02
mass/cubic yard	kilogram/cubic meter (kg/m^3)	0.5933
pound-mass/gallon(U.S.)**	kilogram/cubic meter (kg/m^3)	119.8
pound-mass/gallon(Can.)*	kilogram/cubic meter (kg/m^3)	99.78
Temperature		
deg Celsius (°C)	kelvin (°K)	$t^{\circ K} = (t^{\circ C} + 273.15)$
deg Fahrenheit (°F)	kelvin (°K)	$t^{\circ K} = (t^{\circ F} + 459.67) / 1.8$
deg Fahrenheit (°F)	deg Celsius (°C)	$t^{\circ C} = (t^{\circ F} - 32) / 1.8$

* The reference source for information on SI units and more exact conversion factors is "Metric Practice Guide" ASTM E380.

** One U.S. gallon equals 0.8327 Canadian gallon.

BLANK PAGE

TABLE OF CONTENTS

BLANK PAGE

Introduction

During the winter months the Philadelphia Department of Streets is faced with a special problem relating to the safety of the motoring public, namely icing conditions on roads. Bridges are especially vulnerable to this condition because of their open construction which results in sudden changes in temperature of the structure materials and thus increased probability of an icing condition.

Over the past five years the Department has looked at several strategies to improve the data gathering and response time in combating this problem. One technique which seems to have merit is the Scan Detection System (SCAN) manufactured by Surface Systems, Inc., which through the use of pavement detectors provides early warning of potential icing conditions which can be transmitted to regional or central emergency control centers.

This research project was performed as part of FAM Project No. W36-G181-004 (Improvement of Bells Mill Road). The prime contractor was Tony De Paul & Sons. The subcontractor was Carr and Duff. Notice to Proceed was issued August 13, 1990 and work was completed April 30, 1992.

Objective

The purpose of the research project is to document and analyze under actual field conditions the reliability and usefulness of an ice detection system.

Project Description and Location:

The project involved the installation of the ice detection surface sensors at three bridge locations as follows:

1. Bells Mill Road Bridge is No. 340 a stone twin arch bridge with a span of 230 feet, roadway width of 24 feet - 3 inches and no sidewalks. This structure was built in 1820. (G181)

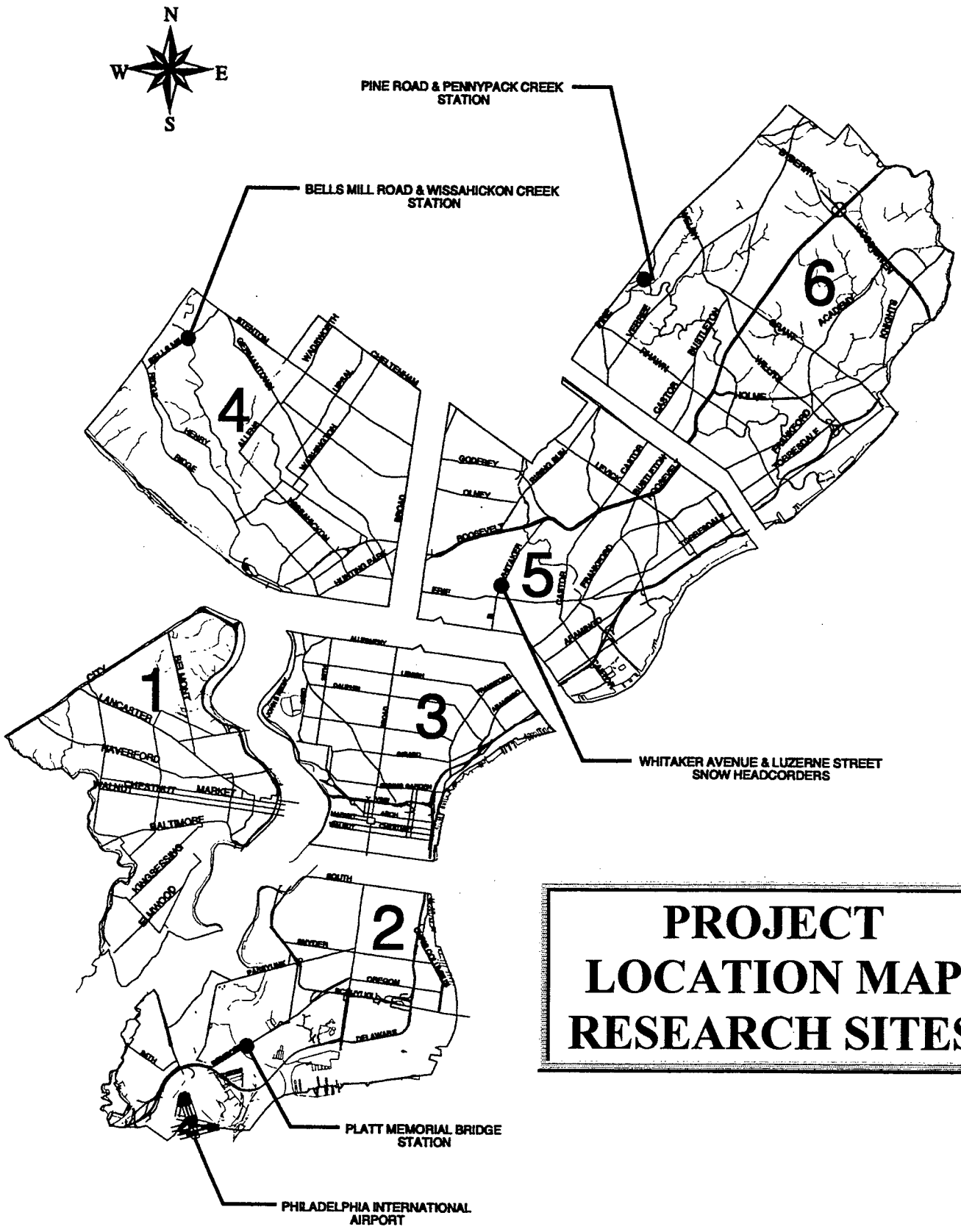
2. Penrose Avenue (Platt) Bridge is Bridge No. 108 concrete on steel cantilevered truss with concrete on steel approach spans. Total length of the bridge deck is 8,793 feet, roadway width 48 feet, and a sidewalk width of 12 feet. This structure was built in 1937. (PA291)

3. Pine Road Bridge is Bridge No. 205 concrete on steel with a span of 80 feet, roadway width of 44 feet – 1 inch and a sidewalk width of 13 feet. This structure was built in 1974. (G121)

The sensors were placed in the bridge decks since this is the road surface most likely to be affected first by ice formation.

There was a Remote Processing Unit (RPU) installed at each bridge location and one Central Processing Unit (CPU) installed at the Department's Highway Garage located at 4040 Whitaker Avenue which serves as the Winter Storm Emergency Center during a snow emergency.

CITY OF PHILADELPHIA
WEATHER SENSOR NETWORK



PROJECT LOCATION MAP RESEARCH SITES

Materials

The ice detection system proposed for this research project consisted of proprietary equipment specifically developed for ice detection. The SCAN System 16, marketed by Surface Systems, Inc., St Louis, Missouri was selected for evaluation during this study.

The SCAN System 16 included the following:

- Surface sensors were placed in the roadway which transmitted surface conditions to a Remote Processing Unit (RPU), see Appendix A, A1 & A2.

- Miscellaneous wind speed, humidity, air temperature, and precipitation sensors, see Appendix A, A3 to A5.

- A remote processing unit was placed one at each bridge site which receives data from the surface sensors and relays this information to the central processing unit, see Appendix A, A6.

- Central processing unit located at the Highway Garage which received and displayed the data received from the remote processing units, see Appendix A, A7.

- Radio Transmitter, antennas on Platt Bridge and an antenna at the Philadelphia Airport, see Appendix A, A8 & A9.

Construction

Construction started in October of 1990, and was completed in April of 1992. Installation of the system at Location 1 and Location 3 was uneventful.

Location #1: Bells Mill Road Bridge over
Wissahickon Creek

Location #3: Pine Road Bridge over
Pennypack Creek

On each of the above referenced bridge decks, a hole was drilled in the deck large enough to hold the sensor flush with the roadway, as shown in Photo's #1 and #2. A smaller hole was then drilled to allow the wires to pass through the deck. The sensors were then placed in the deck or roadway and held in place with epoxy. In the roadway, a groove was cut with a concrete saw to carry the wires as shown in Photo #3. The groove was then sealed with epoxy as shown in Photo #4. The completed installation is shown in Photo #5. The rest of the work consisted of standard wiring, see Appendix B.

Bells Mills Construction Photographs

Photo #1 A hole is cored in the deck in preparation for placing SCAN System sensor.

Photo #2 Shows the sensor placed in the cored hole.

Bells Mills Construction Photographs

Photo#3 Shows the wire being placed in the pavement groove.

Photo #4 Shows the placement of the epoxy adhesive

Bells Mills Construction Photographs

Photo #5 Shows the completed sensor installation.

Sensors are manufactured in a range of colored hues from pure white to pure black. The sensor's color was selected to match the existing pavement color where they were placed.

Location #2: Penrose Avenue (Platt) Bridge over Schuylkill River.

Several problems arose that would delay the project completion for over a year at this location.

The first problem was that the R.P.U. unit required 120 volts. The voltage available on the bridge was 240 volts. This was solved by the addition of a 3KUA single-phase 480/240 to 240/120 volt transformer at an additional cost of $1,350.00.

During the design phase of the project, Bell Telephone had promised the City of Philadelphia that they could provide a telephone line to two R.P.U. units to be installed on the bridge. After the units were installed, Bell Telephone was unable supply service.

The City of Philadelphia was forced to collect data from these R.P.U. units by radio. Two (2) transmitters and antennas were installed on the bridge. These transmitted the data to Philadelphia International Airport that also has a SCAN Ice Detection System. The Highway Division Winter Storm Emergency Center could then access this data via telephone.

In order to install the transmitters, the City of Philadelphia was required to obtain a Federal Communications Commission License to operate them. This was not obtained until January 21, 1992, and work was not completed until April, 1992.

A copy of the contract specification that the contractors bid on is presented in Appendix C.

Project Costs

Anticipated Cost

The anticipated costs for the three (3) installations were $162,800.00 as estimated below:

Location #1 including monitoring equipment	$57,000.00
Location #2	$70,800.00
Location #3	$35,000.00
Total	**$162,800.00**

The estimates were based on costs supplied by Surface Systems, Inc., St Louis, Missouri, and were obviously not applicable to the City of Philadelphia labor market.

Actual Cost

The actual cost for the three (3) installations were $275,680.45, as indicated below:

Location #1 including monitoring equipment		$115,000.00
Location #2	Bid Price	$95,000.00
	Transformer	$1,350.00
	Transformer and Antennas	$22,330.45
	Total Location 2	**$118,680.45**
Location #3		$42,000.00
	Total Cost	**$275,680.45**

APPENDIX A

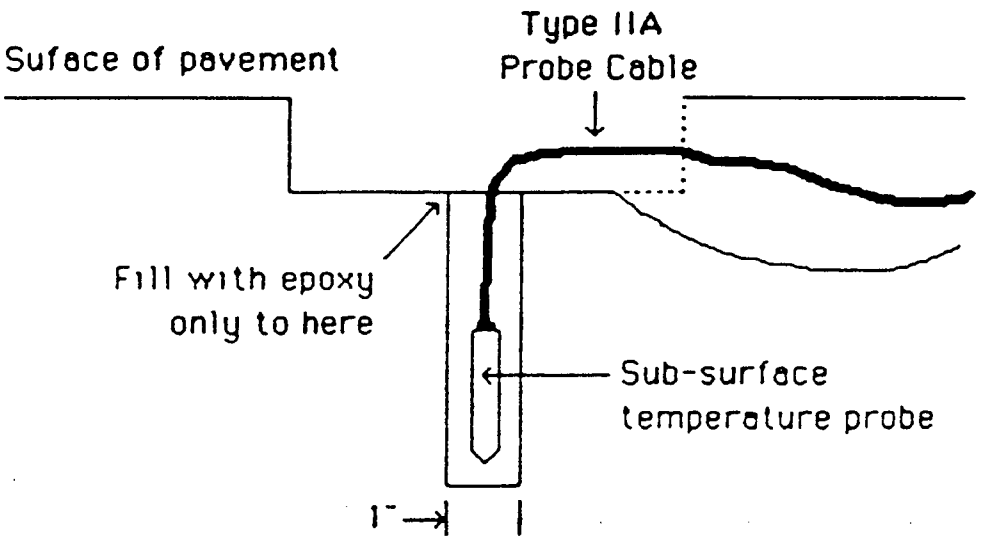
MATERIAL DESCRIPTIONS

SURFACE SENSOR
SSI Model #16201D

The sensor mounts in the pavement and emits electronic signal information about pavement conditions. The sensor head shall be a single unit, solid state, thermally passive, and constructed of a material with sufficient strength and durability to function as a stable system over a range of temperatures from $-22^{o}F$ to $+176^{o}F$, and its performance shall not be degraded by climatic conditions. The temperature sensing element shall be accurate to $+/- .5^{o}F$ over the temperature range of $-22^{o}F$ to $+122^{o}F$. Vehicle traffic impacts shall not deteriorate the sensor head or degrade performance. The sensor head shall be self-contained and not require adjustment after initial installation in the pavement. The sensor head shall be designed for flush mounting in the pavement, have thermal characteristics similar to the most commonly used road surface materials, and approximate the pavement surface texture and color. The head shall be supplied with an input-output cable which is waterproofed and sealed to the head as an integral part of the assembly. Sensor head performance shall not be degraded by the use of ice control chemicals.

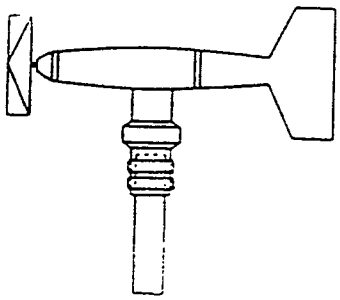
The sensor head shall be capable of proper operation at cable lengths of up to 2500 feet from the RPU.

SUB-SURFACE TEMPERATURE PROBE
SSI Model #S16UG



The Sub-Surface Temperature Probe mounts in the pavement and emits electronic signal information about pavement conditions. The probe is a single unit, solid state, thermally passive, and constructed of a material with sufficient strength and durability to function as a stable system over a range of temperatures from -22°F to +176°F, and its performance shall not be degraded by climatic conditions. The temperature sensing element shall be accurate to +/- .5°F over the temperature range of -22°F to +122°F. The probe shall be self-contained and not require adjustment after initial installation. The probe is designed for mounting in the pavement either under a surface sensor or alone, at a depth of 16 inches. The probe shall have thermal characteristics similar to the most commonly used road surface materials. The probe shall be supplied with an input-output cable which is waterproofed and sealed as an integral part of the assembly.

The probe shall be capable of proper operation at cable lengths of up to 2500 feet from the RPU.



WIND MONITOR

Originally developed for ocean data buoy use the Wind Monitor is well suited for a wide variety of wind measuring applications. Simplicity and lightweight corrosion resistant construction were principal design considerations. Slip rings and brushes have been eliminated resulting in improved reliability with lower cost.

The wind speed sensor is a helicoid shape propeller molded of polypropylene plastic. The propeller is four blade, 18 cm diameter x 30 cm pitch with a distance constant of 3.3 meters (10.5 feet). Threshold of the propeller is 0.4 m/s (0.9 mph). Rotation of the propeller produces an a.c. sine wave voltage signal with frequency directly proportional to wind speed. The a.c. voltage signal is induced in a centrally mounted coil by a six pole magnet mounted on the propeller shaft. The coil is located on the non-rotating central portion of the main mounting assembly, eliminating the need for slip rings and brushes.

The vane assembly has a threshold below 0.8 m/s (1.8 mph) with a damping ratio of 0.23. Vane position is transmitted through a coupling to a precision conductive plastic potentiometer which is located in a sealed chamber in the center of the main housing just below the wind speed transducer coil. The potentiometer requires a regulated excitation voltage. With a constant voltage applied to the potentiometer element, the output signal is an analog voltage directly proportional to azimuth angle.

All transducer leads terminate in a junction box on the mounting post for convenience in making sensor cable connections. Four conductors are required. The tail assembly is thermoformed of rigid U.V. stabilized plastic. The main housing, nose cone assembly, and other internal parts are injection molded. Propeller shaft bearings and the vertical shaft bearings are stainless steel precision grade ball bearings. The instrument mounts on standard 1 inch iron pipe – outside diameter 34 mm (1.34").

A sensor interface circuit card is available for adapting the wind speed signal to an analog d.c. recorder or data logger. The circuit converts the a.c. wind speed signal to an analog d.c. voltage which is directly proportional to wind speed. Output is precalibrated to 0-5 volts d.c. equal to 0-50 m/s. Other output levels can be supplied. The circuit also provides a square wave pulse output at the same frequency as the sine wave input. The 25 x 25 x 60 mm (1 x 1 x 2.4 inch) two card package is designed for low power (1 mA@ 12 Vd.c. typical) and wide temperature range – 40 to + 85 C°.

A line driver circuit is available for using the Wind Monitor with long sensor lines. This circuit converts the wind speed and wind direction signals to proportional analog current outputs. These outputs are ideal for driving lines longer than 900 m (3000 ft.) up to several km. Signal error due to line drop is less than 1% over a temperature range of – 40 to + 40 C°. This circuit is also available with 540° azimuth range. The line driver is housed in a weatherproof plastic case 160 x 80 x 55 mm (6.3 x 3.2 x 2.2"). 12 Vd.c. supply voltage is required.

SPECIFICATIONS: MODEL 05103 WIND MONITOR

RANGE:
- Wind Speed – 0-60 m/s (134 mph).
- Survival – 80 m/s (180 mph).
- Azimuth – 360° mechanical, 355° electrical (5° open).

THRESHOLD:*
- Threshold sensitivity of propeller 0.4 m/s (0.9 mph)
- Threshold sensitivity of vane 0.8 m/s (1.8 mph).

DYNAMIC RESPONSE:*
- Distance constant (63% recovery) of propeller 3.3 m (10.5 feet).
- Delay distance (50% recovery) of vane 1.3 m (4.3 feet).
- Damping ratio of vane 0.23
- Damped natural wavelength of vane 7.2 m (23.6 feet).

SIGNAL OUTPUT:
- Wind Speed – magnetically induced a.c. voltage. Three sine wave voltage pulses per propeller revolution. 1800 rpm (90 Hz) = 8.8 m/s (19.7 mph)
- Azimuth – analog d.c. voltage from precision low torque conductive plastic potentiometer (requires regulated excitation voltage). Resistance 10k ohms, linearity 0.25%, life expectancy 20 million revolutions (2-4 years).

POWER REQUIRED:
- 5 to 15 Vd.c. regulated supply voltage recommended for potentiometer excitation. Sensor interface and line driver circuits require 12 Vd.c. (nominal).

DIMENSIONS:
- Overall height 37 cm (14.6 inches). Overall length of main housing, including vane and propeller 55 cm (21.7 inches). Fin size 24 cm (9 4 inches) high x 14 cm (5.5 inches) long. Propeller diameter 18 cm (7.1 inches). Diameter of main housing 5 cm (2.0 inches). Mounts on standard 1 inch iron pipe – outside diameter 34 mm (1.34 inches).

WEIGHT:
- Sensor weight 1.5 kg (3.2 lbs). Shipping weight approximately 2.5 kg (5.5 lbs).

THIES RELATIVE HUMIDITY SENSOR/SSI AIR TEMPERAURE SENSOR
Model #1.1000.51.551/052-44018-2.5

The Thies Relative Humidity Sensor and the SSI Air Temperature Sensor are housed inside the wind/solar radiation shield.

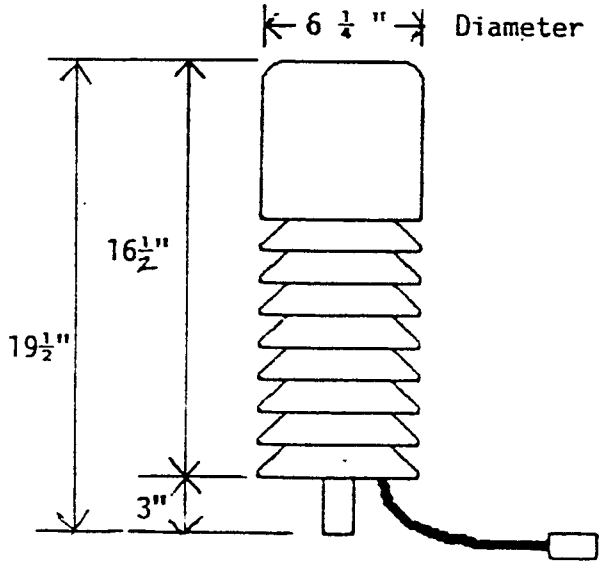
THIES RELATIVE HUMIDITY SENSOR

The sensor is a hygrometer type measuring the change in length of a specially prepared hair, with the change in humidity.

Measuring Range:	10 to 100% relative humidity
Accuracy at 70°F:	+/- 5% relative humidity
Scale Length:	3.7"
Graduation:	1% relative humidity
Load:	maximum 2 Watts
Ambient Temp:	-31 to 158° F
Weight sensor & shield:	6.5 lbs.
Output (VDC):	0-1 VDC

AIR TEMPERATURE SENSOR

The Air Temperature Sensor is constructed of materials with sufficient strength and durability to function as a stable system over a temperature range of -22 to +176° F. The temperature sensing element shall be accurate to +/- .5° F over the temperature range of -22° to +122° F. Sensor performance shall not be degraded by climatic conditions.



RUDOLPH PRECIPITATION SENSOR
Model #IRSS88

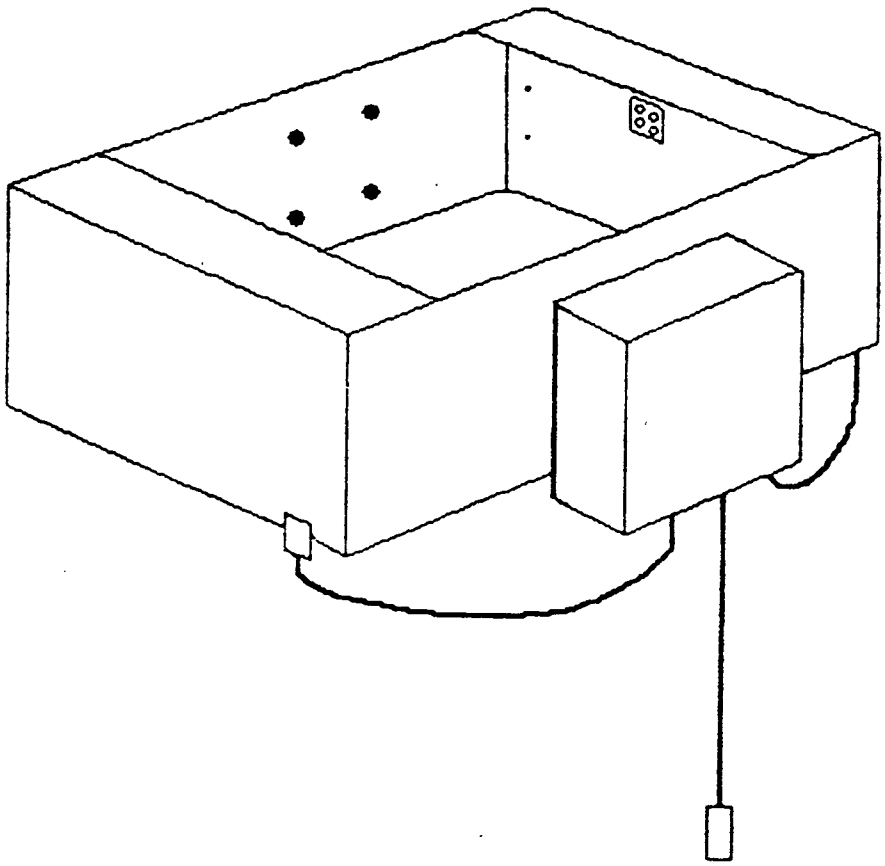
Sensing Principle:	Dual-beam IR-Sensor
Sensing Area:	ca. 4.7 x .98 inches
Operating Voltage (Vcc):	3.15 VDC
Operating Current (Icc):	200 mA maximum

Signal Outputs

Output 1 (POUT):	1 pulse/event. Active High V out = > +9 V < Vcc
Output 2 (SOUT):	Weighted signal output Active High V out = > +9 V < Vcc Selectable (suppressed) events before responding from 1 to 15
Output 3 (SACT):	Sensor active. Active High V out = > +9 V < Vcc

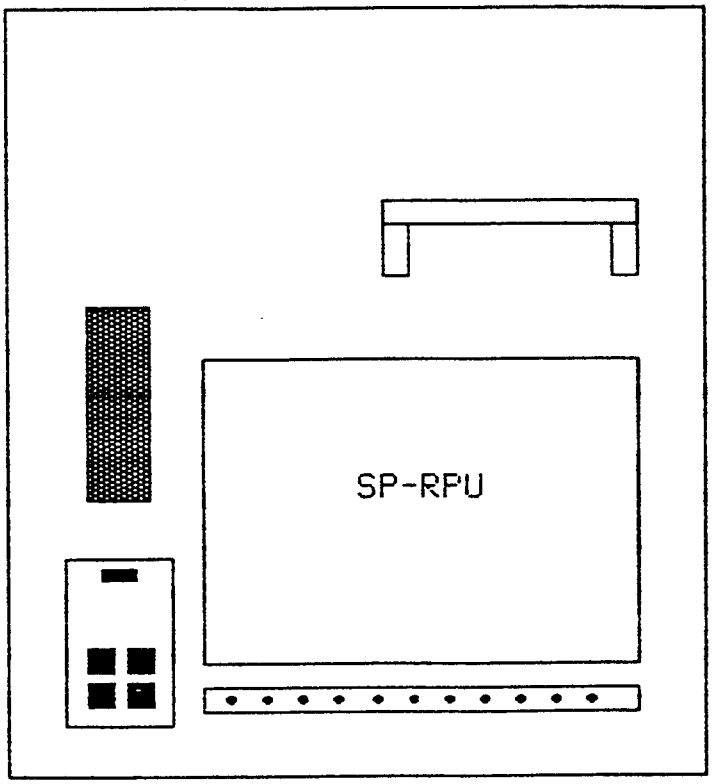
Sensor outputs are open collector pnp types, hence 10k ohm pull-down resistors are installed at the end of the line to obtain valid logic levels. All outputs are short-circuit protected.

Operating Temperature:	-4 to +140°F
Case:	Stainless Steel
Dimensions:	7.67 x 6.49 x 3.35 inches
Weight:	ca 4.40 lbs.
Mounting:	2 stainless steel u-bolts to fit a horizontal or vertical 1" conduit



REMOTE PROCESSING UNIT - RPU
SSI Model #SP-RPU

Power Requirements	100-130 VAC, 50-60 Hz or 200-600 VAC, 50-60 Hz 100 Watts Continuous
Lightning Protection	Power and all inputs are protected against lightning
Operating Range	$-22^{o}F$ to $150^{o}F$
Communications Methods	RPUs communicate to CPUs via: 1) Leased line or private dedicated line 2) Two-way radio 3) PSTN standard dial telephone exchange line



Not to Scale

SCAN Colorterm Software License, Model #PC-CTS

The SCAN Colorterm Software, optionally provided for a Compaq Deskpro 386s, is a terminal program for displaying surface and atmospheric conditions in high-resolution color graphics and text. The Long-Term Histories feature displays historical records of the conditions and temperatures of the sensors from data stored in the Compaq Deskpro 386s from several winter season.

SCAN Color Map Software License, Model #MAP

The SCAN Map, optionally provided for a Compaq Deskpro 386s is a graphics program that can be added to the Colorterm program, displaying high-resolution color maps of a roadway or airfield runway systems showing sensor locations and their current statuses.

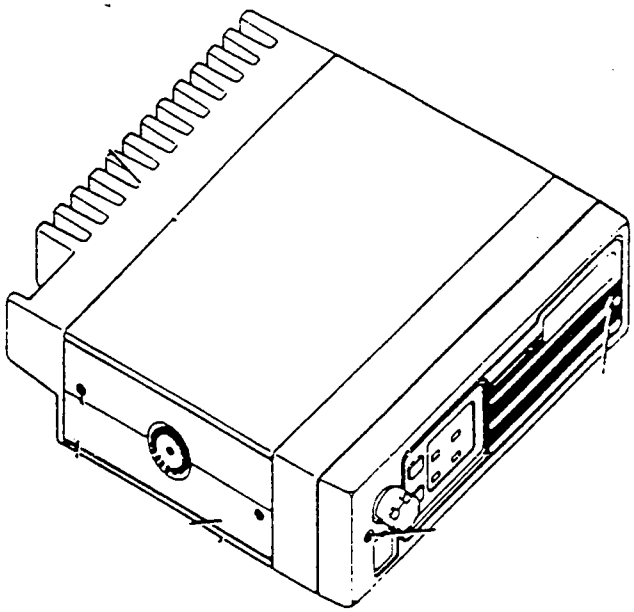
Weather-View Software License, Model #WX-VIEW

The Weather-View program displays color radar and satellite pictures using Compaq Deskpro 386s equipment or compatible. This displays superimposed images of precipitation (radar) and cloud cover patterns of incoming weather systems that can be stored and rechecked to watch movement, build-up or dissipation of weather patterns.

SCAN CPU Software License, Model #SCAN+Plus

The SCAN+Plus CPU Software Package, standard with all SCAN Systems, runs in both the Remote Processing Unit(s) and the Intel Model #386 Central Processing Unit. It is the heart of the system. The software continually gathers sensor data at the RPU, transmits it to the SCAN+Plus CPU, analyzes it, and puts it in text form to present it to the terminals. If power outages occur the software re-boots and brings the system back on line automatically.

MOTOROLA RADIUS VHF RADIO
Model #D34LRA73A5-K



General

Band:	VHF	
Model Series:	D33LRA	
Typical RF Output:	25W	
Frequency:	136-162 MHz 146-174 MHz	
Dimensions (H x W x L):	2" x 7" x 7¾" (50.8 x 178 x 198mm)	
Primary Voltage Input:	13.8 VDC	
Weight:	61 oz. (1.73 kg)	
Typical Current Drain Receive (SW):	1.5A	
Transmit:	7.0A	
Standby:	400mA	
Channel Capability:	Radius M100: 2 channels; Radius M206: 6 channels; Radius M214: 14 channels	
Squelch Capability:	Private-Line, Digital Private-Line coded squelch and/or carrier squelch	

Transmitter

Spurious & Harmonic Emissions:	-57 dB (25W) -60 dB (40W)
Frequency Stability: (-30°C to +60°C, 25°C ref.)	±0.0005%
Modulation:	
Maximum Frequency Separation (MHz):	12 MHz
Audio Distortion:	5% measured per EIA
Output Impedance:	50 Ohms
Modulation Sensitivity:	80 mV rms for 60% maximum deviation at 1000 Hz

Receiver

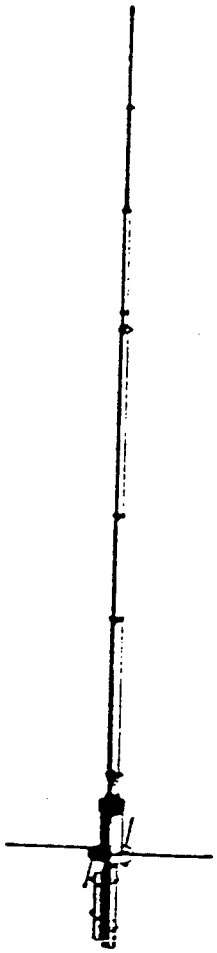
Channel Spacing:	30 kHz
Sensitivity 12 dB SINAD:	0.30 µV
Intermodulation EIA SINAD:	75 dB
Spurious & Image Rejection:	75 dB
Selectivity EIA SINAD:	75 dB
Audio Ouput:	3W (5W with optional external speaker) @ less than 5% distortion
Frequency Stability (-30°C to 60°C, 25°C ref.)	± 0.0005%
Maximum Frequency Separation (MHz):	12 MHz
Input Impedance:	

VHF HUSTLER-ANTENNA
Model #G7-150-4

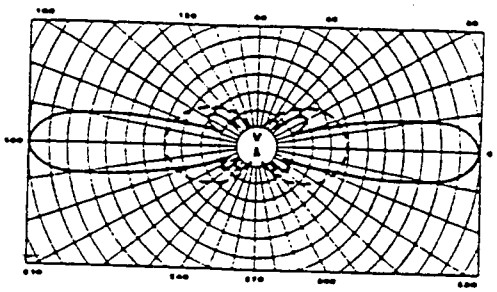
G7-150 Series

148-174 MHz

Omnidirectional Fixed Station



G7-150 Series



E-Plane

- Ideal for fixed or repeater applications.
- Low angle radiation for optimum signal.
- Constructed of high strength aluminum and fiberglass.
- Totally self-supporting design.

SPECIFICATIONS

ELECTRICAL

Maximum power input	1 Kw. FM
Gain	7 dBd
VSWR	3 MHz under 1.5:1
Bandwidth	6 MHz for 2:1
Impedance	50 ohms nominal
Lightning protection	direct ground
Termination	Type N female

MECHANICAL

Length	15 feet 4 inches
Weight	10 lbs.
Wind survival	100 mph
Equivilent flat plate area	1.16 Ft^2
Lateral thrust	46 lbs. at 100 mph
Mounting	up to 2 inch mast

Epoxy Setting Compound
Model #19-9885-533

The compound is a self-levelling sealant used to encapsulate and seal traffic vehicle loop detector wire embedded in asphaltic concrete or Portland cement concrete. The epoxy sealant is a two-component type compound which will adhere to clean concrete or asphalt surfaces and cure to a tough resilient material. Specify whether you are making an installation in concrete or asphalt.

(A) Component A is an epoxy resin with the following characteristics:

Property	Viscosity at 77° F (25° C)
Specific Value	100 - 1200 cps.

(B) Component B is an epoxy resin with the following characteristics:

Property	Viscosity at 77° F (25° C)
Specific Value	100 - 3000 cps.

The two component epoxy is mixed in an OSTARR cartridge and is pre-measured. The mixed sealant shall have the following characteristics:

Gel time at 77° F (25° C)	10-20 minutes
Tack free slot hardening time at 77° F (25° C)	1 - 3 hours
Shore D hardness (ATSM D2240)	40 - 65
Tensil strength after 24 hours (ASTM D638)	400 P.S.I.

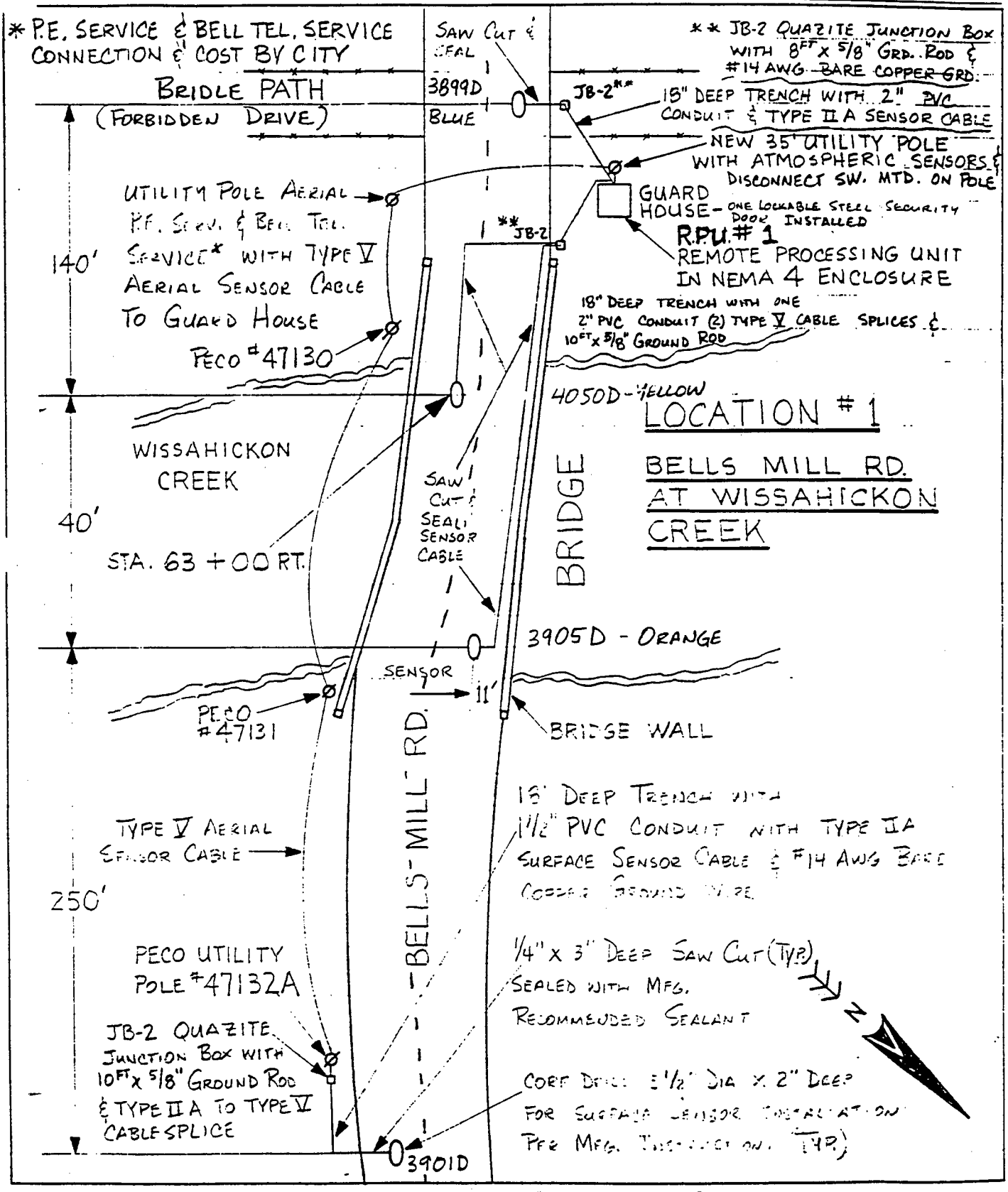
Elongation Percent (ASTM D638)	50% minimum	
Bond to concrete	excellent	
Bond to asphalt	good	
Freeze - thaw resistance	excellent	
Resistance to salt or gasoline	not affected	
Water absorption 24 hours at 77° F (25° C)		1.1% maximum
Dissipation factor at 60 cycles	.041	
10 cycles	.035	
Volume resistivety at room temperature	1.3 x 10	
at 150° F	1.1 x 10	
Dielectric constant at 60 cycles		
10	3.78	

APPENDIX B

AS BUILTS

CARR & DUFF
2100 Byberry Road
HUNTINGDON VALLEY, PA 19006
Phone: 672-4200
FAX: 441-8053

JOB _____
SHEET NO. BELLS MILL RD. SHEET 1 OF 1
CALCULATED BY _____ DATE 9/7/
CHECKED BY _____ DATE _____
SCALE NOT TO SCALE



BLANK PAGE

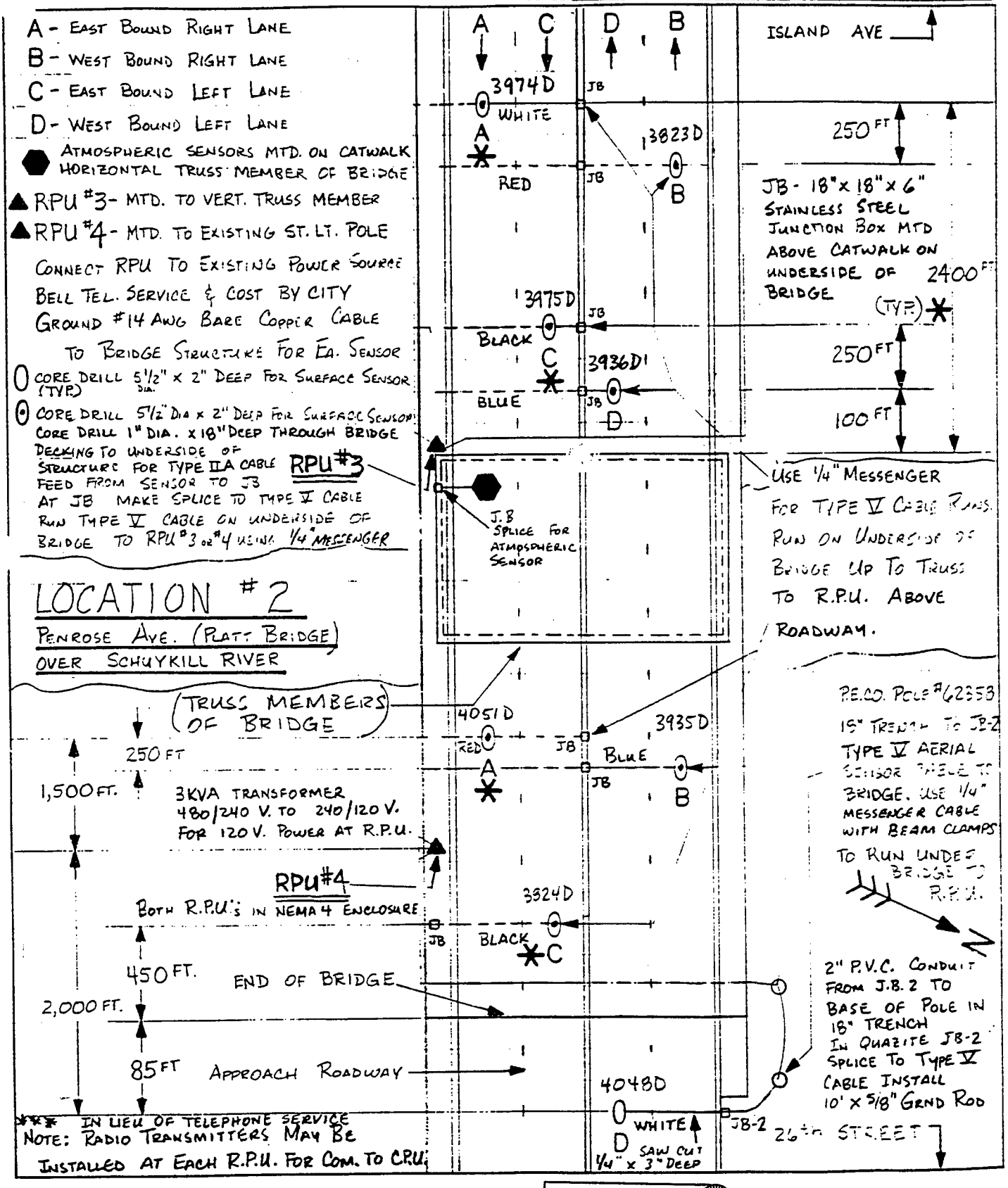
CARR & DUFF
2100 Byberry Road
HUNTINGDON VALLEY, PA 19006
Phone: 672-4200
FAX: 441-8053

JCE _____ SHEET NO. PENROSE AVE LAYOUT DWG OF _____
CALCULATED BY FJT DATE 5/3/00
CHECKED BY RWD DATE _____
SCALE NOT TO SCALE

A - EAST BOUND RIGHT LANE
B - WEST BOUND RIGHT LANE
C - EAST BOUND LEFT LANE
D - WEST BOUND LEFT LANE
⬢ ATMOSPHERIC SENSORS MTD. ON CATWALK HORIZONTAL TRUSS MEMBER OF BRIDGE
▲ RPU #3 - MTD. TO VERT. TRUSS MEMBER
▲ RPU #4 - MTD. TO EXISTING ST. LT. POLE
CONNECT RPU TO EXISTING POWER SOURCE
BELL TEL. SERVICE & COST BY CITY
GROUND #14 AWG BARE COPPER CABLE TO BRIDGE STRUCTURE FOR EA. SENSOR
○ CORE DRILL 5 1/2" DIA. x 2" DEEP FOR SURFACE SENSOR (TYP.)
⊙ CORE DRILL 5 1/2" DIA x 2" DEEP FOR SURFACE SENSOR CORE DRILL 1" DIA. x 18" DEEP THROUGH BRIDGE DECKING TO UNDERSIDE OF STRUCTURE FOR TYPE IIA CABLE FEED FROM SENSOR TO JB AT JB MAKE SPLICE TO TYPE V CABLE RUN TYPE V CABLE ON UNDERSIDE OF BRIDGE TO RPU #3 OR #4 USING 1/4" MESSENGER

LOCATION #2

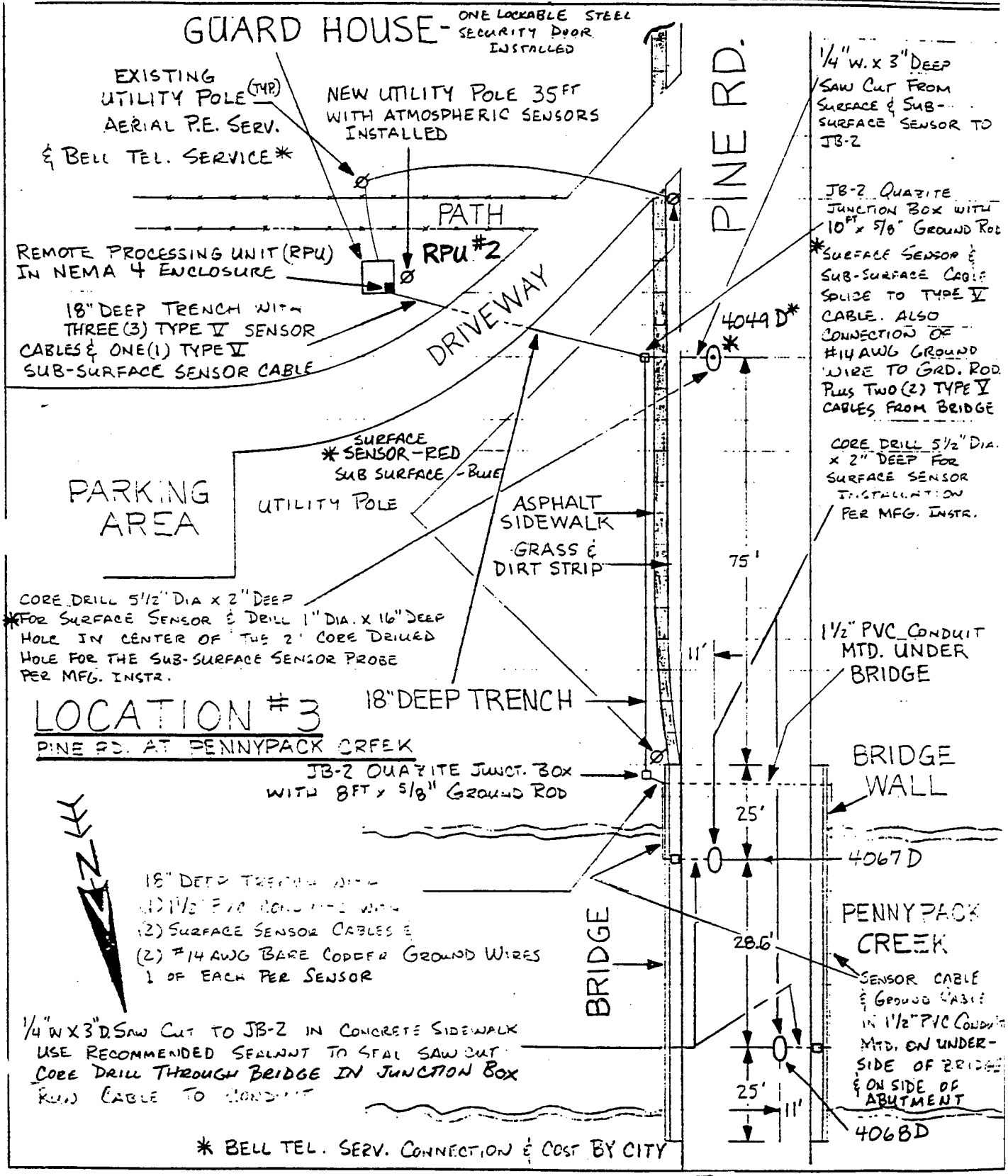
PENROSE AVE. (PLATT BRIDGE) OVER SCHUYKILL RIVER



*** IN LIEU OF TELEPHONE SERVICE NOTE: RADIO TRANSMITTERS MAY BE INSTALLED AT EACH R.P.U. FOR COM. TO C.P.U.

CARR & DUFF
2100 Byberry Road
HUNTINGDON VALLEY, PA 19006
Phone: 672-4200
FAX: 441-8053

JOB TONA VETRALLA & AL - BELLS MILL RD. E.D. FEE
SHEET NO. PINE RD. LAYOUT SHEET 1 OF 1
CALCULATED BY EJT DATE 9/6/90
CHECKED BY _____ DATE _____
SCALE NOT TO SCALE



APPENDIX C

BID SPECIFICATIONS

BLANK PAGE

ITEMS 2004-0201, 2004-0202, 2004-0203 ROADWAY CONDITION DETECTION SYSTEM

DESCRIPTION

This work shall consist of roadway surface and atmospheric devices designed to relay weather conditions at sites to a central monitoring station.

LOCATIONS

1. Bells Mill Road at Wissahickon Creek
2. Penrose Avenue (Platt Bridge) over Schuylkill River
3. Pine Road at Pennypack Creek

MATERIALS

Roadway surface sensors shall be able to withstand traffic loadings and shall have thermal characteristics similar to paving materials. The sensor shall be capable of reporting pavement surface temperature within a range of -20° to 120° F, pavement moisture, and presence of deicing materials on the pavement. The sensor shall be thermally passive, reacting to the environment and not inducing change in the surface condition during operation. The sensor shall be capable of operation at extended cable lengths up to 2500 feet.

Subsurface sensors shall be capable of reporting temperatures within a range similar to that of the surface sensor. The sensor shall be mounted at least 17 inches below the pavement surface.

Air temperature/relative humidity sensors shall detect temperature within a range of -10° to 100° F and humidity within a range of 10% to 100%. The sensor shall be mounted in a solar/wind radiation shield.

Precipitation sensors shall be capable of detection of any type of precipitation via infrared optical technology.

Wind speed/director sensors shall indicate a full range of direction and a velocity range up to 80 mph.

Remote processors shall be located at each site and shall gather data from the various sensors for transmittal to the central processor unit. The remote processor shall be connected to all sensors with waterproof cable. It shall be capable of stable operation within a temperature range of -20° to 150° F. A lockable, weatherproof and vandal-proof enclosure shall be provided to house the remote processor. It shall be connected to the central processor unit via telephone line modem.

The existing central processor unit shall be capable of collecting and handling data from multiple remote processors and shall be modified to accept new data from the three sites to be installed under these items. It shall contain sufficient internal storage to retain the system program and sensor historical data.

A color video display terminal (Compaq DeskPro 386S or equal) and printer shall be installed at the central monitor location. The terminal shall be capable of modem connection to other terminals both at the central monitor locations and at other remote locations.

The entire system shall be 100% compatible with the existing "SCAN" system owned and operated by the City of Philadelphia Division of Aviation at the International Airport and shall meet the requirements of "SCAN" System 16 EF as manufactured by Surface Systems Inc., St. Louis, MO., and the requirements of the FAA's Advisory Circular #150/5220-13A.

CONSTRUCTION METHODS

The roadway surface sensors shall be installed in the roadway flush with the existing surface as indicated on the drawings or as directed by the Engineer. Sensors shall be sealed with an epoxy sealant and shall match the surrounding pavement in texture and color.

All other sensors, the remote processor, and the central monitor shall be installed in accordance with the manufacturer's requirements.

At Locations 1 and 3, the remote processor units shall be placed in existing guard boxes as shown on the sketches. The units shall be placed on shelves a minimum of five feet above the floor. Lockable steel security doors shall be installed on each guard box entrance as part of this item.

The central monitor shall be located at the Department of Streets Highway Garage, 4040 Whitaker Avenue. The precise location of the monitor within the facility shall be directed by the Engineer at the time of installation.

Prior to installation, the Contractor shall submit drawings detailing the proposed mounting locations of all sensors and remote processors for review. No work shall be performed until authorized by the Engineer.

METHOD OF MEASUREMENT

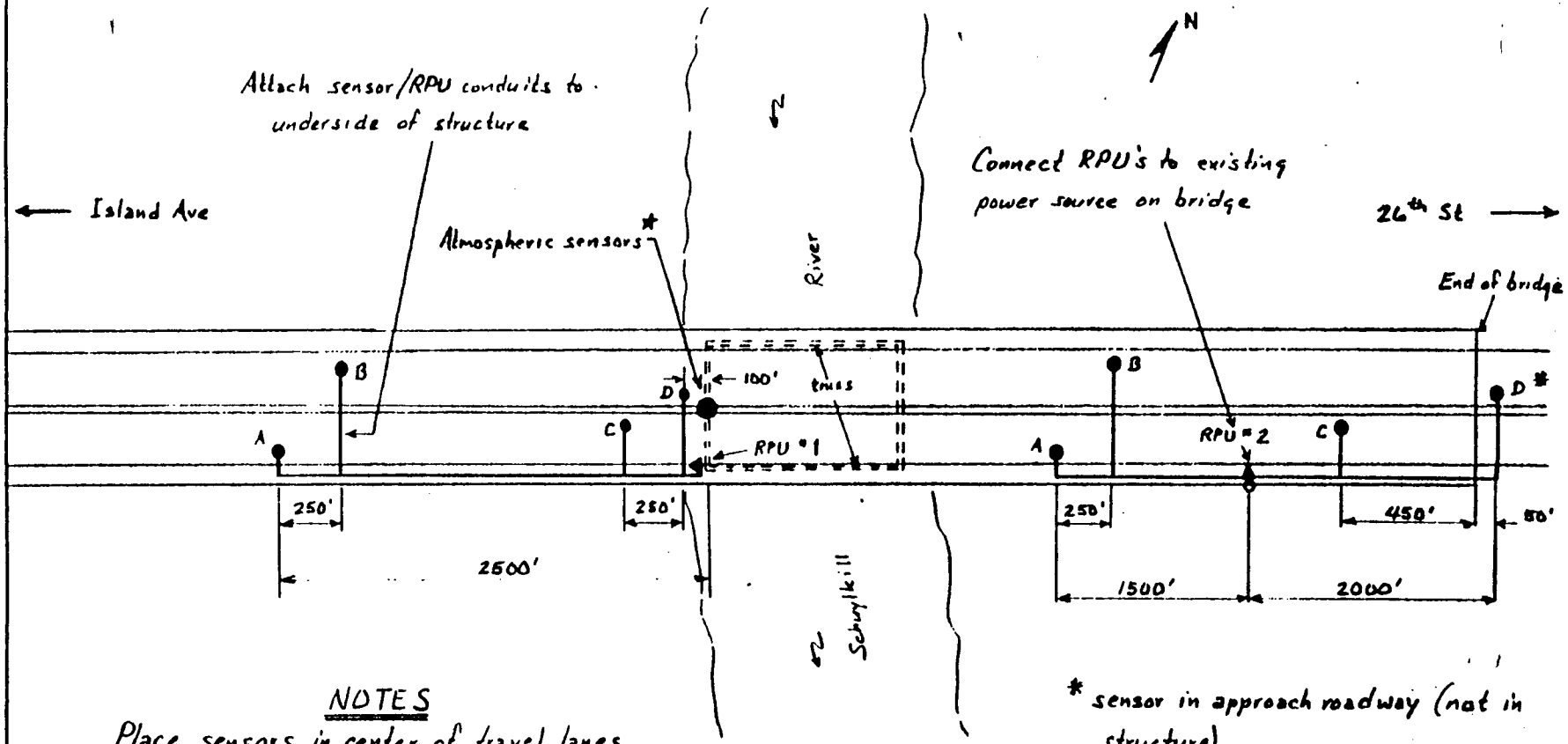
Location 1 shall include all necessary remote sensors and processor for that site and the complete central monitor.

Locations 2 and 3 shall include all necessary remote sensors and processors for each respective site only.

Included for all locations shall be the satisfactory connection of power and telephone services from nearby trunk lines to the detection equipment.

BASIS OF PAYMENT

Each.



NOTES

Place sensors in center of travel lanes as follows:

- A - EB right lane
- B - WB right lane
- C - EB left lane
- D - WB left lane

Mount RPU's as follows:

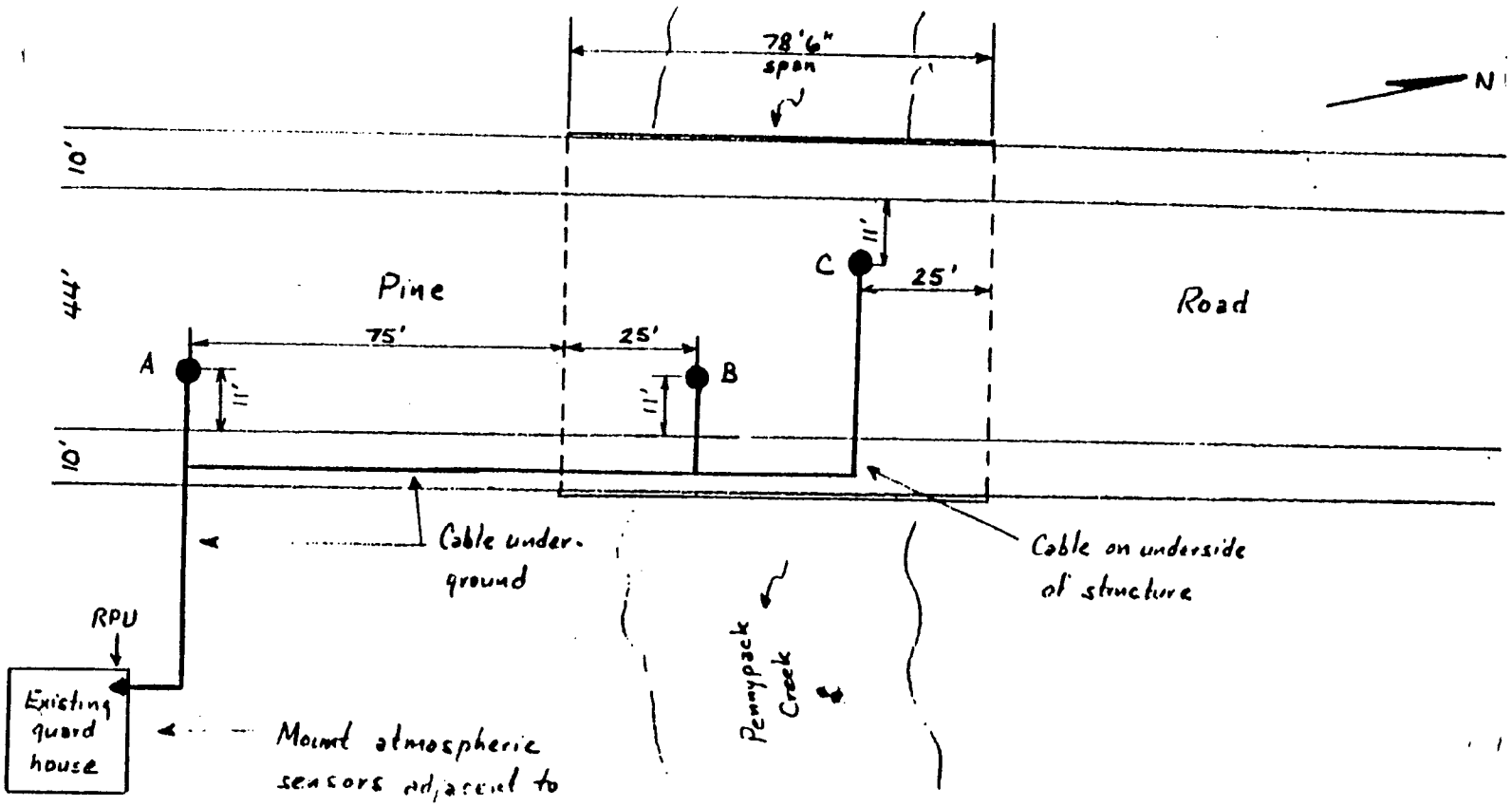
- #1 - truss member (vertical)
- #2 - street light pole (existing)

*Atmospheric sensors to be mounted on horizontal truss member.

Penrose Avenue (Platt) Bridge
Layout of Roadway Condition Detection System

NOT TO SCALE		DWG. PS-1

11/88 a...



Pine Road Bridge

Layout of Roadway Condition Detection System

SCALE 1" = 30' | DWG PR-1