NOTICE

All drawings located at the end of the document.

#000065275

RF/RMRS-97-103, Rev. 0

Task-Specific Health and Safety Plan for the Site Characterization of the 903 Drum Storage Area (IHSS 112), 903 Lip Area (IHSS 155), and Americium Zone

December 18, 1997

DOCUMENT CLASSIFICATION
REVIEW WAIVER PER
CLASSIFICATION OFFICE

This Task-Specific Health and Safety Plan addresses the task specific hazards associated with the Site Characterization of the 903 Drum Storage Area (IHSS 112), 903 Lip Area (IHSS 155), and Americium Zone. Field activities will be conducted using this HASP for task and area specific hazards, and the RMRS Groundwater Monitoring Program Health and Safety Plan (RF/ER-SAF-94-GMP, Rev. 1) for programmatic and general hazards.

GROUNDWATER MONITORING PROGRAM SUBCONTRACTOR
SPECIAL TASK
HEALTH AND SAFETY PLAN
Revision Level 0
Job No. GE6000VS

1. Items 1-9 to be completed by RMRS Special Task Project Manager.

Project Name CHARACTERIZATION OF THE 903 DRUM STORAGE AREA (IHSS 112), 903 LIP AREA (IHSS 155), AND AMERICIUM ZONE

Task: This Special Task Health and Safety Plan (HASP) is only for the work to be conducted for the implementation of the Sampling Analysis Plan (SAP) (RF/RMRS-97-084) for the Characterization of the 903 Drum Storage Area (903 Pad) (IHSS 112), 903 Lip Area (Lip Area) (IHSS 155), and the Americium Zone. The sampling program proposed per the SAP is designed to further delineate and characterize the extent of radiological and VOC contamination for remedial activities. The scope of this proposed activity is limited to the collection of surface radiological data using HPGe methodology and surface soil samples for radiological analysis, collection of subsurface soil samples, using the Geoprobe or hollow-stem auger drilling methodology, for VOC and radiological analysis, and groundwater samples for VOC analysis if DNAPLs are suspected. Sample analyses and interpretation will be the responsibility of RMRS. Activities described in this Special Task HASP will be performed by or at the direction of RMRS Environmental Restoration Projects personnel.

Requested by: Mark Wood

Proposed Start-Up Date: January 1998 Project/Task No. GE6000VS

Reviewed by RMRS Health and Safety Supervisor

Printed Name DAVID E FARLER

Signature [signature] Date 12-19-97

Reviewed by Groundwater Monitoring Program Subcontractor Site Safety Officer

Printed Name Harold K. Sanchez

Signature [signature] Date 12/22/97

Approved by RMRS Special Task Project Manager

Printed Name M. T. Vess

Signature [signature] Date 12-22-97

Title Project Manager

Approved by RMRS Quality Assurance/Quality Control

Printed Name Greg Di Gregorio

Signature [signature] Date 12/19/97

Title RMRS Quality Assurance Engineer

Note to Project Managers: A signed and completed copy of the Health and Safety Plan and a signed and completed copy of the safety briefing must be included in the project file.

2. Project Description:

Description of Non-Intrusive Activities: Approximately 1500 HPGe measurements will be collected from the Americium Zone and possibly the Lip Area investigation areas. Each HPGe measurement will be collected from a 12 meter diameter Field of View (FOV). Follow-up FIDLER surveys may be performed to further delineate the areas with radionuclides equal to or above the RFCA Tier I action levels.

Description of Planned Intrusive Activities: Subsurface soil sampling activities will be conducted in several phases. One phase will be the collection of approximately 15 surface soil samples for radiological analysis for verification and correlation to the surficial HPGe measurements. One phase will consist of 25 soil boring locations on the 903 Pad utilizing Geoprobe drilling methodology to collect subsurface soil samples to a depth of three feet for radiological analysis and possibly volatile organic compound (VOC) analysis. One phase will consist of 25 soil boring locations in the Lip Area utilizing Geoprobe drilling methodology to collect subsurface soil samples to a depth of two feet for radiological analysis and possibly VOC analysis. Another phase, the VOC investigation, will consist of approximately 20 soil boring locations on the 903 Pad and the Lip Area utilizing either Geoprobe or hollow-stem auger drilling methodology to collect subsurface soil samples to depths up to 28 feet for radiological and VOC analysis. Approximately 468 soil cores will be collected per the SAP. Soil core samples will be transported directly to the analytical laboratories after screening for radiological and VOC contamination and minimizing site personnel contact with potentially contaminated soils. Collection of groundwater samples with suspected DNAPLs will be performed per the SAP. Drill cuttings, if generated, will be containerized, temporarily stored in a 90-day RCRA permitted area pending analytical results, and then final disposition per FO.29. Returned environmental samples will be characterized on the basis of analytical results and process knowledge and dispositioned in accordance with FO.09 and FO.29.

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3. Location:

This Task Specific HASP covers planned surface and subsurface soil and groundwater sampling activities to be performed for the site characterization of the 903 Pad (IHSS 112), the Lip Area (IHSS 155), and the Americium Zone, as shown in Figure 1.1. Field activities are scheduled during January to September 1998.

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4. Facility/Work site Description

As shown in Figure 1.1 the work area is at the eastern edge of the industrial area and south of the East Access Road. From 1958 to 1967, the 903 Pad was used to for storing drums containing plutonium and uranium contaminated volatile organic compounds (solvents). Leaking drums resulted in contamination of the 903 Pad, the Lip Area, and the Americium Zone. Several remedial actions took place in the late 1960s and 1970s to remove hot spots and to cap the 903 Pad with eight inches of clean fill and three inches of asphalt. The Lip Area was also graded and covered with seven inches of clean fill. The 903 Pad and the Lip Area are flat lying with a gentle slope to the south and east. The Americium Zone is generally flat lying with a gentle slope to the east and a steep slope to the south on the south side (Figure 1.1).

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5. Proposed Personnel and Tasks:

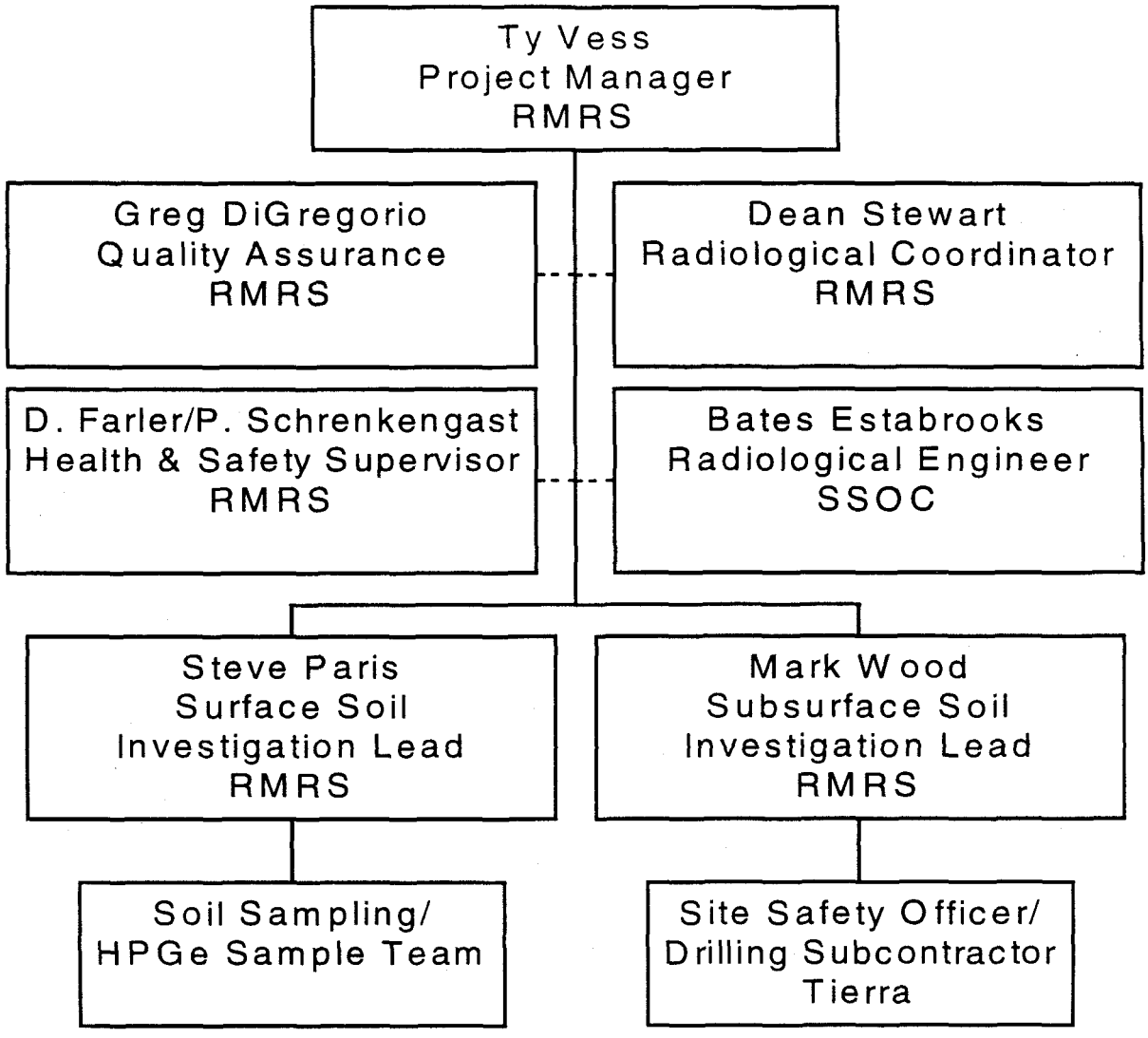
Figure 1.2 shows the project organization chart and project responsibilities.

Project Manager: Ty Vess

Field Team Leader - Surface Soil Inv. Steve Paris

Field Team Leader - Subsurface Soil Inv. Mark Wood

Figure 1.2
903 Pad, 903 Lip Area, and Americium Zone Organizational Chart



Proposed Field Team	Job Function/Tasks
Ty Vess	RMRS Project Manager
Steve Paris	RMRS Surface Soil Team Lead/assist with subsurface soil inv. tasks
Mark Wood	RMRS Subsurface Soil Team Lead/assist with surface soil inv. tasks
Harold Sanchez	Subcontractor Health and Safety Officer/Health and Safety Specialist
J. Boylin/R. Kohler	Subcontractor Geologist/logging and sampling
Rick Gentry	RMRS HPGe Data Coordinator/assist with HPGe data collection
Gary Stretesky	Subcontractor Geoprobe operator
Ray Michaels	Subcontractor Geoprobe operator
Rick Gentry	RMRS HPGe Data Coordinator/assist with HPGe data collection
Bates Estabrooks	SSOC Radiological Engineering

6. Confined Space Entry

A confined space is defined as: 1) large enough to enter; 2) limited access/egress; and 3) not intended for human occupancy. (CFR 1910.146[b]). A permit required confined space also may pose additional hazards such as: toxic contaminants, a flammable or oxygen deficient atmosphere, or other hazards, such as engulfment, or electrical or mechanical hazards should equipment be inadvertently activated while an employee is in the confined space. Confined spaces include but are not limited to storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, air pollution control devices, smoke stacks, underground utility vaults, sewers, septic tanks, and open top spaces more than four feet in depth such as test pits, waste disposal trenches, sumps and vats.

Will this task require entry into any confined or partially confined space?

_____ YES - Describe below
X NO

7. Cutting and Welding

Will this task involve use of a cutting torch or welding?

_____ YES - Describe below
X NO

8. Other Potential Hazards

X Chemical
X Radiological
___ Fire/Explosion
X Heat Stress
___ Electrical
X Machinery/Mechanical Equipment
X Trips, Slips, Falls
_____ Trenching/Shoring
_____ Heavy Equipment/Vehicular Traffic
_____ Overhead Hazards
X Unstable/Uneven Terrain
_____ Other - Describe below

6, 7, 8. Description/Other

Cold weather hazards

9. I, Mark Wood, attest that this information is accurate to the best of my knowledge and hereby request a Health and Safety Plan for the tasks(s) designated above.

Steve Paris for Mark Wood 12/22/97
Signature Date

Surface Soil Investigation Lead
Title

10. Chemical/Radiological Hazard Evaluation

Waste Media

X Airborne Contamination
X Surface Contamination
X Contaminated Soil
X Contaminated Surface Water
X Solid Waste
X Liquid Waste
___ Sludge

Hazardous Characteristics

___ Ignitable
___ Corrosive
___ Reactive
___ Explosive
X Toxic (non-radiological)
X Radioactive

Substance

Hazard Summary. This work involves potential contact with soil and/or water containing concentrations of chemicals in the parts per million range (mg/Kg) and radioisotopes in the nanocuries per gram (nCi/g) range. Site specific data from the 903 Pad and Lip Area is provided in Table 1 which indicates the potential for hazardous levels of contamination in surface and subsurface soil in the work area. Particular attention will be paid to dust suppression and air monitoring activities at locations which could potentially produce contaminated soil or groundwater, and personnel will use real-time air monitoring results to determine when and if it is necessary to upgrade to higher levels of PPE. Table 2 summarizes potential contamination hazards. Table 3 summarizes the chemical hazards. See Appendix A for task-specific hazards, controls, personnel protective equipment, and the task-specific specific Activity Hazard Analysis.

Table 1
Maximum Detected Contaminant Concentrations in Soil and Groundwater at the 903 Pad and Lip Area

Compound	Surface Soil	Subsurface Soil	Groundwater
Carbon Tetrachloride	NA	330 µg/Kg	100,000 µg/L
Chloroform	NA	240 µg/Kg	49,000 µg/L
Chloromethane	NA	ND	2,600 µg/L
Methylene Chloride	0 mg/Kg	66 µg/Kg	24,000 µg/L
Tetrachloroethene	0 mg/Kg	110 µg/Kg	20,000 µg/L
Trichloroethene	0 mg/Kg	27µg/Kg	4,600 µg/L
1,1,1-Trichloroethane	NA	ND	46 µg/L
1,1-Dichloroethane	NA	ND	150 µg/L
1,3-Dichloropropene	NA	NA	8.1 µg/L
1,1-Dichloroethene	NA	3 µg/Kg	26 µg/L
Cis-1,2-Dichloroethene	NA	ND	2900 µg/L
Vinyl Chloride	NA	ND	34 µg/L
Americium-241	2,252 pCi/g	1,137 pCi/g	46.54 pCi/L
Plutonium-239/240	7,658 pCi/g	3,366 pCi/g	354.6 pCi/L
Uranium-238	10.2 pCi/g	1.7 pCi/g	38.6 pCi/L
Beryllium	12 mg/Kg	1 mg/Kg	-
Copper	181 mg/Kg	26 mg/Kg	-
Chromium	177 mg/Kg	73 mg/Kg	-
Lead	228 mg/Kg	33.6 mg/Kg	-
Nickel	93 mg/Kg	44 mg/Kg	-
Strontium	104 mg/Kg	121 mg/Kg	-
Vanadium	70 mg/Kg	73.8 mg/Kg	-

NA = Not Analyzed, ND = Not Detected

Primary Hazard (Rate: low, medium, high, extreme)

Table 2
Potential Contamination Hazards

Task Description	Potential Contaminants	PPE to be Used
HPGe and FIDLER surveys and surface soil sampling.	Soil with low to high levels of radionuclides.	Start in Level D or per RWP requirements. Upgrade to modified Level D, C or B at the discretion of the HSS.
Soil borings, disturbance of subsurface soil and collection of soil samples.	Soil and saturated soil with low to high levels of volatile organic compounds and radionuclides.	Start in modified Level D or per RWP requirements. Air monitoring and/or soil conditions (wet, muddy) may indicate need to upgrade to C, or B at the discretion of the HSS.
Groundwater sampling.	Groundwater with low to high levels of volatile organic compounds.	Start in modified Level D or per RWP requirements. Air monitoring and/or soil conditions (wet, muddy) may indicate need to upgrade to C, or B at the discretion of the HSS.

11. Ambient Air/Site Monitoring Procedures
The following instruments shall be used to monitor the work environment and workers' breathing zones prior to site entry and at the specified intervals.

Instrument	Monitoring Frequency				
X PID (HNU< OVM) w/10.5 and 11.7 eV lamp	Cont.	15 min.	30 min.	hourly	other X
___ OVA	Cont.	15 min.	30 min.	hourly	other ___
___ Combustible Gas Indicator	Cont.	15 min.	30 min.	hourly	other ___
___ H2S Detector	Cont.	15 min.	30 min.	hourly	other ___
___ Colorimetric Detector Tubes	Cont.	15 min.	30 min.	hourly	other ___
X Other (describe below)	Cont.	15 min.	30 min.	hourly	other X

Description/other:
TVA 1000B, Toxic Vapor Analyzer (PID/FID) may be used. Monitor personnel breathing zones and soil sample surfaces during times of potential exposure.
Mini-ram dust monitor. Monitor visible dust.

TABLE 3 Chemical Hazard Summary

CHEMICAL	MATRIX	OSHA PEL	ACGIH TLV	NIOSH REL	STEL	CEILING	IDLH	SKIN NOTATION	CORROSIVE IRRITANT	BOILING POINT °F	VAPOR PRESSURE	FLASH POINT °F	UEL (%)	LEL (%)
Beryllium	S	0.002 mg/m^3	0.002mg/m^3 (B)	0.0005 mg/m3 (A)	0.01mg/m^3 (3)	0.005 mg/m^3 (2)	4 mg/m^3 (1) (as Be)			4532 °F	0 mm	NA	NA	NA
Cadmium	S	0.005 mg/m^3	0.01mg/m^3 (B)	(A)			9 mg/m^3 (1) (A)			1409 °F	0 mm	NA	NA	NA
Carbon Tetrachloride	S/W	10 ppm	5 ppm	(A)	2 ppm (1)	25 ppm (2)	200 ppm (1) (A)	X		170 °F	91 mm	NA	NA	NA
Chloroform	S/W	50 ppm	10 ppm	9.78 mg/m^3 (60 min)	2 ppm (1)		500 ppm (1)			143 °F	160 mm	NA	NA	NA
Chloromethane	S/W													
Chromium (Metal)	S	1 mg/m^3	0.5 mg/m^3	0.5 mg/m^3			250 mg/m^3 (1)	X	X	4788 °F	0 mm	NA	NA	NA
Copper	S	1 mg/m^3	1 mg/m^3	1 mg/m^3	ND	ND	10 mg/m^3			4703 °F	0 mm	NA	NA	NA
Cyanide	S	5 mg/m^3	5 mg/m^3				50 mg/m^3 (3)	X	X	2725 °F	0	NA	NA	NA
1,1-Dichloroethane	S/W	100 ppm	100 ppm	100 ppm		400 mg/m^3 (3)	3000 ppm (1)			135 °F	182 mm	2 °F	11.4	5.4
1,1-Dichloroethene	S/W	1 ppm	5 ppm	(A)	20 ppm	ND	(A)			89 °F	500 mm	-2 °F	15.5	6.5
1,3-Dichloropropene	W	1 ppm (A)	1 ppm	1 ppm (A)			(A)	X		226 °F	20 mm	77 °F	14.5	5.3
Hydrochloric Acid	S/W	5 ppm		5 ppm		5 ppm (1)	50 ppm		X	-121 °F	>1 atm	NA	NA	NA
Lead	S	0.05 mg/m^3	0.05 mg/m^3	0.100 mg/m^3			100 mg/m^3 (1)			3164 °F	0 mm	NA	NA	NA
Methylene Chloride	S/W	25 ppm	50 ppm	(A)	125 ppm (3)		2300 ppm (1)			104 °F	350 mm	?	23	13
Nitric Acid	S	2 ppm	2 ppm	2 ppm	4 ppm		25 ppm (1)		X	181 °F	48 mm	NA	NA	NA
No. 2 Diesel Fuel	S		100 ppm			5 mg/m^3 (3)	-	X		350-700 °F	0.5 mm @ 20 °C	52 @ 125	7.50%	0.60%
Pentachlorophenol	S	0.5 mg/m^3	0.5 mg/m^3	0.5 mg/m^3	-	-	2.5 mg/m^3 (1)	X		588 °F (Decomposes)	77 °F 0.0001 mm	NA	NA	NA
PCBs	S	0.5 mg/m^3	0.5 mg/m^3	0.001 mg/m3 (A)			5 mg/m^3 (1) (A)	X	X	689-734 °F	0.00006 mm	NA	NA	NA
Silver	S	0.01 mg/m^3	0.1 mg/m^3	0.01 mg/m^3			10 mg/m^3 (1)		X	3632 °F	0 mm	NA	NA	NA
Strontium														
Sulfuric Acid	S	1 mg/m^3	1 mg/m^3	1 mg/m^3	3 mg/m^3 (3)		15 mg/m^3 (1)		X	554 °F	0.001 mm	NA	NA	NA
Tetrachloroethene	S/W	100 ppm	25 ppm	(A)	100 ppm	200 ppm	150 ppm (A)			250 °F	14 mm	NA	NA	NA
Toluene	S	200 ppm	50 ppm	100 ppm	150 ppm (1)	300 ppm (2)	500 ppm (1)	X	X	232 °F	21 mm	40 °F	7.10%	1.10%
1,1,1 Trichloroethane	S	350 ppm	350 ppm	350 ppm	450 ppm		1000 ppm(1)			165 °F	100 mm	NA	12.50%	7.5
Trichloroethene	S/W	100 ppm	50 ppm	25 ppm (A)	100 ppm (3)	200 ppm (2)	1000 ppm (1) (A)		X	189 °F	58 mm	NA	10.5% @ 77 °F	8% @ 77 °F
Uranium (soluble compounds)	S	0.05 mg/m^3	0.2 mg/m^3	0.05 mg/m^3	0.6 mg/m^3 (B,3)		10 mg/m^3 (1)					NA		
Vanadium	S	0.05 mg/m^3	0.05 mg/m^3	0.05 mg/m^3 (15 min Ceiling)	ND	0.5 mg/m^3	70 mg/m^3			3182 °F	0 mm	NA	NA	NA
Vinyl Chloride	W	1 ppm		(A)		5 ppm (15 min)	(A)			7 °F	3.3 atm	NA (gas)	33	3.6

Notes: Units are as specified in the column headings unless otherwise noted.
(A) NIOSH Identified Carcinogen
(B) ACGIH Carcinogen
(1) NIOSH REL value
(2) OSHA PEL value
(3) ACGIH TLV value

Abbreviations:
ACGIH = American Conference of Government Industrial Hygienists
atm = atmosphere
eV = electron volt
IDLH = Immediately Dangerous to Life or Health
IP = Inhalable Particles
LEL = Lower Exposure Limit
mg/m^3 = milligrams per cubic meter
S = Soil matrix
W = Water matrix
mm = millimeter
N/A = not applicable
NE = no evidence
NIOSH = National Institute of Occupatinal Safety and Health
OSHA = Occupational Safety and Health Administration
PEL = Permissible Exposure Limit
ppm = parts per million
REL = Recommended Exposure Limit
STEL = Short-term Exposure Limit
TLV = Threshold Limit Value
UEL = Upper Exposure Limit
UNK = unknown
°F = degrees Fahrenheit

903padtable3.xls 12/18/97

12. Action Levels

Task personnel will observe the following Action Levels:

Instrument	Action Level	Specific Action
PID/FID	Any sustained reading (1 to 2 minutes) above background in the breathing zone	If any sustained reading (1 to 2 minutes) above background is present in the breathing zone, affected personnel will move upwind for a time period determined by the HSS. Most likely, the VOC levels will dissipate, as determined by the HSS, and personnel may return to the work area. If readings above background do not dissipate, use a large fan to remove the VOCs from the breathing zone. If the fan does not reduce VOC readings to background levels, stop work and contact RMRS Health & Safety and the task-specific project manager.
Mini-ram dust monitor	1.5 mg/m^3 sustained dust levels for 1 to 2 minutes obtained in the breathing zone.	If 1.5 mg/m^3, sustained (1 to 2 minutes), are obtained in the breathing zone, apply dust suppression and soil wetting techniques using a small sprayer or other equivalent means.
High Volume Air Sampler, if required by RWP	Air samples indicate equal to or greater than 1 DAC Class W Pu-239 or per RWP.	If equal to or greater than 1 DAC or limit per RWP is observed, pause work and evaluate for radon. If not radon, suspend work, contact Rad Engineer and evaluate controls and PPE.

13. Personal Monitoring

X Passive Dosimeter X Personal Air Sampling _____Other

Description/Other:
Personal air monitoring/sampling will be required if sustained readings above 0.1 ppm (1 to 2 minutes) over background after venting are observed.

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14. Biological Monitoring/Medical Surveillance

N/A This project requires medical surveillance or biological monitoring procedures beyond the provisions of the routine medical surveillance program, see description below.

Description:

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15. Onsite Control

Control boundaries have been established, and the Exclusion Zone (the contaminated area), Hotline, decontamination Line, Contamination Control Zone and Support Zone (clean area) have been designated and are identified in Section 6.5 of the GMP HASP. Specifically, work zones will be clearly labeled and an Exclusion Zone of 10 feet will be maintained around the intrusive activity.

Harold Sanchez has been designated to coordinate access control on the work site during the implementation of the site characterization task. No unauthorized person shall be allowed beyond the Contamination Reduction Zone Control Line without approval.

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16. Personal Protective Equipment

Location	Job Function/Task	Initial level of Protection
903 Pad/Lip Area	Subsurface soil sampling	

Exclusion Zone (Contamination Area)	Mod. Level D protection unless the RWP has more stringent requirements _____ _____	B C **D** 1 2 3 OTHER B C D 1 2 3 OTHER B C D 1 2 3 OTHER B C D 1 2 3 OTHER
Contamination Reduction Zone (Radiological Buffer Area)	Level D protection unless the RWP has more stringent requirements _____ _____	B C **D** 1 2 3 OTHER B C D 1 2 3 OTHER B C D 1 2 3 OTHER B C D 1 2 3 OTHER

Location	Job Function/Task	Initial level of Protection
Americium Zone	HPGe/FIDLER surveys and surface soil sampling	
Exclusion Zone (Contamination Area)	Level D protection unless the RWP has more stringent requirements _____ _____	B C **D** 1 2 3 OTHER B C D 1 2 3 OTHER B C D 1 2 3 OTHER B C D 1 2 3 OTHER
Contamination Reduction Zone (Radiological Buffer Area)	Level D protection unless the RWP has more stringent requirements _____	B C **D** 1 2 3 OTHER B C D 1 2 3 OTHER B C D 1 2 3 OTHER

List the specific protective equipment and material (where applicable) for each of the levels of protection identified above.

Level B
X Pressure demand airline with escape provisions
X Pressure demand SCBA

Level C (includes all Mod Level D req.)
_____ Half face air purifying respirator
_____ Full face air purifying respirator
_____ Full face canister air purifying respirator
_____ Inner latex gloves
_____ Outer NBR gloves

Level Mod D
X Standard work clothes/DOE coveralls
X Hard hat, steel-toed boots, safety glasses
X Ear protection during drill rig hammering operation
X Inner nitrile gloves (2 pair)
_ Outer Nitrile Butyl Rubber (NBR) gloves (follow RWP)
_ Outer Nitrile Butyl Rubber (NBR) booties (follow RWP)

Level D
X Standard work clothes/DOE coveralls
X Hard hat, steel-toed boots, safety glasses
X Ear protection during drilling hammering operation
X Outer NBR booties (follow RWP)

Note: Hard hat to be worn when within five feet of Geoprobe operation or 50 feet of hollow-stem auger operation, or if overhead hazards are present. Orange traffic vests required when moving drill rig.

Where air purifying respirators authorized, GMC-H are the appropriate canisters/ cartridges for use with the specific substances and concentrations anticipated. Cartridges will be replaced at the start of each work day.

NO CHANGES TO THE SPECIFIED LEVELS OF PROTECTION SHALL BE MADE WITHOUT THE KNOWLEDGE AND APPROVAL OF THE HEALTH AND SAFETY OFFICER AND THE PROJECT MANAGER.

17. Decontamination

Personnel and equipment leaving the Exclusion Zone/Contamination Area or High Contamination Area will proceed through the decontamination procedures in the contamination reduction zone (Radiological Buffer Area) in accordance with Section 6.5.2.1, Radiological Areas - Step-off Pad Requirements and the task specific RWP:

Emergency decontamination procedures:

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18. Confined Entry Procedures X_____ Not Applicable

Yes	N/A		Yes	N/A	
___	___	Provide Forced Ventilation	___	___	Refer to Personal Protection Equip. (#16)
___	___	Test Atmosphere for:	___	___	Refer to Emergency Procedures. (#29)
___	___	(a) $\%0_2$	___	___	Other Special Procedures
___	___	(b) %LEL			
___	___	© Other			

Descriptions/Other:

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19. Cutting/Welding

Yes	N/A		X____Not Applicable
___	___	Relocate or protect combustibles	
___	___	Wet down or cover combustible floor	
___	___	Check flammable gas concentrations (%LEL) in air	
___	___	Cover wall, floor, duct and tank openings	
___	___	Provide fire extinguisher	

Other Special Instructions:

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20. Onsite Organization and Coordination

Project Manager: Ty Vess

Field Team Leader - Surface Soil Inv.: Steve Paris

Field Team Leader - Subsurface Soil Inv.: Mark Wood

Health & Safety Supervisor: Dave Farler/ Peggy Schreckengast

Field Team Members	Job Function/ Health and Safety Tasks
Ty Vess	RMRS Project Manager responsible for implementation of HASP
Steve Paris	RMRS Surface Soil Team Lead/assist with implementation of HASP
Mark Wood	RMRS Subsurface Soil Team Lead/assist with implementation of HASP
Harold Sanchez	Subcontractor Health and Safety Officer/Health and Safety Specialist responsible for implementation of HASP
J. Boylin/B. Koehler	Subcontractor Geologist responsible for performing work in accordance with the HASP
Gary Stretesky	Subcontractor Geoprobe operator responsible for performing work in accordance with the HASP
Ray Michaels	Subcontractor Geoprobe operator responsible for performing work in accordance with the HASP
Rick Gentry	RMRS HPGe Data Coordinator responsible for performing work in accordance with the HASP
Bates Estabrooks	SSOC Radiological Engineering responsible for work conducted in accordance with ALARA Job Review, Task-specific RWP, property release evaluations, and Radiological Control Manual
Tim Hipsher	Radiological Operations foreman, review surveys, reviews and signs RWPs, point of contact

21. Special Instructions:

Unanticipated Hazards or Conditions

Any hazards that may be encountered which are of an unusual nature or which represent an unknown threat will be managed in accordance with this RMRS policy statement. "In the event unanticipated hazards or conditions are encountered, the project activities will pause to assess the potential hazard or condition. The potential hazard or condition will be evaluated to determine the severity or significance of the hazard or condition and whether the controls on the project are sufficient to address the hazard or condition. Based on this initial evaluation, a determination will be made whether to proceed with controls currently in place; segregate the hazard or condition from the project activity, if it can be done safely; or curtail operations to address the unexpected hazard or condition. Concurrence to proceed down the selected path must be obtained from the RMRS Vice President or their designee. In addition, the resumption of field activities involving radiological issues will be in accordance with Article 345 of the RFETS Radiological Control Manual".

22. Sanitation Requirements

Portable potable water supply available on work site?	X	Yes	
Portable toilets required on work site?		Yes	If Yes, how many?_____
	X	No	
Temporary washing/shower facilities required at work site?		Yes	If Yes, describe below
	X	No	If No, state location of existing facilities.

Description: Toilets and shower facilities are available in the Field Operations Yard.

23. Field Procedures Change Authorization

Instruction Number to be changed

Duration of Authorization Requested
_____ Today only
_____ Duration of Task

Date: _____

Description of Procedures Modification:

Justification:

Person requesting change:

Name

Title

Signature

Verbal authorization received from:

Name

Time

Title

Approved by (Signature of person name above to be obtained within 48 hours of verbal authorization)

24. Emergency Procedures

This page is to be posted at a prominent location onsite.

Yes No

_X_ ___ Onsite communications required?

Emergency Channel Extension or radio number 2911

Nearest telephone Building T891M

Fire and Explosion:
In the event of a fire or explosion, if the situation can be readily controlled with available resources without jeopardizing the health and safety of yourself, the public, or other site personnel, take immediate action to do so if currently trained, otherwise:

1. Notify emergency personnel by calling 2911.
2. If possible, isolate the fire to prevent spreading.
3. Evacuate the area.

Chemical exposure:
Site workers must notify the site health and safety officer immediately in the event of any injury or any of the signs or symptoms of overexposure to hazardous substances identified below:

Substances Present	Symptoms of Acute Exposure	First Aid
Carbon Tetrachloride	Inhalation: irritate eyes, skin, respiratory Absorption: depression, nausea, vomiting Ingestion: kidney, drowsiness, dizziness Consumption: incoordination	Eye: Irrigate immediately Skin: wash immediately Breathing: Resp. support Swallow: Immediate medical attention
Tetrachloroethene	Inhalation: irritate eyes, nose, throat Absorption: nausea, flush face, neck Ingestion: vertigo, dizzy, incoherent, headache Consumption: sleepy, skin redness, liver	Eye: Irrigate immediately Skin: wash immediately Breathing: Resp. support Swallow: Immediate medical attention
Solvents, general	Inhalation: irritate eyes, skin, respiratory Absorption: depression, nausea, vomiting Ingestion: kidney, drowsiness, dizziness Consumption: incoordination	Eye: Irrigate immediately Skin: wash immediately Breathing: Resp. support Swallow: Immediate medical attention

Onsite injury or illness
In the event of an injury requiring more than minor first aid, or any employee reporting any sign or symptom of exposure to hazardous substances, immediately take the victim to the RFETS Medical Facility located at Bldg. 122 (Figure 1.1), phone X2594. In the event of life-threatening or traumatic injury, implement appropriate first-aid and immediately call for emergency medical assistance at 2911.

Designated Personnel Current in first Aid/CPR (Names)

Harold Sanchez	Gary Stretesky
Mark Wood	John Boylan
Peggy Schreckengast	Ray Michael
Dave Farler	

Designated back-up personnel (Names) Function

This page is to be posted at a prominent location onsite.

Required Emergency Back-Up Equipment

Latex or nitrile surgeon gloves, one-way CPR mask.

Emergency Response Authority:
Harold Sanchez is the designated site emergency coordinator and has final authority for first response to onsite emergency situations.

Upon arrival of the appropriate emergency response personnel, the site emergency coordinator will defer all authority but remain on the scene, if necessary, to provide any and all possible assistance. At the earliest opportunity, the site safety officer or the site emergency coordinator will contact the project coordinator or health and safety officer.

Project Manager	Ty Vess	Phone (w)	6540	(h) 456-2725
Health and Safety Supervisor	Peggy Schreckengast	Phone (w)	6790	(h) 940-9538
Site Safety Officer	Harold Sanchez	Phone (w)	4953	(h) 985-2575

Emergency Contact Telephone and Pager Numbers

Fire	x2911	Poison Center	629-1123
Ambulance	x2911	Security	x2911

Nearest Emergency Medical Services Are Located At Building 122 as shown on Figure 1.1.

Nearest telephone is located at: T-1 trailers

Additional Project Telephone Numbers

Vice President - ER - John Law	x8760/d4564
ER Projects Manager - Annette Primrose	x4385/d4675/r3801
H&S Manager - Ken Jenkins	x5374/d7455/r4505
Surface Soil Team Lead - Steve Paris	x3656/d4624
Subsurface Soil Team Lead - Mark Wood	x6689/d5904/r3755
HSS/Site Safety Officer - Harold Sanchez	x4953/d1171/r3754
RMRS Health & Safety Supervisor - Dave Farler	x4340/d5248/r3743
Radiological Engineer - Bates Estabrooks	x3769/d7094
HAZMAT Emergency Response	x2911/r2911
RFETS Shift Supervisor	x2914/r3301
Occupational Health General Information	x2594

Note: d = digital page, the digital page system can be activated on plantsite by dialing extension 4000, then following the instructions. r = radio number.

25. Safety Briefing

The following personnel were present at the pre-job safety briefing conducted at _____ (time) on _____ _____ (date) at _____ (location), and have read the above plan and are familiar with provisions:

Name	Signature

Fully charged ABC class fire extinguisher available onsite? Yes _____

Fully stocked First Aid Kit available onsite? Yes _____

All project personnel advised of location of nearest phone? Yes _____

All project personnel advised of location of designated medical facility? Yes _____

_____

Printed name of field team leader or site safety officer

_____

Signature Date

Appendix A

Appendix A
Task-Specific HASP for the Site Characterization of the 903 Drum Storage Area (IHSS 112), 903 Lip Area (IHSS 155), and Americium Zone

Site Location and Description:

Location : 903 Pad, Lip Area, and Americium Zone

Description: HPGe surveys, FIDLER surveys, surface soil samples, and drill soil borings to collect soil and groundwater samples.

Suspect Contaminants:

MONITORING REQUIREMENTS — ACTION LEVELS

	PEL	Instrument	Range	Level D modified	Level C	Level B	Notes
Hydrocarbons		TVA-1000 w/ 10.4 eV +					
		Minirae w/ 11.7 eV lamp	0-2,000 ppm	>bkg	N/A	*	*Any sustained reading above background in BZ
		PID	0-2,000 ppm	>bkg	N/A	*	*Any sustained reading above background in BZ
		FID	0-50,000ppm	>bkg	N/A	*	
Particulates	3 mg/m3	MIE Miniram	0.1-100 mg/m3	1.5 mg /m3	1.5 mg /m3	*	*Dust Control (misting) will be used above 1.5 mg/m3 In areas where dust is encountered, dust control will be used to minimize dust generation at or below 1.5 mg/m3.

Personal Monitoring

Contaminant	Analytical Method
Monitoring for VOA's using personal sampling methods is required for sustained levels in BZ, upgrade for respiratory protection.	NIOSH Methods
Monitoring for Methane in suspected areas, stop work above 25% LEL explosion hazard. withdraw from area immediately.	Range 0-100% LEL, MSA Passport or equivalent.

Personal Protective Equipment

Type of Work	Level D Doe Coveralls	Level D Modified	Tyvek Coveralls	Saranex Coveralls	Nitrile Gloves	Silvershield Gloves	Latex Gloves	Leather Work Gloves	Face Shield	Rubber Apron	Rubber Booties	Full Face Respirator	Level B Supplied Air
HPGe/FIDLER Surveys	*				*						*		
Surface Soil Sampling	*				*			*			*		
Drilling	*	(3), (1)	(3)	(1)	*			*	(1)		*		(2)
Soil Sampling/ Logging Core	*	(3), (1)	(3)	(1)	*			*	(1)		*		(2)
Sampling groundwater	*	(3), (1)	(3)	(1)	*				(1)		*		(2)
Handling IDM/residual soil samples	*	(3), (1)	(3)	(1)	*			*	(1)	*			(2)

(1) If high VOA's reading or free liquids are encountered personal will upgrade to Saranex and Face Shields. Sustained readings of VOC's in breathing zone will require backing off and allowing samples to vent, if there is no wind present the use of large industrial size fan will be used. If work practices warrant, or wet/muddy conditions exist, Tyvek is required.

(2) If workers must work where VOC readings are sustained in the breathing zone, work will stop and supplied air respiratory protection will be used and more protective PPE requirements.

(3) Unless RWP is more stringent.

(*) Required under normal operations or can be changed at the desecration of HSS. Drillers will wear both inner and outer (11 mil) nitrile gloves or per RWP.

Notes

PEL = Permissible Exposure Limit
PID = Photoionization Detector
FID = Flame-ionization Detector
ppm = parts per million
BZ = breathing zone
mg/m3 = milligrams per cubic meter
PPE = Personal Protective Equipment
VOA = Volatile Organic Analyte
IDM = Investigative derived materials (typically soils)
OSHA = Occupational Safety and Health Administration
EPA = U.S. Environmental Protection Agency
USCG = U.S. Coast Guard

Appendix B
Activity Hazard Analysis

Activity Hazard Analysis for the Task-Specific Health and Safety Plan for the Characterization of the 903 Drum Storage Area (IHSS 112), 903 Lip Area (IHSS 155), and Americium Zone

ACTIVITY DESCRIPTION: Surface soil sampling, HPGe and FIDLER surveys, soil borings and soil and groundwater sampling using a truck-mounted drill rig.

Activity	Potential Hazard	Protective Control Measures
1) HPGe measurements and FIDLER surveys. Surface soil sampling, asphalt coring, soil borings (including soil core and groundwater sampling).	Slips, trips, and falls	Pre-activity work area survey to identify potential hazards associated with operations. Secure area, use safety shoes and glasses. Hazard assessment per the task-specific HASP.
	Exposure to airborne radioactive or chemical contaminants	On-site monitoring requirements will be established prior to project implementation per Section 7.0*, the task-specific HASP, and job-specific RWP.
	Dermal exposure with radioactive or chemical contaminants in soils and groundwater	Establish monitoring program prior to operations per ALARA Job Review. Define appropriate level of PPE per task-specific HASP and RWP.
	Mechanical/hydraulic hazards	Pre-work safety discussion and procedures identified in the task-specific HASP.
	Pinching hazards	Pre-work safety discussion and procedures identified in the task-specific HASP. Use of leather gloves per HSS.
	Noise exposure	Hearing protection will be required during drilling and Geoprobe hammer operations.
	Electrical hazards	Electrical hazards will be prevented per the Section 6.14*.
	Vehicular and pedestrian traffic.	Site control will be maintained per Section 6.0*.
	Underground/above-ground utilities	Utility clearances will be performed per the Soil Disturbance Permit.
	Manual material lifting	Personnel will follow safe lifting practices per Section 6.2.9*.
	Thunderstorms and lightning	Per Sections 6.12* and 8.4.6*.
	Falling objects	Hard hats, steel-toed boots, and safety glasses will be worn per Section 7.0* and per the task-specific HASP.
	Biological Hazards	Pre-work discussion to ensure awareness.
	Cold stress/heat stress	Pre-work discussion to ensure awareness. Follow guidance in Section 6.9* and Section 8.4*.
2) Equipment decontamination	Contact with potentially contaminated rinse water	Personnel PPE will be defined prior to decon operations (Section 7.0*).
	Similar exposure hazards as identified above	PPE and monitoring requirements consistent with intrusive and sampling operations.
	High pressure steaming, as appropriate	PPE as described in Section 7.0.*

*refers to the appropriate section in the Groundwater Monitoring Program HASP, RF/ER-SAF-94-GMP, Rev. 1

H&S CONCURRENCE: [signature] DATE: 12-19-97

PROJECT MANAGER CONCURRENCE: _____ DATE: _____

1.0 BACKGROUND

Reports of plutonium (Pu) and americium (Am) movement in groundwater over distances beyond several meters are rare. Hakonson et al. (1981) reviewed the transport of Pu in terrestrial systems and asserted that vertical leaching of soluble Pu through the soil is probably an important phenomenon. Other findings support this claim. Onishi et al. (1981) concluded that adsorbed Pu can be readily moved through the aqueous environment in colloidal forms. Recently, Penrose et al. (1990) found that Pu and Am were transported in groundwater for at least 3390 meters downgradient from the point of discharge.

Pu and Am were tightly or irreversibly bound to colloidal material (25 to 450 nm). Krey et al. (1976) attributed the successful application of the diffusion term in their Soil-Pu transport model at several diverse sites at the Rocky Flats Plant (RFP) to transportability of Pu in soil interstitial waters rather than to soil characteristics. Minimal research has been conducted on the fate and transport of actinides in soils at RFP. Studies are necessary to determine the physical and chemical attributes that govern the flow of water and plasma in the soils at RFP.

Furthermore, activity of actinides in soils are usually studied by extracting the soil matter. In general, these analyses fail to provide important information regarding the transport mechanisms of actinides within the soil column. In situ measures are necessary. Analysis of the frequency, duration, and intensity of summer precipitation and spring snowmelt events including direct measurements of solute transport in soils will provide essential information to assess the form and magnitude of actinide movement in soil. The area chosen for these *in situ* measurements is shown in Figure 1.0-1.

The information in this scientific notebook is a compilation of the studies done during 1994. It is a continuation of the 1993 scientific notebook titled, "OU 2 Closure Soil Studies Scientific Notebook for The Rocky Flats Environmental Technology Site," document number RFP/ERM-94-00021.

2.0 PROJECT OBJECTIVES

The objectives of the project are: (1) study and monitor the vertical flow in the soil environment upslope from Seep SW-53 during and after major precipitation events and snowmelt, and (2) to assess the relationships between Soil-Pu in the interstitial water and Pu in Seep SW-53. Geohydrological and geochemical data water will provide necessary constraints for the development of vadose zone modelings. The geochemical characterization study will include: (1) total concentrations of Pu and Am in soil interstitial waters that move freely (0-5 kPa) down the soil column, and (2) fractionation of actinides to colloidal and dissolved (<0.1mm) phases in in freely flowing waters (0-5 kPa) and interstitial water at various matric potentials (5-10, 10-30, and 30-50 kPa).

3.0 PERSONNEL

3.1 PRINCIPLE INVESTIGATOR (PI) AND PROJECT MANAGER (PM)

Dr. M.Z. (Iggy) Litaor – Soil Scientist
Group I Closure, Soil Study Team
Rocky Flats Environmental Technology Site – Golden, Colorado
Phone: 303-966-8583

3.2 COLLABORATING PRINCIPLE INVESTIGATORS (Co-PI)

Group I Closure, Soil Study Team
The Rocky Flats Environmental Technology Site – Golden, Colorado

Gilbert Barth – Water Resource Scientist/Co-PI.
Time Domain Reflectometry
Piezometers
Graphic User Interface
Phone: 303-966-8707

Philipp Molzer – Environmental Engineer/Co-PI.
Tensiometers
Phone: 303-966-8754

Hans Daniels – Environmental Engineer/Co-PI.
Evapotranspiration Studies
Phone: 303-966-8591

James Moffitt – Environmental Engineer/Co-PI.
Snow Melt Studies
Phone: 303-966-8515

Elizabeth Zika – D.O.E. Co-Op Student/Co-PI.
Rain Simulations
Phone: 303-966-7164

Suki Rivera – Stoller Corp. Co-Op Student
Ultrafiltration

4.0 TIME DOMAIN RELFECTOMETRY

4.1 INTRODUCTION TO THE TIME DOMAIN REFLECTOMETRY DOCUMENTATION

Time domain reflectometry (TDR) documentation for the 1994-1995 season consists of this text section only. The configuration for testing and calibration is currently being developed. Details on the configuration and the method of determining the final version will be documented in next year's scientific notebook.

4.2 PRINCIPLES OF TIME DOMAIN REFLECTOMETRY CALIBRATION

Time Domain Reflectometry probes installed in the soil pits East of the 903 Pad at RFETS were modified to perform in the high clay content soils typical of the study site. The standard probe lost much of its signal in the high clay content soils, resulting in a diminished signal that was unable to generate the necessary end-of-probe rebound. The end-of-probe rebound is critical for determining the velocity of propagation in the media and the related volumetric water content. Modification consisted of coating the entire length of the probes except for the front half of the taper forming the tip tines with heat shrink tubing. The tubing was unable to shrink onto the smaller diameter which forms the tip due to a 2:1 shrink ratio limit. The tubing served to reduce the apparent conductivity of the soils to the extent that a significant rebound was distinguishable.

After modification the probe was installed in the soil, but the quantitative impact of the coating on the probe's calibration was unknown. The values which were recorded from the modified TDR probe were based on calibration of a standard probe in soils which did not exhibit the apparent high levels of conductivity due to clay. To determine the actual volumetric water content in the soils, calibration was needed to determine the relation between the soil moisture values reported by the modified TDR and the actual gravimetrically determined values. The

relation for the entire range of clay moisture contents occurring in the field needed to be established.

4.3 TIME DOMAIN REFLECTOMETRY CALIBRATION SETUP

The interpretation of field data was the primary concern of this study. In particular, the values interpreted by the Campbell Scientific, Incorporated (CSI) algorithms needed to be converted to actual water content. This meant that the laboratory setup needed to be capable of measuring the gravimetric soil moisture content and the apparent soil moisture content as evaluated by a CSI TDR system identical to the unit in the field.

Determination of the relation between the reported CSI value and the gravimetric value solved the problem. In addition it was critical to determine the actual cause of the signal depletion and the reasons why the modifications were successful.

The laboratory TDR setup consisted of two waveform capturing methods. The first was duplication of the field hardware configuration consisting of a CSI CR-10 running a Tektronix 1502B through a CSI SDMX-50 eight channel multiplexer. A second system composed of the Vadose Zone Equipment Company's IBM PC based software and a sixteen channel VAZEQ multiplexer provided an efficient method of capturing the waveforms and a second method of interpretation. Finally a Denver Instruments IR 100 soil moisture analyzer served to determine moisture contents gravimetrically.

Several configurations of soil containers were evaluated including a large lucite enclosure with sampling ports, split samplers and a manifold for applying suction from the bottom through porous ceramic disks. A simple plastic container measuring 360mm by 810mm by about 160mm deep was used for most of the tests. The container was capable of holding four probes at the same elevation spaced so that they would not interfere with each other. The probes were held in place by a single sheet of plastic 0.48 cm thick (0.48 cm natural polypropylene) mounted into the box. The

probes were held by the sheet 75mm from the bottom and were covered with at least 75mm of material. The end probes were at least 100mm from the sides and spacing between each probe was 100 to 200mm.

The equipment and sample configuration was tested using air alone, distilled water or a #70 silica sand with a range of water contents from dry to about 13 percent. The testing provided insight as to the need for tight control of sample packing, homogeneity of the sample, documentation of specific test configurations and data management.

The first step for evaluation was sample preparation. Air required no preparation and water simply required filling the container while the soil/water mixture required actual preparation. Typically a specified quantity of water was mixed with a known weight of sand. This was done by mixing successive small batches of the same sand/water proportion until the container was filled. The small batches were used to improve the homogeneity of the large batch. The filled container was covered with plastic wrap which was held in place by a thin layer of sand to prevent any gaping and significant evaporation or formation of condensation.

Next, the Vadose equipment was hooked up and adjusted for each probe and the waveforms inspected for any suspicious output. Once reliable waveforms were produced, a series of waveform captures and analyses were performed. Immediately afterward, the interface on the Tektronix was switched to the CSI CR-10 datalogger, all probes rerouted through the SDMX-50 multiplexer and a program downloaded to the datalogger from the PC. Typically the program was set to execute every 15 minutes and would be run for a period of at least 20 executions. Immediately following the last execution the CSI CR-10 was detached from the Tektronix 1502B and the Vadose system brought on line. Once again several waveforms were captured and interpreted. The before and after collection using the Vadose equipment provided a second method of using the TDR Tektronix without relying on any CSI equipment and a confirmation of any overall trends exhibited by the data collected with the CSI datalogger.

4.4 TIME DOMAIN REFLECTOMETRY CALIBRATION DATA

The data collected for the data calibration consists of two types: soil moisture values and equipment configuration. The majority of the data was soil moisture values collected from the Vadose or CSI equipment. The Vadose files consisted of two different types. Vadose output files ending in "WAT" contained interpreted waveform data including dielectric and water content. Filenames ending in "TDR" contained the waveform parameters and ordinate values for 251 waveform sample points. The CSI files are of the form TDR.dat and consist of the soil moisture values from each of the probes. Equipment configuration data can range from notes on the soil composition to details about the physical layout of the probes and water temperature during executions.

Data collected from the various sources was compiled into a MS Excel Version 5.0 spreadsheet. Each spreadsheet name was composed of the Julian days on which the experiment was performed and an alphabetic character indicating the trial number. For example, a file for the second run of data on September 2 would consist of: 245_245A.XLS. The spreadsheet would contain both the Vadose files, the CSI file, any gravimetric data collected and notes on the configuration of probes tested. The spreadsheet serves to combine all sources of data into one file for cross-referencing and sorting of the data. The Vadose and CSI output was in array for each execution. A macro was used to sort out readings from each probe for the duration of an experiment. Once sorted the data could be graphed and inspected for variance and drift during the experiment. For additional statistics the sorted data was copied into a Statistica/W file of the same name but with a ".STA" suffix. In Statistica/W the descriptive statistics were generated as well as evaluating the distribution and ANOVA tests when applicable.

The initial tests provided several significant contributions. By testing the response of the probes held in air and then placed in the container with only air in it the impact of the container could be evaluated. Placing the probes in water and monitoring temperature provided a control for

the system to evaluate whether the results were accurate and characterize and quantify the impact of the transition from parallel transmission wire to the probe. Configuration testing and evaluation also revealed the range of differences in response between the bare and modified probes. The trial runs in air with bare and modified probes side by side demonstrated the similarity in response for media with a low dielectric. Preliminary measurements in water demonstrated the other extreme with the modified probe underestimating soil moisture by as much as 50%. These results and the range of conditions in between will be more thoroughly quantified during the 1995-1996 season.

piezometer hole was fitted with a PVC pipe as a casing, movement or expansion of the soil as well as some variation from absolute vertical installation precluded using a larger size transducer. The hole diameter was limited by the method used to create the holes. The piezometer holes were created with a hydraulic ram mounted on an all terrain vehicle (ATV). The ATV unit was limited in its ability to penetrate the local soils and could not create a hole larger than 6.35 centimeters in diameter.

In addition to size limitations the pressure transducer needed to be compatible with the existing Campbell Scientific (CSI) datalogger. The datalogger, a CR-10, controlled two AM416 multiplexers. The AM-416 multiplexers provided up to 16 channels each. The multiplexers were spread from the CR-10 so that the total length of pressure transducer cable run would be reduced. The AM-416s were connected to the CR-10 with polyethylene jacketed, 4 conductor with drain, 22 gauge wire (Carol® model C2523).

Finally, the pressure transducer needed to be able to tolerate down hole conditions found in the field. The Keller-PSI model number 169-110-0010 was chosen. The Keller-PSI 169-110-0010 was designed to function with the CR-10 CSI datalogger, the outside diameter was 2.54 cm and it was designed for down-hole field applications. A 0 to 6.9 kPa range was selected because the depth of the holes varied from 2.4 to 9 meters.

Each pressure transducer was ordered with a length of cable consisting of the signal wires and the vent tube. The cable lengths ranged from 30 to 67 meters depending on the intended destination of the transducer, the depth of the piezometer hole and the relative location of the datalogger (see appendix 2 for a sketch of the general layout). The lengths of cable ordered with each pressure transducer were calculated by using a AutoCad/GIS file and plotting the location of the two multiplexers and each of the proposed piezometer locations. After determining the distance according to AutoCad, an additional 9.1 meters of cable was added to allow for the deepest possible installation. Determination of individual cable lengths as opposed to ordering all with a maximum anticipated length reduced the overall cost of the pressure transducers.

vehicle combined with the angle of the slope caused the vehicle to roll one-and-a-half times down the hill causing minor damage to several of the site instrumentation cables.

Once a piezometer hole was completed it was developed. This consisted of adding water to the hole if it was dry and then pumping the water out. The goal was to remove some of the material which had been displaced and compacted as a result of the hydraulic ram penetrating through the soil. The displaced soil and the surrounding compacted soil would limit flow if some portion were not removed. Each hole was repeatedly surged so that the soil matrix surrounding the screened section was flushed as much as possible to enhance flow into the piezometer.

5.5 PRESSURE TRANSDUCER INSTALLATION

The transducers which had been tested and performed to specifications were installed in the field. The offset and calibration for each pressure transducer was incorporated into the CR 10 piezometer program so that output was reported in terms of the water table elevation above mean sea level. The cable from each pressure transducer was feed through the cap at the top of the PVC casing and bent so that the cable followed the outside of the PVC casing down to the ground. The bend in the cable was restricted to a radius larger than the manufacturers recommended minimum radius of curvature for the cable. The cables, upon leaving the PVC housing were encased in a grey, non-metallic, waterproof conduit (Carflex® liquidtight flexible nonmetallic conduit) all the way back to their respective AM-416 multiplexer.

To calibrate the piezometers the depth to water level was measured manually and then the pressure transducers were placed in the piezometer. The survey of the piezometer PVC casings was completed at a later date and the elevation data for each piezometer was incorporated into the CR-10 program at a later date. Incorporation of the survey data meant that the piezometers read in terms of actual water table elevation as well as depth to water table from ground level. A printout of the datalogger program is included in appendix 4.

The piezometers were queried every 1.5 hours. The piezometer data is retrieved by the SWMS GUI and incorporated into a database consisting of just the piezometers.

6.0 SNOWMELT STUDY

6.1 SNOWMELT MONITORING SYSTEM FIELD UPDATES

6.1.1 Snowmelt Pan Maintenance

The five snowmelt pans installed in the field are constructed of stainless steel. Field observations during the 1993-94 snow season indicated that sunlight had the potential to heat up the pans and accelerate the melting of the snow. Therefore, the pans were painted white in an attempt to reduce the thermal conductivity and increase reflectivity of the snowmelt pans. The pans were power sanded, brush coated with Rustoelum, then painted with three coats of white acrylic latex enamel paint. Observations will be made to compare the surrounding snowcover and the snow in the pan during the end stages of snowmelt.

6.1.2 Snowmelt gauge calibrations

Important progress was made in snowmelt gauge calibrations. Output from the snowmelt gauges will be used for snowmelt model verifications. Calibrations are made with a vendor supplied 1-liter calibration bottle. One liter is poured into the snowmelt gauge and the number of measurement cup tips is recorded. It was discovered that the water output from this bottle was too high, resulting in water splashing over and around the internal measurement cups. Because of this, calibration results varied up to 40%.

The flow from the calibration bottle was decreased by applying electrical shrink-wrap to its nozzle. The output rate was reduced from 20 liters/hr to 6 liters/hr. An output

rate of 6 liters/hr is equivalent to a 1 m^2 area of 6 cm of new snow (with density of 100 kg/m^3) melting in one hour. This rate is slow enough to prevent spillage, while representing a conservative upper limit in natural snowmelt rates. After this re-design, calibration results have been varying no more than 7%. Ten calibrations per snowmelt pan will be performed during the 1994-1995 winter season.

6.1.3 Purpose of Snow Fences

Since the snowfall events of the 12/93-4/94 data collection period were all isolated and less than 15 cm, snow fences were installed in the field. Snow fences act as artificial collectors of wind-blown snow. Since RFETS experiences frequent high winds, it should be an effective location for such structures. The snow fences increase the odds of collecting snowmelt data for deeper and/or multiple events. This would allow improved assessment of the snowmelt model's handling of more extreme snowfall events.

6.1.4 Snow Fence Design

The snow fence dimensions and locations were based upon general guidelines (Ron Tabler, personal communication). The snow fence height is equal to the maximum potential depth of collected snow. The height of the snow fences is 1.2 meters (4 ft). This maximum snow depth will be centered down-wind from the fence by a distance equal to six times the fence's height. Therefore, the fences were installed 7 meters uphill (and up-wind) from the subsurface soil moisture and snow monitoring instruments.

The snow fences were designed to collect snow along the length of the entire pit, including the snow instrumentation. This distance is equal to approximately fifteen meters. To compensate for 'end-effects', snow fences should be double the target length. Therefore, the length of the installed snow fences is thirty meters. Snow fence aerodynamic end-effects prevent snow from being collected along the outer ends of the structure.

For maximum snow collection, fences should be installed perpendicular to the predominate wind direction. Winds at the research site tend to come from the north-west, although directional variation is common. Most storms bringing snow approach from the west. Another factor is topography. The research site is on a hill, with the slope falling from the north-west to the south-east. Therefore, the fences were installed with a south-west to north-east direction. The fences are positioned uphill, to the northwest of the pit instrumentation.

6.1.5 Snow Fence Material and Installation

The snow fences were constructed with standard materials found at most hardware stores: 5 ft fence posts, 4 ft high wooden-slat fencing, and standard fence wire. Several tools were required: a fence hammer, fence-wire twisting tool, and ear protection.

The fence posts were driven one foot into the ground with a fence post hammer. Ear protection is critical for this procedure. The posts were installed with a 8 foot interval (each 100 foot fence consists of 13 posts). Starting on one end, the fencing material was anchored to the end post with standard fence wire. The fence slat was tied to the fence

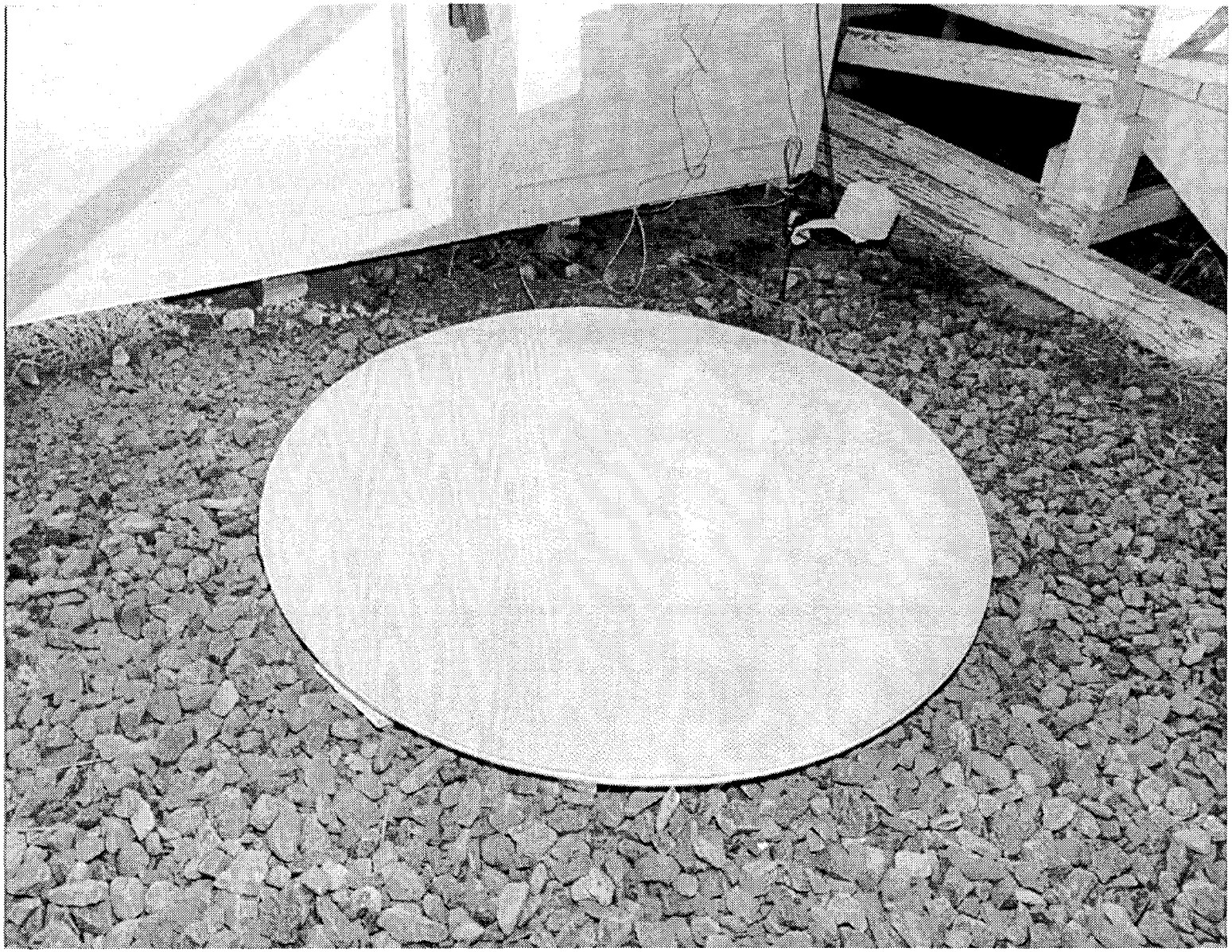
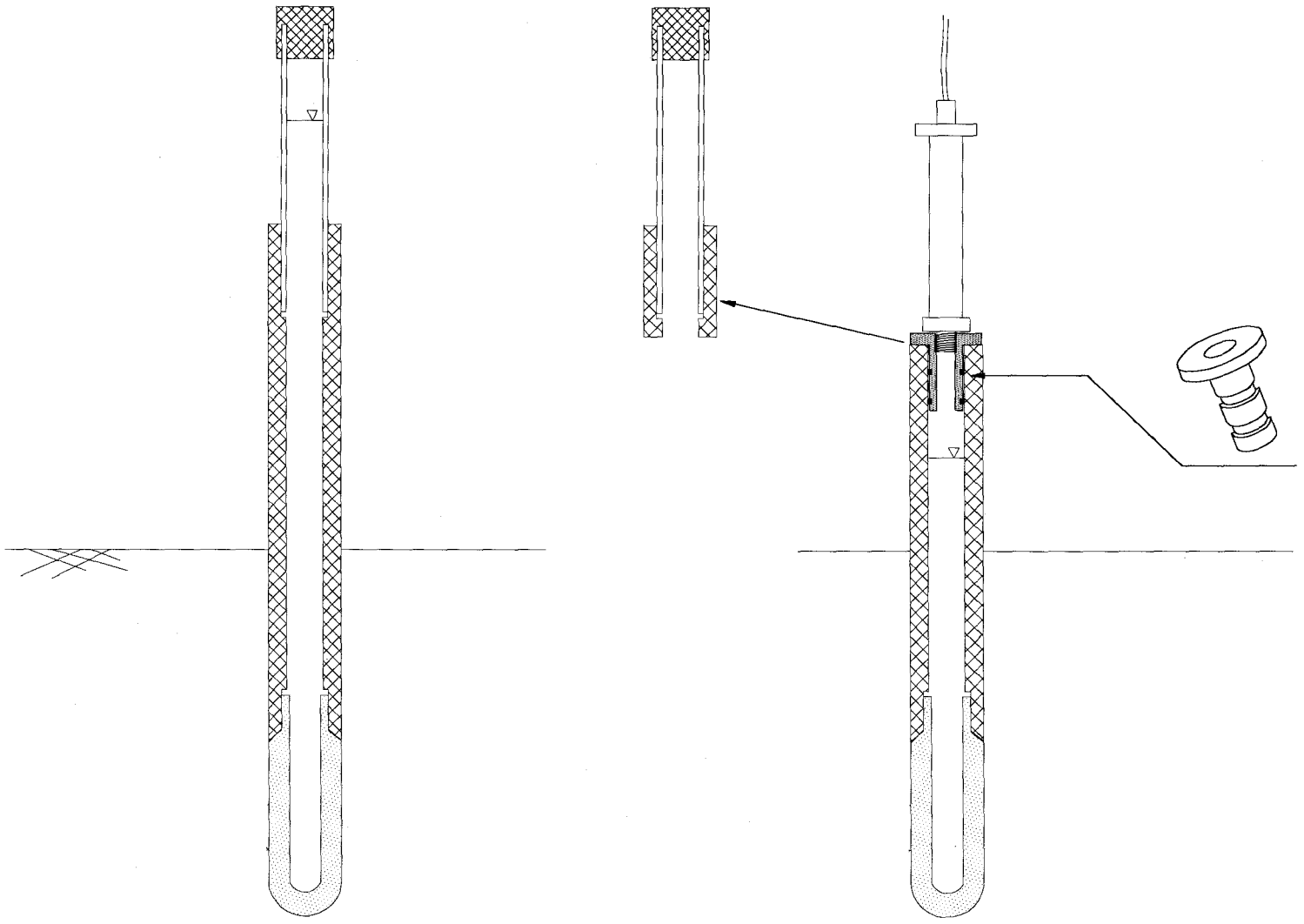


FIG 6.5
ASSEMBLED SNOW DENSITY PLATE



SUBK 3

FIG 9.22a, b

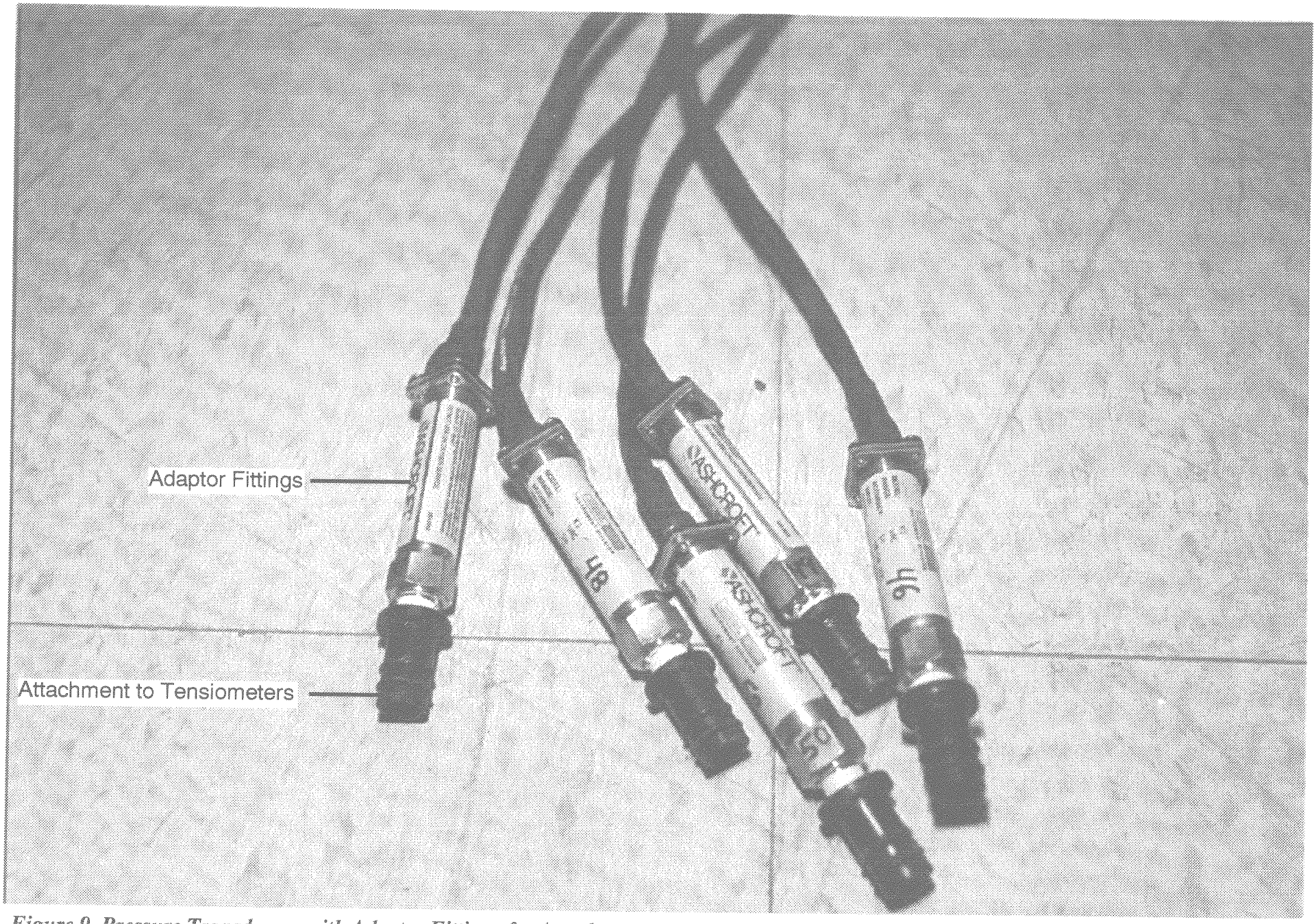


Figure 9 Pressure Transducers with Adaptor Fittings for Attachment to Tensiometers

PIT 2 PRESSURE TRANSDUCER WIRING HARNESS

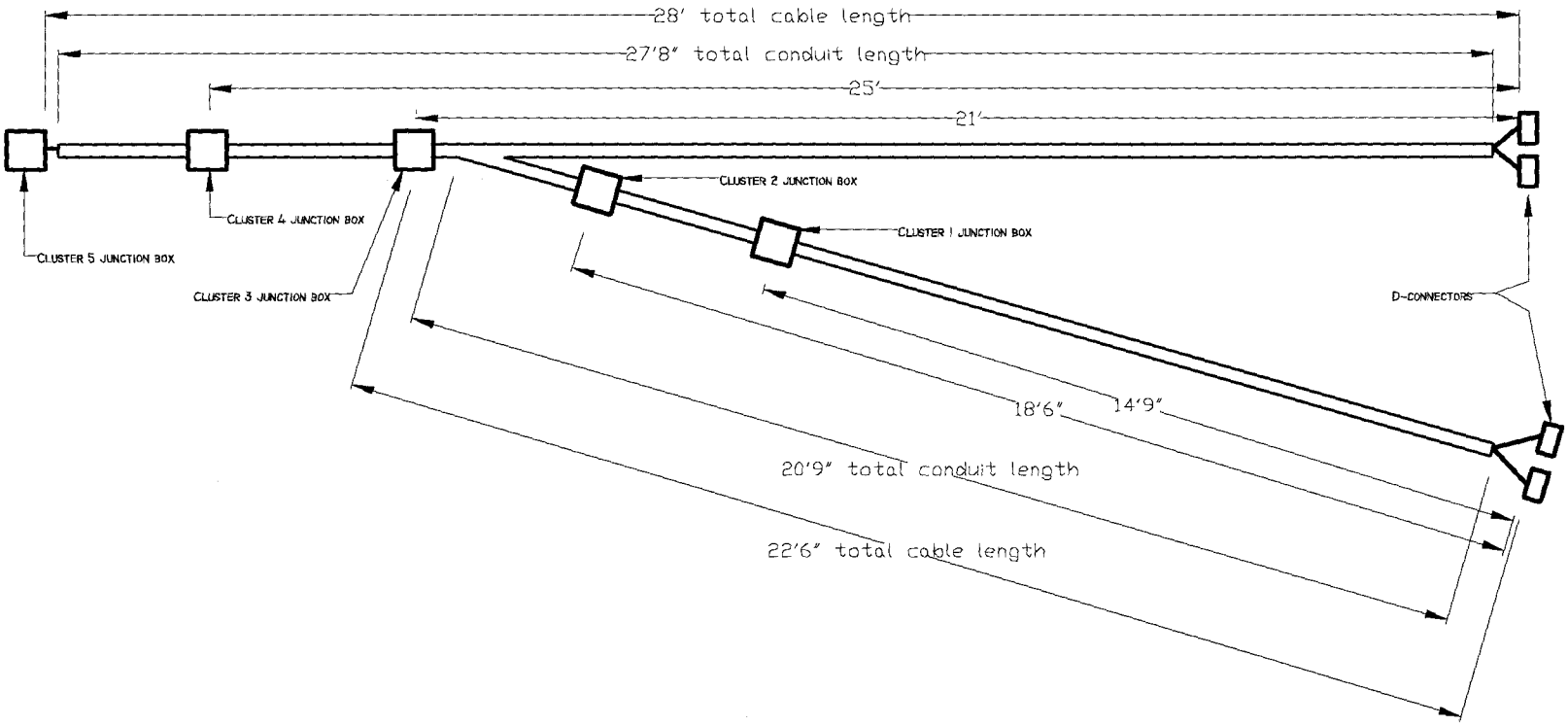


FIG 9.24

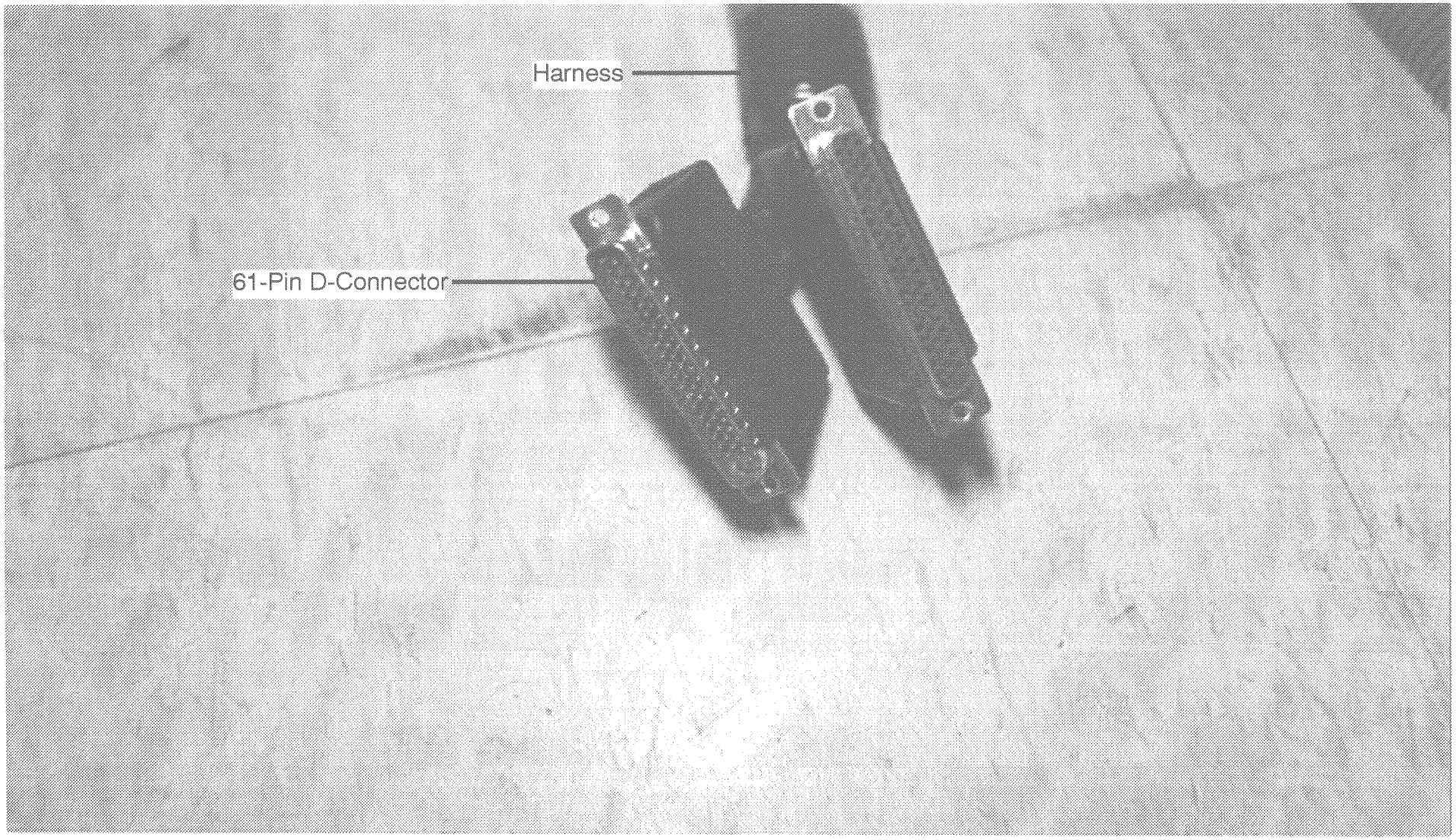


Figure 5 Pressure Transducer Wiring Harness Termination

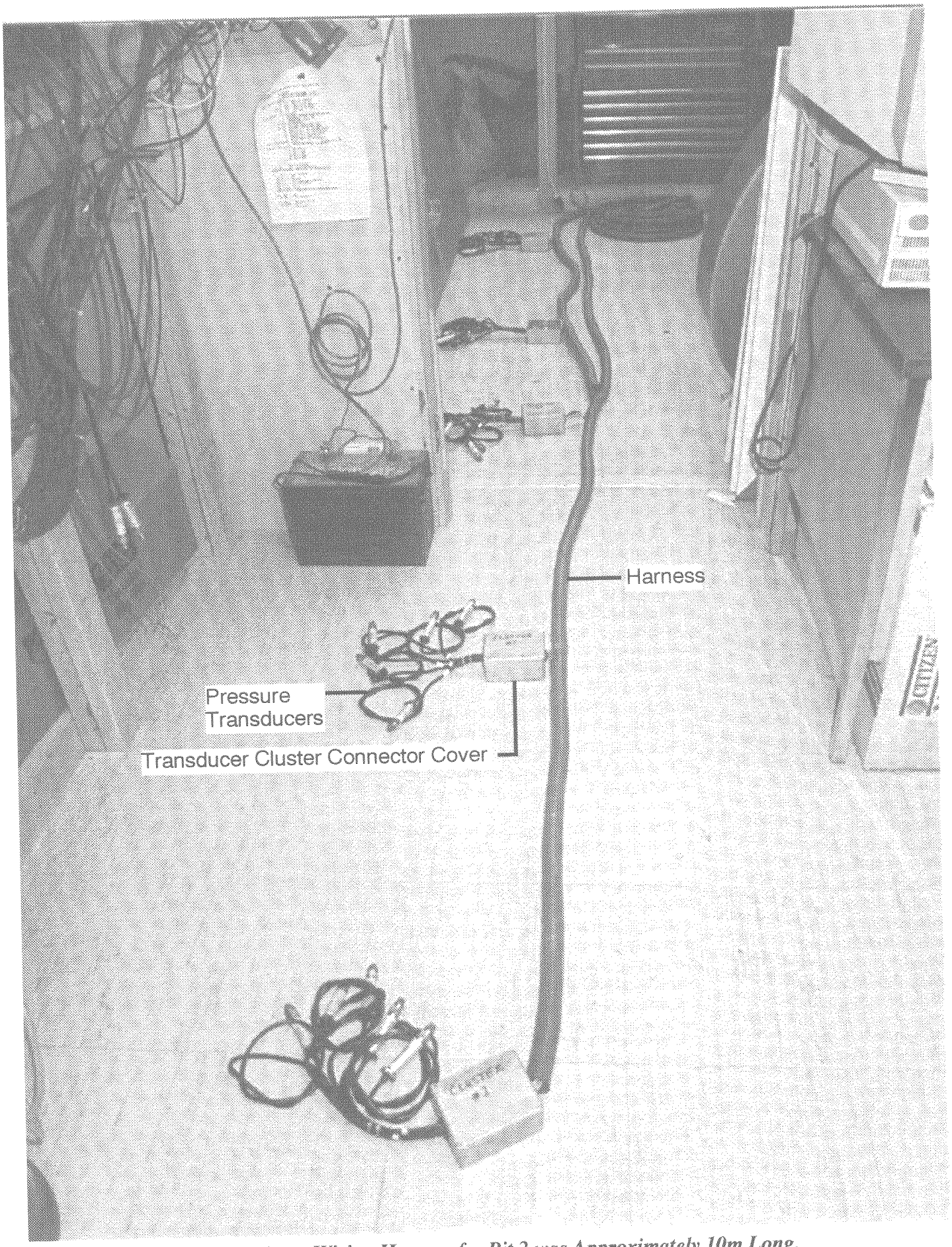
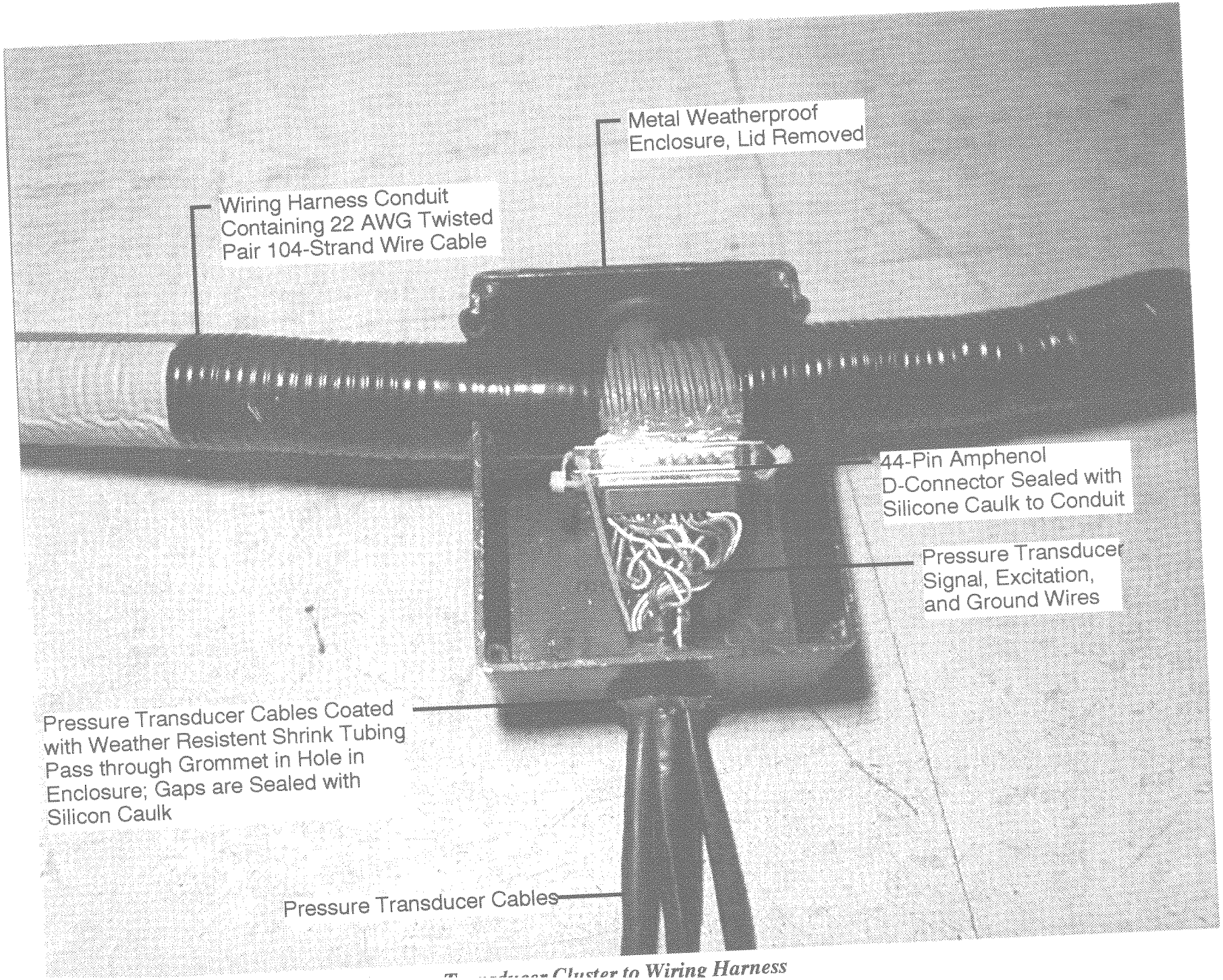


Figure 4 Prototype Transducer Wiring Harness for Pit 2 was Approximately 10m Long.



Transducer Cluster to Wiring Harness

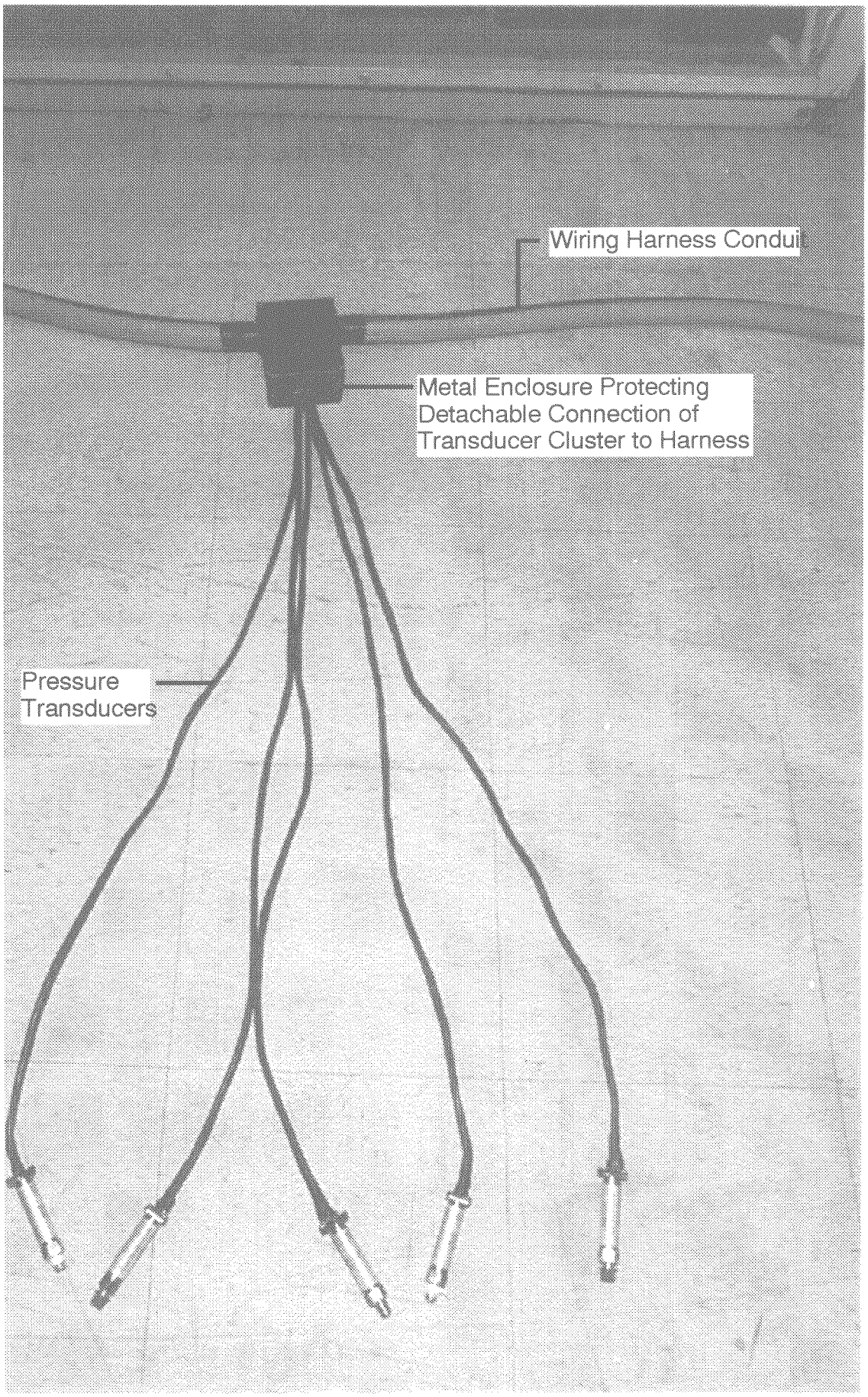


Figure 6 Pressure Transducer Cluster on Wiring Harness

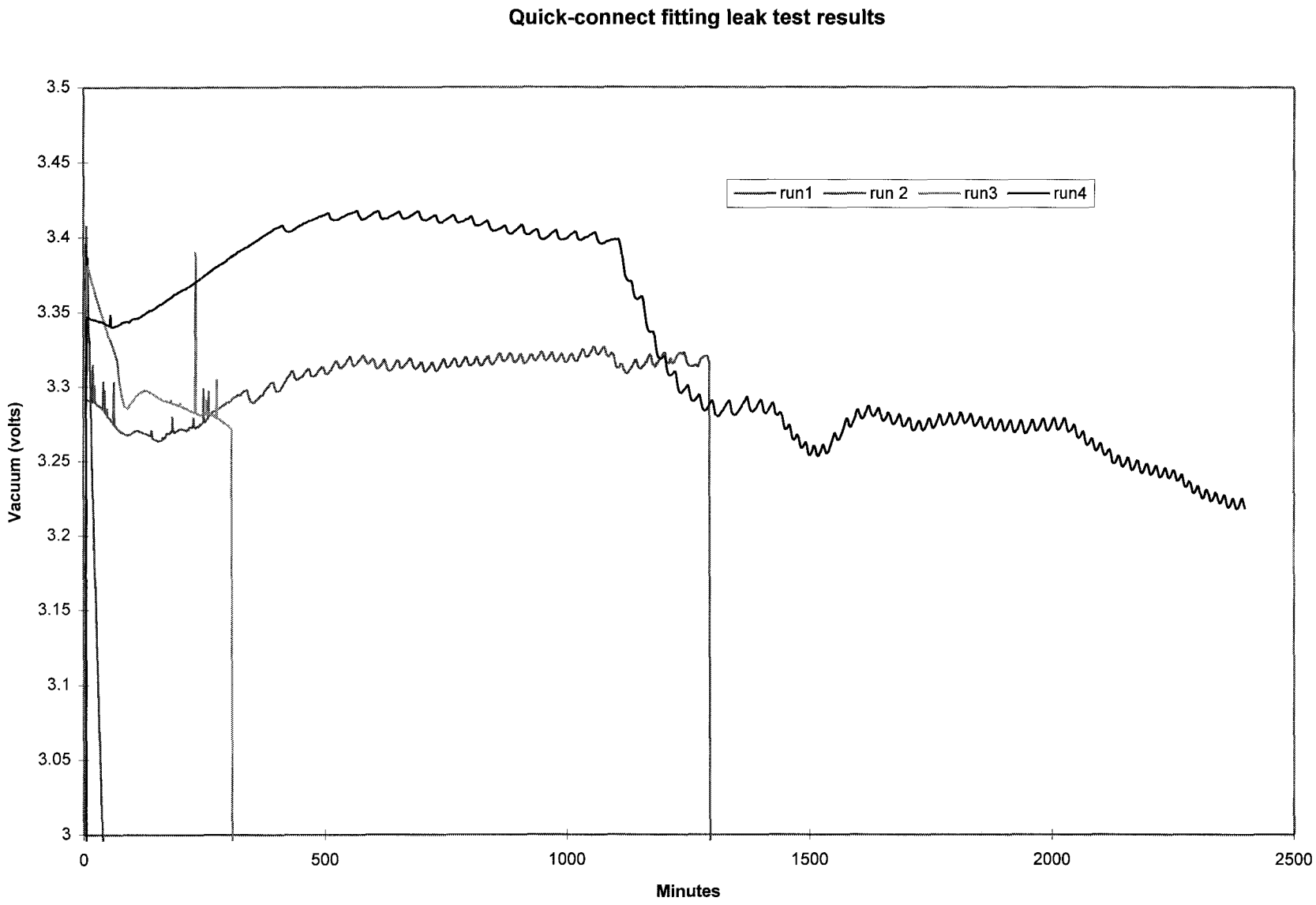
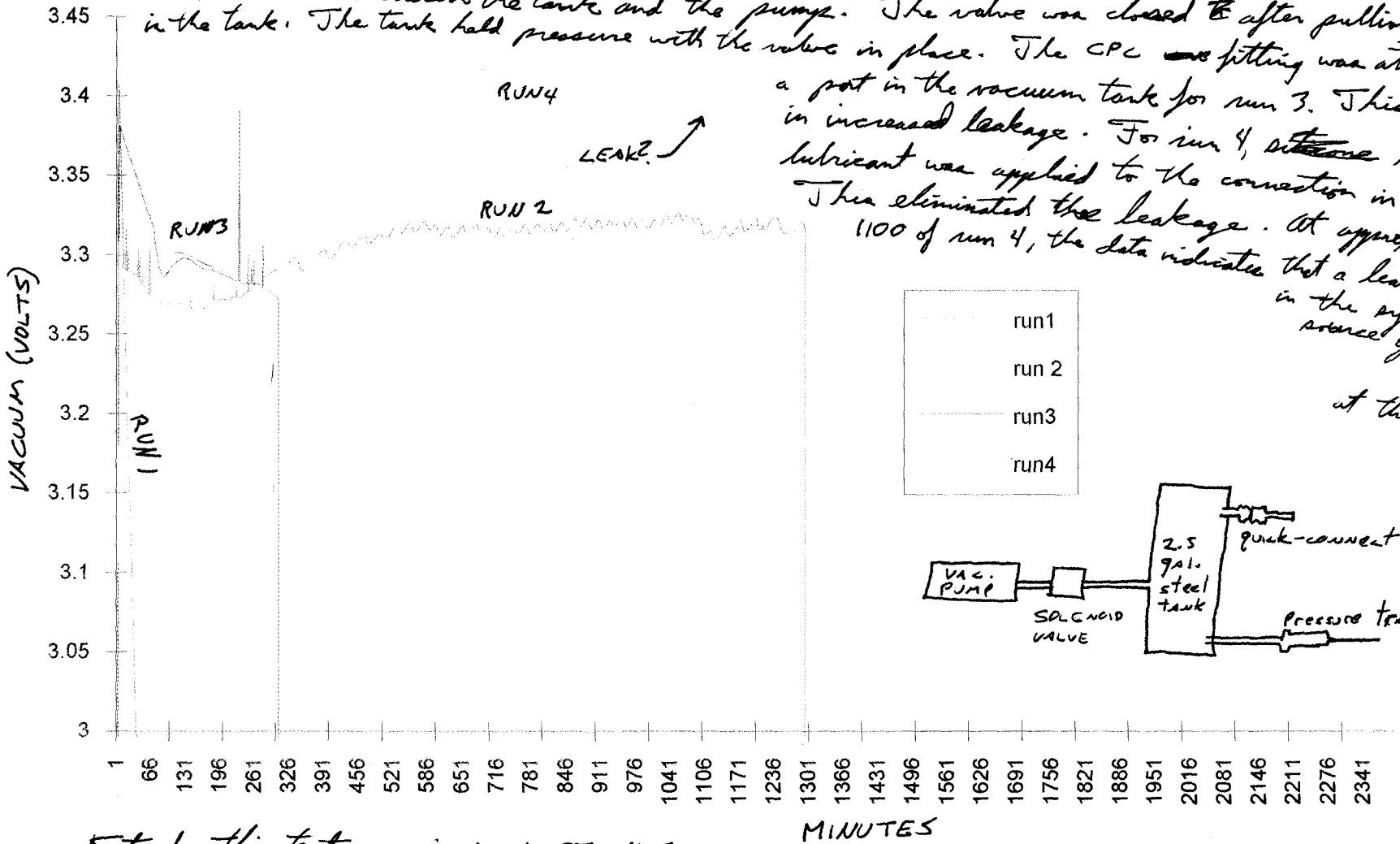
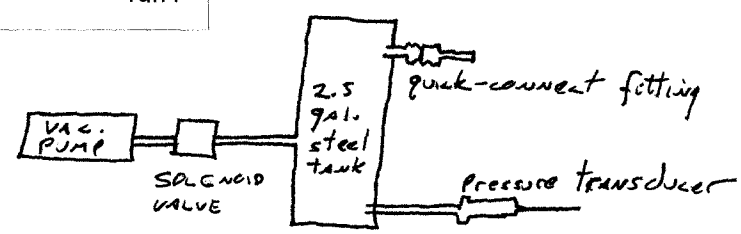

Quick-connect fitting leak test results
run1
run 2
run3
run4
Vacuum (volts)
3.5
3.45
3.4
3.35
3.3
3.25
3.2
3.15
3.1
3.05
3
0
500
1000
1500
2000
2500
Minutes

FIG 9.30

4-11-94 Philippe Mv

This test was to verify that the CPC quick connect fittings are ~~able to~~ vacuum tight with little or no leaking. Run 1 was done with a sealed vacuum tank connected directly to a vacuum pump. Pressure drained quickly because the pump leaked. Before run 2, a solenoid valve was connected between the tank and the pump. The valve was closed ~~to~~ after pulling a vacuum in the tank. The tank held pressure with the valve in place. The CPC ~~one~~ fitting was attached to a port in the vacuum tank for run 3. This resulted in increased leakage. For run 4, ~~silicone~~ silicone lubricant was applied to the connection in the fitting. This eliminated ~~the~~ leakage. At approx. minute 1100 of run 4, the data indicates that a leak developed in the system. The source of this leak is unclear at this time.





Data for this test are in LEAKTST.XLS

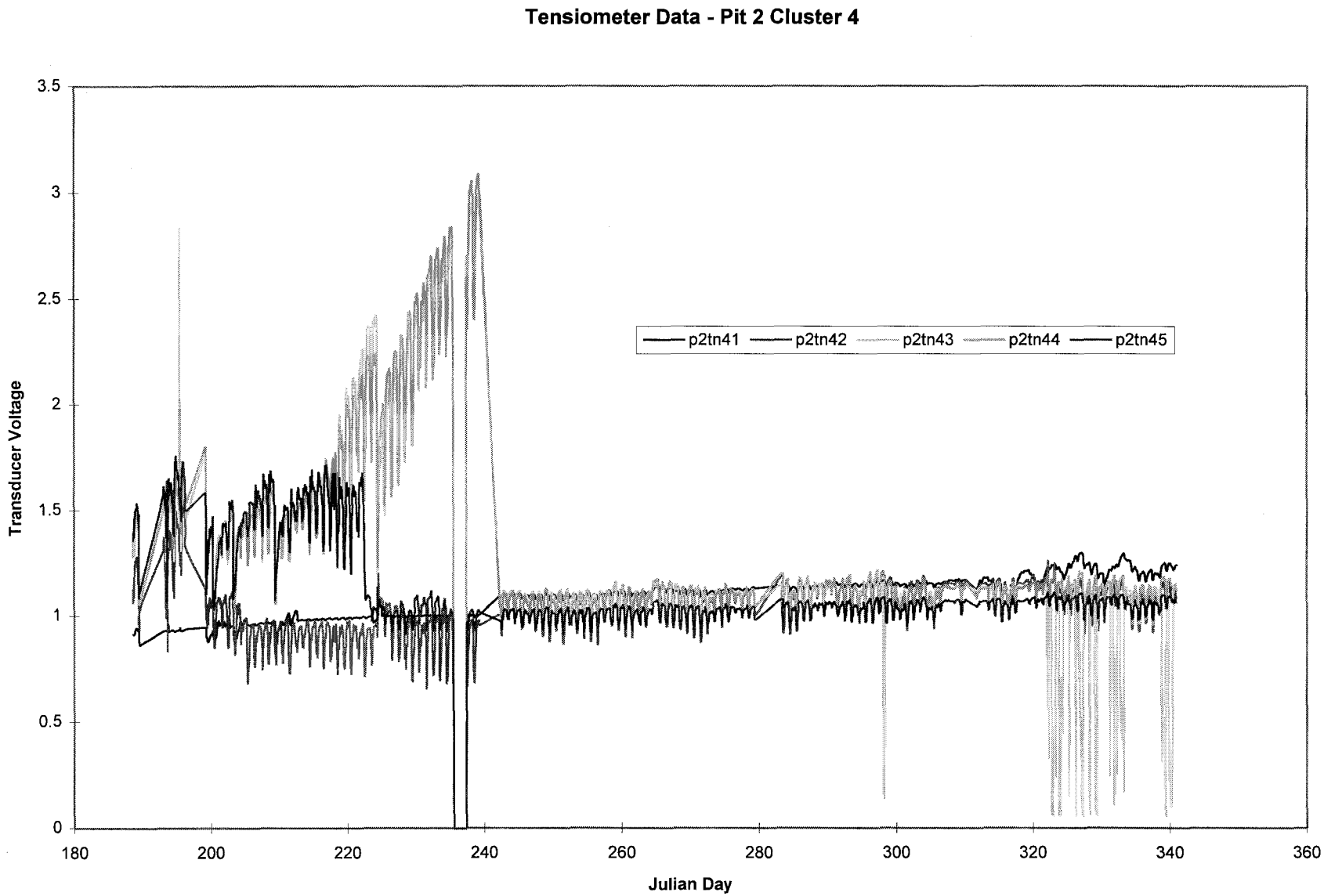

Tensiometer Data - Pit 2 Cluster 4
Transducer Voltage
Julian Day
p2tn41
p2tn42
p2tn43
p2tn44
p2tn45
3.5
3
2.5
2
1.5
1
0.5
0
180
200
220
240
260
280
300
320
340
360

FIG 9.32

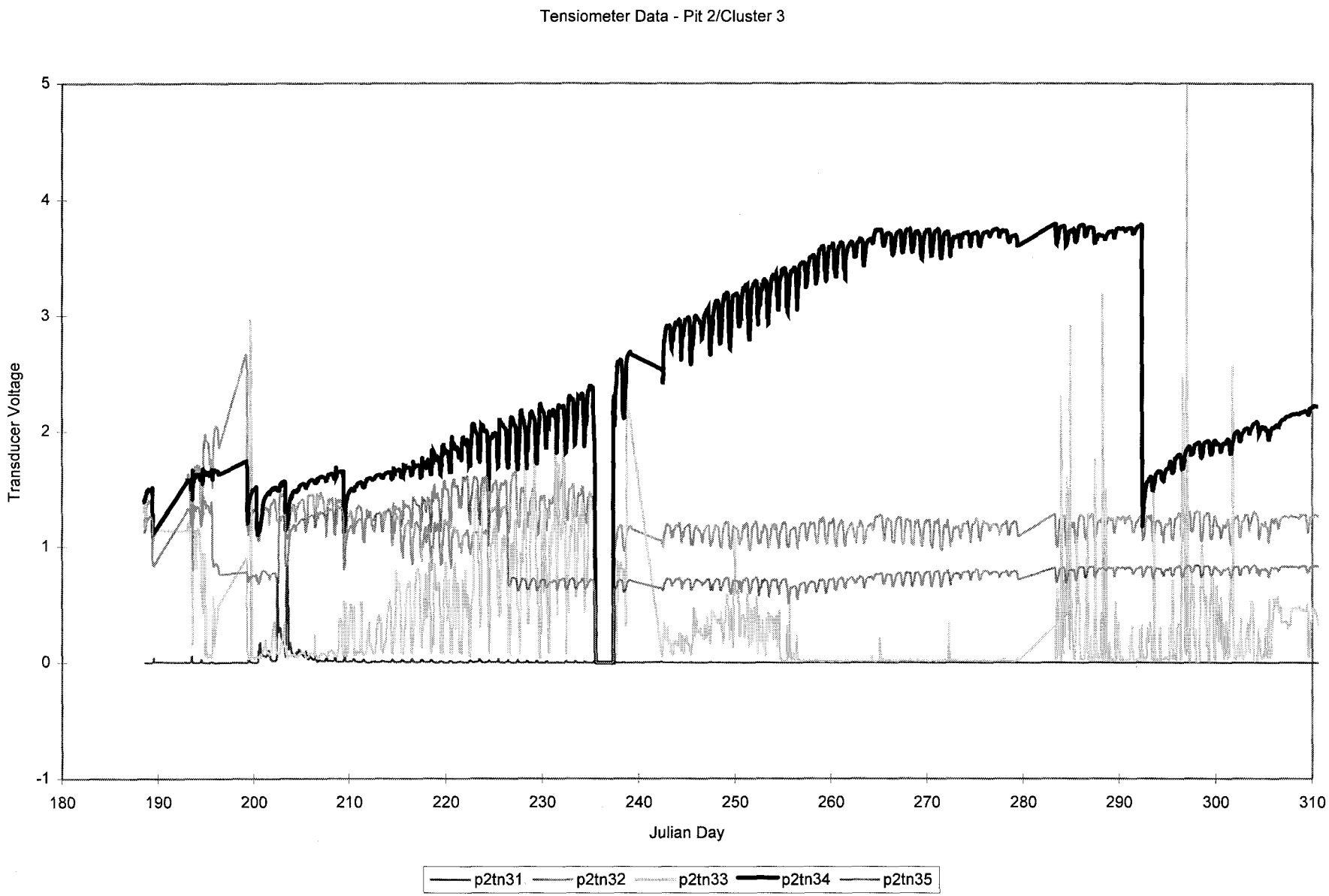

Tensiometer Data - Pit 2/Cluster 3
Transducer Voltage
5
4
3
2
1
0
-1
180
190
200
210
220
230
240
250
260
270
280
290
300
310
Julian Day
p2tn31
p2tn32
p2tn33
p2tn34
p2tn35

FIG 9.31

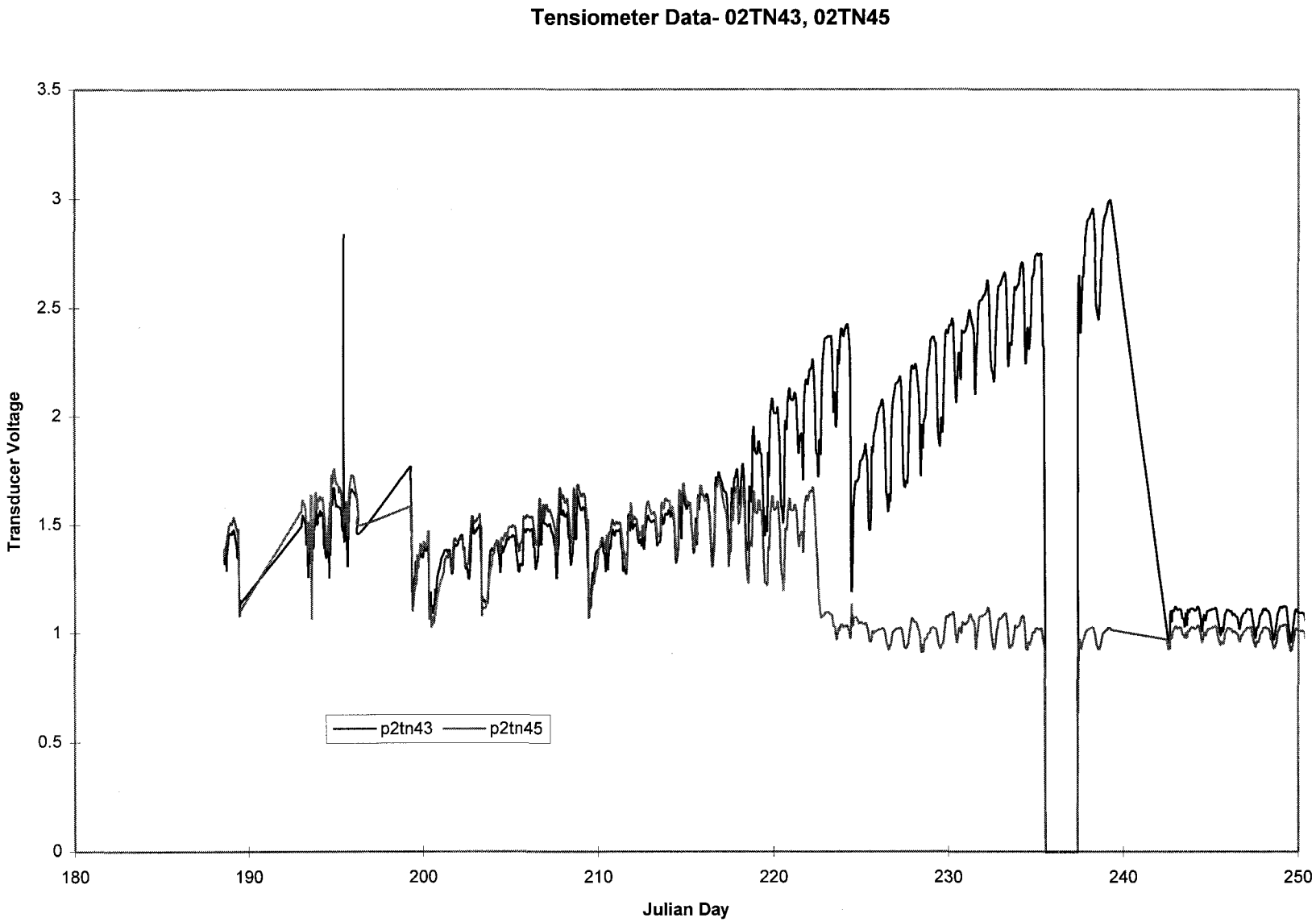

Tensiometer Data- 02TN43, 02TN45
Transducer Voltage
3.5
3
2.5
2
1.5
1
0.5
0
180
190
200
210
220
230
240
250
Julian Day
p2tn43
p2tn45

FIG 9.33

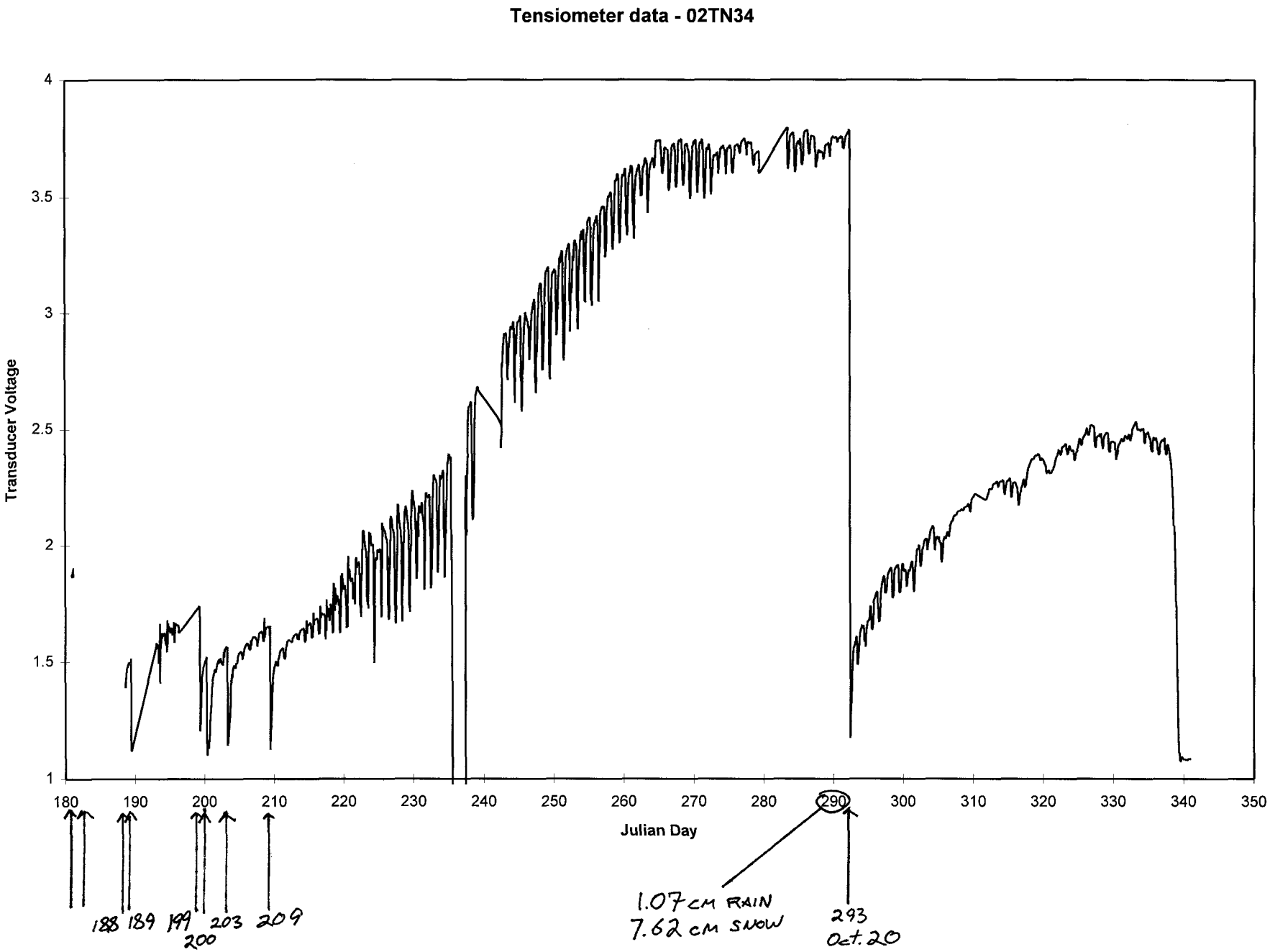
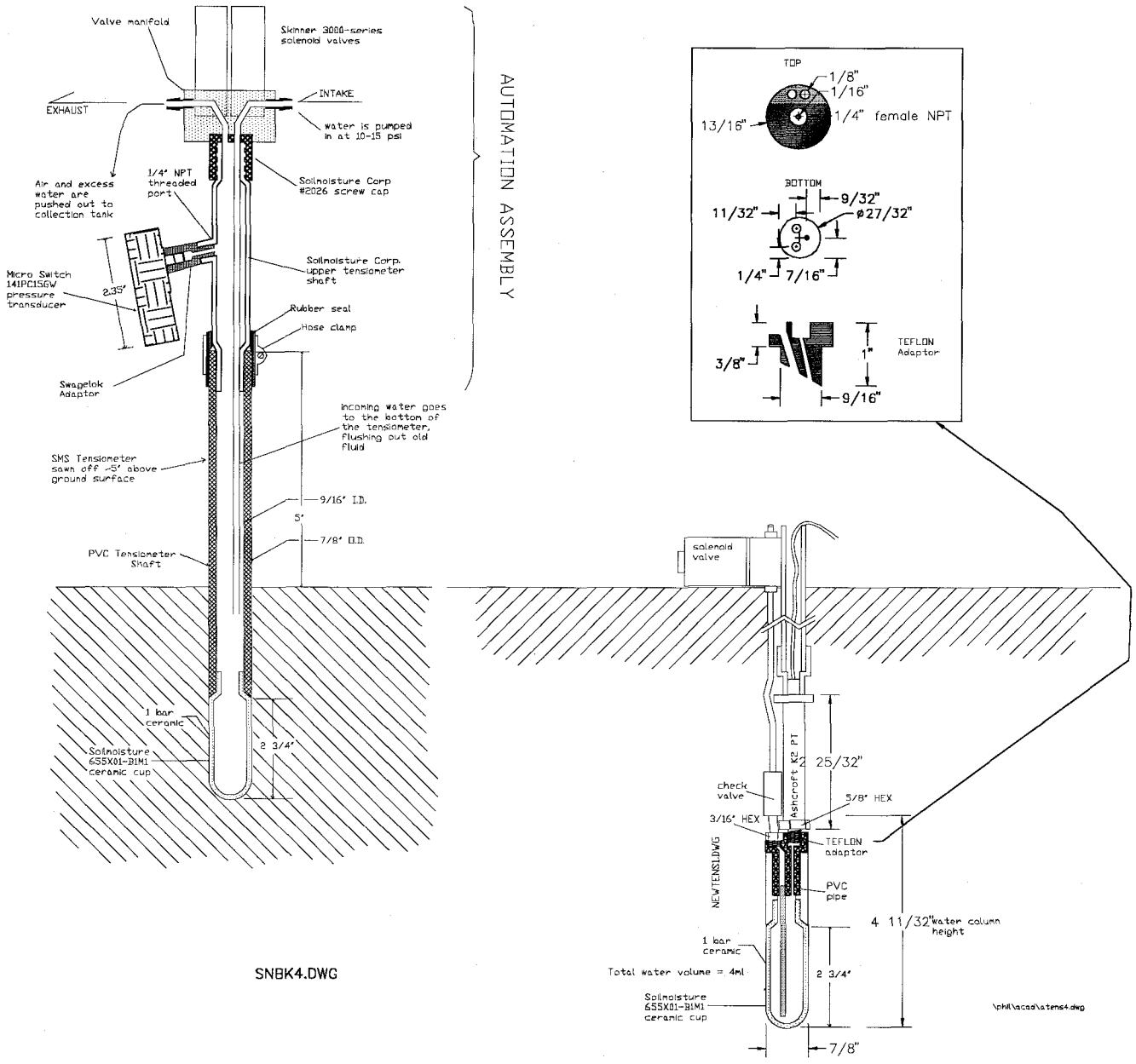

Tensiometer data - 02TN34
Transducer Voltage
Julian Day
4
3.5
3
2.5
2
1.5
1
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
188
189
199
200
203
209
1.07 cm RAIN
7.62 cm SNOW
293
Oct. 20

FIG 9.34



SNBK4.DWG

FIG 9.35

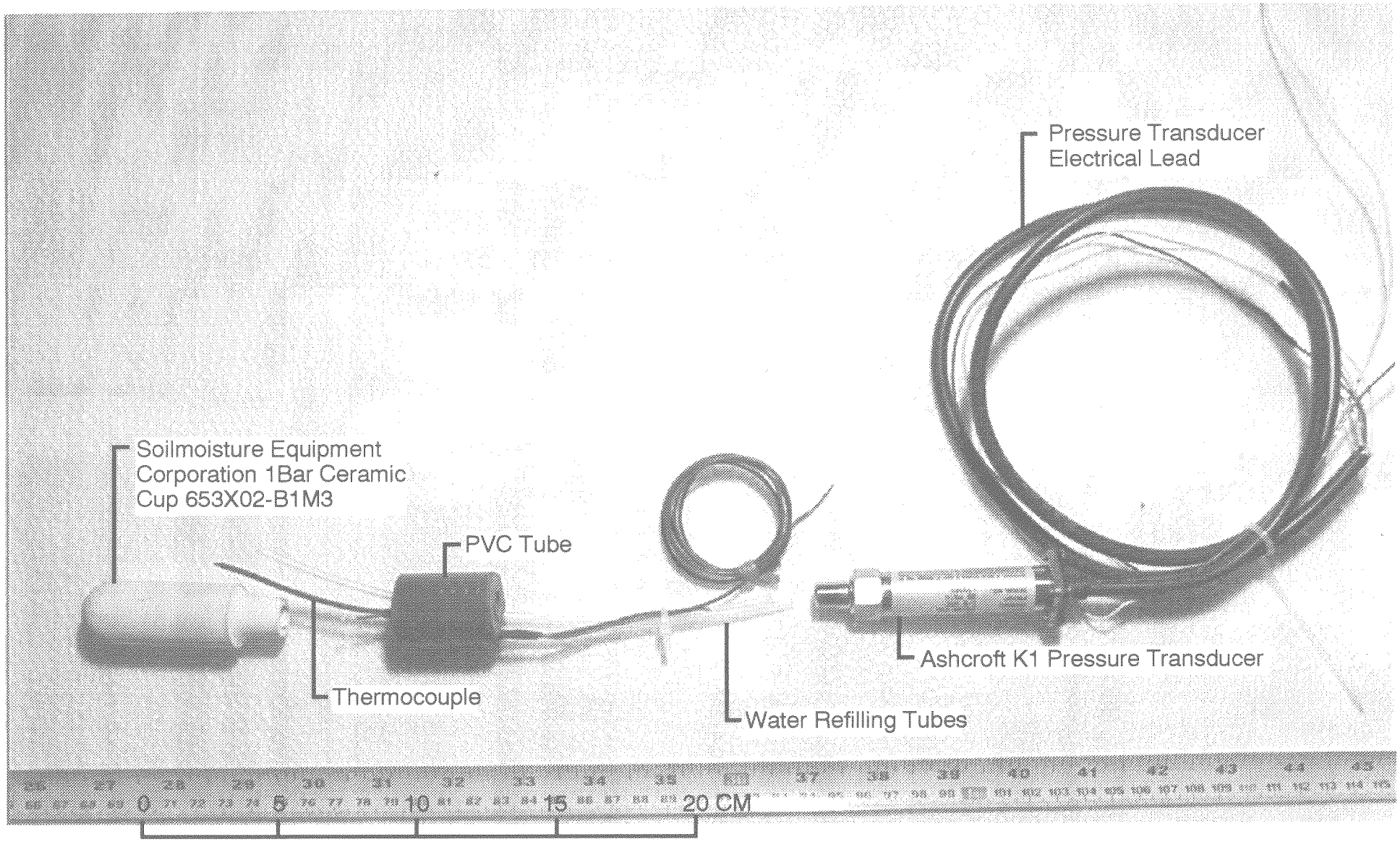


Figure 3 Prototype Tensiometer-Exploded

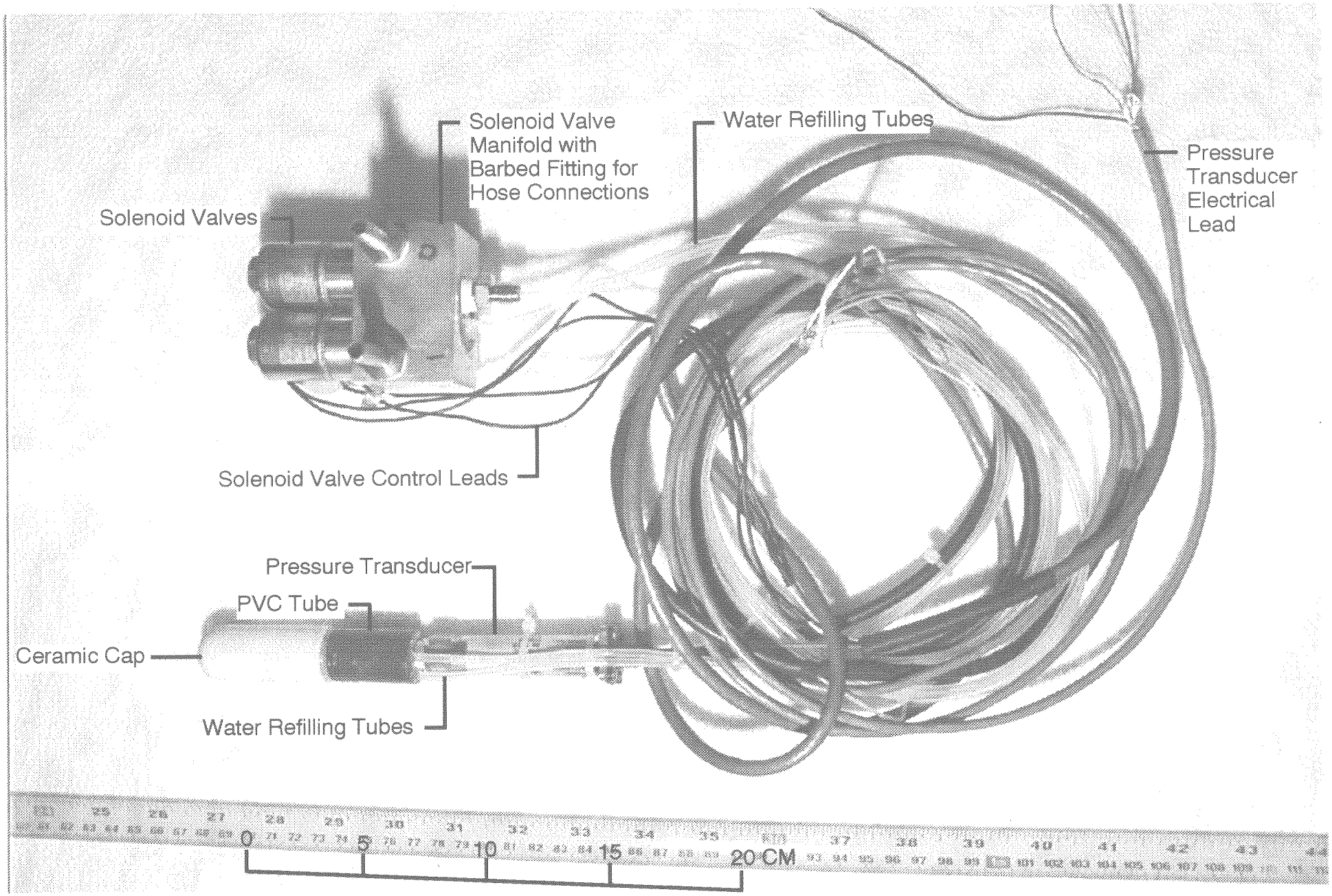


Figure 2 Prototype of Fully-Automated Tensiometer

FIG 9.37

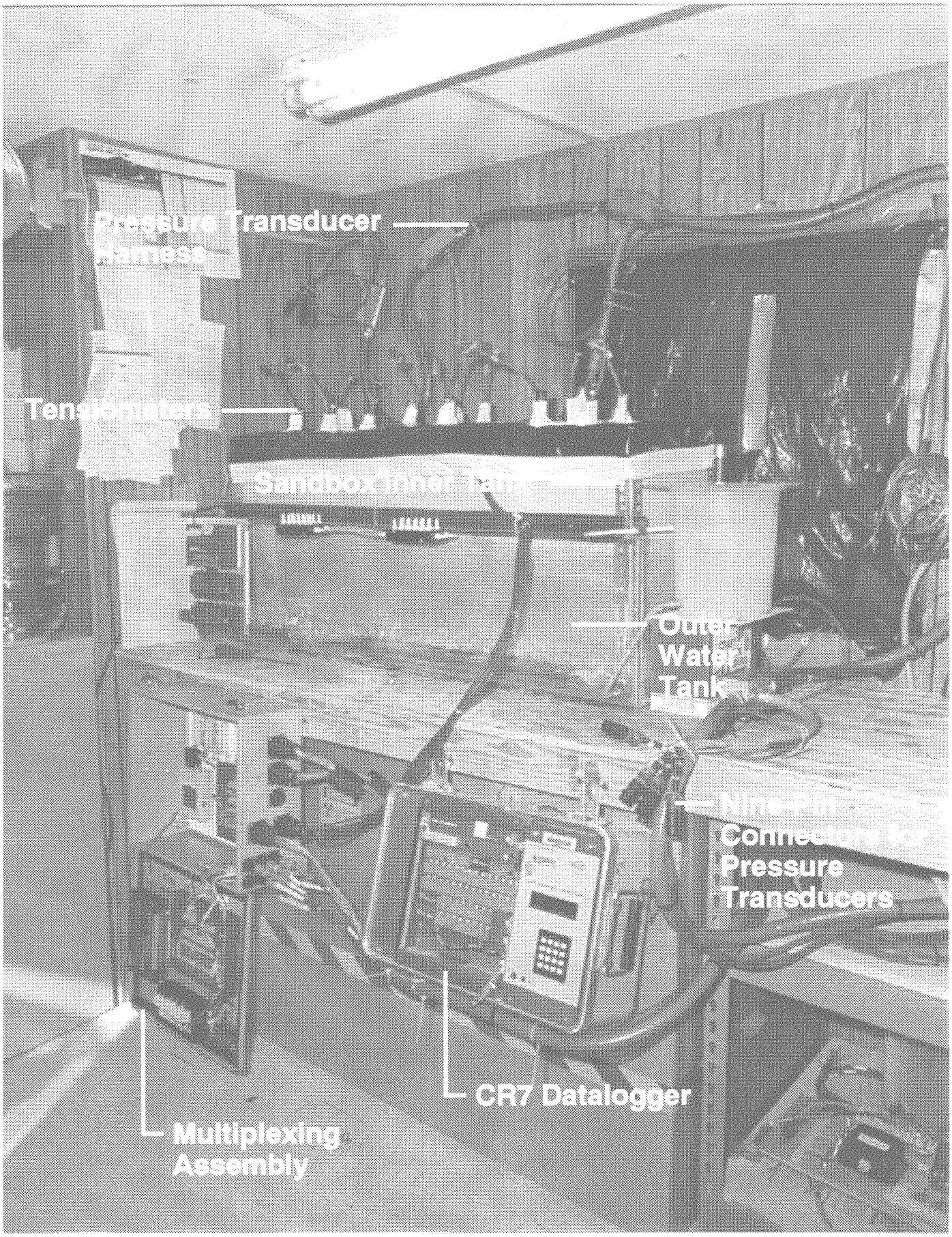


Figure 40 Need a Title

TABLE 1				
Power Supply Parts List				
ITEM	MANUFACTURER	PART #	SUPPLIER	QUANTITY
12 volt relay	?	67238P32	Newark Electronics	2
3 volt LED	?	32F1457	Newark Electronics	2
Transistor	National Semiconductor	LM317	J.B. Saunders	1
Plastic box	?	LMB-402	J.B. Saunders	1
Terminal strip	?	25POS-025	J.B. Saunders	1
35V 0.1 microF Capacitor	?	?	J.B. Saunders	1
20V 1 microF capacitor	?	?	J.B. Saunders	1
5 k ohm variable resistor	?	5k AJST	J.B. Saunders	2
240 ohm resistor, .5W	?	?	J.B. Saunders	1
12V, 800Amp deep cycle marine battery				1 to 3
12V, 40W solar panel	Campbell Scientific	MSX18R	Campbell Scientific	2
4-pin connector	AMP		CSID	2
Connector pins m/f	AMP		CSID	8
4-pin panel mount connector	AMP		CSID	2
6-terminal bus strip			Newark Electronics	1
12 gauge wire				~10m
Weatherproof battery box				1
steel reinforced conduit				~10m

TABLE 2		
Field CR7 Datalogger components		
Manufactured by Campbell Scientific Inc.		
ITEM	PART #	QUANTITY
Control Module	700X	1
512K Memory Card	709	1
I/O Module	720	1
Analog Input Card	723	2
Excitation Card	725	2
50 Volt Full-Scale Analog Input Card	726	2
Environmentally Sealed Fiberglass Case	ENC 7F	1

TABLE 3

CR7 FIELD DATALOGGER WIRING ASSIGNMENTS

725 EXCITATION CARD #1			725 EXCITATION CARD #2			ANALOG INPUT CARD #1	ANALOG INPUT CARD #2	50V INPUT CARD #3			50V INPUT CARD #4		
COLOR		SWITCHED ANALOG OUT	COLOR		SWITCHED ANALOG OUT	COLOR	COLOR	COLOR			COLOR		
BLUE	1	P1M2L1	BLUE	1	P3M2L1	H1	H1	ORG/RED	H1	P1M1H1	ORG/RED	H1	P3M1H1
GRN/WHT/BLK	2	P1M2L2	GRN/WHT/BLK	2	P3M2L2	L1	L1	RED	L1	P1M1L1	RED	L1	P3M1L1
BLUE	3	P2M2L1	BLUE	3	P4M2L1	H2	H2	BLU/BLK	H2	P1M1H2	BLU/BLK	H2	P3M1H2
GRN/WHT/BLK	4	P2M2L2	GRN/WHT/BLK	4	P4M2L2	L2	L2	RED/GRN	L2	P1M1L2	RED/GRN	L2	P3M1L2
	5			5		H3	H3	BLK	H3	P1M2H1	BLK	H3	P3M2H1
	6			6		L3	L3		L3			L3	
	7			7		H4	H4	ORG/BLK	H4	P1M2H2	ORG/BLK	H4	P3M2H2
	8			8		L4	L4		L4			L4	
		CONTINUOUS ANALOG OUT			CONTINUOUS ANALOG OUT	H5	H5	ORG/RED	H5	P2M1H1	ORG/RED	H5	P4M1H1
	1			1		L5	L5	RED	L5	P2M1L1	RED	L5	P4M1L1
	2			2		H6	H6	BLU/BLK	H6	P2M1H2	BLU/BLK	H6	P4M1H2
		DIGITAL CONTROL OUT			DIGITAL CONTROL OUT	L6	L6	RED/GRN	L6	P2M1L2	RED/GRN	L6	P4M1L2
GREEN	1	SDMCD16-C1:PT	GREEN	1	SDMCD16-C1:WR	H7	H7	BLK	H7	P2M2H1	BLK	H7	P4M2H1
BLU/RED	2	SDMCD16-C2:PT	BLU/RED	2	SDMCD16-C2:WR	L7	L7		L7			L7	
BLK/RED	3	SCMCD16-C3:PT	BLK/RED	3	SCMCD16-C3:WR	H8	H8	ORG/BLK	H8	P2M2H2	ORG/BLK	H8	P4M2H2
ORANGE	4	AM416-RES:P1-M1,P1-M2	ORANGE	4	AM416-RES:P3-M1,P3-M2	L8	L8		L8			L8	
ORANGE	5	AM416-RES:P2-M1,P2-M2	ORANGE	5	AM416-RES:P4-M1,P4-M2	H9	H9						
RED/WHT	6	AM416-CLK:P1-M1,P2-M1	RED/WHT	6	AM416-CLK:P3-M1,P4-M1	L9	L9						
ORG/GRN	7	AM416-CLK:P1-M2,P2-M2	ORG/GRN	7	AM416-CLK:P3-M2,P4-M2	H10	H10						
	8			8		L10	L10						
						H11	H11						
						L11	L11						
						H12	H12						
						L12	L12						
						H13	H13						
						L13	L13						
						H14	H14						
						L14	L14						

FIELD CR7 WIRING SCHEDULE

CR7 FIELD DATALOGGER WIRING ASSIGNMENTS						ANALOG INPUT CARD #1			ANALOG INPUT CARD #2			50V INPUT CARD #3			50V INPUT CARD #4		
725 EXCITATION CARD #1			725 EXCITATION CARD #2			COLOR			COLOR			COLOR			COLOR		
COLOR		SWITCHED ANALOG OUT	COLOR		SWITCHED ANALOG OUT		H1			H1		ORG/RED	H1	P1M1H1	ORG/RED	H1	P3M1H1
BLUE	1	P1M2L1	BLUE	1	P3M2L1		L1			L1		RED	L1	P1M1L1	RED	L1	P3M1L1
GRN/WHT/BLK	2	P1M2L2	GRN/WHT/BLK	2	P3M2L2		H2			H2		BLU/BLK	H2	P1M1H2	BLU/BLK	H2	P3M1H2
BLUE	3	P2M2L1	BLUE	3	P4M2L1		L2			L2		RED/GRN	L2	P1M1L2	RED/GRN	L2	P3M1L2
GRN/WHT/BLK	4	P2M2L2	GRN/WHT/BLK	4	P4M2L2		H3			H3		BLK	H3	P1M2H1	BLK	H3	P3M2H1
	5			5			L3			L3			L3			L3	
	6			6			H4			H4		ORG/BLK	H4	P1M2H2	ORG/BLK	H4	P3M2H2
	7			7			L4			L4			L4			L4	
	8			8			H5			H5		ORG/RED	H5	P2M1H1	ORG/RED	H5	P4M1H1
	CONTINUOUS ANALOG OUT			CONTINUOUS ANALOG OUT			L5			L5		RED	L5	P2M1L1	RED	L5	P4M1L1
	1			1			H6			H6		BLU/BLK	H6	P2M1H2	BLU/BLK	H6	P4M1H2
	2			2			L6			L6		RED/GRN	L6	P2M1L2	RED/GRN	L6	P4M1L2
	DIGITAL CONTROL OUT			DIGITAL CONTROL OUT			H7			H7		BLK	H7	P2M2H1	BLK	H7	P4M2H1
GREEN	1	SDMCD16-C1:PT	GREEN	1	SDMCD16-C1:WR		L7			L7			L7			L7	
BLU/RED	2	SDMCD16-C2:PT	BLU/RED	2	SDMCD16-C2:WR		H8			H8		ORG/BLK	H8	P2M2H2	ORG/BLK	H8	P4M2H2
BLK/RED	3	SCMCD16-C3:PT	BLK/RED	3	SCMCD16-C3:WR		L8			L8			L8			L8	
ORANGE	4	AM416-RES:P1-M1,P1-M2	ORANGE	4	AM416-RES:P3-M1,P3-M2		H9			H9							
ORANGE	5	AM416-RES:P2-M1,P2-M2	ORANGE	5	AM416-RES:P4-M1,P4-M2		L9			L9							
RED/WHT	6	AM416-CLK:P1-M1,P2-M1	RED/WHT	6	AM416-CLK:P3-M1,P4-M1		H10			H10							
ORG/GRN	7	AM416-CLK:P1-M2,P2-M2	ORG/GRN	7	AM416-CLK:P3-M2,P4-M2		L10			L10							
	8			8			H11			H11							
							L11			L11							
							H12			H12							
							L12			L12							
							H13			H13							
							L13			L13							
							H14			H14							
							L14			L14							

TNS - CCHD.XLS

TABLE 4

TENSIOMETER AUTOMATION MONITORING FINAL ARRAY ASSIGNMENTS

	FINAL ARRAY 1					FINAL ARRAY 2		
LOCATION	CONTENTS	LOCATION	CONTENTS		LOCATION	CONTENTS	LOCATION	CONTENTS
1	array i.d.							
2	j.date				1	array i.d.		
3	hr-min				2	j.date		
4	cr7-vlt				3	hr-min		
5	01-vlt	67	02-vlt		4	03-vlt	86	04-vlt
6	01-ex	68	02-ex		5	03-ex	87	04-ex
7	01cl1-tmp	69	02cl1-tmp		6	03cl1-tmp	88	04cl1-tmp
8	01cl2-tmp	70	02cl2-tmp		7	03cl2-tmp	89	04cl2-tmp
9	01cl3-tmp	71	02cl3-tmp		8	03cl3-tmp	90	04cl3-tmp
10	01cl4-tmp	72	02cl4-tmp		9	03cl4-tmp	91	04cl4-tmp
11	01cl5-tmp	73	02cl5-tmp		10	03cl5-tmp	92	04cl5-tmp
12	01it-lvl	74	02it-lvl		11	03it-lvl	93	04it-lvl
13	01xt-lvl	75	02xt-lvl		12	03xt-lvl	94	04xt-lvl
14	***	76	***		13	***	95	***
15	***	77	***		14	***	96	***
16	***	78	***		15	***	97	***
17	01tn11	79	02tn11		16	03tn11	98	04tn11
18	01tn12	80	02tn12		17	03tn12	99	04tn12
19	01tn13	81	02tn13		18	03tn13	100	04tn13
20	01tn14	82	02tn14		19	03tn14	101	04tn14
21	01tn15	83	02tn15		20	03tn15	102	04tn15
22	01tn21	84	20tn21		21	03tn16	103	04tn21
23	01tn22	85	02tn22		22	03tn17	104	04tn22
24	01tn23	86	02tn23		23	03tn21	105	04tn23
25	01tn24	87	02tn24		24	03tn22	106	04tn24
26	01tn25	88	02tn25		25	03tn23	107	04tn25
27	01tn31	89	02tn31		26	03tn24	108	04tn31
28	01tn32	90	02tn32		27	03tn25	109	04tn32
29	01tn33	91	02tn33		28	03tn26	110	04tn33
30	01tn34	92	02tn34		29	03tn27	111	04tn34
31	01tn35	93	02tn35		30	03th31	112	04tn35
32	01tn41	94	02tn41		31	03tn32	113	04tn41
33	01tn42	95	02tn42		32	03tn33	114	04tn42
34	01tn43	96	02tn43		33	03tn34	115	04tn43
35	01tn44	97	02tn44		34	03tn35	116	04tn44
36	01tn45	98	02tn45		35	03tn36	117	04tn45
37	01th51	99	02tn51		36	03tn37	118	04tn51
38	01tn52	100	02tn52		37	03tn41	119	04tn52
39	01tn53	101	02tn53		38	03tn42	120	04tn53
40	01tn54	102	02tn54		39	03tn43	121	04tn54
41	01tn55	103	02tn55		40	03tn44	122	04tn55
42	01tn11-lv	104	02tn11-lv		41	03tn45	123	04tn11-lv
43	01tn12-lv	105	02tn12-lv		42	03tn46	124	04tn12-lv
44	01tn13-lv	106	02tn13-lv		43	03tn47	125	04tn13-lv
45	01tn14-lv	107	02tn14-lv		44	03tn51	126	04tn14-lv
46	01tn15-lv	108	02tn15-lv		45	03tn52	127	04tn15-lv
47	01tn21-lv	109	20tn21-lv		46	03tn53	128	04tn21-lv
48	01tn22-lv	110	02tn22-lv		47	03tn54	129	04tn22-lv
49	01tn23-lv	111	02tn23-lv		48	03tn55	130	04tn23-lv
50	01tn24-lv	112	02tn24-lv		49	03tn56	131	04tn24-lv
51	01tn25-lv	113	02tn25-lv		50	03tn57	132	04tn25-lv
52	01tn31-lv	114	02tn31-lv		51	03tn11-lv	133	04tn31-lv
53	01tn32-lv	115	02tn32-lv		52	03tn12-lv	134	04tn32-lv
54	01tn33-lv	116	02tn33-lv		53	03tn13-lv	135	04tn33-lv
55	01tn34-lv	117	02tn34-lv		54	03tn14-lv	136	04tn34-lv
56	01tn35-lv	118	02tn35-lv		55	03tn15-lv	137	04tn35-lv
57	01tn41-lv	119	02tn41-lv		56	03tn16-lv	138	04tn41-lv
58	01tn42-lv	120	02tn42-lv		57	03tn17-lv	139	04tn42-lv
59	01tn43-lv	121	02tn43-lv		58	03tn21-lv	140	04tn43-lv
60	01tn44-lv	122	02tn44-lv		59	03tn22-lv	141	04tn44-lv
61	01tn45-lv	123	02tn45-lv		60	03tn23-lv	142	04tn45-lv
62	01th51-lv	124	02tn51-lv		61	03tn24-lv	143	04tn51-lv
63	01tn52-lv	125	02tn52-lv		62	03tn25-lv	144	04tn52-lv
64	01tn53-lv	126	02tn53-lv		63	03tn26-lv	145	04tn53-lv
65	01tn54-lv	127	02tn54-lv		64	03tn27-lv	146	04tn54-lv
66	01tn55-lv	128	02tn55-lv		65	03tn31-lv	147	04tn55-lv
		129	YEAR		66	03tn32-lv	148	YEAR
					67	03tn33-lv		
					68	03tn34-lv		
					69	03tn35-lv		
					70	03tn36-lv		
					71	03tn37-lv		
					72	03tn41-lv		
					73	03tn42-lv		
					74	03tn43-lv		
					75	03tn44-lv		
					76	03tn45-lv		
					77	03tn46-lv		
					78	03tn47-lv		
					79	03tn51-lv		
					80	03tn52-lv		
					81	03tn53-lv		
					82	03tn54-lv		
					83	03tn55-lv		
					84	03tn56-lv		
					85	03tn57-lv		

TENSIOMETER AUTOMATION MONITORING FINAL ARRAY ASSIGNMENTS								
	FINAL ARRAY 1					FINAL ARRAY 2		
LOCATION	CONTENTS	LOCATION	CONTENTS		LOCATION	CONTENTS	LOCATION	CONTENTS
1	array i.d.							
2	j.date				1	array i.d.		
3	hr-min				2	j.date		
4	cr7-vlt				3	hr-min		
5	01-vlt	67	02-vlt		4	03-vlt	86	04-vlt
6	01-ex	68	02-ex		5	03-ex	87	04-ex
7	01cl1-tmp	69	02cl1-tmp		6	03cl1-tmp	88	04cl1-tmp
8	01cl2-tmp	70	02cl2-tmp		7	03cl2-tmp	89	04cl2-tmp
9	01cl3-tmp	71	02cl3-tmp		8	03cl3-tmp	90	04cl3-tmp
10	01cl4-tmp	72	02cl4-tmp		9	03cl4-tmp	91	04cl4-tmp
11	01cl5-tmp	73	02cl5-tmp		10	03cl5-tmp	92	04cl5-tmp
12	01it-lvl	74	02it-lvl		11	03it-lvl	93	04it-lvl
13	01xt-lvl	75	02xt-lvl		12	03xt-lvl	94	04xt-lvl
14	***	76	***		13	***	95	***
15	***	77	***		14	***	96	***
16	***	78	***		15	***	97	***
17	01tn11	79	02tn11		16	03tn11	98	04tn11
18	01tn12	80	02tn12		17	03tn12	99	04tn12
19	01tn13	81	02tn13		18	03tn13	100	04tn13
20	01tn14	82	02tn14		19	03tn14	101	04tn14
21	01tn15	83	02tn15		20	03tn15	102	04tn15
22	01tn21	84	20tn21		21	03tn16	103	04tn21
23	01tn22	85	02tn22		22	03tn17	104	04tn22
24	01tn23	86	02tn23		23	03tn21	105	04tn23
25	01tn24	87	02tn24		24	03tn22	106	04tn24
26	01tn25	88	02tn25		25	03tn23	107	04tn25
27	01tn31	89	02tn31		26	03tn24	108	04tn31
28	01tn32	90	02tn32		27	03tn25	109	04tn32
29	01tn33	91	02tn33		28	03tn26	110	04tn33
30	01tn34	92	02tn34		29	03tn27	111	04tn34
31	01tn35	93	02tn35		30	03th31	112	04tn35
32	01tn41	94	02tn41		31	03tn32	113	04tn41
33	01tn42	95	02tn42		32	03tn33	114	04tn42
34	01tn43	96	02tn43		33	03tn34	115	04tn43
35	01tn44	97	02tn44		34	03tn35	116	04tn44
36	01tn45	98	02tn45		35	03tn36	117	04tn45
37	01th51	99	02tn51		36	03tn37	118	04tn51
38	01tn52	100	02tn52		37	03tn41	119	04tn52
39	01tn53	101	02tn53		38	03tn42	120	04tn53
40	01tn54	102	02tn54		39	03tn43	121	04tn54
41	01tn55	103	02tn55		40	03tn44	122	04tn55
42	01tn11-lv	104	02tn11-lv		41	03tn45	123	04tn11-lv
43	01tn12-lv	105	02tn12-lv		42	03tn46	124	04tn12-lv
44	01tn13-lv	106	02tn13-lv		43	03tn47	125	04tn13-lv
45	01tn14-lv	107	02tn14-lv		44	03tn51	126	04tn14-lv
46	01tn15-lv	108	02tn15-lv		45	03tn52	127	04tn15-lv
47	01tn21-lv	109	20tn21-lv		46	03tn53	128	04tn21-lv
48	01tn22-lv	110	02tn22-lv		47	03tn54	129	04tn22-lv
49	01tn23-lv	111	02tn23-lv		48	03tn55	130	04tn23-lv
50	01tn24-lv	112	02tn24-lv		49	03tn56	131	04tn24-lv
51	01tn25-lv	113	02tn25-lv		50	03tn57	132	04tn25-lv
52	01tn31-lv	114	02tn31-lv		51	03tn11-lv	133	04tn31-lv
53	01tn32-lv	115	02tn32-lv		52	03tn12-lv	134	04tn32-lv
54	01tn33-lv	116	02tn33-lv		53	03tn13-lv	135	04tn33-lv
55	01tn34-lv	117	02tn34-lv		54	03tn14-lv	136	04tn34-lv
56	01tn35-lv	118	02tn35-lv		55	03tn15-lv	137	04tn35-lv
57	01tn41-lv	119	02tn41-lv		56	03tn16-lv	138	04tn41-lv
58	01tn42-lv	120	02tn42-lv		57	03tn17-lv	139	04tn42-lv
59	01tn43-lv	121	02tn43-lv		58	03tn21-lv	140	04tn43-lv
60	01tn44-lv	122	02tn44-lv		59	03tn22-lv	141	04tn44-lv
61	01tn45-lv	123	02tn45-lv		60	03tn23-lv	142	04tn45-lv
62	01th51-lv	124	02tn51-lv		61	03tn24-lv	143	04tn51-lv
63	01tn52-lv	125	02tn52-lv		62	03tn25-lv	144	04tn52-lv
64	01tn53-lv	126	02tn53-lv		63	03tn26-lv	145	04tn53-lv
65	01tn54-lv	127	02tn54-lv		64	03tn27-lv	146	04tn54-lv
66	01tn55-lv	128	02tn55-lv		65	03tn31-lv	147	04tn55-lv
		129	YEAR		66	03tn32-lv	148	YEAR
					67	03tn33-lv		
					68	03tn34-lv		
					69	03tn35-lv		
					70	03tn36-lv		
					71	03tn37-lv		
					72	03tn41-lv		
					73	03tn42-lv		
					74	03tn43-lv		
					75	03tn44-lv		
					76	03tn45-lv		
					77	03tn46-lv		
					78	03tn47-lv		
					79	03tn51-lv		
					80	03tn52-lv		
					81	03tn53-lv		
					82	03tn54-lv		
					83	03tn55-lv		
					84	03tn56-lv		
					85	03tn57-lv		

TNARR2.XLS

TABLE 5				
MULTIPLEXING ASSEMBLY PARTS LIST				
ITEM	MANUFACTURER	PART #	SUPPLIER	QUANTITY
power supply (see table 1)	various		various	1
water level indicator (not used)	various		various	1
metal box		38F928	Newark Electronics	1
relay multiplexer	Campbell Scientific	AM-416	Campbell Scientific	2
control port multiplexer	Campbell Scientific	SDM-CD16	Campbell Scientific	1
terminal strip		89F3067	Newark Electronics	7
4 pos. female AMP connector	AMP	206430-2	CSID	6
24 pos. female AMP connector	AMP	206-838-1	CSID	2
16 pos. female AMP connector	AMP	206640-1	CSID	1
55 pos. female AMP connector	AMP	206438-1	CSID	2
assorted o-rings			McGuckins	11
22 AWG color coded wire	Belden			~100'

Table 5

MULTIPLEXING ASSEMBLY PARTS LIST				
ITEM	MANUFACTURER	PART #	SUPPLIER	QUANTITY
power supply (see table 1)	various		various	1
water level indicator (not used)	various		various	1
metal box		38F928	Newark Electronics	1
relay multiplexer	Campbell Scientific	AM-416	Campbell Scientific	2
control port multiplexer	Campbell Scientific	SDM-CD16	Campbell Scientific	1
terminal strip		89F3067	Newark Electronics	7
4 pos. female AMP connector	AMP	206430-2	CSID	6
24 pos. female AMP connector	AMP	206-838-1	CSID	2
16 pos. female AMP connector	AMP	206640-1	CSID	1
55 pos. female AMP connector	AMP	206438-1	CSID	2
assorted o-rings			McGuckins	11
22 AWG color coded wire	Belden			~100'

TABLE 6

PIT2 SDM-CD16 #__		COLOR	PIT1 SDM-CD16#__		COLOR
C1	PIN 5	GREEN	C1		
C2	PIN 3	BLU/RED	C2		
C3	PIN 23	BLK/RED	C3		
1	10V EXCITATION		1		
2	24V EXCITATION		2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		
16			16		

MUX BOX PIGTAIL			CR7 PIGTAIL AND CABLE		
PIN #	LOCATIO	COLOR	PIN #	LOCATIO	COLOR
1	MUX2-L1	BLUE	1	EX1AN3	BLUE
2	GND	BLU/WHT	2	GND	BLU/WHT
3	SDM#10C	BLU/RED	3	EX1DC2	BLU/RED
4	MUX1-H2	BLU/BLK	4	IN3H6	BLU/BLK
5	SDM#10C	GREEN	5	EX1DC1	GREEN
6	GND	GRN/WHT	6	GND	GRN/WHT
7	GND	GRN/BLK	7	GND	GRN/BLK
8	MUX2-L2	GRN/WHT	8	EX1AN4	GRN/WHT
9	MUX1-L1	RED	9	IN3L5	RED
10	MUX1-CL	RED/WHT	10	EX1DC6	RED/WHT
11	MUX1-L2	RED/GRN	11	IN3L6	RED/GRN
12	GND	RED/BLK	12	GND	RED/BLK
13	GND	RED/WHT	13	GND	RED/WHT
14	MUX1,2-R	ORNG	14	EX1DC5	ORNG
15	MUX2-CL	ORG/GRN	15	EX1DC7	ORG/GRN
16	MUX1-H1	ORG/RED	16	IN3H5	ORG/RED
17	MUX2-H2	ORG/BLK	17	IN3H8	ORG/BLK
18	GND	WHITE	18	GND	WHITE
19	GND	WHT/RED	19	GND	WHT/RED
20		WHT/BLK	20		WHT/BLK
21	GND	WHT/RED	21	GND	WHT/RED
22	MUX2-H1	BLK	22	IN3H7	BLK
23	SDM#10C	BLK/RED	23	EX1DC3	BLK/RED
24	SHIELD	SHIELD	24	CASE	SHIELD

PIT2 AM416-1	PIN #	WIRE USE	COLOR	PIT2 AM416-2	PIN #	WIRE USE	COLOR
RES	14		ORNG	RES	14		ORNG
CLK	10		RED/WHT	CLK	15		ORG/GRN
H1COM	16		ORG/RED	H1COM	22		BLK
L1COM	9		RED	L1COM	1		BLUE
H2COM	4		BLU/BLK	H2COM	17		ORG/BLK
L2COM	11		RED/GRN	L2COM	8		GRN/WHT/BLK
1-H1		PT1-1		1-H1		C1-107B-HI	
1-L1		PT1-2		1-L1		C1-107B-EX	
1-H2		PT1-3		1-H2		C2-107B-HI	
1-L2		PT1-4		1-L2		C2-107B-EX	
2-H1		PT1-5		2-H1		C3-107B-HI	
2-L1		PT2-1		2-L1		C3-107B-EX	
2-H2		PT2-2		2-H2		C4-107B-HI	
2-L2		PT2-3		2-L2		C4-107B-EX	
3-H1		PT2-4		3-H1		C5-107B-HI	
3-L1		PT2-5		3-L1		C5-107B-EX	
3-H2		PT3-1		3-H2			
3-L2		PT3-2		3-L2			
4-H1		PT3-3		4-H1			
4-L1		PT3-4		4-L1			
4-H2		PT3-5		4-H2			
4-L2		PT4-1		4-L2			
5-H1		PT4-2		5-H1			
5-L1		PT4-3		5-L1			
5-H2		PT4-4		5-H2			
5-L2		PT4-5		5-L2			
6-H1		PT3-7		6-H1			
6-L1		PT5-1		6-L1			
6-H2		PT5-2		6-H2			
6-L2		PT5-3		6-L2			
7-H1		PT5-4		7-H1			
7-L1		PT5-5		7-L1			
7-H2		PIT2-BATT		7-H2			
7-L2		10V-EXITATION		7-L2			
8-H1		24V-EXCITATION		8-H1			
8-L1		LV1-1		8-L1			
8-H2		LV1-2		8-H2			
8-L2		LV1-3		8-L2			
9-H1		LV1-4		9-H1			
9-L1		LV1-5		9-L1			
9-H2		PT5-7		9-H2			
9-L2		LV2-1		9-L2			
10-H1		LV2-2		10-H1			
10-L1		LV2-3		10-L1			
10-H2		LV2-4		10-H2			
10-L2		LV2-5		10-L2			
11-H1		LV3-1		11-H1			
11-L1		LV3-2		11-L1			
11-H2		LV3-3		11-H2			
11-L2		LV3-4		11-L2			
12-H1		LV3-5		12-H1			
12-L1		LV4-1		12-L1			
12-H2		LV4-2		12-H2			
12-L2		LV4-3		12-L2			
13-H1		LV4-4		13-H1			
13-L1		LV4-5		13-L1			
13-H2		LV5-1		13-H2			
13-L2		LV5-2		13-L2			
14-H1		LV5-3		14-H1			
14-L1		LV5-4		14-L1			
14-H2		LV5-5		14-H2			
14-L2				14-L2			
15-H1				15-H1			
15-L1				15-L1			
15-H2				15-H2			
15-L2				15-L2			
16-H1				16-H1			
16-L1				16-L1			
16-H2				16-H2			
16-L2				16-L2			

PIT2 SDM-CD16 #__		COLOR	PIT1 SDM-CD16#__		COLOR	PIT2 AM416-1	PIN #	IRE USE	COLOR	PIT2 AM416-2	PIN #	IRE USE	COLOR
C1	PIN 5	GREEN	C1			RES	14		ORNG	RES	14		ORNG
C2	PIN 3	BLU/RED	C2			CLK	10		RED/WHT	CLK	15		ORG/GRN
C3	PIN 23	BLK/RED	C3			H1COM	16		ORG/RED	H1COM	22		BLK
						L1COM	9		RED	L1COM	1		BLUE
						H2COM	4		BLU/BLK	H2COM	17		ORG/BLK
						L2COM	11		RED/GRN	L2COM	8		GRN/WHT/BLK
1	10V EXCITATION		1			1-H1		PT1-1		1-H1		C1-107B-HI	
2	24V EXCITATION		2			1-L1		PT1-2		1-L1		C1-107B-EX	
3			3			1-H2		PT1-3		1-H2		C2-107B-HI	
4			4			1-L2		PT1-4		1-L2		C2-107B-EX	
5			5			2-H1		PT1-5		2-H1		C3-107B-HI	
6			6			2-L1		PT2-1		2-L1		C3-107B-EX	
7			7			2-H2		PT2-2		2-H2		C4-107B-HI	
8			8			2-L2		PT2-3		2-L2		C4-107B-EX	
9			9			3-H1		PT2-4		3-H1		C5-107B-HI	
10			10			3-L1		PT2-5		3-L1		C5-107B-EX	
11			11			3-H2		PT3-1		3-H2			
12			12			3-L2		PT3-2		3-L2			
13			13			4-H1		PT3-3		4-H1			
14			14			4-L1		PT3-4		4-L1			
15			15			4-H2		PT3-5		4-H2			
16			16			4-L2		PT4-1		4-L2			
						5-H1		PT4-2		5-H1			
						5-L1		PT4-3		5-L1			
						5-H2		PT4-4		5-H2			
						5-L2		PT4-5		5-L2			
						6-H1		PT3-7		6-H1			
						6-L1		PT5-1		6-L1			
						6-H2		PT5-2		6-H2			
						6-L2		PT5-3		6-L2			
						7-H1		PT5-4		7-H1			
						7-L1		PT5-5		7-L1			
						7-H2		PIGBATT		7-H2			
						7-L2		10V-EXITATION		7-L2			
						8-H1		24V-EXCITATION		8-H1			
						8-L1		LV1-1		8-L1			
						8-H2		LV1-2		8-H2			
						8-L2		LV1-3		8-L2			
						9-H1		LV1-4		9-H1			
						9-L1		LV1-5		9-L1			
						9-H2		PT5-7		9-H2			
						9-L2		LV2-1		9-L2			
MUX BOX PIGTAIL			CR7 PIGTAIL AND CABLE			10-H1		LV2-2		10-H1			
PIN #	LOCATIO	COLOR	PIN #	LOCATIO	COLOR	10-L1		LV2-3		10-L1			
1	MUX2-L1	BLUE	1	EX1AN3	BLUE	10-H2		LV2-4		10-H2			
2	GND	BLU/WHT	2	GND	BLU/WHT	10-L2		LV2-5		10-L2			
3	SDM#10C	BLU/RED	3	EX1DC2	BLU/RED	11-H1		LV3-1		11-H1			
4	MUX1-H2	BLU/BLK	4	IN3H6	BLU/BLK	11-L1		LV3-2		11-L1			
5	SDM#10C	GREEN	5	EX1DC1	GREEN	11-H2		LV3-3		11-H2			
6	GND	GRN/WH	6	GND	GRN/WH	11-L2		LV3-4		11-L2			
7	GND	GRN/BLK	7	GND	GRN/BLK	12-H1		LV3-5		12-H1			
8	MUX2-L2	GRN/WH	8	EX1AN4	GRN/WH	12-L1		LV4-1		12-L1			
9	MUX1-L1	RED	9	IN3L5	RED	12-H2		LV4-2		12-H2			
10	MUX1-CL	RED/WHT	10	EX1DC6	RED/WHT	12-L2		LV4-3		12-L2			
11	MUX1-L2	RED/GRN	11	IN3L6	RED/GRN	13-H1		LV4-4		13-H1			
12	GND	RED/BLK	12	GND	RED/BLK	13-L1		LV4-5		13-L1			
13	GND	RED/WHT	13	GND	RED/WHT	13-H2		LV5-1		13-H2			
14	MUX1,2-R	ORNG	14	EX1DC5	ORNG	13-L2		LV5-2		13-L2			
15	MUX2-CL	ORG/GR	15	EX1DC7	ORG/GR	14-H1		LV5-3		14-H1			
16	MUX1-H1	ORG/RED	16	IN3H5	ORG/RED	14-L1		LV5-4		14-L1			
17	MUX2-H2	ORG/BLK	17	IN3H8	ORG/BLK	14-H2		LV5-5		14-H2			
18	GND	WHITE	18	GND	WHITE	14-L2				14-L2			
19	GND	WHT/RED	19	GND	WHT/RED	15-H1				15-H1			
20		WHT/BLK	20		WHT/BLK	15-L1				15-L1			
21	GND	WHT/RED	21	GND	WHT/RED	15-H2				15-H2			
22	MUX2-H1	BLK	22	IN3H7	BLK	15-L2				15-L2			
23	SDM#10C	BLK/RED	23	EX1DC3	BLK/RED	16-H1				16-H1			
24	SHIELD	SHIELD	24	CASE	SHIELD	16-L1				16-L1			
						16-H2				16-H2			
						16-L2				16-L2			

TABLE 7

TR3 SDM-CD16 #		COLOR	TR3 SDM-CD16#	COLOR
C1	PIN 5	GREEN	C1	
C2	PIN 3	ORANGE	C2	
C3	PIN 23	GRAY	C3	
1	10V EXCITATION		1	
2	24V EXCITATION		2	
3			3	
4			4	
5			5	
6			6	
7			7	
8			8	
9			9	
10			10	
11			11	
12			12	
13			13	
14			14	
15			15	
16			16	

MUX BOX PIGTAIL			CR7 PIGTAIL AND CABLE		
PIN #	LOCATION	COLOR	PIN #	LOCATION	COLOR
1	MUX2-L1	GRN/GRY	1	EX2AN1	BLUE
2	GND	GRY/WHT	2	GND	BLU/WHT
3	SDM#10C2	ORNG	3	EX1DC2	BLU/RED
4	MUX1-H2	BLU/GRY	4	IN4H2	BLU/BLK
5	SDM#10C1	GRN	5	EX1DC1	GREEN
6	GND	BLK	6	GND	GRN/WHT
7	GND	BRN/WHT	7	GND	GRN/BLK
8	MUX2-L2	GRN/WHT	8	EX2AN2	GRN/WHT
9	MUX1-L1	BLU/WHT	9	IN4L1	RED
10	MUX1-CLK	ORG/GRN	10	EX2DC6	RED/WHT
11	MUX1-L2	BLU/GRN	11	IN4L2	RED/GRN
12	GND	RED	12	GND	RED/BLK
13	GND	BLU/BRN	13	GND	RED/WHT
14	MUX1,2-RE	ORG/GRY	14	EX2DC4	ORNG
15	MUX2-CLK	ORG/WHT	15	EX2DC7	ORG/GRN
16	MUX1-H1	BLUE	16	IN4H1	ORG/RED
17	MUX2-H2	BRN/GRY	17	IN4H4	ORG/BLK
18	GND	WHITE	18	GND	WHITE
19	GND	ORG/BRN	19	GND	WHT/RED
20			20		WHT/BLK
21	GND	BRN	21	GND	WHT/RED
22	MUX2-H1	GRN/BRN	22	IN4H3	BLK
23	SDM#10C3	GRAY	23	EX1DC3	BLK/RED
24	SHIELD	WHITE	24	CASE	SHIELD

TR3 AM416-1			COLOR
	PIN#	WIRE USE	
RES	14		ORG/GRY
CLK	10		ORG/GRN
H1COM	16		BLUE
L1COM	9		BLU/WHT
H2COM	4		BLU/GRY
L2COM	11		BLU/GRN
1-H1		PT1-1	
1-L1		PT1-2	
1-H2		PT1-3	
1-L2		PT1-4	
2-H1		PT1-5	
2-L1		PT1-6	
2-H2		PT1-7	
2-L2		PT2-1	
3-H1		PT2-2	
3-L1		PT2-3	
3-H2		PT2-4	
3-L2		PT2-5	
4-H1		PT2-6	
4-L1		PT2-7	
4-H2		PT3-1	
4-L2		PT3-2	
5-H1		PT3-3	
5-L1		PT3-4	
5-H2		PT3-5	
5-L2		PT3-6	
6-H1		PT3-7	
6-L1		PT4-1	
6-H2		PT4-2	
6-L2		PT4-3	
7-H1		PT4-4	
7-L1		PT4-5	
7-H2		PT4-6	
7-L2		PT4-7	
8-H1		PT5-1	
8-L1		PT5-2	
8-H2		PT5-3	
8-L2		PT5-4	
9-H1		PT5-5	
9-L1		PT5-6	
9-H2		PT5-7	
9-L2		PIT3-BATT	
10-H1		10V-EXITATION	
10-L1		24V-EXCITATION	
10-H2		LV1-1	
10-L2		LV1-2	
11-H1		LV1-3	
11-L1		LV1-4	
11-H2		LV1-5	
11-L2		LV1-6	
12-H1		LV1-7	
12-L1		LV2-1	
12-H2		LV2-2	
12-L2		LV2-3	
13-H1		LV2-4	
13-L1		LV2-5	
13-H2		LV2-6	
13-L2		LV2-7	
14-H1		LV3-1	
14-L1		LV3-2	
14-H2		LV3-3	
14-L2		LV3-4	
15-H1		LV3-5	
15-L1		LV3-6	
15-H2		LV3-7	
15-L2		LV4-1	
16-H1		LV4-2	
16-L1		LV4-3	
16-H2		LV4-4	
16-L2		LV4-5	

TR3 AM416-2			COLOR
	PIN#	WIRE USE	
RES	14		ORG/GRY
CLK	15		ORG/WHT
H1C	22		GRN/BRN
L1C	1		GRN/GRY
H2C	17		BRN/GRY
L2C	8		GRN/WHT
1-H1		LV4-6	
1-L1			
1-H2		LV4-7	
1-L2			
2-H1		LV5-1	
2-L1			
2-H2		LV5-2	
2-L2			
3-H1		LV5-3	
3-L1			
3-H2		LV5-4	
3-L2			
4-H1		LV5-5	
4-L1			
4-H2		LV5-6	
4-L2			
5-H1		LV5-7	
5-L1			
5-H2			
5-L2			
6-H1			
6-L1			
6-H2			
6-L2			
7-H1		C1-107B-HI	
7-L1		C1-107B-EX	
7-H2		C2-107B-HI	
7-L2		C2-107B-EX	
8-H1		C3-107B-HI	
8-L1		C3-107B-EX	
8-H2		C4-107B-HI	
8-L2		C4-107B-EX	
9-H1		C5-107B-HI	
9-L1		C5-107B-EX	
9-H2			
9-L2			
10-H1			
10-L1			
10-H2			
10-L2			
11-H1			
11-L1			
11-H2			
11-L2			
12-H1			
12-L1			
12-H2			
12-L2			
13-H1			
13-L1			
13-H2			
13-L2			
14-H1			
14-L1			
14-H2			
14-L2			
15-H1			
15-L1			
15-H2			
15-L2			
16-H1			
16-L1			
16-H2			
16-L2			

FIELD CR7 WIRING SCHEDULE

TR3 SDM-CD16 #		COLOR	TR3 SDM-CD16#__		COLOR
C1	PIN 5	GREEN	C1		
C2	PIN 3	ORANGE	C2		
C3	PIN 23	GRAY	C3		
1	10V EXCITATION		1		
2	24V EXCITATION		2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
11			11		
12			12		
13			13		
14			14		
15			15		
16			16		

MUX BOX PIGTAIL			CR7 PIGTAIL AND CABLE		
PIN #	LOCATION	COLOR	PIN #	LOCATION	COLOR
1	MUX2-L1	GRN/GRY	1	EX2AN1	BLUE
2	GND	GRY/WHT	2	GND	BLU/WHT
3	SDM#10C2	ORNG	3	EX1DC2	BLU/RED
4	MUX1-H2	BLU/GRY	4	IN4H2	BLU/BLK
5	SDM#10C1	GRN	5	EX1DC1	GREEN
6	GND	BLK	6	GND	GRN/WHT
7	GND	BRN/WHT	7	GND	GRN/BLK
8	MUX2-L2	GRN/WHT	8	EX2AN2	GRN/WHT
9	MUX1-L1	BLU/WHT	9	IN4L1	RED
10	MUX1-CLK	ORG/GRN	10	EX2DC6	RED/WHT
11	MUX1-L2	BLU/GRN	11	IN4L2	RED/GRN
12	GND	RED	12	GND	RED/BLK
13	GND	BLU/BRN	13	GND	RED/WHT
14	MUX1,2-RE	ORG/GRY	14	EX2DC4	ORNG
15	MUX2-CLK	ORG/WHT	15	EX2DC7	ORG/GRN
16	MUX1-H1	BLUE	16	IN4H1	ORG/RED
17	MUX2-H2	BRN/GRY	17	IN4H4	ORG/BLK
18	GND	WHITE	18	GND	WHITE
19	GND	ORG/BRN	19	GND	WHT/RED
20			20		WHT/BLK
21	GND	BRN	21	GND	WHT/RED
22	MUX2-H1	GRN/BRN	22	IN4H3	BLK
23	SDM#10C3	GRAY	23	EX1DC3	BLK/RED
24	SHIELD	WHITE	24	CASE	SHIELD

TR3 AM416-1			COLOR	TR3 AM416-2			COLOR
	PIN#	WIRE USE			PIN#	WIRE USE	
RES	14		ORG/GRY	RES	14		ORG/GR
CLK	10		ORG/GRN	CLK	15		ORG/WH
H1COM	16		BLUE	H1C	22		GRN/BRN
L1COM	9		BLU/WHT	L1C	1		GRN/GRY
H2COM	4		BLU/GRY	H2C	17		BRN/GRY
L2COM	11		BLU/GRN	L2C	8		GRN/WH
1-H1		PT1-1		1-H1		LV4-6	
1-L1		PT1-2		1-L1			
1-H2		PT1-3		1-H2		LV4-7	
1-L2		PT1-4		1-L2			
2-H1		PT1-5		2-H1		LV5-1	
2-L1		PT1-6		2-L1			
2-H2		PT1-7		2-H2		LV5-2	
2-L2		PT2-1		2-L2			
3-H1		PT2-2		3-H1		LV5-3	
3-L1		PT2-3		3-L1			
3-H2		PT2-4		3-H2		LV5-4	
3-L2		PT2-5		3-L2			
4-H1		PT2-6		4-H1		LV5-5	
4-L1		PT2-7		4-L1			
4-H2		PT3-1		4-H2		LV5-6	
4-L2		PT3-2		4-L2			
5-H1		PT3-3		5-H1		LV5-7	
5-L1		PT3-4		5-L1			
5-H2		PT3-5		5-H2			
5-L2		PT3-6		5-L2			
6-H1		PT3-7		6-H1			
6-L1		PT4-1		6-L1			
6-H2		PT4-2		6-H2			
6-L2		PT4-3		6-L2			
7-H1		PT4-4		7-H1		C1-107B-HI	
7-L1		PT4-5		7-L1		C1-107B-EX	
7-H2		PT4-6		7-H2		C2-107B-HI	
7-L2		PT4-7		7-L2		C2-107B-EX	
8-H1		PT5-1		8-H1		C3-107B-HI	
8-L1		PT5-2		8-L1		C3-107B-EX	
8-H2		PT5-3		8-H2		C4-107B-HI	
8-L2		PT5-4		8-L2		C4-107B-EX	
9-H1		PT5-5		9-H1		C5-107B-HI	
9-L1		PT5-6		9-L1		C5-107B-EX	
9-H2		PT5-7		9-H2			
9-L2		PIT3-BATT		9-L2			
10-H1		10V-EXITATION		10-H1			
10-L1		24V-EXCITATION		10-L1			
10-H2		LV1-1		10-H2			
10-L2		LV1-2		10-L2			
11-H1		LV1-3		11-H1			
11-L1		LV1-4		11-L1			
11-H2		LV1-5		11-H2			
11-L2		LV1-6		11-L2			
12-H1		LV1-7		12-H1			
12-L1		LV2-1		12-L1			
12-H2		LV2-2		12-H2			
12-L2		LV2-3		12-L2			
13-H1		LV2-4		13-H1			
13-L1		LV2-5		13-L1			
13-H2		LV2-6		13-H2			
13-L2		LV2-7		13-L2			
14-H1		LV3-1		14-H1			
14-L1		LV3-2		14-L1			
14-H2		LV3-3		14-H2			
14-L2		LV3-4		14-L2			
15-H1		LV3-5		15-H1			
15-L1		LV3-6		15-L1			
15-H2		LV3-7		15-H2			
15-L2		LV4-1		15-L2			
16-H1		LV4-2		16-H1			
16-L1		LV4-3		16-L1			
16-H2		LV4-4		16-H2			
16-L2		LV4-5		16-L2			

TABLE 8

SDUCER HARNESS SCHEDULES

PIT 2 HRNS LOC	P.T. I.D. #	CALIBRATION OFFSET	PIT 3 HRNS LOC	P.T. I.D. #
CL1-1	70	PT1-offset by -0.08775	CL1-1	46
CL1-2	27	PT2-offset by -0.0731	CL1-2	53
CL1-3	28	PT3-offset by -0.08002	CL1-3	105
CL1-4	140	PT4-offset by -0.11506	CL1-4	128
CL1-5	30	PT5-offset by -0.0861	CL1-5	75
CL2-1	93	PT6 offset by -0.09371	CL1-6	133
CL2-2	143	PT7 offset by -0.08171	CL1-7	88
CL2-3	142	PT8 offset by -0.10955	CL2-1	36
CL2-4	34	PT9 offset by -0.10053	CL2-2	64
CL2-5	35	PT10 offset by -0.06303	CL2-3	10
CL3-1	76	PT11 offset by -0.06041	CL2-4	51
CL3-2	37	PT12 offset by -0.07796	CL2-5	55
CL3-3	146	PT13 offset by -0.08989	CL2-6	117
CL3-4	144	PT14 offset by -0.03685	CL2-7	77
CL3-5	81	PT15 offset by -0.00805	CL3-1	136
CL4-1	N/A	PT16 offset by -0.12466	CL3-2	129
CL4-2	79	PT17 offset by -0.00251	CL3-3	4
CL4-3	43	PT18 offset by -0.1034	CL3-4	126
CL4-4	44	PT19 offset by -0.08672	CL3-5	145
CL4-5	45	Pt20 offset by -0.02378	CL3-6	135
CL5-1	N/A	PT21 offset by -0.07575	CL3-7	122
CL5-2	82	PT22 offset by -0.06976	CL4-1	115
CL5-3	48	PT23 offset by -0.02442	CL4-2	102
CL5-4	49	PT24 offset by-0.057	CL4-3	103
CL5-5	50	PT25 offset by -0.01242	CL4-4	97
			CL4-5	113
			CL4-6	119
			CL4-7	99
			CL5-1	52
			CL5-2	65
			CL5-3	41
			CL5-4	141
			CL5-5	42
			CL5-6	84
			CL5-7	74

Transducer Harness Parts List				
ITEM	MANUFACTURER	PART #	SUPPLIER	QUANTITY
104 strand twisted pair 18 AWG cable	Belden			52'
.75" UV-resistant, metal reinforced conduit	Fluid Tight		McGuckins	52'
.5" UV-resistant, metal reinforced conduit	Fluid Tight		McGuckins	6'
standard 4"x3" outside junction boxes	GamPak	14250	Hugh M. Woods	5
box lids and lid gaskets	GamPak	14240	Hugh M. Woods	5
.75 compression fittings	Halex	4194768	Hugh M. Woods	10
.5" compression fittings	Halex	4194767	Hugh M. Woods	5
.75" shrink tubing	3M		J.B.Saunders	14'
.5" shrink tubing	3M		J.B.Saunders	35'
9 pin connectors	AMP	206705-2	CSID	25
strain relief for 9 pin connectors	AMP	206704-2	CSID	25
9 pin connector pins	AMP	66105-2	CSID	280
9-pin connector o-rings				25
55 pin connectors	AMP	206437-1	CSID	2
strain relief for 55 pin connectors	AMP	206436-1	CSID	2
55 pin connector pins	AMP	350611-2	CSID	104
55 pin connector o-rings				2
hot glue for weather proofing strain reliefs	Black & Decker		Hugh M. Woods	10 sticks
wire ties to reinforce heat shrink		WT-8N	J.B. Saunders	100

~~Table 5~~
T8

TABLE 9				
Transducer Harness Parts List				
ITEM	MANUFACTURER	PART #	SUPPLIER	QUANTITY
104 strand twisted pair 22 AWG cable	Belden			52'
.75" UV-resistant, metal reinforced conduit	Fluid Tight		McGuckins	52'
.5" UV-resistant, metal reinforced conduit	Fluid Tight		McGuckins	6'
standard 4"x3" outside junction boxes	GamPak	14250	Hugh M. Woods	5
box lids and lid gaskets	GamPak	14240	Hugh M. Woods	5
.75 compression fittings	Halex	4194768	Hugh M. Woods	10
.5" compression fittings	Halex	4194767	Hugh M. Woods	5
.75" shrink tubing	3M		J.B.Saunders	14'
.5" shrink tubing	3M		J.B.Saunders	35'
9 pin connectors	AMP	206705-2	CSID	25
strain relief for 9 pin connectors	AMP	206704-2	CSID	25
9 pin connector pins	AMP	66105-2	CSID	280
9-pin connector o-rings			McGuckins	25
55 pin connectors	AMP	206437-1	CSID	2
strain relief for 55 pin connectors	AMP	206436-1	CSID	2
55 pin connector pins	AMP	350611-2	CSID	104
55 pin connector o-rings			McGuckins	2
hot glue for weather proofing strain reliefs	Black & Decker		Hugh M. Woods	10 sticks
wire ties to reinforce heat shrink		WT-8N	J.B. Saunders	100
Datalogger-to-Multiplexing Assembly Parts List				
ITEM	MANUFACTURER	PART #	SUPPLIER	QUANTITY
.5" UV-resistant, metal reinforced conduit	Fluid Tight		McGuckins	~100'
.75" shrink tubing	3M		J.B.Saunders	1'
24 strand twisted pair 22 AWG cable	Belden			~100'
24 pin male connectors	AMP	206838-1	CSID	2
24 pin connector pins	AMP		CSID	48
24 pin connector o-rings			McGuckins	2
hot glue for weather proofing strain reliefs	Black & Decker		Hugh M. Woods	10 sticks
wire ties to reinforce heat shrink		WT-8N	J.B. Saunders	4

TABLE 10					
Datalogger communication cable pinning					
			MUX		
	CABLE		ENCLOSURE	MUX	
PIN #	WIRE	DATALOGGER	WIRE	ENCLOSURE	
	COLOR	CONNECTION	COLOR	CONNECTION	
1	blue	MUX2-L1	blue	EX2AN1	
2	blu/wht	GND	blu/wht	GND	
3	blu/red	SDM#10C2	blu/red	EX1DC2	
4	blu/blk	MUX1-H2	blu/blk	IN4H2	
5	green	SDM#10C1	green	EX1DC1	
6	grn/wht	GND	grn/wht	GND	
7	grn/blk	GND	grn/blk	GND	
8	grn/wht/blk	MUX2-L2	grn/wht/blk	EX2AN2	
9	red	MUX1-L1	red	IN4L1	
10	red/wht	MUX1-CLK	red/wht	EX2DC6	
11	red/grn	MUX1-L2	red/grn	IN4L2	
12	red/blk	GND	red/blk	GND	
13	red/wht/blk	GND	red/wht/blk	GND	
14	orange	MUX1,2-RES	orange	EX2DC4	
15	org/grn	MUX2-CLK	org/grn	EX2DC7	
16	org/red	MUX1-H1	org/red	IN4H1	
17	org/blk	MUX2-H2	org/blk	IN4H4	
18	white	GND	white	GND	
19	wht/red	GND	wht/red	GND	
20	wht/blk		wht/blk		
21	wht/red/blk	GND	wht/red/blk	GND	
22	black	MUX2-H1	black	IN4H3	
23	blk/red	SDM#10C3	blk/red	EX1DC3	
24	shield	SHIELD	shield	CASE	

TABLE 11-1					
PRESSURE TRANSDUCER PINNING					
FOR ALL CLUSTERS AND PITS					
PIN #	WIRE	WIRE			
	COLOR	NAME			
1	WHITE	-BIAS			
2	RED	+BIAS			
3	GREEN	SIGNAL			
4	N/C				
5	CLEAR	SHEILD			
6	VARIES	LED WIRE LEVEL			
7	VARIES	LED WIRE 24V			
8	YELLOW	CASE GROUND			
9	N/C				
PIT 2 CLUSTER 1 WIRING SCHEDULE					
				55 PIN ML	
PT/TC	9 PIN FEM	WIRE	51 PAIR	CONN#1	
#	PIN #	NAME	WIRE COLOR	PIN#	
1	1	- BIAS	GREEN/BROWN	8	
1	2	+ BIAS	GREEN/WHITE	6	
1	3	SIGNAL	ORANGE/WHITE	1	
1	5	SHIELD	BLUE/GREEN	10	
1	6	+2V	WHITE	14	
1	7	LVL1	BROWN/WHITE	15	
1	8	CASE	GREEN/SLATE	12	
1		BOX	WHITE	20	
2	1	- BIAS	GREEN/BROWN	8	
2	2	+ BIAS	GREEN/WHITE	6	
2	3	SIGNAL	WHITE	2	
2	5	SHIELD	BLUE/GREEN	10	
2	6	+2V	WHITE	14	
2	7	LVL2	WHITE	16	
2	8	CASE	GREEN/SLATE	12	
2		BOX	WHITE	20	
3	1	- BIAS	WHITE	9	
3	2	+ BIAS	WHITE	7	
3	3	SIGNAL	ORANGE/GREEN	3	
3	5	SHIELD	WHITE	11	
3	6	+2V	WHITE	14	
3	7	LVL3	BROWN/SLATE	17	
3	8	CASE	WHITE	13	
3		BOX	WHITE	20	
4	1	- BIAS	WHITE	9	
4	2	+ BIAS	WHITE	7	
4	3	SIGNAL	WHITE	4	
4	5	SHIELD	WHITE	11	
4	6	+2V	WHITE	14	
4	7	LVL4	WHITE	18	
4	8	CASE	WHITE	13	
4		BOX	WHITE	20	
5	1	- BIAS	WHITE	9	
5	2	+ BIAS	WHITE	7	
5	3	SIGNAL	ORANGE/BROWN	5	
5	5	SHIELD	WHITE	11	
5	6	+2V	WHITE	14	
5	7	LVL5	SLATE/WHITE	19	
5	8	CASE	WHITE	13	
5		BOX	WHITE	20	

TR-3	44 PIN FEM				62 PIN ML	44 PIN FEM				62 PIN ML
CL#	PT/TC	CONN.# 5	WIRE	51 PAIR	CONN#1	PT/TC	CONN.# 5	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	WIRE COLO	PIN#	#	PIN #	NAME	IRE COLO	PIN#
1	1	1	SIGNA	RANGE/WHI	1	1	1	SIGNAL	ANGE/WHI	1
1	2	6	SIGNA	WHITE	2	1	2	SHIELD		
1	3	11	SIGNA	RANGE/GRE	3	1	3	+ BIAS	REEN/WHI	9
1	4	16	SIGNA	WHITE	4	1	4	- BIAS	REEN/BRO	11
1	5	21	SIGNA	ANGE/BRO	5	1	5	CASE	REEN/SLAT	13
1	6	26	SIGNA	WHITE	6	2	6	SIGNAL	WHITE	2
1	7	31	SIGNA	RANGE/SLA	7	2	7	SHIELD		
1		37	+2V	WHITE	8	2	8	+ BIAS	WHITE	10
1	1	3	+ BIA	REEN/WHIT	9	2	9	- BIAS	WHITE	12
1	2	8	+ BIA	WHITE	10	2	10	CASE	WHITE	14
1	3	13	+ BIAS			3	11	SIGNAL	ANGE/GRE	3
1	4	18	+ BIAS			3	12	SHIELD		
1	5	23	+ BIAS			3	13	+ BIAS		
1	6	28	+ BIAS			3	14	- BIAS		
1	7	33	+ BIAS			3	15	CASE		
1		16				4	16	SIGNAL	WHITE	4
1	1	4	- BIAS	REEN/BROW	11		16			
1	2	9	- BIAS	WHITE	12	4	17	SHIELD		
1	3	14	- BIAS			4	18	+ BIAS		
1	4	19	- BIAS			4	19	- BIAS		
1	5	24	- BIAS			4	20	CASE		
1	6	29	- BIAS			5	21	SIGNAL	ANGE/BRO	5
1	7	34	- BIAS			5	22	SHIELD		
1	1	2	SHIELD			5	23	+ BIAS		
1	2	7	SHIELD			5	24	- BIAS		
1	3	12	SHIELD			5	25	CASE		
1	4	17	SHIELD			6	26	SIGNAL	WHITE	6
1	5	22	SHIELD			6	27	SHIELD		
1	6	27	SHIELD			6	28	+ BIAS		
1	7	32	SHIELD			6	29	- BIAS		
1	1	5	CASE	REEN/SLAT	13	6	30	CASE		
1	2	10	CASE	WHITE	14	7	31	SIGNAL	ANGE/SLA	7
1	3	15	CASE			7	32	SHIELD		
1	4	20	CASE			7	33	+ BIAS		
1	5	25	CASE			7	34	- BIAS		
1	6	30	CASE			7	35	CASE		
1	7	35	CASE				37	+2V	WHITE	8
1	1	38	LVL1	ROWN/WHI	15	1	38	LVL1	OWN/WHI	15
1	2	39	LVL2	WHITE	16	2	39	LVL2	WHITE	16
1	3	40	LVL3	ROWN/SLA	17	3	40	LVL3	OWN/SLA	17
1	4	41	LVL4	WHITE	18	4	41	LVL4	WHITE	18
1	5	42	LVL5	LATE/WHIT	19	5	42	LVL5	LATE/WHIT	19
1	6	43	LVL6	WHITE	20	6	43	LVL6	WHITE	20
1	7	44	LVL7	BLUE/GRN	21	7	44	LVL7	BLUE/GRN	21

TABLE 11-2				
PIT 2 CLUSTER 2 WIRING SCHEDULE				
			51 PAIR	55 PIN M
PT/TC	PIN FEM	WIRE	CABLE	CONN#1
#	PIN #	NAME	WIRE COLOR	PIN#
1	1	- BIAS	BLU/SLATE	28
1	2	+ BIAS	BROWN	26
1	3	SIGNAL	SLATE/WHITE	21
1	5	SHIELD	ORNG/SLATE	30
1	6	+2V	WHITE	34
1	7	LVL1	BLUE/ORANGE	35
1	8	CASE	ORNG/WHITE	32
1		BOX		40
2	1	- BIAS	BLU/SLATE	28
2	2	+ BIAS	BROWN	26
2	3	SIGNAL	RED	22
2	5	SHIELD	ORNG/SLATE	30
2	6	+2V	WHITE	34
2	7	LVL2	BLACK	36
2	8	CASE	ORNG/WHITE	32
2		BOX		40
3	1	- BIAS	BLACK	29
3	2	+ BIAS	RED	27
3	3	SIGNAL	BLUE	23
3	5	SHIELD	WHITE	31
3	6	+2V	WHITE	34
3	7	LVL3	BLUE/GREEN	37
3	8	CASE	BLACK	33
3		BOX		40
3	1	- BIAS	BLACK	29
3	2	+ BIAS	RED	27
4	3	SIGNAL	WHITE	24
3	5	SHIELD	WHITE	31
4	6	+2V	WHITE	34
4	7	LVL4	BLACK	38
3	8	CASE	BLACK	33
4		BOX		40
3	1	- BIAS	BLACK	29
3	2	+ BIAS	RED	27
5	3	SIGNAL	ORANGE	25
3	5	SHIELD	WHITE	31
5	6	+2V	WHITE	34
5	7	LVL5	BLUE/BROWN	39
3	8	CASE	BLACK	33
5		BOX		40

TR-3	44 PIN FEM				62 PIN ML	44 PIN FEM				62 PIN ML
CL#	PT/TC	CONN.#	WIRE	51 PAIR	CONN#1	PT/TC	CONN.#	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	IRE COLO	PIN#	#	PIN #	NAME	IRE COLO	PIN#
2	1	1	SIGNAL	LATE/WHIT	22	1	1	SIGNAL	LATE/WHIT	22
2	2	6	SIGNAL	RED	23	1	2	SHIELD		
2	3	11	SIGNAL	BLUE	24	1	3	+ BIAS	BROWN	30
2	4	16	SIGNAL	WHITE	25	1	4	- BIAS	BLU/SLATE	32
2	5	21	SIGNAL	ORANGE	26	1	5	CASE	RNG/WHIT	34
2	6	26	SIGNAL	WHITE	27	2	6	SIGNAL	RED	23
2	7	31	SIGNAL	RED	28	2	7	SHIELD		
2		37	+2V	WHITE	29	2	8	+ BIAS	RED	31
2	1	3	+ BIAS	BROWN	30	2	9	- BIAS	BLACK	33
2	2	8	+ BIAS	RED	31	2	10	CASE	BLACK	35
2	3	13	+ BIAS			3	11	SIGNAL	BLUE	24
2	4	18	+ BIAS			3	12	SHIELD		
2	5	23	+ BIAS			3	13	+ BIAS		
2	6	28	+ BIAS			3	14	- BIAS		
2	7	33	+ BIAS			3	15	CASE		
2		16				4	16	SIGNAL	WHITE	25
2	1	4	- BIAS	BLU/SLATE	32		16			
2	2	9	- BIAS	BLACK	33	4	17	SHIELD		
2	3	14	- BIAS			4	18	+ BIAS		
2	4	19	- BIAS			4	19	- BIAS		
2	5	24	- BIAS			4	20	CASE		
2	6	29	- BIAS			5	21	SIGNAL	ORANGE	26
2	7	34	- BIAS			5	22	SHIELD		
2	1	2	SHIELD			5	23	+ BIAS		
2	2	7	SHIELD			5	24	- BIAS		
2	3	12	SHIELD			5	25	CASE		
2	4	17	SHIELD			6	26	SIGNAL	WHITE	27
2	5	22	SHIELD			6	27	SHIELD		
2	6	27	SHIELD			6	28	+ BIAS		
2	7	32	SHIELD			6	29	- BIAS		
2	1	5	CASE	RNG/WHIT	34	6	30	CASE		
2	2	10	CASE	BLACK	35	7	31	SIGNAL	RED	28
2	3	15	CASE			7	32	SHIELD		
2	4	20	CASE			7	33	+ BIAS		
2	5	25	CASE			7	34	- BIAS		
2	6	30	CASE			7	35	CASE		
2	7	35	CASE				37	+2V	WHITE	29
2	1	38	LVL1	LUE/ORAN	36	1	38	LVL1	LUE/ORAN	36
2	2	39	LVL2	BLACK	37	2	39	LVL2	BLACK	37
2	3	40	LVL3	LUE/GREE	38	3	40	LVL3	LUE/GREE	38
2	4	41	LVL4	BLACK	39	4	41	LVL4	BLACK	39
2	5	42	LVL5	LUE/BROW	40	5	42	LVL5	LUE/BROW	40
2	6	43	LVL6	BLACK	41	6	43	LVL6	BLACK	41
2	7	44	LVL7	RED	42	7	44	LVL7	RED	42

TABLE 11-3				
PIT 2CLUSTER 3 WIRING SCHEDULE				
			51 PAIR	55 PIN M
PT/TC	9 PIN FEM	WIRE	CABLE	CONN#1
1	1	- BIAS	ORANGE/SLATE	48
1	2	+ BIAS	RANGE/BROW	46
1	3	SIGNAL	BLUE/BROWN	41
1	5	SHIELD	BROWN/SLATE	50
1	6	+2V	RED	4
1	7	LVL1	GREEN/BROWN	5
1	8	CASE	GREEN/WHITE	2
1		BOX		10
2	1	- BIAS	ORANGE/SLATE	48
2	2	+ BIAS	RANGE/BROW	46
2	3	SIGNAL	RED	42
2	5	SHIELD	BROWN/SLATE	50
2	6	+2V	RED	4
2	7	LVL2	RED	6
2	8	CASE	GREEN/WHITE	2
2		BOX		10
3	1	- BIAS	RED	49
3	2	+ BIAS	RED	47
3	3	SIGNAL	BLUE/SLATE	43
3	5	SHIELD	RED	1
3	6	+2V	RED	4
3	7	LVL3	GREEN/SLATE	7
3	8	CASE	RED	3
3		BOX		10
3	1	- BIAS	RED	49
3	2	+ BIAS	RED	47
4	3	SIGNAL	RED	44
3	5	SHIELD	RED	1
4	6	+2V	RED	4
4	7	LVL4	RED	8
3	8	CASE	RED	3
4		BOX		10
3	1	- BIAS	RED	49
3	2	+ BIAS	RED	47
5	3	SIGNAL	ORANGE/WHIT	45
3	5	SHIELD	RED	1
5	6	+2V	RED	4
5	7	LVL5	BROWN/WHITE	9
3	8	CASE	RED	3
5		BOX		10

TR-3	44 PIN FEM			62 PIN ML		44 PIN FEM			62 PIN ML	
CL#	PT/TC	CONN.# 3	WIRE	51 PAIR	CONN#1	PT/TC	CONN.# 3	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	WIRE COLOR	PIN#	#	PIN #	NAME	WIRE COLO	PIN#
3	1	1	SIGNAL	BLUE/BROWN	43	1	1	SIGNAL	LUE/BROW	43
3	2	6	SIGNAL	RED	44	1	2	SHIELD		
3	3	11	SIGNAL	BLUE/SLATE	45	1	3	+ BIAS	ANGE/BRO	51
3	4	16	SIGNAL	RED	46	1	4	- BIAS	RANGE/SLA	53
3	5	21	SIGNAL	ORANGE/WHIT	47	1	5	CASE	REEN/WHIT	55
3	6	26	SIGNAL	RED	48	2	6	SIGNAL	RED	44
3	7	31	SIGNAL	RANGE/GREE	49	2	7	SHIELD		
3		37	+2V	RED	50	2	8	+ BIAS	RED	52
3	1	3	+ BIAS	RANGE/BROW	51	2	9	- BIAS	RED	54
3	2	8	+ BIAS	RED	52	2	10	CASE	RED	56
3	3	13	+ BIAS			3	11	SIGNAL	BLUE/SLATE	45
3	4	18	+ BIAS			3	12	SHIELD		
3	5	23	+ BIAS			3	13	+ BIAS		
3	6	28	+ BIAS			3	14	- BIAS		
3	7	33	+ BIAS			3	15	CASE		
3		16				4	16	SIGNAL	RED	46
3	1	4	- BIAS	ORANGE/SLAT	53		16			
3	2	9	- BIAS	RED	54	4	17	SHIELD		
3	3	14	- BIAS			4	18	+ BIAS		
3	4	19	- BIAS			4	19	- BIAS		
3	5	24	- BIAS			4	20	CASE		
3	6	29	- BIAS			5	21	SIGNAL	RANGE/WHI	47
3	7	34	- BIAS			5	22	SHIELD		
3	1	2	SHIELD			5	23	+ BIAS		
3	2	7	SHIELD			5	24	- BIAS		
3	3	12	SHIELD			5	25	CASE		
3	4	17	SHIELD			6	26	SIGNAL	RED	48
3	5	22	SHIELD			6	27	SHIELD		
3	6	27	SHIELD			6	28	+ BIAS		
3	7	32	SHIELD			6	29	- BIAS		
3	1	5	CASE	GREEN/WHITE	55	6	30	CASE		
3	2	10	CASE	RED	56	7	31	SIGNAL	RANGE/GRE	49
3	3	15	CASE			7	32	SHIELD		
3	4	20	CASE			7	33	+ BIAS		
3	5	25	CASE			7	34	- BIAS		
3	6	30	CASE			7	35	CASE		
3	7	35	CASE		CONN#2		37	+2V	RED	50
3	1	38	LVL1	GREEN/BROWN	1	1	38	LVL1	REEN/BROW	CONN#2-1
3	2	39	LVL2	RED	2	2	39	LVL2	RED	2
3	3	40	LVL3	GREEN/SLATE	3	3	40	LVL3	REEN/SLAT	3
3	4	41	LVL4	RED	4	4	41	LVL4	RED	4
3	5	42	LVL5	BROWN/WHITE	5	5	42	LVL5	ROWN/WHI	5
3	6	43	LVL6	RED	6	6	43	LVL6	RED	6
3	7	44	LVL7	BROWN/SLATE	7	7	44	LVL7	ROWN/SLA	7

TABLE 11-4				
PIT 2 CLUSTER 4 WIRING SCHEDULE				
			51 PAIR	55 PIN ML
PT/TC	9 PIN FEM	WIRE	CABLE	CONN#1
#	PIN #	NAME	WIRE COLOR	PIN#
1	1	- BIAS	GREEN	18
1	2	+ BIAS	WHITE	16
1	3	SIGNAL	BLUE/GREEN	11
1	5	SHIELD	ORANGE	20
1	6	+2V	RED	24
1	7	LVL1	SLATE	25
1	8	CASE	BROWN	22
1		BOX		30
2	1	- BIAS	GREEN	18
2	2	+ BIAS	WHITE	16
2	3	SIGNAL	RED	12
2	5	SHIELD	ORANGE	20
2	6	+2V	RED	24
2	7	LVL2	RED	26
2	8	CASE	BROWN	22
2		BOX		30
3	1	- BIAS	RED	19
3	2	+ BIAS	ORNG/GREEN	17
3	3	SIGNAL	BLUE/BROWN	13
3	5	SHIELD	WHITE	21
3	6	+2V	RED	24
3	7	LVL3	BLUE/WHITE	27
3	8	CASE	RED	23
3		BOX		30
3	1	- BIAS	RED	19
3	2	+ BIAS	ORNG/GREEN	17
4	3	SIGNAL	BLACK	14
3	5	SHIELD	WHITE	21
4	6	+2V	RED	24
4	7	LVL4	RED	28
3	8	CASE	RED	23
4		BOX		30
3	1	- BIAS	RED	19
3	2	+ BIAS	ORNG/GREEN	17
5	3	SIGNAL	BLUE/SLATE	15
3	5	SHIELD	WHITE	21
5	6	+2V	RED	24
5	7	LVL5	BLUE/ORANGE	29
3	8	CASE	RED	23
5	BOX			30

		44 PIN FEM			62 PIN ML		44 PIN FEM			62 PIN ML
TR-3	PT/TC	CONN.#	WIRE	51 PAIR	CONN#2	PT/TC	CONN.#	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	IRE COLO	PIN#	#	PIN #	NAME	IRE COLO	PIN#
4	1	1	SIGNAL	LUE/GREE	8	1	1	SIGNA	LUE/GREE	8
4	2	6	SIGNAL	WHITE	9	1	2	SHIELD		
4	3	11	SIGNAL	LUE/BROW	10	1	3	+ BIA	ORANGE	16
4	4	16	SIGNAL	WHITE	11	1	4	- BIAS	GREEN	18
4	5	21	SIGNAL	BLUE/SLAT	12	1	5	CASE	BROWN	20
4	6	26	SIGNAL	WHITE	13	2	6	SIGNA	WHITE	9
4	7	31	SIGNAL	BLUE	14	2	7	SHIELD		
4		37	+2V	RED	15	2	8	+ BIA	RED	17
4	1	3	+ BIAS	ORANGE	16	2	9	- BIAS	RED	19
4	2	8	+ BIAS	RED	17	2	10	CASE	RED	21
4	3	13	+ BIAS			3	11	SIGNA	LUE/BROW	10
4	4	18	+ BIAS			3	12	SHIELD		
4	5	23	+ BIAS			3	13	+ BIAS		
4	6	28	+ BIAS			3	14	- BIAS		
4	7	33	+ BIAS			3	15	CASE		
4		16				4	16	SIGNA	WHITE	11
4	1	4	- BIAS	GREEN	18		16			
4	2	9	- BIAS	RED	19	4	17	SHIELD		
4	3	14	- BIAS			4	18	+ BIAS		
4	4	19	- BIAS			4	19	- BIAS		
4	5	24	- BIAS			4	20	CASE		
4	6	29	- BIAS			5	21	SIGNA	BLUE/SLAT	12
4	7	34	- BIAS			5	22	SHIELD		
4	1	2	SHIELD			5	23	+ BIAS		
4	2	7	SHIELD			5	24	- BIAS		
4	3	12	SHIELD			5	25	CASE		
4	4	17	SHIELD			6	26	SIGNA	WHITE	13
4	5	22	SHIELD			6	27	SHIELD		
4	6	27	SHIELD			6	28	+ BIAS		
4	7	32	SHIELD			6	29	- BIAS		
4	1	5	CASE	BROWN	20	6	30	CASE		
4	2	10	CASE	RED	21	7	31	SIGNA	BLUE	14
4	3	15	CASE			7	32	SHIELD		
4	4	20	CASE			7	33	+ BIAS		
4	5	25	CASE			7	34	- BIAS		
4	6	30	CASE			7	35	CASE		
4	7	35	CASE				37	+2V	RED	15
4	1	38	LVL1	SLATE	22	1	38	LVL1	SLATE	22
4	2	39	LVL2	RED	23	2	39	LVL2	RED	23
4	3	40	LVL3	LUE/WHIT	24	3	40	LVL3	LUE/WHIT	24
4	4	41	LVL4	RED	25	4	41	LVL4	RED	25
4	5	42	LVL5	LUE/ORAN	26	5	42	LVL5	LUE/ORAN	26
4	6	43	LVL6	RED	27	6	43	LVL6	RED	27
4	7	44	LVL7	LUE/GREE	28	7	44	LVL7	LUE/GREE	28

TABLE 11-5				
PIT 2 CLUSTER 5 WIRING SCHEDULE				
			51 PAIR	
PT/TC	9 PIN FEM	WIRE	CABLE	55 PIN ML
#	PIN #	NAME	WIRE COLOR	PIN#
1	1	- BIAS	BLUE/WHITE	38
1	2	+ BIAS	SLATE	36
1	3	SIGNAL	BLUE	31
1	5	SHIELD	BLUE	40
1	6	+2V	BLACK	44
1	7	LVL1	BROWN	45
1	8	CASE	GREEN	42
1		BOX		50
2	1	- BIAS	BLUE/WHITE	38
2	2	+ BIAS	SLATE	36
2	3	SIGNAL	BLACK	32
2	5	SHIELD	BLUE	40
2	6	+2V	BLACK	44
2	7	LVL2	WHITE	46
2	8	CASE	GREEN	42
2		BOX		50
3	1	- BIAS	BLACK	39
3	2	+ BIAS	BLACK	37
3	3	SIGNAL	ORANGE	33
3	5	SHIELD	RED	41
3	6	+2V	BLACK	44
3	7	LVL3	SLATE	47
3	8	CASE	WHITE	43
3		BOX		50
3	1	- BIAS	BLACK	39
3	2	+ BIAS	BLACK	37
4	3	SIGNAL	BLACK	34
3	5	SHIELD	RED	41
4	6	+2V	BLACK	44
4	7	LVL4	WHITE	48
3	8	CASE	WHITE	43
4		BOX		50
3	1	- BIAS	BLACK	39
3	2	+ BIAS	BLACK	37
5	3	SIGNAL	GREEN	35
3	5	SHIELD	RED	41
5	6	+2V	BLACK	44
5	7	LVL5	BLUE/WHITE	49
3	8	CASE	WHITE	43
5		BOX		50

TR-3		44 PIN FEM			62 PIN ML		44 PIN FEM			62 PIN ML
CL#	PT/TC	CONN.# 1	WIRE	51 PAIR	CONN#2	PT/TC	CONN.# 1	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	WIRE COLOR	PIN#	#	PIN #	NAME	WIRE COLOR	PIN#
5	1	1	SIGNAL	BLUE	29	1	1	SIGNAL	BLUE	29
5	2	6	SIGNAL	BLACK	30	1	2	SHIELD		
5	3	11	SIGNAL	ORANGE	31	1	3	+ BIAS	SLATE	37
5	4	16	SIGNAL	BLACK	32	1	4	- BIAS	BLUE/WHITE	39
5	5	21	SIGNAL	GREEN	33	1	5	CASE	GREEN	41
5	6	26	SIGNAL	BLACK	34	2	6	SIGNAL	BLACK	30
5	7	31	SIGNAL	BROWN	35	2	7	SHIELD		
5		37	+2V	BLACK	36	2	8	+ BIAS	BLACK	38
5	1	3	+ BIAS	SLATE	37	2	9	- BIAS	BLACK	40
5	2	8	+ BIAS	BLACK	38	2	10	CASE	WHITE	42
5	3	13	+ BIAS			3	11	SIGNAL	ORANGE	31
5	4	18	+ BIAS			3	12	SHIELD		
5	5	23	+ BIAS			3	13	+ BIAS		
5	6	28	+ BIAS			3	14	- BIAS		
5	7	33	+ BIAS			3	15	CASE		
5		16				4	16	SIGNAL	BLACK	32
5	1	4	- BIAS	BLUE/WHITE	39		16			
5	2	9	- BIAS	BLACK	40	4	17	SHIELD		
5	3	14	- BIAS			4	18	+ BIAS		
5	4	19	- BIAS			4	19	- BIAS		
5	5	24	- BIAS			4	20	CASE		
5	6	29	- BIAS			5	21	SIGNAL	GREEN	33
5	7	34	- BIAS			5	22	SHIELD		
5	1	2	SHIELD			5	23	+ BIAS		
5	2	7	SHIELD			5	24	- BIAS		
5	3	12	SHIELD			5	25	CASE		
5	4	17	SHIELD			6	26	SIGNAL	BLACK	34
5	5	22	SHIELD			6	27	SHIELD		
5	6	27	SHIELD			6	28	+ BIAS		
5	7	32	SHIELD			6	29	- BIAS		
5	1	5	CASE	GREEN	41	6	30	CASE		
5	2	10	CASE	WHITE	42	7	31	SIGNAL	BROWN	35
5	3	15	CASE			7	32	SHIELD		
5	4	20	CASE			7	33	+ BIAS		
5	5	25	CASE			7	34	- BIAS		
5	6	30	CASE			7	35	CASE		
5	7	35	CASE				37	+2V	BLACK	36
5	1	38	LVL1	BROWN	43	1	38	LVL1	BROWN	43
5	2	39	LVL2	WHITE	44	2	39	LVL2	WHITE	44
5	3	40	LVL3	SLATE	45	3	40	LVL3	SLATE	45
5	4	41	LVL4	WHITE	46	4	41	LVL4	WHITE	46
5	5	42	LVL5	BLUE/WHITE	47	5	42	LVL5	BLUE/WHITE	47
5	6	43	LVL6	WHITE	48	6	43	LVL6	WHITE	48
5	7	44	LVL7	LUE/ORANG	49	7	44	LVL7	LUE/ORANG	49

			TABLE 12-1							
TR-3		44 PIN FEM			62 PIN ML		44 PIN FEM			62 PIN ML
CL#	PT/TC	CONN.# 5	WIRE	51 PAIR	CONN#1	PT/TC	CONN.# 5	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	WIRE COLOR	PIN#	#	PIN #	NAME	WIRE COLOR	PIN#
1	1	1	SIGNAL	ORANGE/WHITE	1	1	1	SIGNAL	ORANGE/WHITE	1
1	2	6	SIGNAL	WHITE	2	1	2	SHIELD		
1	3	11	SIGNAL	ORANGE/GREEN	3	1	3	+ BIAS	GREEN/WHITE	9
1	4	16	SIGNAL	WHITE	4	1	4	- BIAS	GREEN/BROWN	11
1	5	21	SIGNAL	ORANGE/BROWN	5	1	5	CASE	GREEN/SLATE	13
1	6	26	SIGNAL	WHITE	6	2	6	SIGNAL	WHITE	2
1	7	31	SIGNAL	ORANGE/SLATE	7	2	7	SHIELD		
1		37	+2V	WHITE	8	2	8	+ BIAS	WHITE	10
1	1	3	+ BIAS	GREEN/WHITE	9	2	9	- BIAS	WHITE	12
1	2	8	+ BIAS	WHITE	10	2	10	CASE	WHITE	14
1	3	13	+ BIAS			3	11	SIGNAL	ORANGE/GREEN	3
1	4	18	+ BIAS			3	12	SHIELD		
1	5	23	+ BIAS			3	13	+ BIAS		
1	6	28	+ BIAS			3	14	- BIAS		
1	7	33	+ BIAS			3	15	CASE		
1		16				4	16	SIGNAL	WHITE	4
1	1	4	- BIAS	GREEN/BROWN	11		16			
1	2	9	- BIAS	WHITE	12	4	17	SHIELD		
1	3	14	- BIAS			4	18	+ BIAS		
1	4	19	- BIAS			4	19	- BIAS		
1	5	24	- BIAS			4	20	CASE		
1	6	29	- BIAS			5	21	SIGNAL	ORANGE/BROWN	5
1	7	34	- BIAS			5	22	SHIELD		
1	1	2	SHIELD			5	23	+ BIAS		
1	2	7	SHIELD			5	24	- BIAS		
1	3	12	SHIELD			5	25	CASE		
1	4	17	SHIELD			6	26	SIGNAL	WHITE	6
1	5	22	SHIELD			6	27	SHIELD		
1	6	27	SHIELD			6	28	+ BIAS		
1	7	32	SHIELD			6	29	- BIAS		
1	1	5	CASE	GREEN/SLATE	13	6	30	CASE		
1	2	10	CASE	WHITE	14	7	31	SIGNAL	ORANGE/SLATE	7
1	3	15	CASE			7	32	SHIELD		
1	4	20	CASE			7	33	+ BIAS		
1	5	25	CASE			7	34	- BIAS		
1	6	30	CASE			7	35	CASE		
1	7	35	CASE				37	+2V	WHITE	8
1	1	38	LVL1	BROWN/WHITE	15	1	38	LVL1	BROWN/WHITE	15
1	2	39	LVL2	WHITE	16	2	39	LVL2	WHITE	16
1	3	40	LVL3	BROWN/SLATE	17	3	40	LVL3	BROWN/SLATE	17
1	4	41	LVL4	WHITE	18	4	41	LVL4	WHITE	18
1	5	42	LVL5	SLATE/WHITE	19	5	42	LVL5	SLATE/WHITE	19
1	6	43	LVL6	WHITE	20	6	43	LVL6	WHITE	20
1	7	44	LVL7	BLUE/GRN	21	7	44	LVL7	BLUE/GRN	21

TABLE 12-2										
TR-3		44 PIN FEM			62 PIN ML		44 PIN FEM			62 PIN ML
CL#	PT/TC	CONN.# 4	WIRE	51 PAIR	CONN#1	PT/TC	CONN.# 4	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	WIRE COLOR	PIN#	#	PIN #	NAME	WIRE COLOR	PIN#
2	1	1	SIGNAL	SLATE/WHITE	22	1	1	SIGNAL	SLATE/WHITE	22
2	2	6	SIGNAL	RED	23	1	2	SHIELD		
2	3	11	SIGNAL	BLUE	24	1	3	+ BIAS	BROWN	30
2	4	16	SIGNAL	WHITE	25	1	4	- BIAS	BLU/SLATE	32
2	5	21	SIGNAL	ORANGE	26	1	5	CASE	ORNG/WHITE	34
2	6	26	SIGNAL	WHITE	27	2	6	SIGNAL	RED	23
2	7	31	SIGNAL	RED	28	2	7	SHIELD		
2		37	+2V	WHITE	29	2	8	+ BIAS	RED	31
2	1	3	+ BIAS	BROWN	30	2	9	- BIAS	BLACK	33
2	2	8	+ BIAS	RED	31	2	10	CASE	BLACK	35
2	3	13	+ BIAS			3	11	SIGNAL	BLUE	24
2	4	18	+ BIAS			3	12	SHIELD		
2	5	23	+ BIAS			3	13	+ BIAS		
2	6	28	+ BIAS			3	14	- BIAS		
2	7	33	+ BIAS			3	15	CASE		
2		16				4	16	SIGNAL	WHITE	25
2	1	4	- BIAS	BLU/SLATE	32		16			
2	2	9	- BIAS	BLACK	33	4	17	SHIELD		
2	3	14	- BIAS			4	18	+ BIAS		
2	4	19	- BIAS			4	19	- BIAS		
2	5	24	- BIAS			4	20	CASE		
2	6	29	- BIAS			5	21	SIGNAL	ORANGE	26
2	7	34	- BIAS			5	22	SHIELD		
2	1	2	SHIELD			5	23	+ BIAS		
2	2	7	SHIELD			5	24	- BIAS		
2	3	12	SHIELD			5	25	CASE		
2	4	17	SHIELD			6	26	SIGNAL	WHITE	27
2	5	22	SHIELD			6	27	SHIELD		
2	6	27	SHIELD			6	28	+ BIAS		
2	7	32	SHIELD			6	29	- BIAS		
2	1	5	CASE	ORNG/WHITE	34	6	30	CASE		
2	2	10	CASE	BLACK	35	7	31	SIGNAL	RED	28
2	3	15	CASE			7	32	SHIELD		
2	4	20	CASE			7	33	+ BIAS		
2	5	25	CASE			7	34	- BIAS		
2	6	30	CASE			7	35	CASE		
2	7	35	CASE				37	+2V	WHITE	29
2	1	38	LVL1	BLUE/ORANGE	36	1	38	LVL1	BLUE/ORANGE	36
2	2	39	LVL2	BLACK	37	2	39	LVL2	BLACK	37
2	3	40	LVL3	BLUE/GREEN	38	3	40	LVL3	BLUE/GREEN	38
2	4	41	LVL4	BLACK	39	4	41	LVL4	BLACK	39
2	5	42	LVL5	BLUE/BROWN	40	5	42	LVL5	BLUE/BROWN	40
2	6	43	LVL6	BLACK	41	6	43	LVL6	BLACK	41
2	7	44	LVL7	RED	42	7	44	LVL7	RED	42

TABLE 12-3										
TR-3		44 PIN FEM			62 PIN ML		44 PIN FEM			62 PIN ML
CL#	PT/TC	CONN.# 3	WIRE	51 PAIR	CONN#1	PT/TC	CONN.# 3	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	WIRE COLOR	PIN#	#	PIN #	NAME	WIRE COLOR	PIN#
3	1	1	SIGNAL	BLUE/BROWN	43	1	1	SIGNAL	BLUE/BROWN	43
3	2	6	SIGNAL	RED	44	1	2	SHIELD		
3	3	11	SIGNAL	BLUE/SLATE	45	1	3	+ BIAS	ORANGE/BROWN	51
3	4	16	SIGNAL	RED	46	1	4	- BIAS	ORANGE/SLATE	53
3	5	21	SIGNAL	ORANGE/WHITE	47	1	5	CASE	GREEN/WHITE	55
3	6	26	SIGNAL	RED	48	2	6	SIGNAL	RED	44
3	7	31	SIGNAL	ORANGE/GREEN	49	2	7	SHIELD		
3		37	+2V	RED	50	2	8	+ BIAS	RED	52
3	1	3	+ BIAS	ORANGE/BROWN	51	2	9	- BIAS	RED	54
3	2	8	+ BIAS	RED	52	2	10	CASE	RED	56
3	3	13	+ BIAS			3	11	SIGNAL	BLUE/SLATE	45
3	4	18	+ BIAS			3	12	SHIELD		
3	5	23	+ BIAS			3	13	+ BIAS		
3	6	28	+ BIAS			3	14	- BIAS		
3	7	33	+ BIAS			3	15	CASE		
3		16				4	16	SIGNAL	RED	46
3	1	4	- BIAS	ORANGE/SLATE	53		16			
3	2	9	- BIAS	RED	54	4	17	SHIELD		
3	3	14	- BIAS			4	18	+ BIAS		
3	4	19	- BIAS			4	19	- BIAS		
3	5	24	- BIAS			4	20	CASE		
3	6	29	- BIAS			5	21	SIGNAL	ORANGE/WHITE	47
3	7	34	- BIAS			5	22	SHIELD		
3	1	2	SHIELD			5	23	+ BIAS		
3	2	7	SHIELD			5	24	- BIAS		
3	3	12	SHIELD			5	25	CASE		
3	4	17	SHIELD			6	26	SIGNAL	RED	48
3	5	22	SHIELD			6	27	SHIELD		
3	6	27	SHIELD			6	28	+ BIAS		
3	7	32	SHIELD			6	29	- BIAS		
3	1	5	CASE	GREEN/WHITE	55	6	30	CASE		
3	2	10	CASE	RED	56	7	31	SIGNAL	ORANGE/GREEN	49
3	3	15	CASE			7	32	SHIELD		
3	4	20	CASE			7	33	+ BIAS		
3	5	25	CASE			7	34	- BIAS		
3	6	30	CASE			7	35	CASE		
3	7	35	CASE		CONN#2		37	+2V	RED	50
3	1	38	LVL1	GREEN/BROWN	1	1	38	LVL1	GREEN/BROWN	CONN#2-1
3	2	39	LVL2	RED	2	2	39	LVL2	RED	2
3	3	40	LVL3	GREEN/SLATE	3	3	40	LVL3	GREEN/SLATE	3
3	4	41	LVL4	RED	4	4	41	LVL4	RED	4
3	5	42	LVL5	BROWN/WHITE	5	5	42	LVL5	BROWN/WHITE	5
3	6	43	LVL6	RED	6	6	43	LVL6	RED	6
3	7	44	LVL7	BROWN/SLATE	7	7	44	LVL7	BROWN/SLATE	7

table 12-4

TABLE 12-4										
		44 PIN FEM			62 PIN ML		44 PIN FEM			62 PIN ML
TR-3	PT/TC	CONN.# 2	WIRE	51 PAIR	CONN#2	PT/TC	CONN.# 2	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	WIRE COLOR	PIN#	#	PIN #	NAME	WIRE COLOR	PIN#
4	1	1	SIGNAL	BLUE/GREEN	8	1	1	SIGNAL	BLUE/GREEN	8
4	2	6	SIGNAL	WHITE	9	1	2	SHIELD		
4	3	11	SIGNAL	BLUE/BROWN	10	1	3	+ BIAS	ORANGE	16
4	4	16	SIGNAL	WHITE	11	1	4	- BIAS	GREEN	18
4	5	21	SIGNAL	BLUE/SLATE	12	1	5	CASE	BROWN	20
4	6	26	SIGNAL	WHITE	13	2	6	SIGNAL	WHITE	9
4	7	31	SIGNAL	BLUE	14	2	7	SHIELD		
4		37	+2V	RED	15	2	8	+ BIAS	RED	17
4	1	3	+ BIAS	ORANGE	16	2	9	- BIAS	RED	19
4	2	8	+ BIAS	RED	17	2	10	CASE	RED	21
4	3	13	+ BIAS			3	11	SIGNAL	BLUE/BROWN	10
4	4	18	+ BIAS			3	12	SHIELD		
4	5	23	+ BIAS			3	13	+ BIAS		
4	6	28	+ BIAS			3	14	- BIAS		
4	7	33	+ BIAS			3	15	CASE		
4		16				4	16	SIGNAL	WHITE	11
4	1	4	- BIAS	GREEN	18		16			
4	2	9	- BIAS	RED	19	4	17	SHIELD		
4	3	14	- BIAS			4	18	+ BIAS		
4	4	19	- BIAS			4	19	- BIAS		
4	5	24	- BIAS			4	20	CASE		
4	6	29	- BIAS			5	21	SIGNAL	BLUE/SLATE	12
4	7	34	- BIAS			5	22	SHIELD		
4	1	2	SHIELD			5	23	+ BIAS		
4	2	7	SHIELD			5	24	- BIAS		
4	3	12	SHIELD			5	25	CASE		
4	4	17	SHIELD			6	26	SIGNAL	WHITE	13
4	5	22	SHIELD			6	27	SHIELD		
4	6	27	SHIELD			6	28	+ BIAS		
4	7	32	SHIELD			6	29	- BIAS		
4	1	5	CASE	BROWN	20	6	30	CASE		
4	2	10	CASE	RED	21	7	31	SIGNAL	BLUE	14
4	3	15	CASE			7	32	SHIELD		
4	4	20	CASE			7	33	+ BIAS		
4	5	25	CASE			7	34	- BIAS		
4	6	30	CASE			7	35	CASE		
4	7	35	CASE				37	+2V	RED	15
4	1	38	LVL1	SLATE	22	1	38	LVL1	SLATE	22
4	2	39	LVL2	RED	23	2	39	LVL2	RED	23
4	3	40	LVL3	BLUE/WHITE	24	3	40	LVL3	BLUE/WHITE	24
4	4	41	LVL4	RED	25	4	41	LVL4	RED	25
4	5	42	LVL5	BLUE/ORANGE	26	5	42	LVL5	BLUE/ORANGE	26
4	6	43	LVL6	RED	27	6	43	LVL6	RED	27
4	7	44	LVL7	BLUE/GREEN	28	7	44	LVL7	BLUE/GREEN	28

TABLE 12-5										
TR-3		44 PIN FEM			62 PIN ML		44 PIN FEM			62 PIN ML
CL#	PT/TC	CONN.# 1	WIRE	51 PAIR	CONN#2	PT/TC	CONN.# 1	WIRE	51 PAIR	CONN#1
	#	PIN #	NAME	WIRE COLOR	PIN#	#	PIN #	NAME	WIRE COLOR	PIN#
5	1	1	SIGNAL	BLUE	29	1	1	SIGNAL	BLUE	29
5	2	6	SIGNAL	BLACK	30	1	2	SHIELD		
5	3	11	SIGNAL	ORANGE	31	1	3	+ BIAS	SLATE	37
5	4	16	SIGNAL	BLACK	32	1	4	- BIAS	BLUE/WHITE	39
5	5	21	SIGNAL	GREEN	33	1	5	CASE	GREEN	41
5	6	26	SIGNAL	BLACK	34	2	6	SIGNAL	BLACK	30
5	7	31	SIGNAL	BROWN	35	2	7	SHIELD		
5		37	+2V	BLACK	36	2	8	+ BIAS	BLACK	38
5	1	3	+ BIAS	SLATE	37	2	9	- BIAS	BLACK	40
5	2	8	+ BIAS	BLACK	38	2	10	CASE	WHITE	42
5	3	13	+ BIAS			3	11	SIGNAL	ORANGE	31
5	4	18	+ BIAS			3	12	SHIELD		
5	5	23	+ BIAS			3	13	+ BIAS		
5	6	28	+ BIAS			3	14	- BIAS		
5	7	33	+ BIAS			3	15	CASE		
5		16				4	16	SIGNAL	BLACK	32
5	1	4	- BIAS	BLUE/WHITE	39		16			
5	2	9	- BIAS	BLACK	40	4	17	SHIELD		
5	3	14	- BIAS			4	18	+ BIAS		
5	4	19	- BIAS			4	19	- BIAS		
5	5	24	- BIAS			4	20	CASE		
5	6	29	- BIAS			5	21	SIGNAL	GREEN	33
5	7	34	- BIAS			5	22	SHIELD		
5	1	2	SHIELD			5	23	+ BIAS		
5	2	7	SHIELD			5	24	- BIAS		
5	3	12	SHIELD			5	25	CASE		
5	4	17	SHIELD			6	26	SIGNAL	BLACK	34
5	5	22	SHIELD			6	27	SHIELD		
5	6	27	SHIELD			6	28	+ BIAS		
5	7	32	SHIELD			6	29	- BIAS		
5	1	5	CASE	GREEN	41	6	30	CASE		
5	2	10	CASE	WHITE	42	7	31	SIGNAL	BROWN	35
5	3	15	CASE			7	32	SHIELD		
5	4	20	CASE			7	33	+ BIAS		
5	5	25	CASE			7	34	- BIAS		
5	6	30	CASE			7	35	CASE		
5	7	35	CASE				37	+2V	BLACK	36
5	1	38	LVL1	BROWN	43	1	38	LVL1	BROWN	43
5	2	39	LVL2	WHITE	44	2	39	LVL2	WHITE	44
5	3	40	LVL3	SLATE	45	3	40	LVL3	SLATE	45
5	4	41	LVL4	WHITE	46	4	41	LVL4	WHITE	46
5	5	42	LVL5	BLUE/WHITE	47	5	42	LVL5	BLUE/WHITE	47
5	6	43	LVL6	WHITE	48	6	43	LVL6	WHITE	48
5	7	44	LVL7	BLUE/ORANGE	49	7	44	LVL7	BLUE/ORANGE	49

TABLE 13

tensiometer locations (cm)

measured from southwest trench corner

I.D.	x	y	z	I.D.	x	y	z	I.D.	x	y	z	I.D.	x	y	z
01ts51	556.26	109.22	9.24	02TS41	373.38	147.32	14.74	03TS51	416.56	198.12	13.2	04TS21	233.68	167.64	11.6
01ts11	149.86	83.82	11.5	02TS31	279.4	152.4	15.24	03TS31	231.14	220.98	13.3	04TS41	408.94	149.86	13.4
01ts41	449.58	78.74	13.84	02TS11	134.62	129.54	16.64	03TS21	180.34	233.68	14	04TS31	322.58	172.72	14
01ts21	246.38	78.74	16.44	02TS21	205.74	129.54	16.94	32	246.38	246.38	14.1	04TS51	464.82	162.56	14.7
01ts31	358.14	93.98	19.54	32	269.24	142.24	17.92	03TS41	365.76	220.98	14.3	04TS11	142.24	154.94	15
12	137.16	83.82	20.02	02TS51	439.42	162.56	18.64	03TS11	76.2	223.52	18.6	22	228.6	157.48	25.1
52	523.24	91.44	20.12	42	370.84	129.54	23.32	22	167.64	243.84	23.3	52	482.6	157.48	26.9
22	233.68	78.74	22.12	52	452.12	162.56	24.62	12	76.2	233.68	23.5	32	317.5	147.32	28.9
42	439.42	71.12	23.72	12	124.46	119.38	25.12	52	424.18	190.5	23.8	12	149.86	152.4	31.6
13	119.38	86.36	35.7	22	193.04	114.3	25.12	42	340.36	223.52	24.7	34	294.64	172.72	34.8
53	535.94	101.6	36.2	13	109.22	119.38	34.6	33	269.24	220.98	32.2	42	403.86	162.56	42.2
32	345.44	88.9	36.42	23	226.06	132.08	38.6	43	353.06	238.76	34.2	53	472.44	154.94	43.1
33	342.9	109.22	36.5	43	360.68	149.86	43.9	23	182.88	246.38	34.4	13	137.16	170.18	43.6
43	426.72	71.12	39.3	53	462.28	149.86	45.3	13	60.96	233.68	36	43	396.24	149.86	45.6
23	220.98	78.74	40.9	33	292.1	157.48	45.8	53	388.62	218.44	36.8	44	383.54	157.48	57.6
24	243.84	99.06	52.78	54	444.5	152.4	53.08	24	187.96	236.22	41.8	14	175.26	170.18	59.1
14	142.24	99.06	54.98	44	345.44	139.7	56.78	54	447.04	208.28	42.8	23	243.84	152.4	62.7
34	325.12	111.76	55.88	24	231.14	124.46	58.58	34	271.78	233.68	43.3	55	487.68	147.32	64.1
44	416.56	78.74	56.18	34	281.94	129.54	59.28	44	327.66	236.22	43.8	24	220.98	175.26	65.8
54	508	91.44	56.18	14	116.84	129.54	62.38	14	96.52	220.98	44.2	33	330.2	160.02	66.3
35	314.96	81.28	67.86	45	360.68	139.7	63.38	35	254	243.84	52	45	391.16	165.1	66.6
25	226.06	104.14	69.16	35	297.18	142.24	65.88	25	154.94	236.22	53.8	25	213.36	157.48	69.3
45	426.72	93.98	71.46	55	429.26	149.86	69.88	55	464.82	200.66	55.7	54	485.14	157.48	69.8
55	515.62	109.22	73.46	25	210.82	116.84	71.88	15	96.52	233.68	56.5	15	162.56	154.94	70.3
15	119.38	109.22	77.06	15	137.16	119.38	78.88	45	363.22	238.76	58.9	35	307.34	160.02	75.2
								46	337.82	241.3	64.4				
								56	467.36	218.44	68.1	05TS11	40.64	-162.56	101.52
								36	243.84	220.98	69	12	55.88	-177.8	95.7288
								16	111.76	215.9	70	13	40.64	-187.96	96.948
								26	205.74	228.6	73	05TS21	200.66	-187.96	99.996
								57	439.42	218.44	79.1	22	200.66	-162.56	102.04
								27	205.74	241.3	82	23	210.82	-177.8	94.42
								17	106.68	231.14	82.4	05TS31	294.64	-162.56	106.3072
								37	254	228.6	84.9	32	314.96	-177.8	103.564
								47	317.5	238.76	85	33	294.64	-187.96	98.6872

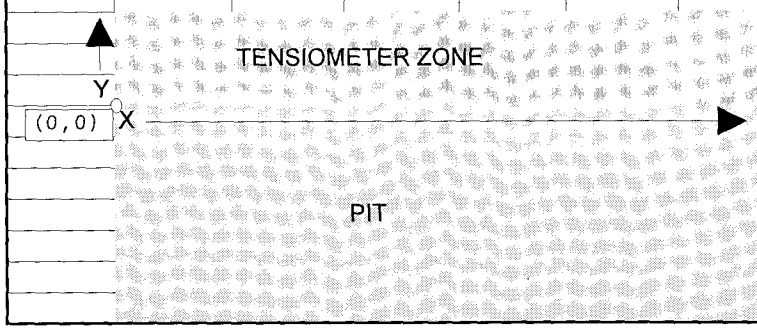


table 14

Antifreeze Calibration Experiment Instrument Locations					
Dimensions are in centimeters					
position (x,y,z)=(0,0,0) is located at top of sandbox, rear left corner.					
x increases lengthwise to the right along the box.					
y increases with width towards the front of the box.					
z increases with depth from the top of the box.					
Positions are of the tensiometer cup midpoints and temperature probe tips					
Cluster #	Tensiometer #	107B Probe #	x	y	z
1	1		150	90.5	36
1	2		150	240	36
1	3		300	240	36
1	4		300	90	36
1		1	150	90	36
1		2	300	240	36
2	1		530	90	36
2	2		530	240	36
2	3		680	240	36
2	4		680	90	36
2		1	530	90	36
2		2	680	240	36
3	1		910	90	36
3	2		910	240	36
3	3		1060	240	36
3	4		1060	90	36
3		1	910	90	36
3		2	1060	240	36

LABCAL

TABLE LABCAL					
Pinning of pit 2 multiplexing assembly components to the 24-pin datalogger communication connector					
PIN#	WIRE COLOR	CONNECTS TO:	LAB DATALOGGER CONNECTION		
1	GRN/GRY	MUX2-L1	CARD 1 SW.AN.OUT 1		
2	GRY/WHT				
3	ORG	SDMCD16#10-C2	CARD 1 DCO 2		
4	BLU/GRY	MUX1-H2	CARD 4 H2		
5	GRN	SDMCD16#10-C1	CARD 1 DCO 1		
6	BLK				
7	BRN/WHT				
8	GRN/WHT	MUX2-L2	CARD 1 SW.AN.OUT 5		
9	BLU/WHT	MUX1-L1	CARD 4 L1		
10	ORG/GRN	MUX1-CLK	CARD 1 DCO 6		
11	BLU/GRN	MUX1-L2	CARD 4 L2		
12	RED				
13	BLU/BRN				
14	ORG/GRY	MUX1,2-RES	CARD 1 DCO 4		
15	ORG/WHT	MUX2-CLK	CARD 1 DCO 7		
16	BLU	MUX1-H1	CARD 4 H1		
17	BRN/GRY	MUX2-H2	CARD 4 H4		
18	WHT				
19	ORG/BRN				
20					
21	BRN				
22	GRN/BRN	MUX2-H1	CARD4-H3		
23	GRY	SDMCD16#10-C3	CARD 1 DCO 3		
24					

10.0 INTRODUCTION TO GROUNDING

The existing ground system was improved primarily using materials on hand, however, no effort was made to harden the system against a direct lightning strike or provide immunity from strong electro-magnetic pulse (EMP) events from close strikes. An improvement in three areas was achieved:

- lower resistance,
- lower inductance in the interconnects between rods, and
- a reduction in average system to earth resistivity.

Ideas were adapted from accepted grounding standards and practices as described in Polyphaser Corporation's, "The 'Grounds' For Lightning and EMP Protection," 2nd Edition, and Biddle Instruments' pamphlet, "Getting Down to Earth," 4th Edition.

The three areas of improvement benefitted the project in several ways. Lower resistance between rods improved low level signal handling capability and immunity from low frequency noise. Lower inductance, defined in Equation 10.1, improved the systems ability to shunt to ground high frequency noise or energy pulses such as EMP with a fast rise time.

$$X_L = 2 \pi f l \qquad \text{Equation 10.1}$$

where: X_L = Lower Inductance (ohms)

π = 3.14159...

f = Frequency (hertz)

l = Inductance (henrys)

Lower system to ground resistance (spread over a large area) smoothed out variations in ground resistance seen by the equipment due to localized changes in moisture and temperature, thus, minimizing their effects as a source of long term drift on the data. Finally, if a direct lightning strike should occur, the three improvements will greatly increase survival of the equipment by providing a very low resistance path for energy to dissipate to ground.

10.1 GROUNDING DESCRIPTION

The instruments and data loggers in the Americium zone were referenced to 15 separate ground rods by No. 12 wire at the pits, muxes, and data logging stations.

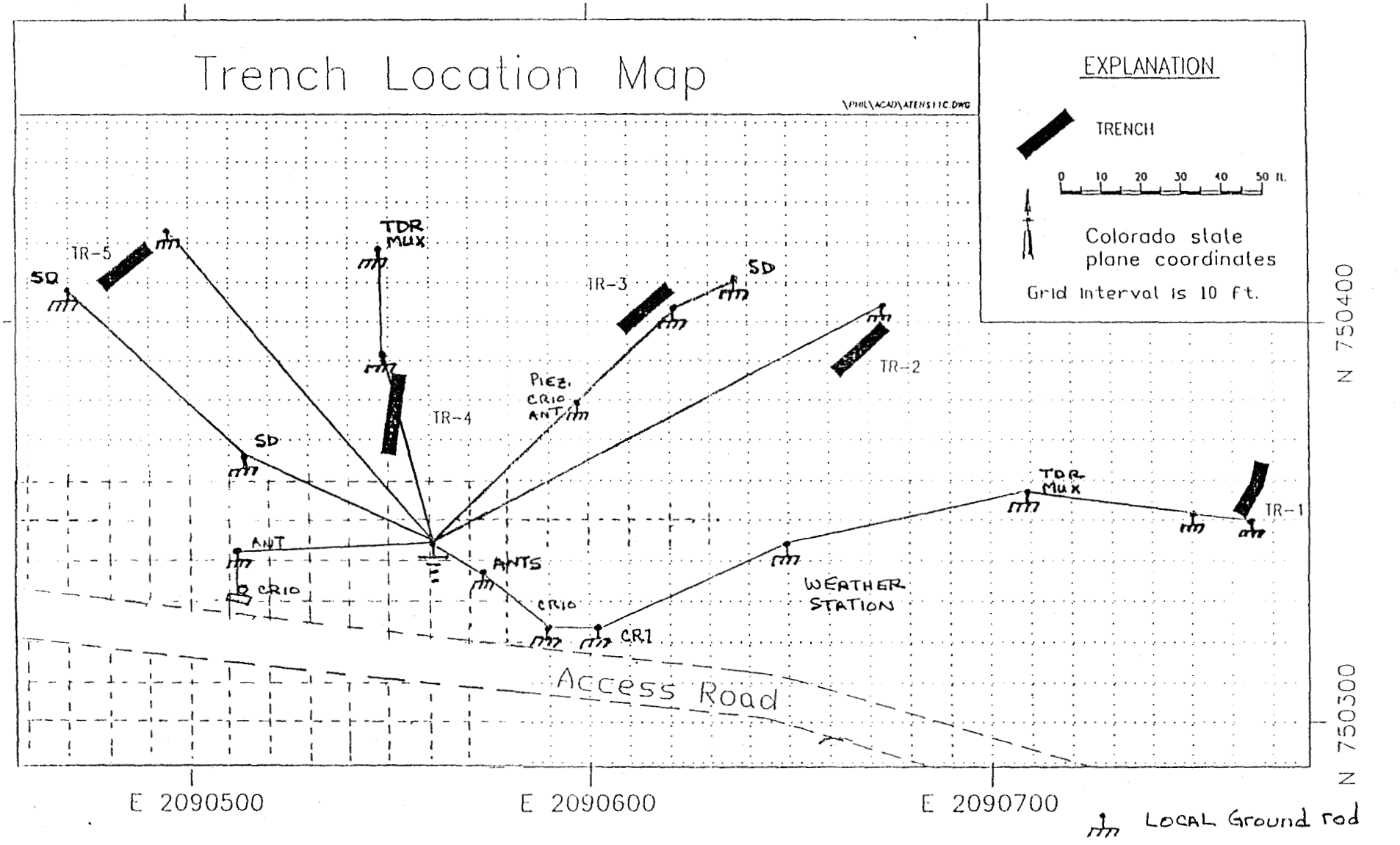
Although instrument cable shielding ultimately tied all grounds together, the shielding was not of sufficiently low resistance to reference the grounding system at the same level. This was due to variations in local ground conductivity throughout the Americium zone, and the higher resistance of the interconnecting shielding.

Sub-systems (Snow, T.D.R., Tensiometers) were tied together through the braid of RF coaxial cable. The common connection point was on the antenna tower where all three antennas were bolted to the same metal structure. A nominal resistance Direct Current (DC) continuity existed between all elements throughout the system. Long runs of small wire (typically No. 22) were used to supply control voltages to the multiplexers and excitation and signal voltages between transducers and the data loggers. Nominal resistance for 100 feet of No. 22 wire is 1.62 ohm. (See Appendix 13) A total of 6.5 ohms is typical for a 4 wire bridge circuit per 100 feet.

To improve the ground system, all rods were connected together using 1/0 copper wire. A single point layout scheme was developed by installing a central 5/8" diameter, 8 foot long, copper clad rod in a position to connect all rods in a "crows foot" pattern with as straight a run as possible out to each rod. Figure 10.1 shows the layout of the grounding system at the Pit Study Site. To minimize the number of compression clamps, wire was threaded through clamps and installed over the ground rods wherever possible. The longest run to Pit 1 was about 200 feet but added only .010 ohm over the typical 100 foot length.

The new configuration parallels a total of 18 installed ground rods by interconnecting less than 1000 feet of No. 1/0 copper wire with a maximum resistance of .098 ohms per 1000 feet. This lowered the grounding system's resistance by 1/9th of the average rod's resistance to the earth.

No effort to measure or track ground resistivity over time was done. Estimates of the resistivity in clay soil vary from 340 ohm-cm to 16,300 ohm-cm (U.S. Bureau of Standards Technical Report 108). In this system reasonable effort to lower the resistance to earth was accomplished.



LOCAL Ground rod

centeral Ground rod

SD snow Depth

ANT/ANTS antenna

Figure 4.3-1 Trench Location Map

11.0 Ultrafiltration and Tangential Flow Filtration of Interstitial Water Collected by the SWMS

11.1 Project Objective

The immediate goal of this project was to develop a system to separate particles from water samples into different size fractions. The techniques used in this project are a small scale variant of those used by Harnish et al. (1993). Harnish describes the use of particle size fractionation to determine the fate and transport of plutonium (Pu), americium (Am), and uranium (Ur) in well and surface water samples collected from various sites at Rocky Flats. SOP ... describes the procedure for separating the particles via ultrafiltration and tangential flow filtration into the following particle size ranges:

- greater than or equal to 5 microns
- less than 5 microns and greater than or equal to 0.45 microns
- less than 0.45 microns and greater than or equal to 100,000 Daltons[1]
- less than 100,000 Daltons and greater than or equal to 10,000 Daltons
- less than 10,00 Daltons.

Ultimately, the fractions will be analyzed to determine the affinity that plutonium (Pu), americium (Am) and uranium (U) have for a particular size range. The results will be used to determine the fate and transport of actinides in the vadose zone of the study area.

11.2 Principles of Tangential Flow Filtration

In this project, separating the particles contained in the water samples into the five size ranges given above in section 4.1 requires tangential flow filtration. In tangential flow filtration, acrylic or stainless steel manifolds are combined with either microporous or ultrafiltration membranes. These membranes are either single cut sheets or sheets bound to plastic plates to ease handling or to accommodate increased volume. In classic tangential flow filtration, a single pump is used to move fluid tangentially across the membrane. Molecules smaller than the membrane pores are forced through the membrane by the pressure inside the manifold and are collected as filtrate. Molecules larger than the membrane pores are swept across the membrane

[1] 10,000 Daltons = 1 nm

and returned to the feed reservoir as retentate. During the course of filtration, the feed stream becomes increasingly concentrated with particles larger than the membrane pore size.

The driving force behind filtration is pressure, which forces the small components and buffer through the membrane. Uncountered, this pressure can result in a clogged membrane. As pressure forces particulates toward the membrane, the components tend to form a polarizing layer, resulting in a phenomenon called concentration polarization. Concentration polarization lowers the effective size of the membrane pores and reduces the filtration rate. This type of filtration is referred to as dead-ended filtration. Tangential flow filtration is not a dead-ended process. In contrast, the liquid sweeps across the membrane surface, keeping particulates in solution. This sweeping action limits contact time with the membrane, thereby eliminating concentration polarization and maximizing recoveries.

The two types of tangential flow filtration membranes are designed differently and have important differences in performance. Both ultrafilter and microporous membrane filters retain particles on the basis of size. However, ultrafilters must discriminate between much smaller particles (molecules) than do standard membrane filters. A filter of this type consists of a thin polymeric film or skin supported on or bonded to a highly porous substrate. The substrate contributes strength and durability to the filter, but the thin skin is the actual ultrafiltration membrane and is placed on the upstream side, facing the fluid to be filtered. Retained molecules and particles are rejected at the surface of the membrane and do not enter the porous structure of the substrate. Because of surface rejection, and because material which passes through the skin is much smaller than the pore diameter of the substrate, ultrafiltration membranes seldom become irreversibly plugged. This resistance to plugging contrasts sharply with the susceptibility to plugging of microporous membrane filters.

A microporous membrane filter is a thin plastic sheet with a uniform, continuous structure containing millions of capillary pores.. A microporous membrane filter functions as an absolute screen or sieve, retaining on its surface all particles larger than the pore size. Many smaller particles will pass through the filter, but some particles whose size approximately equals the pore diameter, may become trapped in the matrix. If enough pores are plugged, the filter becomes irreversibly plugged and the flow rate declines. Plugging can be minimized by maintaining a high flow across the membrane and lowering the transmembrane flow.

The above information is obtained directly from an article by K. Ludwig and K. O'Shaughnessey. Please refer to that article for more detailed information.

11.2.1 Model TCF-10 Amicon Thin Channel Ultrafiltration System

The Amicon, Model TCF-10, Thin Channel Ultrafiltration System is operated before the Millipore system and separates the particles that are 5 microns or larger from the rest of the sample. The Model TCF-10 filter is a self-contained internally circulating ultrafiltration system designed for efficient concentration or fractionation of macromolecular solutions or suspensions. An integral peristaltic pump recirculates fluid through a spiral thin-channel, producing laminar flow over the thin sheet membrane. (1992 Amicon, Inc.) The five micron pore size membranes used in the Amicon filter are products of Poretics Corporation, PCTE 90 mm diameter.

In contrast to the Millipore filter, operating the Thin Channel Ultrafiltration System manufactured by Amicon Inc., according to this SOP results in a solid and a liquid product. The single sheet membrane place in the Amicon ultrafilter gradually accumulates particles larger than or similar to its pore size. Eventually, all of the liquid feed passes through the membrane as filtrate and only solid particles remain on the membrane. This filter still works using the principal of ultrafiltration, but the final products are a liquid filtrate and the solid sample left on the membrane.

11.2.2 Millipore Minitan Ultrafiltration System

The Minitan Ultrafiltration System manufactured by Millipore Corporation works with both ultrafilter packets and microporous filter packets. The Minitan Ultrafilter uses the classic tangential flow filtration mentioned in the first paragraph of section 4.0. The final products are a liquid retentate derived from concentrating the feed, and a liquid filtrate. The last four particle size fractions:

- less than 5 microns and greater than or equal to 0.45 microns
- less than 0.45 microns and greater than or equal to 100,000 Daltons[2]
- less than 100,000 Daltons and greater than or equal to 10,000 Daltons
- less than 10,00 Daltons

are separated, or fractionated, using the following membrane plates: Durapore 45 μm, PT series 100k Daltons, Pt series 10k Daltons. The Durapore membrane is microporous, whereas the PT 100k and PT 10k membranes are ultrafilter membranes.

Upon fractionating a sample into 5 particle size ranges, the resulting bottles are sent off for laboratory analysis to determine the amounts of the following actinides in each particle size range:

[2] 10,000 Daltons = 1 nm

1. Plutonium 239 and plutonium 240
2. Americium 241
3. Uranium 234, uranium 235, and uranium 238.

11.3 Laboratory set up

The two filters are set up in an indoor office, designated as a Radiologically Controlled Area.

The five micron pore size membranes used in the Amicon filter are products of Poretics Corporation, PCTE 90 mm diameter. The Millipore Minitan Ultrafilter separates the sample into the remaining fractions, using the following membrane plates: Durapore 45 μm, PT series 100k Daltons, Pt series 10k Daltons. The Durapore membrane is microporous, whereas the PT 100k and PT 10k membranes are ultrafilter membranes. Both filtration systems are necessary to obtain the required particle ranges as neither system offers all of the necessary pore sizes. Refer to SOP.. for more detailed product information.

Measures are taken to ensure that the samples are exposed to air as little as possible. The water samples taken from the vadose zone are richer in carbon dioxide than the air above ground. Upon exposure to air, the carbon dioxide in the liquid would escape to establish equilibrium with the ambient air, thereby changing the pH of the sample and altering particle composition. Nitrogen gas is necessary to flush out all head space of any containers used to hold the samples. After sampling, the water is transferred to wide-mouth, plastic two-liter jars with gasket seals. These processing bottles have caps retrofitted with quick connect coupling bodies. The fittings have automatic shutoff valves so that the sample is isolated in the bottle except when male inserts are attached to the quick connect coupling bodies. All tubing from both filters and also a nitrogen gas cylinder have male inserts attached. Fluid and air flow is controlled by manipulating the various liquid and gas lines, without actually having to open up the processing bottles. For a more detailed equipment list and equipment set-up refer to SOP...

11.4 Data

No analytical results are available at this time. Some samples, specifically from trench 2 in OU2, have been sent off for analysis. The tables below list those samples and their corresponding sample numbers, obtained from the sample manager. The sample manager

processes the data and transfers it to RFEDS, Rocky Flats Environmental Database System. Please refer to SOP 4-B29-ER-OPS-FO.14 Field Data Management.

The classification "Real" listed under "Sample type" refers to an aliquot taken from the original field sample, whereas "Rinsate" is distilled water used to rinse the membrane after following cleaning procedures, see SOP...The rinsate is sent off for the same analysis as the "real" samples to determine whether or not the cleaning procedure is sufficient to remove actinides.

Sample Source:		Sample No.	Size Range	Sample type	Media
Trench	2	TR00361ST	x >= 5 μm	Real	Solid
Horizon	2	TR00362ST	5 μm > x >= .45 μm	Real	Water
Point(s)	1,5	TR00363ST	.45 μm > x >= 100k D	Real	Water
Sample date:	7/25/94	TR00364ST	x < 100k D	Real	Water
		TR00365ST	NA	Rinsate, .45 m	Water
		TR00366ST	NA	Rinsate, .45 m	Water
		TR00367ST	NA	Rinsate, 100 k D	Water
		TR00368ST	NA	Rinsate, Distilled	Water

Sample Source:		Sample #	Size Range	Sample type	Media
Trench	2	TR00386ST	x >= 5 μm	Real	Solid
Horizon	1	TR00387ST	5 μm > x >= .45 μm	Real	Water
Point(s)	5	TR00388ST	.45 μm > x >= 100k D	Real	Water
Sample date:	7/29/94	TR00389ST	x < 100k D	Real	Water
		TR00390ST	NA	Rinsate, .45 m	Water

Sample Source:		Sample No.	Size Range	Sample type	Media
Trench	2	TR00371ST	x >= 5 μm	Real	Solid
Horizon	1	TR00372ST	5 μm > x >= .45 μm	Real	Water
Point(s)	1,2,4,5	TR00373ST	.45 μm > x >= 100k D	Real	Water
Sample date:	7/25/94	TR00374ST	x < 100k D	Real	Water
		TR00375ST	.45 μm > x >= 100k D	Real	Water
		TR00376ST	x < 100k D	Real	Water
		TR00377ST	NA	Rinsate, .45 m	Water
		TR00378ST	NA	Rinsate, 100 k D	Water
		TR00379ST	NA	Rinsate, 100 k D	Water

Sample Source:	
Trench	2
Horizon	3
Point(s)	1,3,4,5
Sample date:	7/25/94

Sample #	Size Range	Sample type	Media
TR00380ST	x >= 5 µm	Real	Solid
TR00381ST	5 µm > x >= .45 µm	Real	Water
TR00382ST	.45 µm > x >= 100k D	Real	Water
TR00383ST	x < 100k D	Real	Water
TR00384ST	NA	Rinsate, .45 m	Water
TR00385ST	NA	Rinsate, 100 k D	Water

11.5 Discussion

The filtration process bottles used to minimize air exposure were initially made from four liter wide mouth glass jars (Lab Safety, part number WB-13084). The glass jars became undesirable for a number of reasons. Pressurizing the jars posed a safety risk, despite having one way vents to release pressure. The jars were also clumsy to handle and larger than necessary. The hard plastic caps cracked easily and did not seal well. These glass jars were replaced by half gallon polypropylene jars (Bel-Art, part number 10915-0000). The wide mouth plastic jars have screw caps with seal rings and grip lugs that seal well. Pressurizing the bottles is no longer a serious safety risk and the bottles are smaller and easier to handle. The quick connect coupling bodies also seal better in the softer plastic of the newer bottle caps.

Determining when to stop a filtration cycle was also a problem. The Amicon system filters until no liquid feed remains, but there is no obvious cut off time for the Milllipore system, where both retentate and filtrate products are liquids. Filtering for a longer time concentrates the retentate, but concentrating a sample too long will result in coagulation. R.A. Harnish et al.(1993) experienced a similar problem and suggested setting a filtration time limit based on volume. SOP .. concentrates a one liter feed to yield 100 to 200 ml of retentate. This ratio will have to be constantly evaluated, to make sure that samples do not coagulate.

The final problems occurring in this project involve the Millipore Minitan System. The membranes with the smallest pore size, Pt series 10k, repeatedly fail to pass a required integrity test. The samples processed so far do not include fractions resulting from a 10k separation. Further 10k membrane testing will occur, although the membranes will most likely be exchanged for a new set, despite already having a previously exchanged batch now. Furthermore, the operating manual for the Millipore system is dated to 1985 with no recent editions available. SOP... incorporates useful information from the 1985 operating manual, with various corrections and additions provided by Millipore technical representatives.

12.0 GRAPHICAL USER INTERFACE

12.1 INTRODUCTION

The documentation for the 1994-1995 GUI component of the scientific notebook consists of this text section, flowcharts depicting the structure of the GUI (Appendix 15), help screens which go into detail about the various functions (Appendix 16), a listing of the structure of each database (Appendix 17), a copy of the GUI description which was submitted to Microsoft and an electronic appendix consisting of all the data files to date and all the system files necessary to create the GUI (Appendix 18).

The flow charts can be used to trace the control of the GUI as various functions are selected. This may be critical for performing effective troubleshooting of the system. The help screens are useful for explaining the function of a screen or option and the appropriate response. The structural details of the databases are vital for understanding the data importation operations and troubleshooting in that area. In addition details of the databases' structure is vital if any changes in the number of sensors, type of sensors or name of sensors is made. The form which describes the GUI gives insight to the functionality of the interface as a whole and provides screen shots of the interface's actual appearance. Finally, the electronic format is included to insure that a representative working system could be recreated in order to better understand the function of the GUI.

12.2 Principles of the Graphical User Interface

A graphical user interface allows a user access to a system's full potential without requiring expert knowledge of the underlying operations, software and hardware. The GUI presents options which can be selected by pointing and clicking. The options displayed are self-explanatory by virtue of their appearance and labeling.

The SST created a GUI for the SWMS for a variety of reasons. The most basic was to supply an interface which would allow a wide range of users to access the SWMS without expert knowledge of the entire data structure, radio telemetry/data retrieval operations and archiving system. In addition the GUI was established to insure a standardized format of all data collected from the SWMS. The GUI serves as the primary method of data QA/QC for the SWMS. All data retrieved is stored in its initial format and then transformed into the standardized database format. The GUI goes through monthly backups and is copied to RFEDS on a quarterly basis.

12.3 Graphical User Interface Development

During 1994 and 1995 the GUI was transformed from essentially a prototype configuration, version 1.X, into the full working system: version 2.X (Table 12.1). The basic hierarchy of the GUI did not change significantly from version 1.X to version 2.X. In all versions the GUI retrieved data using the radio telemetry, it standardized and sorted the data to the correct databases, gave a series of file creation and graphing options and performed backup operations. In upgrading from version 1.X to 2.X the efforts centered around expanding the system to include data from all five of the SWMS components. Version 1.0 through 1.3 operated only on the TDR component while version 2.0 and all subsequent versions operated on all components of the SWMS. In addition version 2.0 made the transition from a Dbase to FoxPro for Windows based configuration. FoxPro offered several advantages especially the fact that it was a Windows based program and featured extensive built in interface/screen creation utilities.

Table 12.1: Evolution of the SWMS GUI

Version Number	Functions/Software	Data Sets Incorporated

1.0 - 1.3	**Development of basic configuration.** Borland Dbase MS Excel Version 4.0 Campbell Scientific Telcom Assorted batch and PIF files	TDR
2.0	**Conversion to FoxPro.** FoxPro for Windows Version 2.5 MS Excel Version 4.0 Campbell Scientific Telcom Assorted batch and PIF files	TDR
2.1	**Incorporation of all Field Stations** FoxPro for Windows Version 2.5 MS Excel Version 4.0 Campbell Scientific Telcom Assorted batch and PIF files	TDR Snow/Snowmelt Evapotranspiration Tensiometers Piezometers
2.2	**Upgrade to FoxPro 2.6 and compression archiving option.** FoxPro for Windows Version 2.6 MS Excel Version 4.0 Campbell Scientific Telcom Assorted batch and PIF files	TDR Snow/Snowmelt Evapotranspiration Tensiometers Piezometers

2.3	**Incorporation of automated telemetry and data importation.** FoxPro for Windows Version 2.6 MS Excel Version 4.0 Campbell Scientific Telcom Assorted batch and PIF files Norton Scheduler	TDR Snow/Snowmelt Evapotranspiration Tensiometers Piezometers

Version 2.X was essentially a FoxPro application. It was however a fairly extensive one which called DOS batch files, Windows PIF files, DOS programs, other Windows programs, FoxPro screen files and extensive FoxPro code. A series of screens presented by the GUI displayed the options to the user. All options were well labeled and self-explanatory requiring minimal orientation to the SWMS.

The actual FoxPro application functioned by linking a large number of FoxPro *.prg and *.scr files. These files contained the necessary code to execute functions and the interface to accept and query the user. In addition the files also activated the various other programs and batch files. A Bernoulli cartridge is included which contains all for the GUI. In addition hard-copies of the SWMS flowchart/hierarchy and printouts of the data structure of all databases are included.

13.1 DATA STORAGE

The 1995 SST_SNBK Bernoulli data diskette contains the SWMS GUI files and updated databases. The directory structure of the 1995 SST_SNBK Bernoulli data diskette is shown below. This directory structure must be set up on the 'C' hard drive to operate the SWMS GUI system. The use of other director,v structures and hard drives will require extensive program code changes. The root directory contains two files which contain descriptions of the SWMS GUI system. A Word 6.0 document, named flaw.gui, containing an overview of the so~ware using screen graphics as examples. The ASCII file swmsdoc. txt describes the system structure and file naming conventions. The following sections contain details on the contents of the specified directories.

```
SOIL
  ├─ AUTOCOM
  ├─ AUTOPLOT
  ├─ BATCH
  ├─ BMPS
  ├─ DATABASE
  ├─ MACROS
  ├─ PROGRAMS
  ├─ REPORTS
  ├─ SCREENS
  └─
```

13.2 LOCATION OF STORED DATA

13.1.1 AUTOCOM DIRECTORY

This directory contains the FoxPro and batch files used for automatic data retrieval calls to the field dataloggers. Automatic data retrieval is initiated with Norton's Scheduler. The Scheduler is used to schedule the execution of a datalogger specific FoxPro program. These programs first assemble a file name based upon the current date, then executes a communication batch file. These batch files execute the Campbell Scientific Inc. Telcom communication software.

The file name conventions are based upon the SWMS component abreviation names (tdr, snow, tens, evt and piez). The FoxPro program files are named auto*.prg (e.g. autotdr.prg). The compiled versions have a *.fxp extension. The batch files are named au~o*.bat. There are also communication batch files for DOS manual retrieval calls. These are named manu*.bat.

After these automatic calls are made, an automatic database importation FoxPro program is executed with Norton's Scheduler. This program imports the raw data files into the appropiate database. This program's files are named autoimp. *.

13.1.2 AUTOPLOT DIRECTORY

This directory is used to temporarily store files to be plotted by the AutoPlot Excel macros (currently set up for the snow system only). When the 'Auto Plot' option is selected, the current data query selection files are archived in the c:\soil directoly and also copied into the c:\soil\autoplot directory. The Excel 4.0 snowauto.xlm macro is then executed. This macro checks the c:\soil\autoplot directory and plots what files it finds. After plotting, the files in this directory are deleted.

13.1.3 BATCH DIRECTORY

The batch files used to back up the SWMS GUI files are stored in this directory. The Windows based PIF and batch files used to call the field dataloggers from within the SWMS GUI are also stored here. These files have the read*.pif and read*.bat naming conventions (e.g. readtdr.pif and readtdr. bat).

13.1.4 BMPS DIRECTORY

This directory contains the fourteen bit-map icon files used by the SWMS GUI system. These icon are used with the SWMS Main Menu screen and the Data Query screen, and are called by the FoxPro program, swms.prg.

13.1.5 DATABASE DIRECTORY

All of the current SWMS databases are found in this directory. These files contain all data collected by the SWMS during 1994 and 1995 up until March 20, 1995. These database files can be viewed with FoxPro or dBase.
Database field names closely follow the naming conventions of the raw field data files documented in Appendix 10 of the 1994 OU2 Closure Soil Studies Scientific Notebook for the RFETS, RFP/ERM-94-00021.

13.1.6 MACROS DIRECTORY

This directory contains Excel 4.0 macros used for graphing. All of these macros are executed from FoxPro programs. These macros can be viewed with the Excel so~[ware (the window must be unhidden to view the code). These macros display a menu system with which the user selects what data to plot. The macro then plots the specified data * xls file produced with the SWMS GUI.

The naming convention is *mac.xlm (e.g. tdrmac.xlm). These macros are executed by the component specific FoxPro program, such as tdrmain.prg. The snow component has a macro which automatically plots current selections (no menu selection system is used). This macro is named automow.xlm.

13.1.7 PROGRAMS DIRECTORY

The FoxPro program files are found in this directory. The source code files are named with a *.prg extension. The compiled versions have a *.fxp extension. Hard copies of all FoxPro SWMS GUI programs are on file in the Soil Study Team laboratory (T891M, computer room).

The main program files have the swms. * name. This prograrn calls the SWMS GUI main menu and data query interface screens. Based upon user selections, the other FoxPro programs are executed. There is a prograrn for each of the SWMS components. These programs are tailored to each of the component's set of intruments. These programs

call the data query screens, produce export and plot files, and execute the Excel plotting macros. These programs have the *main.prg name convention (e.g., tdrmain.prg). The sqmain.prg file contains the 'Super Query' option programrning.

13.1.8 REPORTS DIRECTORY

This directory contains the SWMS help and evapotranspiration component FoxPro report templates.

13.1.9 SCREENS Directory

The SWMS GUI screen files are stored in this directory. There are four FoxPro files associated with each SWMS GUI screen. The *.scx files contain the graphic information which is editted within FoxPro. The *.sct files contain screen information on screen size, position, and associated programming code (called 'code snippets'). The FoxPro screen generator produces the *.spr files. The *.spx files are the compiled versions of the *.spr files. The only files that should be editted are the *.scx files. FoxPro generates the other three file types.

13.1.10 RUNNING THE SWMS GUI SYSTEM

Running the SWMS GUI System requires that the FoxPro application files be built on the target computer. This procedure is required when any SWMS GUI updates are made. The SWMS GUI application is built by opening the project file swms.pjx. This is done by starting FoxPro, and selecting 'Open' from the 'File' menu. After setting the directory to '\soil\programs' and setting 'List Files of Type:' to 'Projects', press the 'Open' button. The user will then see the swms.pjx dialog box, and should press the 'Build' button. The 'Build Option' dialog box is display, from which the user should select the 'Build Application' and press 'OK.' FoxPro then builds and compiles the SWMS GUI application and produces a swms.app file, which is executable from within FoxPro (or can be specified in the 'run FoxPro' command line). If additional information is required, please refer to the FoxPro manuals.

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INFORMATION ONLY

Rocky Flats Environmental Technology Site

2-G01-ER-ADM-06.01

REVISION 1

ERPD DOCUMENT CONTROL PROCESS

APPROVED BY: _____ / S.G. Stoer / 12-7-94

Director, Environmental Restoration Program Division — Print Name — Date

_____ / R S LUKER / 12.6.94

Quality Assurance Program Manager, Data Management and Reporting Services — Print Name — Date

DOE RFFO/ER Concurrence on file: ☐ Yes ☐ No ☑ NA

Environmental Protection Agency Approval Received: ☐ Yes ☐ No ☑ NA

Responsible Organization: Environmental Restoration Program Division Effective Date: _____

CONCURRENCE BY THE FOLLOWING DISCIPLINES IS DOCUMENTED IN THE PROCEDURE HISTORY FILE:

ERPD Remediation Project Management
ERPD Environmental Engineering & Technology
ERPD Geosciences
ERPD Solar Pond Projects
ERPD Environmental Operations Management
Environmental Documentation
Information Management
ERPD Program Integration and Reporting
ERPD Environmental Quality Support
ERPD Sample Management

USE CATEGORY 4

ORC review not required
The following have been incorporated in this revision:
93-DMR-000722
This revision supersedes 3-21000-ADM-06.01, Revision 0.

Periodic review frequency: 1 year from the effective date

DEC 1994 RECEIVED

LIST OF EFFECTIVE PAGES

Pages	Effective Date	Change Number
1-20	___/___/___	

TOTAL NUMBER OF PAGES: 20

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1. PURPOSE

This procedure establishes the responsibilities and instructions for managing the distribution, accountability, revision control, and disposition of the Environmental Restoration Program Division (ERPD) controlled documents and processing by the ERPD Document Control Center (DCC). This procedure implements 1-77000-DC-002, Endorsement Document Control Program.

2. SCOPE

This procedure applies to all ERPD Rocky Flats Environmental Technology Site (Site)employees and ERPD subcontractors, including contracted services organizations performing work for ERPD.

This procedure applies to all documents generated to define and control activities affecting quality in accordance with:

- Rocky Flats Plant Quality Assurance Manual, Quality Requirement (QR-6), Revision 2, Document Control
- Environmental Restoration Management Quality Assurance Program Description, RFP/ER-MP-QAPD, Section 4.0, Document Control
- Environmental Restoration Management Site-Wide Quality Assurance Project Plan, QAPjP, Rev 0, Section 6.0, Document Control

This procedure addresses the following topics:

- Identification, preparation, review, and approval of controlled documents
- Receipt and verification of controlled documents
- Distribution of controlled documents
- Copyholder receipt of controlled documents
- Receipt acknowledgement follow-up
- Changes in controlled distribution
- Working copies
- Information only copies
- Disposition of controlled documents
- Self Assessment

This revision is a total rewrite and revision bars are omitted. This revision supersedes 3-21000-ADM-06.01.

3. DEFINITIONS

Camera Ready. An approved hard copy of a document ready to reproduce and distribute.

3. DEFINITIONS (continued)

Closed Distribution. A limited controlled distribution that is determined by the originator of the controlled document. New copy holders may be added to the closed distribution list after acquiring the signature of the responsible manager or the originator of the document and controlled distribution list.

Controlled Copy. A copy of an active, current, approved, controlled document used by an individual to perform work.

Controlled Copy Number. The unique number that is assigned to individual copy holders.

Controlled Document. An active, current, approved document used to perform work identified by ERPD organizations that prescribe, generate, or result in or impact national security, environmental, health, safety, and quality management as requiring control. This includes, but is not limited to policies, program plans, procedures, instructions, or design documents including calculations, drawings and specifications. For the purposes of this procedure a controlled document is an active, current, approved document generated to support ERPD activities and is used to describe how work is to be accomplished, to produce quality affecting data, and to support and affect an IAG decision or deliverable. A controlled document is also used when national security, health, safety, and the environment is impacted and when identified by ERPD organizations as requiring control. Refer to Appendix 1, ERPD Controlled Document Type List.

Controlled Document Distribution List. A list prepared by the Originator or Manager and maintained by the ERPD DCC, that identifies the individuals designated to receive a specific controlled document and the updates.

Controlled Manual Number. A unique identification number assigned by the ERPD DCC to each controlled manual.

Document Identification Number. A unique number assigned to a specific document by the ERPD DCC.

ERPD Document Control Center (DCC). The organization in ERPD responsible for the maintenance and distribution of ERPD controlled documents.

ERPD Document Control Index. A log (computerized or hard copy) maintained by the ERPD DCC that identifies all ERPD DCC controlled documents.

Information Only Copy. A copy of a controlled document that is circulated or transmitted for information purposes only. Such documents are stamped Information Only, and are excluded from capture in the ERPD DCC Database System. Work cannot be performed to an Information Only Copy.

3. DEFINITIONS (continued)

Limited Scope Document. A document that is applicable to a specifically limited area, activity, or task.

Obsolete Document. A document that is no longer required for program use, will not be superseded, and is removed from controlled distribution.

Superseded Document. A previously released controlled document that has been replaced in entirety by another controlled document or revision.

Temporary Change. A change to a document that normally does not exceed 120 days.

Working Copy. A current, active, and approved controlled document with an assigned expiration date that is used to perform work and document work activities.

Working Copy Log (WCL). A log (computerized or hard copy) maintained at the ERPD DCC for tracking the issuance of Working Copies of controlled documents.

4. RESPONSIBILITIES

4.1 Controlled Copyholder (functional title)

Acknowledges receipt of a controlled document and the accompanying instructions by signing and returning Form 06.01-A2, Document Transmittal Acknowledgement Notice, (DTAN), shown in Appendix 2, ERPD DCC Document Transmittal Acknowledgement Notice (DTAN), that accompanies the controlled document copy.

Maintains assigned controlled documents in accordance with this procedure.

Returns controlled copies to ERPD DCC if the document is no longer required, including employee transfer to another organization, and termination.

4.2 Document Control Center Staff (functional title)

Assigns and tracks ERPD controlled document numbers.

Maintains and distributes ERPD controlled documents.

Provides the History File and current documents to the PFC upon completion of a document.

Ensures the maintenance and protection of current revision History Files before transmittal to the ERPD Project File Center (PFC).

4.3 Program and Project Managers (functional title)

Identifies documents within respective organizations that are to be controlled.

Ensures that documents meet records acceptance criteria stated in 2-G18-ER-ADM-17.01, Records Capture and Transmittal.

Ensures organizational compliance with this procedure.

Ensures the return of controlled copies to the ERPD DCC when a document is no longer required and when an employee transfers to another organization or terminates.

Obtains DOE approval for issuance of working copies when required.

Notifies ERPD DCC when a controlled document becomes obsolete.

Initiates periodic review of controlled documents that are the manager's responsibility.

Approves document distribution list.

4.4 Originator (functional title)

Prepares Form 06.01-A3, Controlled Document Release, shown in Appendix 3, ERPD DCC Controlled Document Release Form, and submits the form to QA.

Develops, maintains, and submits a History File to Plant Procedures for all controlled documents.

Obtains unique identification numbers and revision indicator for controlled documents from ERPD DCC.

4.5 Quality Assurance Program Manager (QAPM)

Approves Form 06.01-A3 after verifying the adequacy of the document History File, as appropriate.

Submits the approved Form 06.01-A3, the document, and the history file to the ERPD DCC for issue.

5. INSTRUCTIONS

Initiation, revision, and disposition of ERPD controlled documents is accomplished using a DMR in accordance with 2-E04-ER-ADM-05.07, Preparation and Use of Document Modification Requests.

NOTE *Document numbers for all ERPD controlled documents are assigned and maintained by the ERPD DCC. ERPD DCC interfaces with Plant Procedures, as required.*

5.1 Identification, Preparation, Review, and Approval of Controlled Documents

Originator

[1] Determine if the document is to be released as a controlled document in accordance with Appendix 1.

[2] IF the document is NOT to be released as a controlled document, THEN exit this procedure.

[3] Prepare a DMR in accordance with 2-E04-ER-ADM-05.07

[4] Obtain the following from the ERPD DCC:
- A DMR number
- A document identification number for a new document
- A revision indicator for a revised document

[5] Ensure that the document is reviewed for adequacy and approved for release in accordance with 2-E02-ER-ADM-05.05, ERM Document Review Process.

[6] Ensure that the document meets the records acceptance requirements in accordance with 2-G18-ER-ADM-17.01.

[7] Prepare or update the controlled document distribution list by completing Form 06.01-A3 in accordance with 2-E02-ER-ADM-05.05.

[8] Complete the document History File in accordance with 2-E02-ER-ADM-05.05.

The History File includes, but is not limited to, the following:
- The completed DMR
- Document drafts
- Signed and resolved comment resolution sheets
- Any other applicable information

[9] Prepare a table of contents for the document History File.

5.1 Identification, Preparation, Review, and Approval of Controlled Documents (continued)

Originator (continued)

[10] Submit the following to the ERPD QAPM for review:

- Completed document History File
- Camera ready document copy
- Form 06.01-A3, Controlled Document Release

5.2 Receipt and Verification of Controlled Documents

QAPM or Designee

[1] Verify that :

- The document is legible.
- The History File is complete.
- The History File contents correspond with the History File table of contents.

[2] IF discrepancies are identified,
THEN resolve the discrepancies with the document originator.

[3] Sign Form 06.01-A3, Controlled Document Release.

[4] Forward the following to the ERPD DCC:

- The History File
- Camera ready document
- Signed Form 06.01-A3, Controlled Document Release

ERPD DCC

[5] Assign a controlled copy holder number and update the ERPD DCC database.

[6] Update the Site Master Controlled Document Index in accordance with 1-77000-DC-002.

5.3 Distribution of Controlled Documents

NOTE *Controlled documents are identified with a* CONTROLLED COPY *stamp and copyholder number.*

ERPD DCC

[1] Ensure that the documents that are to become records, record package segments, and record packages are protected from deterioration, loss, larceny, or damage.

[2] Prepare Form 06.01-A2 with document instructions for the controlled copyholder.

5.3 Distribution of Controlled Documents (continued)

ERPD DCC (continued)

[3] IF the document being distributed is Limited Scope,
THEN limit the distribution to the designated Closed Distribution List.

The Closed Distribution List is established by the Responsible Manager.

[4] IF the document being distributed is Temporary,
THEN ensure that a DTAN is issued to withdraw this document upon expiration.

[5] Distribute the controlled documents with the DTAN.

5.4 Copyholder Receipt of Controlled Documents

Controlled Copyholder

[1] Follow all instructions on the DTAN or attached instruction sheet, and include the following:

[A] Sign and date the DTAN to acknowledge receipt of the document and compliance with instructions for update, as instructed.

[B] Return the DTAN and superseded documents, if instructed, to the ERPD DCC within the time specified on Form 06.01-A2.

5.5 Receipt Acknowledgement Follow-up

NOTE *Step [1] is not required for offsite, legally mandated distribution [Reading Room, Environmental Protection Agency (EPA) or Colorado Department of Public Health and Environment (CDPHE)].*

DCC

[1] IF a DTAN is NOT returned within 10 working days,
THEN issue a Document Inquiry Notice, shown on Appendix 4, ERPD DCC Document Inquiry Notice, or equivalent to the copyholder, to indicate the delinquency status and the consequences of the copyholder who does not acknowledge receipt of the Document Inquiry Notice.

[2] IF a controlled copyholder does NOT respond to the Document Inquiry Notice within 10 working days,
THEN notify the copyholder and the copyholder's manager that the copyholder has been removed from controlled distribution of controlled documents.

5.5 Receipt Acknowledgement Follow-up (continued)

Cognizant Manager or Controlled Copyholder

[3] IF the copyholder is removed from controlled distribution,
THEN perform one of the following:

[A] Return the controlled copies to the ERPD DCC within 5 working days.

[B] Have the ERPD DCC stamp the controlled copies INFORMATION ONLY.

ERPD DCC

[4] IF a decontrolled document CANNOT be recovered,
THEN initiate a Deficiency Report in accordance with the ERPD Quality Assurance Program.

5.6 Changes in Controlled Distribution

Responsible Manager

[1] Notify the ERPD DCC of any changes in the distribution of a controlled document.

NOTE *Individual requests for copies of controlled documents are submitted on Form 06.01-A5, Controlled Document Request.*

[2] Approve individual requests for copies of controlled documents.

Controlled Copyholder

[3] Notify the ERPD DCC of changes in the physical location of controlled documents. Written notice is preferred.

NOTE *Controlled documents are not to be transferred from one copyholder to another.*

[4] IF a controlled document is no longer needed by the current copyholder,
THEN return the controlled copy to the ERPD DCC.

5.7 Working Copies

NOTE 1 *Work will not be performed to "draft" procedures. Those procedures requiring review by DOE and the regulators will be considered final when a letter of approval has been received from the regulators. If review of the procedure is not required by DOE or the regulators, the procedure will be considered final when approved by the ERPD Director and the QAPM.*

5.7 Working Copies (continued)

NOTE 2 *If it is imperative that a procedure be implemented prior to regulatory approval, Rocky ERPD management shall formally request and justify the procedure's use on a case by case basis. DOE shall grant or deny approval for interim use of the procedure in writing. If the request is approved, the implemented draft procedure, the requesting letter, and the approval letter will be placed into the procedure history file and archived by ERPD DCC as a quality record. The draft procedure will be issued as a controlled "working copy" with an expiration date indicated on the cover page. Comments received from the regulators will be resolved and resolved comments will be incorporated into the document and an approval letter obtained from the regulators prior to the document being issued as a final controlled copy. If the request is denied, only the requesting letter and the letter of denial shall be entered into the history file and the procedure will not be implemented.*

ERPD DCC

[1] Stamp the cover (title) page in red with the Working Copy stamp.

[2] Complete the stamp with the expiration date, and initial and date the entry.

[3] Update the Working Copy Log.

[4] Transmit the Working Copy to the requester.

[5] Obtain receipt acknowledgements.

[6] Notify the Working Copy holder of any change in document status, such as receipt of a new revision or notification that a DMR has been issued, and arrange for immediate distribution.

Controlled Copyholder

[7] Work only to Working Copies that have <u>not</u> expired.

[8] **IF** the need arises for an extension of the Working Copy expiration date, **THEN** contact the ERPD DCC for approval.

ERPD DCC

[9] Obtain extension approval from the appropriate manager or DOE.

Controlled Copyholder

[10] **WHEN** the requested extension has been approved, **THEN** document the extension:

5.7 **Working Copies (continued)**

Controlled Copyholder (continued)

[A] Draw a line through the expiration date on the working copy.

[B] Add the new expiration date.

[C] Initial and date the extension.

ERPD DCC

[11] Verify the requested extension by making applicable changes in the Working Copy Log.

5.8 Information Only Copies

NOTE *Copies of controlled documents cannot be used to perform work, are stamped INFORMATION ONLY, and are not subject to updates.*

Prospective Copyholder

[1] Submit a completed Document Request form to the ERPD DCC.

ERPD DCC

[2] Provide the requester with a copy of the document stamped INFORMATION ONLY.

5.9 Disposition of Controlled Documents

Responsible Manager and SME

[1] Prepare a DMR in accordance with 2-E04-ER-ADM-05.07 to cancel or supersede a document, and notify ERPD DCC in writing of documents that are obsolete..

NOTE *Copyholder may retain canceled or obsolete document for information only provided the document is stamped by ERPD DCC.*

ERPD DCC

[2] Notify all copyholders of canceled, obsolete, or superseded documents with instructions on Form 06.01-A2 or equivalent.

5.10 Self Assessment

ERPD DCC

[1] Perform self assessment of accuracy of field documents in accordance with 2–G23–ER-ADM-18.05, Environmental Restoration Management Self Evaluation.

6. RECORDS

Management of all records is consistent with 1-77000-RM-001, Records Management Guidance for Records Sources.

ERPD DCC

[1] Ensure that the original and one copy of the following quality-related records, as appropriate, are transmitted to the ERPD Project File Center in accordance with 2-G18-ER-ADM-17.01.

- Controlled documents and revisions
- History Files
- Completed DMR forms (RF-47940, 5/93)
- Controlled ERPD Controlled Document List (Appendix 1)
- Completed Form 06.01-A2, Document Transmittal Acknowledgement Notice (DTAN)
- Completed Form 06.01-A3, Controlled Document Release
- Completed Document Inquiry Notice (Appendix 4)
- Completed Form 06.01-A5, Controlled Document Request

Submission of record copies to the ERPD Project File Center will satisfy Administrative Record requirements in accordance with 3-21000-ADM-17.02, Administrative Records Screeening and Processing.

7. REFERENCES

DOE Order 5700.6C, Quality Assurance

QAPjP, Rocky Flats Plant Environmental Management Site-Wide Quality Assurance Project Plan, Section 6.0, Document Control

RFP/ER-MP-QAPD, Environmental Restoration Management Quality Assurance Program Description

RFP QAM, Quality Requirement (QR-6), Revision 2, Document Control

1-77000-DC-002, Endorsement Document Control Program

1-77000-RM-001, Records Management Guidance for Records Sources

2-E02-ER-ADM-05.05, ERPD Document Review Process

2-E04-ER-ADM-05.07, ERPD Preparation and Use of Document Modification Requests

2-G23-ER-ADM-18.05, Environmental Restoration Management Self Evaluation

7. REFERENCES (continued)

2-G18-ER-ADM-17.01, Records Capture and Transmittal

3-21000-ADM-17.02, Administrative Records Screening and Processing

APPENDIX 1

Page 1 of 1

ERPD CONTROLLED DOCUMENT TYPE LIST

The following is a list of the minimum documents to be controlled by the ERPD DCC. These documents include, but are not limited to:

Contractor Plans
Decision Documents
Deep Seismic Data Acquisition Plans
Drawings
Feasibility Study
Field Sampling Plan
Geologic Characterization Plans
Geotechnical Procedures
Guidance Documents
Hazardous Substance List (at management discretion)
Health and Safety Plans
Health Effects Assessment Summary Tables
Log Books
Management Plan
OU Work Plan
Procedures [Environmental Management administrative requirements procedures, ERPD administrative procedures, ERPD operational procedures, Operational Management single-use instructions, and operational desk instructions (nonquality-related instructions)]
Procurement Requirements
Project Management Plans
Quality Assurance Amendments
Safety Plan
Scientific Note Books
Specifications (only controlled when routinely used as determined by management)
Technical Memo [as defined in the Interagency Agreement (IAG)]
Technical Reports
Test Plans
Well Abandonment Plans
Work Plan supporting documents (as appropriate)
Work Plan

APPENDIX 2
Page 1 of 1

ERPD DCC DOCUMENT TRANSMITTAL ACKNOLEDGEMENT NOTICE (DTAN)

Rocky Flats
Environmental Technology Site
ENVIRONMENTAL RESTORATION PROGRAM DIVISION

DOCUMENT TRANSMITTAL ACKNOWLEDGEMENT NOTICE (DTAN)

FORM 06.01-A2
REVISION 1

To: M. Buddy
T130B
Rocky Flats - P.O. Box 464
Golden, CO 80402

Copy Number: 206

Date: Novemberber 19, 1994

From: Carlotta Muheim, Rocky Flats ERPD Document Control

The following controlled documents are being transmitted to you. Signed receipt acknowledgement must be returned to the sender within 14 days of the transmittal date.

Document Number/Revision	Title
3-21000-GD.01, Revision 1	Technical Contract Management - EMD Guidance Document

SAMPLE

The material listed has been received and handled as instructed.

Name: _____
Signature of addressee or designee

Date: _____

RETURN WITHIN 14 DAYS TO:
Carlotta Muheim, ERPD Document Control
Environmental Management, T130B/#77
Rocky Flats Environmental Technology Site
P.O.Box 464, Golden, Co 80402

APPENDIX 3

Page 1 of 1

ERPD DCC CONTROLLED DOCUMENT RELEASE FORM

Rocky Flats Environmental Technology Site *ENVIRONMENTAL RESTORATION PROGRAM DIVISION*	**CONTROLLED DOCUMENT RELEASE**	FORM 06.01-A3 REVISION 1

The following controlled documents have received satisfactory reviews and approvals in accordance with 2-G01-ER-ADM-06.01, ERPD Document Control Process, and are released for distribution.

Document Number, Revision:	Title:

Existing DistributionList:_____
or
DistributionList:

Name/Organization:	Address:

SAMPLE

(Additional sheets may be used as necessary)

BY: _____ _____
QA Program Manager Date

APPENDIX 4
Page 1 of 1

ERPD DCC DOCUMENT INQUIRY NOTICE

Environmental Restoration Program Division
Document Control Center

DOCUMENT INQUIRY NOTICE

Date: 10/04/94

To: P. J. Rodgers
Colorado Geological Survey
1313 Sherman, Room 715
Denver, CO 80203

From: **Environmental Restoration Program Division**
Document Control Center
Rocky Flats Environmental Technology Site, Building 080
Golden, CO 80402-0464

SAMPLE

According to our records, we have not received a signed Document Transmittal Notice (DTN) for the following:

Document Number	Title
5-21000-OPS-GT.08, R3	Editorial Correction GT.08
5-21000-OPS-GT.TOC, R54	Table of Contents for EMD Operating Procedures

Serial Number 1877940298, mailed 09/07/94

If you have not received the document(s), please call the Document Control Center in Building 080 at (303) 966-8732 or (303) 966-8720. If you have received the document(s), please acknowledge receipt either by signing and returning the original DTN or by signing below and returning this letter within 10 days of the date of this letter to the address above.

Copyholder's signature _____ Date _____

APPENDIX 5
Page 1 of 1

ERPD DCC CONTROLLED DOCUMENT REQUEST FORM

Rocky Flats Environmental Technology Site *ENVIRONMENTAL RESTORATION PROGRAM DIVISION*	**CONTROLLED DOCUMENT REQUEST**	FORM 06.01-A5 REVISION 1

REQUEST FOR:

- ❑ CONTROLLED DOCUMENTS:
  - ❑ CONTROLLED COPY
  - ❑ WORKING COPY
  - ❑ INFORMATION COPY
- ❑ DELETION FROM DISTRIBUTION (CANCEL DOCUMENTS)
- ❑ CHANGE OF NAME/ADDRESS

DOCUMENT NUMBER	DOCUMENT TITLE

SAMPLE

REQUEST DATE _____ DEPT. _____ ER EP DOE OTHER

COPY # _____ EMPLOYEE # _____ PHONE/PAGER # _____

IMMEDIATE MANAGER _____

NAME _____

ADDRESS _____

_____

_____

REQUESTOR SIGNATURE

RETURN TO:
Rocky Flats Environmental Technology Site
Building 080, ERPD Document Control,
P.O.Box 464, Golden, Co 80402-0464
FAX Number 303-966-8575, Phone 303-966-8732/8720/8735

Am	Americium
ATV	All-Terrain Vehicle
BNC	Bulkhead 'N' Chassis
Co-PI	Collaborating Principle Investigators
CSI	Campbell Scientific, Inc.
DC	Deep-Cycle
EM	Electromagnetic
ER	Environmental Restoration
ERD	Earth Resources Division
ES&T	Environmental Science and Technology
gm	Gravitational Measurement
GPR	Ground Penetrating Radar
H&S	Health and Safety
I.D.	Interior Diameter
LF	Lateral Flow
lpm	liters per minute
mV	Output Voltage
PI	Principle Investigator
PM	Project Manager
PROM	Program Read Only Memory
PTFE	Polyethylene Tetrafluoride
Pu	Plutonium
PVC	Polyvinylchloride
REBS	Radiation Energy Balance Systems
RFEDS	Rocky Flats Environmental Database System
RFETS	Rocky Flats Environmental Technology Site

RFP	Rocky Flats Plant
SOP	Standard Operating Procedure
SSSP	Surficial Soil Sampling Program
TDR	Time Domain Reflectometry
TS	Tension Sampler
TSSS	Tension Soil Solution Sampler
V	Voltage
VAC	Voltage Alternating Current
ZT	Zero Tension

PIEZOMETER WELL DATA - - 042

Well #	Well I.D. #	Transducer Ser. #	Well Depth	Survey Coordinates North	East
1	60694	941196	14.56 ft	748904.9611	2086678.9252
2	60794	941212	13.57 ft	748904.7675	2086677.4376
3	60894	941211	9.45 ft	748904.4113	2086676.1718
4	61594	941198	19.77 ft	748894.9306	2086503.0604
5	61494	941199	14.54 ft	748894.6844	2086504.7503
6	61394	941202	13.37 ft	748894.4453	2086506.5618
7	60594	941191	20.77 ft	748895.5292	2086748.6569
8	60494	941194	10.76 ft	748894.1174	2086747.8392
9	60394	941192	14.87 ft	748891.7777	2086746.3604
10	60294	941210	8.92 ft	748913.7678	2086858.7917
11	60194	941190	9.9 ft	748852.7659	2086847.822
12	61094	932411	14.9 ft	748870.3996	2086634.1066
13	60994	941189	11.66 ft	748806.5994	2086570.3914
14	61194	941205	14.46 ft	748848.5481	2086555.3021
15	61294	941206	12.25 ft	748850.4542	2086555.7031

PIEZOMETER WELL DATA II-OU2

WELL #	WELL ID #	TRANSDUCER SERIAL NO.	GND. ELEV.	ELEV. TOP PVC	MUX Hook-ups MUX #	IN. #	WIRE #
1	60694	941196	5930.63	5931.67	2	8	4
2	60794	941212	5930.83	5931.87	2	9	6
3	60894	941211	5930.94	5931.98	2	10	7
4	61594	941198	5932.47	5945.33	2	1	9
5	61494	941199	5944.45	5945.49	2	2	10
6	61394	941202	5944.29	5945.33	2	3	11
7	60594	941191	5924.52	5925.56	1	1	3
8	60494	941194	5924.46	5925.50	1	2	NA
9	60394	941192	5924.24	5925.18	1	3	2
10	60294	941210	5920.79	5921.83	1	4	8
11	60194	941190	5916.18	5917.52	1	5	3
12	61094	932411	5931.40	5932.24	2	6	NA
13	60994	941189	5931.13	5932.07	2	7	12
14	61194	941205	5936.23	5937.27	2	4	6
15	61294	941206	5936.45	5937.49	2	5	7

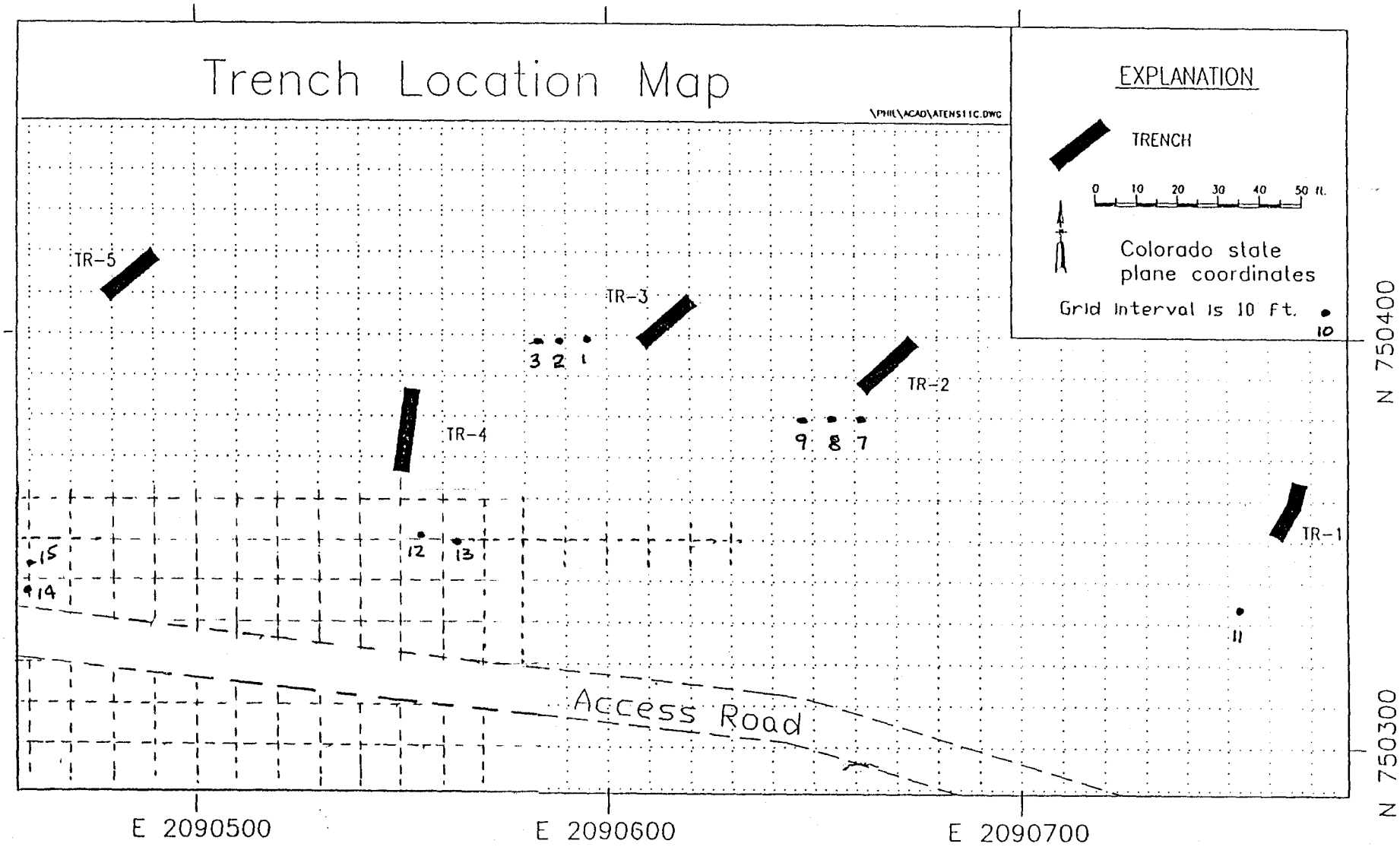


Figure 4.3-1 Trench Location Map

corrosion f[illegible]r submersible pressure transducers. Galvanic corrosion occurs when dissimilar metals are placed in contact with an electrolyte. This condition causes a potential difference to exist between the two metals, causing electron flow between them. Corrosion of the less corrosion-resistant metal is increased, and attack of the more resistant metal is decreased. The Series 820 Sacrificial Anode is clamped to the exterior of the transducer.

Keller PSI sacrificial anodes are made from a special zinc alloy formulated to guarantee continued effectiveness over long periods. Because the anodes are 95% galvanic, they will not corrode unless there is an electrolytic demand. The 2.38" diameter anodes maintain a high driving potential throughout their 12 month life, are self-sluffing and always expose new zinc for the best possible protection. For those applications where cable buoyancy is a problem, the 21 ounce sacrificial anode can be substituted for hanging weights.

Polyurethane & Tefzel Jacketed Cable: Most installations of our submersible pressure transducers connect our cable to a junction box. From this junction box, end-users run their own cable to the required instrumentation. Specifications for our polyurethane tefzel jacketed cable are as follows:

Weight	0.04 lbs/ft
Min. OD.	0.28"
Max. OD	0.31"
Conductors	3,4
Insulation	PVC
Imprint	Keller PSI Hampton VA
Shield	36 gauge spiral tinned copper
Wire	22 AWG (19/34) tinned copper stranding
Vent Tube	polyethylene, .060 " OD

Chemical Resistance of Polyurethane: Potable Water, Waste Water, Borax, Butane, Animal Fat, Carbonic Acid, Citric Acid, Cod Liver Oil, Corn Oil, Glycerin, Glycol, Mineral Oils, Potassium Nitrate, Potassium Sulfate, Silicone Oils, Stoddard Solvent, Tannic Acid (10), Tartaric Acid, Turbine Oil

Chemical Resistance of Tefzel: Acetic Acid (Glacial), Acetic Anhydride, Acetone, Aluminum Chloride, Anti-Freeze, Bromine, Calcium Chloride, Calcium Hydroxide, Chlorine, Copper Chloride, Ferrous Chloride, Hydrochloric Acid, Ketones, Lacquer Thinners, Sulfuric Acid.

Quick Tips

Cable Lengths: The maximum length of cable to be used with our submersible pressure transducers is largely dependent upon the type of electrical output of the pressure transducer. For a 0-5 VDC output a maximum cable length of 100 feet is recommended. A 4-20 mA signal can be transmitted up to 10,000 feet. Lengths greater than those mentioned above are available upon special order.

Vacuum Readings: This is a must for effective site remediation work requiring vapor extraction. Consult sales department for most appropriate transducer to use if you need to monitor pressure below atmosphere.

Reverse Signal: For some applications, it is important to know how far the water is from the top of the tank or the surface of the ground. This can be done by setting the transducer so that zero pressure reads full scale electrical output and maximum pressure reads zero output.

Drying Transducers: If you happen to get water in your vent tube and in the submersible pressure transducer, coil the cable and place the cable and transducer in a pan and place the pan in an oven at 50C for 2 hours. This on-site remedy may do the trick. Be careful that the oven temperature does not exceed 50C. Otherwise, you may damage the transducer and cable.

Variety of Electrical Outputs: Most applications call for a 0-5 VDC, 4-20 mA or a mV output. But where necessary, our transducers offer a broad choice of possibilities including, among others, 1.5 to 7 VDC, 0-10 VDC and 0-2.5 VDC.

1/2" Conduit Fitting: Submersible pressure transducers can be attached to a rigid conduit and the cable run through the conduit. To achieve this, all of our submersible transducers can be fitted with a 1/2" NPT male conduit fitting where the cable exits the transducer. This fitting can then be mated to a standard rigid conduit.

4-20 mA Connection: To connect a 2 wire 4-20mA transducer to the power supply and readout take the + (red) lead of the transducer and connect it to the + terminal of the power supply. Connect the - (black) lead of the transducer to the + input terminal of the readout. Connect the - input terminal of the readout to the - terminal of the power supply.

VDC Connection: To connect a 3 wire VDC output transducer to the power supply and the readout connect the - terminal of the power supply to the - input terminal of the readout. Connect the - excitation (black) lead of the transducer to the - input terminal of the readout. Connect the + input terminal of the readout to the signal lead (white) of the transducer. Connect the + terminal of the power supply to the + lead (red) of the transducer.

Lightning Strikes: This is one of the toughest problems to guard against. Our research team is working hard to come up with an economical means to prevent our units from being hit by lightning. We have not found a satisfactory solution...yet. We do recommend that the cable shield be connected to earth ground, not the power supply - input. Also, all metal materials that come into contact with our transducer should be grounded to earth ground.

Bending of Cable: Our polyurethane and tefzel jacketed cables are quite flexible. Care needs to be taken to ensure that when bending the cable to suit your installation you do not crimp the vent tube inside the cable. Consequently, do not bend the cable more that a radius of 1 inch.

Cable Compression: Many users require a compression fitting to secure our tefzel and polyurethane jacketed cable as it enters a junction box. You can put approximately 15 ft/lbs of force on this cable without damaging the cable or pinching the vent tube.

Transducer Quick Check: Ever wonder if your submersible transducer is working but you are unable to lift the cable up and down to check? Blow into the open end of the Series 810 vent filter. This causes an increase in pressure on the back side of our pressure sensor. If the transducer is working you will see a change in output. Typically, the average individual can exert about 1 PSI (27" of H20) by blowing into the tube.

1/4" NPT Pressure Fitting: Our submersible pressure transducers can be fitted with a 1/4" NPT male pressure fitting. Not only does this help when calibrating instrumentation, but it is extremely useful for those applications where one needs to tap into a pressure line that lies at the bottom of a tank, well or shallow pit.

Water Level Transducers From Keller PSI, INC.

Part No.	Description
Series 21B	In-Line
Series 169	Depth(mv Out)
Series 173	Depth(mv Out)
Series 27,28.29,30B	Bubbler
Series 200 S	Environmental
Series 210 S	High Accuracy
Series 700	Industrial (1% Static Accuracy)
Series 710	Industrial (0.25% Static Accuracy)
Series 720	Industrial (0.50% Static Accuracy)
Series 730	Industrial (0.1% Static Accuracy)
Options	Installed polyurethane and tefzel jacketed vented cable (Specify Length) Conduit Attachment Mounting Clamp
Series 810	Vent Filter/Water Vapor Trap
Series 820	Sacrificial Anode
PD610 (formerly Series 3000)	3 1/2 Digit Process Meter Level Control Option Channel Alarm Option
PD690	4 1/2 Digit Readout 2 Point Relay Isolated 4-20 Output

Note: Information contained in this User's Guide is subject to change without notice. Contact our Information Hotline (800-328-3665) for updates.

Your Pressure Measurement Source

Keller PSI, INC is U.S. manufacturer of all-media above ground and submersible pressure transducers. All products are shipped from our factory at 34 Research Dr., Hampton, VA 23666. Warranty & repair questions are handled by our staff in Hampton. They can be reached by calling **800-678-7226**.

Application support and ordering information is supplied by our Sales and Application staff at 503 Vista Bella, #11 Oceanside, CA 92057. They can be reached by calling **800-328-3665**.

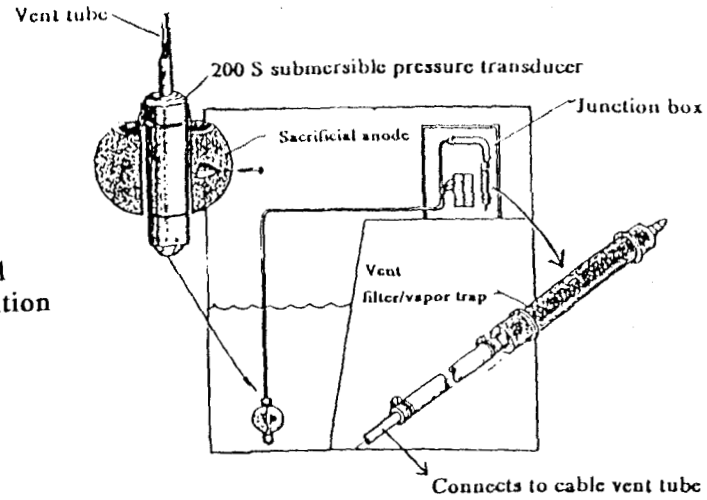
Customer Representatives are available from Monday through Friday from 8 A.M until 5 P.M.

FAX: 619-967-0563
We accept fax orders 24 hours a day 7 days a week.

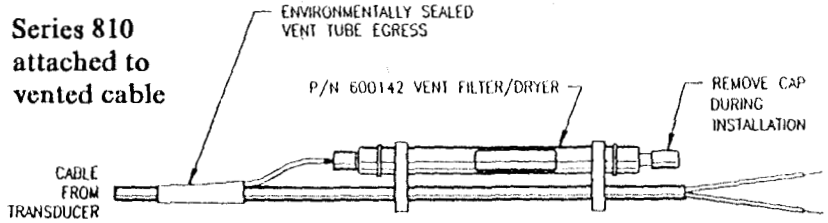
VISA/MASTER CARD ACCEPTED

Applications Diagrams

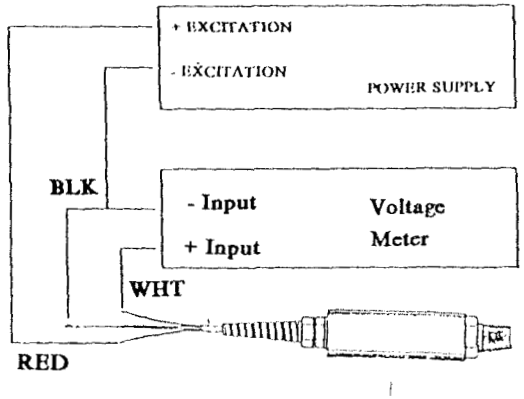
General Installation



Series 810 attached to vented cable

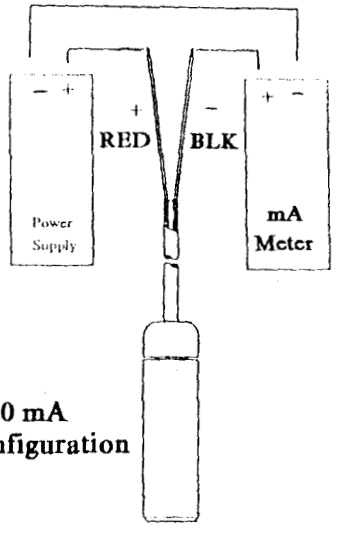


0-5 VDC Configuration



Note: This is a typical single-ended installation. Refer to your power supply and instrumentation manufacturer for the specifics of your application.

m-20 mA Configuration



Note: This is a typical current loop installation. Refer to your power supply

KELLER PSI

User's Manual
Liquid Level Measurement

Congratulations on your purchase of a Keller PSI pressure transducer. These devices are built at our factory in Hampton, VA to exacting standards. Before shipping, all units pass rigorous inspection by our Quality Assurance program.

Please read this brief user's manual to acquaint yourself with the features and benefits of your transducer. Make sure the calibration card is kept in a secure location. This card specifies I/O conditions and data stating the unit's static accuracy and thermal characteristics.

Characteristics of Keller PSI Transducers/Transmitters: All Keller PSI transducers incorporate our isolated diaphragm sensors which are specifically designed for use with hostile fluids and gases.

These sensors utilize a silicon pressure cell that has been fitted into a stainless steel package with an integral, compliant stainless steel barrier diaphragm. This sensor assembly is housed in a rugged 316 SS case which provides for a variety of pressure inputs. Our devices feature internal signal conditioning. Standard outputs are 4 to 20 mA and 0 to 5 VDC. Other outputs are available upon request.

All units have surge and reverse polarity protection. For ease of use in the field, Keller PSI transducers are permanently etched with our logo and name, wiring information, part number (P/N), serial number (S/N), date of manufacture (DOM), range, excitation, and output.

Keller PSI submersible transducers are designed for rugged use. But, they need protection from overpressure and sharp impact. When lowering them into a liquid, penetrate the surface slowly and only to the depth necessary. Avoid dropping the unit from above the surface. Clean transducers by rinsing them in a mild detergent. Direct probing of the diaphragm or attempts to remove protective screens (Series 700) can damage the sensor.

Warranty: Keller PSI warrants its products against defects in material and workmanship for 12 months from date of shipment. Products not subjected to misuse will be repaired or replaced. The Foregoing is in lieu of any other expressed or implied warranties. Keller PSI reserves the right to make changes to any product herein and assumes no liability arising out of the applications or use of any product or circuit described. Keller PSI products are not intended for life support applications.

Keller PSI's free 5 year extended warranty program covers all of its water related pressure transducers. This industry-first customer support coverage automatically kicks in 12 months after purchase. Under this program, Keller PSI will repair your pressure transducer for a fraction of the original list price. Details of this program can be obtained by calling Warranty/Repair at 800-678-7226.

Delivery: Standard delivery is 4 weeks. Expedited delivery options are offered for users needing rapid turnaround on standard products. Option 1: Order shipment within 5 working days. Expedite fee is $60.00/unit. Option 2: Order shipment within 10 working days. Expedite fee is $30.00/unit.

Hazardous Locations Certification: Keller PSI now has several standard products (27B, 28B, 29B, 30B, 169, 173, 200S, 210S, 220S, 240S, 700, 710, 720, 730) certified intrinsically safe for use in Class I, II and III Division I, applicable Groups A, B, C, D, E, F & G hazardous indoor locations.

Series 810 Vent Filter & Water Vapor Trap: The Series 810 is a replaceable vent tube dehumidifier intended for use with our submersible pressure transducers. This device protects sensitive electronic components from mildew, corrosion, rust and prevents the formation of a liquid column in the vent tube. Any such column directly affects calibration.

The Series 810 connects to the existing vent tube via a 10 inch flexible tube. The acrylic drying tube is 6 inches in length and 3/4 inches in diameter. Inserted in each pull-off molded polypropylene drying tube end cap is a 20 micron polypropylene filter.

The drying tube is filled with 30 grams of indicating desiccant (drying agent). The maximum flow rate through the drying tube is 300 cubic centimeters per minute, more than sufficient to allow the transducer to respond to barometric changes. As air passes through the drying tube, moisture is absorbed by the desiccant. The desiccant changes from blue to a rose red as its drying capacity becomes diminished.

The desiccant can be rejuvenated after normal use by spreading it in a layer one granule deep and heating for one hour at 205 C or 400 F. The heating temperature is very important for if it is lower than 205 C or 400 F the desiccant will not rejuvenate. Alternatively, spare vent filters can be ordered by calling 800-328-3665. The Series 810 vent filter and water vapor trap can be exposed to air, industrial gases, refrigerants, organic liquids and solvents. It should not be used when ammonia is present.

Series 820: Sacrificial Anode: Keller PSI offers the Series 820 zinc Sacrificial Anode

KELLER PSI

SERIES 810 VENT FILTER & WATER VAPOR TRAP

THE SERIES 810 IS A REPLACEABLE VENT TUBE DEHUMIDIFIER FOR USE WITH SUBMERSIBLE PRESSURE TRANSDUCERS. THIS DEVICE PROTECTS SENSITIVE ELECTRONIC COMPONENTS FROM MILDEW, CORROSION, RUST AND OTHER FORMS OF DETERIORATION WHILE AT THE SAME TIME PREVENTING THE FORMATION OF A LIQUID COLUMN IN THE CABLE VENT TUBE.

THE INSTALLATION PROCESS CONSISTS OF INSERTING THE METAL PIN OF THE VENT FILTER INTO THE VENT TUBE EXTRUDING FROM THE SUBMERSIBLE CABLE. THE YELLOW CAP SHOULD BE REMOVED DURING SERVICE. THE VENT FILTER SHOULD BE REPLACED WHEN 75% OF THE CONTENTS TURN PINK. REPLACEMENT FILTERS ARE AVAILABLE FOR $14.95 BY CALLING 1-800-328-3665.

READ THIS BEFORE USE!

THIS IS A PRECISION INSTRUMENT!
REFRAIN FROM OVER-PRESSURING. WHEN LOWERING INTO A LIQUID, PENETRATE THE SURFACE SLOWLY AND ONLY TO THE DEPTH NECESSARY. (HAND-OVER-HAND METHOD IS RECOMMENDED) CARE SHOULD BE TAKEN TO AVOID SHARP IMPACTS. CLEAN BY RINSING UNIT IN MILD DETERGENT. DO NOT USE COMPRESSED AIR. USE OF A SERIES 810 VENT FILTER IS VITAL TO PREVENTING MOISTURE DAMAGE TO THE SILICON SENSOR. (SEE BACK OF CARD FOR MORE INFORMATION.)

FOR TECHNICAL ASSISTANCE OR REPAIRS CALL 1-800-678-7226.

FOR ORDER PLACEMENT CALL 1-800-328-3665.

KELLER PSI

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941135
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-08-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Logged IL
6-18-94
P.O. 3449
JD

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0001	-0.17	-0.159	0.037	-0.181	-0.033	-0.026	0.017
1.9997	6.18	6.193	0.041	6.178	-0.006	6.319	0.016
3.9993	12.53	12.542	0.036	12.535	0.014	12.657	0.015
6.0007	18.89	18.891	0.013	18.885	-0.006	18.989	0.012
7.9998	25.24	25.234	-0.005	25.234	-0.005	25.320	0.010
9.9996	31.59	31.578	-0.029	31.582	-0.016	31.644	0.007
7.9991	25.23	25.234	0.001	25.236	0.007	25.317	0.010
5.9998	18.88	18.888	0.013	18.887	0.009	18.991	0.012
4.0001	12.53	12.538	0.015	12.533	-0.000	12.660	0.015
1.9997	6.18	6.180	-0.000	6.175	-0.016	6.320	0.016
-0.0001	-0.17	-0.179	-0.025	-0.185	-0.044	-0.023	0.017

Maximum Static Error: -.044 %FSO

Maximum Thermal Error @ Cold: 0.017 %FSO/C

Maximum Non-Repeatability: -.069 %FSO

Slope : 0.315 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941189
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-10-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0001	-0.87	-0.871	0.008	-0.916	-0.080	-0.941	-0.005
1.9994	9.36	9.385	0.059	9.354	-0.002	9.319	-0.003
3.9998	19.59	19.632	0.081	19.610	0.037	19.553	-0.003
5.9997	29.82	29.854	0.060	29.841	0.034	29.756	-0.005
8.0003	40.06	40.061	0.001	40.053	-0.014	39.936	-0.009
9.9999	50.29	50.244	-0.093	50.245	-0.091	50.085	-0.015
7.9997	40.06	40.058	0.001	40.058	0.001	39.937	-0.009
6.0004	29.83	29.845	0.035	29.844	0.033	29.758	-0.005
3.9999	19.59	19.615	0.047	19.614	0.044	19.557	-0.002
2.0001	9.36	9.358	-0.001	9.357	-0.003	9.329	-0.002
0.0000	-0.88	-0.915	-0.077	-0.917	-0.082	-0.926	-0.004

Maximum Static Error: -.093 %FSO

Maximum Thermal Error @ Cold: -.015 %FSO/C

Maximum Non-Repeatability: -.088 %FSO

Slope : 0.195 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941190
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-45 mV

Test Date: 06-06-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Logged In
W
6-17-94
P.O. 3449
SA

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
-0.0002	3.96	3.966	0.020	3.945	-0.031	4.172	0.019
2.0002	12.13	12.145	0.029	12.127	-0.015	12.344	0.019
4.0002	20.31	20.324	0.042	20.313	0.015	20.515	0.019
6.0003	28.48	28.496	0.036	28.484	0.007	28.673	0.017
7.9997	36.65	36.662	0.023	36.651	-0.004	36.823	0.015
9.9998	44.83	44.813	-0.034	44.801	-0.064	44.961	0.012
8.0000	36.65	36.655	0.002	36.649	-0.013	36.826	0.016
5.9996	28.48	28.491	0.031	28.482	0.009	28.672	0.018
3.9995	20.30	20.320	0.039	20.308	0.009	20.517	0.019
1.9999	12.13	12.133	0.003	12.126	-0.014	12.341	0.019
0.0001	3.96	3.946	-0.031	3.935	-0.058	4.163	0.019

Maximum Static Error: -.064 %FSO

Maximum Thermal Error @ Cold: 0.019 %FSO/C

Maximum Non-Repeatability: -.051 %FSO

Slope : 0.245 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941191
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-08-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Logged In
6-18-94
P.O. 3449
SA

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0001	2.98	3.003	0.040	2.961	-0.045	3.160	0.013
1.9997	12.85	12.864	0.034	12.843	-0.009	12.955	0.008
3.9993	22.71	22.726	0.029	22.723	0.023	22.746	0.003
6.0007	32.58	32.584	-0.001	32.592	0.015	32.524	-0.005
7.9998	42.45	42.438	-0.017	42.451	0.010	42.295	-0.011
9.9996	52.31	52.281	-0.062	52.300	-0.024	52.043	-0.020
7.9991	42.44	42.441	-0.004	42.453	0.020	42.293	-0.011
5.9998	32.58	32.591	0.022	32.592	0.024	32.528	-0.004
4.0001	22.72	22.728	0.025	22.725	0.019	22.752	0.003
1.9997	12.85	12.852	0.009	12.841	-0.013	12.960	0.008
-0.0001	2.98	2.963	-0.039	2.954	-0.057	3.159	0.013

Maximum Static Error: -.062 %FSO

Maximum Thermal Error @ Cold: -.020 %FSO/C

Maximum Non-Repeatability: -.085 %FSO

Slope : 0.203 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941192
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-07-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Logged In
6-17-94
P.O. 3449
SP

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0000	-0.59	-0.605	-0.034	-0.633	-0.087	-0.287	0.021
1.9995	9.96	9.967	0.023	9.964	0.017	10.253	0.021
3.9995	20.50	20.523	0.044	20.533	0.063	20.778	0.020
6.0006	31.05	31.065	0.029	31.078	0.054	31.271	0.016
7.9999	41.59	41.578	-0.025	41.597	0.011	41.738	0.010
10.0003	52.14	52.072	-0.124	52.090	-0.090	52.172	0.002
7.9998	41.59	41.587	-0.007	41.599	0.016	41.744	0.011
6.0002	31.05	31.073	0.047	31.079	0.059	31.273	0.016
4.0001	20.50	20.536	0.063	20.531	0.054	20.784	0.020
1.9998	9.96	9.972	0.030	9.959	0.005	10.255	0.021
-0.0002	-0.59	-0.621	-0.062	-0.634	-0.087	-0.294	0.021

Maximum Static Error: -.124 %FSO

Maximum Thermal Error @ Cold: 0.021 %FSO/C

Maximum Non-Repeatability: -.053 %FSO

Slope : 0.190 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941193
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-07-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

logged in 6-17-94 P.O. 3449 SD

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0001	-0.02	-0.074	-0.097	-0.070	-0.089	0.138	0.012
2.0003	10.14	10.149	0.014	10.156	0.028	10.381	0.017
4.0002	20.31	20.350	0.084	20.350	0.084	20.583	0.020
5.9999	30.47	30.505	0.067	30.504	0.065	30.748	0.020
8.0009	40.64	40.639	-0.005	40.630	-0.023	40.875	0.017
10.0000	50.80	50.722	-0.158	50.723	-0.156	50.957	0.011
7.9996	40.63	40.642	0.014	40.634	-0.002	40.880	0.018
6.0006	30.47	30.520	0.090	30.503	0.056	30.756	0.021
3.9999	20.31	20.361	0.110	20.343	0.074	20.591	0.021
1.9999	10.14	10.165	0.050	10.143	0.007	10.386	0.018
-0.0001	-0.03	-0.069	-0.085	-0.090	-0.127	0.140	0.012

Maximum Static Error: -.158 %FSO

Maximum Thermal Error @ Cold: 0.021 %FSO/C

Maximum Non-Repeatability: -.043 %FSO

Slope : 0.197 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941194
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-07-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Logged In 6-17-94 P.O. 34449 SA

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0001	2.70	2.682	-0.028	2.687	-0.018	2.910	0.016
2.0003	12.57	12.563	-0.007	12.566	-0.001	12.714	0.011
4.0002	22.44	22.445	0.018	22.446	0.020	22.503	0.005
5.9999	32.30	32.309	0.010	32.314	0.020	32.283	-0.002
8.0009	42.18	42.170	-0.017	42.176	-0.005	42.056	-0.009
10.0000	52.04	52.014	-0.060	52.028	-0.032	51.806	-0.018
7.9996	42.17	42.174	0.004	42.181	0.018	42.058	-0.009
6.0006	32.31	32.321	0.028	32.316	0.018	32.289	-0.001
3.9999	22.43	22.455	0.042	22.446	0.024	22.510	0.006
1.9999	12.56	12.582	0.036	12.581	-0.007	12.719	0.012
-0.0001	2.69	2.690	-0.010	2.668	-0.055	2.916	0.017

Maximum Static Error: -.060 %FSO

Maximum Thermal Error @ Cold: -.018 %FSO/C

Maximum Non-Repeatability: -.045 %FSO

Slope : 0.203 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941195
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-07-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
-0.0001	0.88	0.859	-0.046	0.876	-0.009	1.012	0.011
1.9997	10.14	10.125	-0.029	10.141	0.005	10.239	0.008
3.9997	19.40	19.390	-0.016	19.409	0.025	19.469	0.006
5.9999	28.66	28.651	-0.015	28.669	0.024	28.689	0.002
7.9998	37.92	37.907	-0.021	37.926	0.020	37.904	-0.001
9.9999	47.18	47.151	-0.055	47.173	-0.007	47.101	-0.006
8.0002	37.92	37.912	-0.014	37.928	0.020	37.907	-0.001
6.0001	28.66	28.661	0.005	28.677	0.040	28.696	0.003
4.0000	19.40	19.407	0.018	19.414	0.033	19.477	0.006
1.9995	10.14	10.140	0.006	10.149	0.025	10.247	0.009
-0.0001	0.88	0.876	-0.009	0.880	0.000	1.018	0.011

Maximum Static Error: -.055 %FSO

Maximum Thermal Error @ Cold: 0.011 %FSO/C

Maximum Non-Repeatability: 0.048 %FSO

Slope : 0.216 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941196
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-10-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0001	-0.73	-0.769	-0.081	-0.781	-0.105	-0.569	0.011
1.9994	9.62	9.638	0.041	9.630	0.026	9.862	0.013
3.9998	19.97	20.009	0.084	20.005	0.076	20.258	0.021
5.9997	30.31	30.349	0.072	30.349	0.072	30.609	0.021
8.0003	40.66	40.651	-0.022	40.661	-0.003	40.921	0.019
9.9999	51.01	50.924	-0.160	50.935	-0.139	51.192	0.013
7.9997	40.66	40.653	-0.012	40.666	0.013	40.926	0.019
6.0004	30.32	30.346	0.059	30.353	0.073	30.619	0.022
3.9999	19.97	20.006	0.077	20.012	0.088	20.272	0.022
2.0001	9.62	9.630	0.019	9.635	0.028	9.882	0.019
0.0000	-0.73	-0.781	-0.104	-0.780	-0.101	-0.549	0.013

Maximum Static Error: -.160 %FSO

Maximum Thermal Error @ Cold: 0.022 %FSO/C

Maximum Non-Repeatability: 0.025 %FSO

Slope : 0.193 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941197
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50-mV

Test Date: 06-07-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Logged In 6-17-94 P.O. 3449 SL

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
-0.0001	0.14	0.095	-0.098	0.116	-0.048	0.160	0.002
1.9997	8.43	8.418	-0.028	8.436	0.016	8.521	0.008
3.9997	16.72	16.731	0.017	16.749	0.061	16.865	0.013
5.9999	25.02	25.027	0.018	25.040	0.050	25.188	0.015
7.9998	33.31	33.305	-0.020	33.320	0.016	33.494	0.016
9.9999	41.61	41.561	-0.114	41.578	-0.073	41.780	0.015
8.0002	33.32	33.309	-0.015	33.321	0.014	33.502	0.017
6.0001	25.02	25.034	0.034	25.048	0.068	25.198	0.016
4.0000	16.72	16.747	0.053	16.754	0.070	16.879	0.014
1.9995	8.43	8.436	0.018	8.445	0.040	8.539	0.010
-0.0001	0.14	0.116	-0.047	0.122	-0.033	0.182	0.004

Maximum Static Error: -.114 %FSO

Maximum Thermal Error @ Cold: 0.017 %FSO/C

Maximum Non-Repeatability: 0.051 %FSO

Slope : 0.241 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941198
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-08-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0000	0.40	0.340	-0.151	0.389	-0.033	0.270	-0.012
2.0000	8.71	8.679	-0.067	8.721	0.035	8.636	-0.006
4.0001	17.01	17.005	-0.014	17.040	0.070	16.991	-0.002
5.9997	25.31	25.310	-0.007	25.342	0.070	25.322	0.001
7.9997	33.62	33.601	-0.038	33.627	0.024	33.637	0.002
9.9995	41.92	41.868	-0.125	41.895	-0.060	41.928	0.001
7.9997	33.62	33.607	-0.024	33.630	0.031	33.643	0.002
6.0001	25.31	25.328	0.032	25.349	0.082	25.338	0.002
4.0003	17.01	17.030	0.045	17.046	0.083	17.011	-0.000
1.9995	8.70	8.717	0.030	8.729	0.059	8.666	-0.003
0.0001	0.40	0.388	-0.036	0.401	-0.005	0.302	-0.009

Maximum Static Error: -.151 %FSO

Maximum Thermal Error @ Cold: -.012 %FSO/C

Maximum Non-Repeatability: 0.118 %FSO

Slope : 0.241 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941199
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-09-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0000	-0.28	-0.249	0.058	-0.232	0.093	-0.047	0.018
2.0001	9.47	9.440	-0.066	9.458	-0.030	9.575	0.008
4.0001	19.22	19.172	-0.103	19.187	-0.072	19.237	0.001
5.9998	28.97	28.929	-0.084	28.949	-0.043	28.925	-0.003
8.0001	38.72	38.717	-0.007	38.733	0.025	38.641	-0.006
10.0001	48.47	48.518	0.099	48.536	0.136	48.370	-0.008
8.0001	38.72	38.720	-0.001	38.736	0.032	38.645	-0.006
6.0000	28.97	28.940	-0.063	28.955	-0.032	28.932	-0.003
3.9997	19.22	19.185	-0.072	19.198	-0.045	19.245	0.002
1.9997	9.47	9.458	-0.026	9.470	-0.001	9.590	0.009
-0.0001	-0.28	-0.235	0.088	-0.223	0.113	-0.035	0.018

Maximum Static Error: 0.136 %FSO

Maximum Thermal Error @ Cold: 0.018 %FSO/C

Maximum Non-Repeatability: 0.041 %FSO

Slope : 0.205 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941200
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-08-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Logged In 6-18-94 P.O. 3449 SA

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0000	-0.94	-0.932	0.023	-0.979	-0.070	-0.931	0.001
2.0000	9.24	9.282	0.080	9.238	-0.007	9.256	0.001
4.0002	19.43	19.479	0.102	19.444	0.033	19.425	-0.000
6.0000	29.61	29.658	0.091	29.622	0.020	29.562	-0.004
8.0000	39.80	39.813	0.033	39.782	-0.028	39.675	-0.009
9.9996	49.98	49.948	-0.062	49.915	-0.127	49.764	-0.016
7.9998	39.80	39.810	0.028	39.777	-0.037	39.680	-0.008
6.0004	29.61	29.647	0.066	29.610	-0.007	29.568	-0.003
4.0004	19.43	19.461	0.064	19.427	-0.003	19.431	0.000
1.9994	9.24	9.251	0.025	9.218	-0.040	9.266	0.002
-0.0002	-0.94	-0.977	-0.064	-1.006	-0.121	-0.921	0.002

Maximum Static Error: -.127 %FSO

Maximum Thermal Error @ Cold: -.016 %FSO/C

Maximum Non-Repeatability: -.092 %FSO

Slope : 0.196 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941202
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-09-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
-0.0001	-0.75	-0.756	-0.007	-0.795	-0.086	-0.629	0.009
2.0003	9.05	9.079	0.059	9.057	0.015	9.163	0.009
3.9995	18.85	18.898	0.104	18.888	0.082	18.917	0.005
6.0002	28.65	28.684	0.066	28.683	0.064	28.636	-0.001
7.9996	38.45	38.452	0.004	38.447	-0.006	38.320	-0.010
10.0005	48.26	48.185	-0.144	48.184	-0.146	47.971	-0.022
7.9999	38.45	38.453	0.003	38.440	-0.024	38.321	-0.010
5.9994	28.65	28.688	0.082	28.671	0.047	28.636	-0.001
3.9998	18.85	18.895	0.094	18.876	0.056	18.917	0.005
2.0003	9.05	9.066	0.033	9.043	-0.013	9.160	0.008
-0.0001	-0.75	-0.825	-0.148	-0.819	-0.135	-0.630	0.009

Maximum Static Error: -.148 %FSO

Maximum Thermal Error @ Cold: -.022 %FSO/C

Maximum Non-Repeatability: -.079 %FSO

Slope : 0.204 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941203
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-13-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
-0.0001	0.32	0.308	-0.026	0.277	-0.098	0.531	0.018
1.9996	8.96	8.988	0.061	8.964	0.005	9.206	0.021
3.9995	17.61	17.650	0.104	17.632	0.061	17.852	0.021
5.9996	26.25	26.284	0.080	26.272	0.052	26.468	0.019
7.9999	34.90	34.895	-0.000	34.889	-0.014	35.060	0.014
10.0001	43.54	43.484	-0.129	43.484	-0.129	43.617	0.007
8.0001	34.90	34.893	-0.007	34.892	-0.009	35.063	0.014
5.9994	26.25	26.275	0.061	26.274	0.059	26.475	0.019
4.0002	17.61	17.637	0.067	17.632	0.054	17.862	0.022
1.9996	8.96	8.970	0.018	8.962	-0.000	9.218	0.022
-0.0001	0.32	0.278	-0.095	0.269	-0.115	0.546	0.019

Maximum Static Error: -.129 %FSO

Maximum Thermal Error @ Cold: 0.022 %FSO/C

Maximum Non-Repeatability: -.071 %FSO

Slope : 0.231 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941205
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-10-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0000	0.47	0.441	-0.066	0.448	-0.049	0.485	0.001
2.0002	8.84	8.836	-0.006	8.843	0.011	8.888	0.004
3.9994	17.20	17.218	0.033	17.229	0.059	17.276	0.006
5.9996	25.57	25.584	0.025	25.593	0.046	25.645	0.006
7.9998	33.94	33.937	-0.016	33.947	0.008	33.994	0.004
9.9994	42.31	42.270	-0.097	42.280	-0.074	42.322	0.001
8.0001	33.94	33.941	-0.009	33.947	0.005	33.999	0.005
6.0006	25.58	25.589	0.026	25.602	0.057	25.645	0.006
4.0000	17.21	17.226	0.046	17.233	0.064	17.282	0.007
2.0002	8.84	8.843	0.010	8.850	0.026	8.892	0.005
0.0002	0.47	0.448	-0.051	0.450	-0.046	0.485	0.001

Maximum Static Error: -.097 %FSO

Maximum Thermal Error @ Cold: 0.007 %FSO/C

Maximum Non-Repeatability: 0.031 %FSO

Slope : 0.239 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941206
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-08-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0001	-0.85	-0.836	0.027	-0.909	-0.112	-0.571	0.020
1.9997	9.68	9.728	0.099	9.670	-0.011	9.979	0.021
3.9993	20.20	20.267	0.124	20.231	0.056	20.505	0.021
6.0007	30.74	30.781	0.084	30.756	0.036	30.989	0.018
7.9998	41.26	41.266	0.011	41.251	-0.017	41.445	0.013
9.9996	51.79	51.721	-0.126	51.713	-0.141	51.853	0.005
7.9991	41.26	41.262	0.010	41.253	-0.007	41.448	0.013
5.9998	30.73	30.768	0.068	30.752	0.038	30.995	0.018
4.0001	20.21	20.242	0.069	20.227	0.040	20.509	0.021
1.9997	9.68	9.685	0.017	9.666	-0.019	9.984	0.022
-0.0001	-0.85	-0.907	-0.106	-0.926	-0.142	-0.578	0.019

Maximum Static Error: -.142 %FSO

Maximum Thermal Error @ Cold: 0.022 %FSO/C

Maximum Non-Repeatability: -.139 %FSO

Slope : 0.190 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941209
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-13-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	------Run #1------ Rm Temp Outputs	Error %FSO	------Run #2------ Rm Temp Outputs	Error %FSO	------Run #3------ Cd Temp Outputs	Error %FSO
-0.0001	-0.24	-0.286	-0.123	-0.266	-0.067	-0.314	-0.007
1.9996	7.11	7.094	-0.035	7.117	0.027	7.069	-0.004
3.9995	14.46	14.462	0.016	14.483	0.074	14.438	-0.002
5.9996	21.80	21.811	0.016	21.830	0.068	21.780	-0.003
7.9999	29.16	29.139	-0.045	29.163	0.021	29.108	-0.005
10.0001	36.50	36.451	-0.147	36.471	-0.092	36.408	-0.010
8.0001	29.16	29.149	-0.019	29.166	0.027	29.110	-0.005
5.9994	21.80	21.823	0.051	21.839	0.095	21.788	-0.002
4.0002	14.46	14.481	0.061	14.494	0.097	14.444	-0.001
1.9996	7.11	7.116	0.025	7.128	0.057	7.077	-0.003
-0.0001	-0.24	-0.266	-0.068	-0.255	-0.039	-0.311	-0.007

Maximum Static Error: -.147 %FSO

Maximum Thermal Error @ Cold: -.010 %FSO/C

Maximum Non-Repeatability: 0.065 %FSO

Slope : 0.272 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941210
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-10-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0000	-0.32	-0.361	-0.097	-0.342	-0.049	-0.288	0.003
2.0002	7.49	7.488	-0.019	7.501	0.015	7.551	0.005
3.9995	15.31	15.321	0.030	15.331	0.056	15.379	0.007
6.0002	23.13	23.134	0.013	23.149	0.051	23.186	0.005
8.0002	30.95	30.935	-0.028	30.948	0.005	30.977	0.003
10.0000	38.76	38.721	-0.105	38.735	-0.069	38.749	-0.001
8.0000	30.95	30.938	-0.019	30.955	0.025	30.979	0.003
6.0001	23.13	23.140	0.029	23.153	0.062	23.188	0.006
3.9999	15.31	15.331	0.052	15.339	0.072	15.381	0.007
1.9996	7.49	7.501	0.022	7.509	0.041	7.554	0.006
-0.0001	-0.32	-0.343	-0.052	-0.336	-0.033	-0.291	0.003

Maximum Static Error: -.105 %FSO

Maximum Thermal Error @ Cold: 0.007 %FSO/C

Maximum Non-Repeatability: 0.048 %FSO

Slope : 0.256 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941211
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-10-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0000	-0.73	-0.779	-0.095	-0.750	-0.040	-0.482	0.018
2.0002	9.58	9.551	-0.061	9.589	0.012	9.758	0.013
3.9995	19.89	19.879	-0.020	19.918	0.055	19.988	0.007
6.0002	30.20	30.188	-0.031	30.230	0.050	30.197	-0.001
8.0002	40.51	40.490	-0.048	40.530	0.029	40.389	-0.009
10.0000	50.82	50.762	-0.121	50.811	-0.026	50.557	-0.019
8.0000	40.51	40.498	-0.031	40.543	0.057	40.388	-0.009
6.0001	30.20	30.207	0.007	30.249	0.088	30.197	-0.000
3.9999	19.89	19.910	0.036	19.939	0.093	19.988	0.007
1.9996	9.58	9.587	0.016	9.613	0.066	9.757	0.013
-0.0001	-0.73	-0.752	-0.043	-0.727	0.006	-0.489	0.017

Maximum Static Error: -.121 %FSO

Maximum Thermal Error @ Cold: -.019 %FSO/C

Maximum Non-Repeatability: 0.095 %FSO

Slope : 0.194 psi/mV

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941212
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-09-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0000	-0.42	-0.430	-0.018	-0.443	-0.047	-0.370	0.004
2.0004	8.54	8.541	0.011	8.535	-0.001	8.605	0.006
4.0000	17.49	17.505	0.033	17.506	0.035	17.576	0.007
5.9996	26.44	26.456	0.025	26.463	0.040	26.529	0.007
7.9995	35.40	35.397	-0.008	35.401	0.001	35.472	0.006
9.9998	44.36	44.322	-0.081	44.332	-0.058	44.380	0.002
7.9996	35.40	35.401	-0.000	35.404	0.006	35.472	0.006
6.0003	26.45	26.461	0.030	26.460	0.027	26.533	0.007
4.0000	17.49	17.511	0.045	17.507	0.038	17.591	0.008
2.0001	8.53	8.541	0.015	8.539	0.010	8.617	0.007
-0.0001	-0.42	-0.443	-0.046	-0.448	-0.056	-0.367	0.005

Maximum Static Error: -.081 %FSO

Maximum Thermal Error @ Cold: 0.008 %FSO/C

Maximum Non-Repeatability: -.029 %FSO

Slope : 0.223 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 941213
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-50 mV

Test Date: 06-13-94
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
-0.0001	0.10	0.063	-0.079	0.087	-0.033	0.269	0.012
1.9996	10.40	10.403	0.006	10.417	0.032	10.586	0.013
3.9995	20.70	20.721	0.046	20.728	0.059	20.878	0.013
5.9996	31.00	31.018	0.043	31.017	0.041	31.143	0.011
7.9999	41.30	41.291	-0.009	41.293	-0.005	41.387	0.007
10.0001	51.59	51.544	-0.097	51.543	-0.099	51.595	0.000
8.0001	41.30	41.303	0.013	41.290	-0.012	41.395	0.007
5.9994	30.99	31.031	0.071	31.011	0.032	31.162	0.012
4.0002	20.70	20.738	0.072	20.712	0.021	20.910	0.015
1.9996	10.40	10.424	0.047	10.393	-0.014	10.626	0.016
-0.0001	0.10	0.086	-0.035	0.052	-0.101	0.319	0.015

Maximum Static Error: -.101 %FSO

Maximum Thermal Error @ Cold: 0.016 %FSO/C

Maximum Non-Repeatability: -.067 %FSO

Slope : 0.194 psi/mV

Electrical Termination: Black +Input
Red +Output
Green -Output
White -Input

FACTORY CALIBRATION LINEAR REGRESSION 9/30/93 CLYDE BEST 801-750-9576

KELLER S/N 932388

PSI	MV
-0.0004	-0.24
2.0009	7.53
3.9997	15.29
5.9992	23.06
7.9991	30.83
9.9991	38.6

Regression Output:

OFFSET b	0.062232	psi
	0.143569	feet
Std Err of Y Est	0.000771	
R Squared	0.999999	
No. of Observations	6	
Degrees of Freedom	4	
SLOPE m	0.257445	psi/mv
	0.593925	feet/mv
Std Err of Coef.	0.000023	

KELLER-PSI CALIBRATION REPORT

Customer: CAMPBELL SCIENTIFIC
Model No: 169-110-0010
Serial No: 932388
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-35 mV

Test Date: 09-11-93
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
-0.0004	-0.24	-0.225	0.048	-0.223	0.053	-0.384	-0.013
2.0009	7.53	7.503	-0.069	7.511	-0.049	7.375	-0.015
3.9997	15.29	15.275	-0.048	15.283	-0.028	15.163	-0.012
5.9992	23.06	23.054	-0.016	23.069	0.022	22.976	-0.008
7.9991	30.83	30.838	0.024	30.851	0.058	30.784	-0.004
9.9991	38.60	38.585	-0.031	38.581	-0.041	38.553	-0.004
8.0008	30.84	30.853	0.046	30.854	0.049	30.795	-0.004
6.0010	23.07	23.078	0.027	23.076	0.022	22.993	-0.007
4.0007	15.30	15.288	-0.025	15.281	-0.043	15.180	-0.011
2.0010	7.53	7.499	-0.081	7.522	-0.021	7.404	-0.012
-0.0007	-0.24	-0.224	0.054	-0.225	0.051	-0.389	-0.014

Maximum Static Error: -.081 %FSO

Maximum Thermal Error @ Cold: -.015 %FSO/C

Maximum Non-Repeatability: 0.059 %FSO

Electrical Termination:

Black	+Input
Red	+ Output
Green	-Output
White	-Input

FACTORY CALIBRATION LINEAR REGRESSION 9/30/93 CLYDE BEST 801-750-9576

KELLER S/N 932411

PSI	MV
0.0001	-0.04
1.999	6.39
3.9992	12.82
5.9991	19.25
7.9991	25.68
9.9997	32.12

Regression Output:

OFFSET b	0.012526	psi
	0.028898	feet
Std Err of Y Est	0.000812	
R Squared	0.999999	
No. of Observations	6	
Degrees of Freedom	4	
SLOPE m	0.310964	psi/mv
	0.717396	feet/mv
Std Err of Coef.	0.000030	

Customer: CAMPBELL SCIENTIFIC
Model No: 164-110-0010
Serial No: 932411
Pressure Range: 0 to 10 PSIG
Excitation: .5 mA
Output: 0-35 mV

Test Date: 09-15-93
Test Excitation: .5 mA
Test Temperatures: Room = 27 C
Cold = 0 C

Test Pressure PSIG	BFSL Rm Temp Outputs	Run #1 Rm Temp Outputs	Run #1 Error %FSO	Run #2 Rm Temp Outputs	Run #2 Error %FSO	Run #3 Cd Temp Outputs	Run #3 Error %FSO
0.0001	-0.04	-0.038	0.011	-0.036	0.017	-0.136	-0.011
1.9990	6.39	6.390	0.010	6.380	-0.021	6.339	-0.006
3.9992	12.82	12.806	-0.042	12.312	-0.023	12.794	-0.003
5.9991	19.23	19.245	-0.013	19.250	-0.003	19.256	0.002
7.9991	25.68	25.685	0.007	25.689	0.019	25.751	0.008
9.9997	32.12	32.118	0.005	32.118	0.005	32.215	0.011
9.0008	25.69	25.691	0.009	25.697	0.027	25.758	0.008
6.0008	19.26	19.254	-0.007	19.256	-0.001	19.276	0.002
4.0005	12.82	12.817	-0.020	12.819	-0.014	12.801	-0.003
2.0007	6.39	6.386	-0.020	6.400	0.024	6.331	-0.007
-0.0002	-0.04	-0.036	0.020	-0.037	0.017	-0.134	-0.011

Maximum Static Error: -.042 %FSO

Maximum Thermal Error @ Cold: 0.011 %FSO/C

Maximum Non-Repeatability: 0.044 %FSO

Electrical Termination:

Black	+Input
Red	+Output
Green	-Output
White	-Input

Program:
Flag Usage:
Input Channel Usage:
Excitation Channel Usage:
Control Port Usage:
Pulse Input Channel Usage:
Output Array Definitions:

MEMORY MAP

Input Location Usage:

1 - 5	Water Elevation (Meters), AM416 #1
6 - 16	Not Used (reserved for above)
17 - 26	Water Elevation (Meters), AM416 #2
27 - 32	Not Used (reserved for above)
33	Battery Voltage (from CR10)
34	CR10 Temperature
35 - 40	Not Used
41 - 45	Slope Calibration Values, AM416 #1
46 - 56	Not Used (reserved for above)
57 - 60	Not Used
61 - 70	Slope Calibration Values, AM416 #2
71 - 76	Not Used (reserved for above)
77 - 80	Not Used
81 - 85	Offset Cal Values, AM416 #1
86 - 96	Not Used (reserved for above)
97 - 100	Not Used
101 - 110	Offset Cal Values, AM416 #2
111 - 116	Not Used (reserved for above)
117 - 120	Not Used
121 - 125	Casing Elevation Values, AM416 #1
126 - 136	Not Used (reserved for above)
137 - 140	Not Used
141 - 150	Casing Elevation Values, AM416 #2
151 - 156	Not Used (reserved for above)
157 - 160	Not Used
161	Precision Resistor Voltage Input
162	Transducer Voltage Input
163 - 165	Temporary Storage for Calculations

```
*      1        Table 1 Programs
  01: 900       Sec. Execution Interval
```

*** BUILD CALIBRATION AND ELEVATION TABLES ***

** ATTENTION: ALL VALUES ARE IN METERS!!!

TRANSDUCERS ON AM416 MULTIPLEXER #1

Piezometer/Well #7: Transducer S/N 941191

```
01:  P30        Z=F
  01: 1.4252    F
  02: 1--       Exponent of 10
  03: 41        Z Loc : Slope 7

02:  P30        Z=F
  01: 5.9696    F
  02: 0         Exponent of 10
  03: 81        Z Loc : Offset 7

03:  P30        Z=F
  01: 0         F
  02: 3         Exponent of 10
  03: 121       Z Loc : Elev 7
```

Piezometer/Well #8: Transducer S/N 941194

```
04:  P30        Z=F
  01: 1.4250    F
  02: 1--       Exponent of 10
  03: 42        Z Loc : Slope 8

05:  P30        Z=F
  01: 3.1540    F
  02: 0         Exponent of 10
  03: 82        Z Loc : Offset 8

06:  P30        Z=F
  01: 0         F
  02: 3         Exponent of 10
  03: 122       Z Loc : Elev 8
```

Piezometer/Well #9: Transducer S/N 941192

```
07:  P30        Z=F
  01: 1.3334    F
  02: 1--       Exponent of 10
  03: 43        Z Loc : Slope 9

08:  P30        Z=F
  01: 4.2876    F
  02: 0         Exponent of 10
  03: 83        Z Loc : Offset 9

09:  P30        Z=F
  01: 0         F
  02: 3         Exponent of 10
  03: 123       Z Loc : Elev 9
```

Piezometer/Well #10: Transducer S/N 941210

```
10:  P30       Z=F
  01: 1.7991   F
  02: 1--      Exponent of 10
  03: 44       Z Loc : Slope 10

11:  P30       Z=F
  01: 2.6569   F
  02: 0        Exponent of 10
  03: 84       Z Loc : Offset 10

12:  P30       Z=F
  01: 0        F
  02: 3        Exponent of 10
  03: 124      Z Loc : Elev 10
```

Piezometer/Well #11: Transducer S/N 941190

```
13:  P30       Z=F
  01: 1.7203   F
  02: 1--      Exponent of 10
  03: 45       Z Loc : Slope 11

14:  P30       Z=F
  01: 3.5999   F
  02: 0        Exponent of 10
  03: 85       Z Loc : Offset 11

15:  P30       Z=F
  01: 0        F
  02: 3        Exponent of 10
  03: 125      Z Loc : Elev 11
```

TRANSDUCERS ON MULTIPLEXER #2

Piezometer/Well #4: Transducer S/N 941198

```
16:  P30       Z=F
  01: 1.6933   F
  02: 1--      Exponent of 10
  03: 61       Z Loc : Slope 4

17:  P30       Z=F
  01: 6.0601   F
  02: 0        Exponent of 10
  03: 101      Z Loc : Offset 4

18:  P30       Z=F
  01: 0        F
  02: 3        Exponent of 10
  03: 141      Z Loc : Elev 4
```

Piezometer/Well #5: Transducer S/N 941199

```
19:  P30       Z=F
  01: 1.4423   F
  02: 1--      Exponent of 10
  03: 62       Z Loc : Slope 5

20:  P30       Z=F
  01: 4.3177   F
  02: 0        Exponent of 10
  03: 102      Z Loc : Offset 5

21:  P30       Z=F
  01: 0        F
  02: 3        Exponent of 10
  03: 142      Z Loc : Elev 5
```

Piezometer/Well #6: Tranducer S/N 941202

```
22:  P30       Z=F
  01: 1.4347   F
  02: 1--      Exponent of 10
  03: 63       Z Loc : Slope 6

23:  P30       Z=F
  01: 3.8531   F
  02: 0        Exponent of 10
  03: 103      Z Loc : Offset 6

24:  P30       Z=F
  01: 0        F
  02: 3        Exponent of 10
  03: 143      Z Loc : Elev 6
```

Piezometer/Well #14: Transducer S/N 941205

```
25:  P30       Z=F
  01: 1.6803   F
  02: 1--      Exponent of 10
  03: 64       Z Loc : Slope 14

26:  P30       Z=F
  01: 4.3396   F
  02: 0        Exponent of 10
  03: 104      Z Loc : Offset 14

27:  P30       Z=F
  01: 0        F
  02: 3        Exponent of 10
  03: 144      Z Loc : Elev 14
```

Piezometer/Well #15: Transducer S/N 941206

```
28:  P30       Z=F
  01: 1.3356   F
  02: 1--      Exponent of 10
  03: 65       Z Loc : Slope 15

29:  P30       Z=F
  01: 3.5283   F
  02: 0        Exponent of 10
  03: 105      Z Loc : Offset 15

30:  P30       Z=F
  01: 0        F
  02: 3        Exponent of 10
  03: 145      Z Loc : Elev 15
```

Piezometer/Well #12: Transducer S/N 932411

```
31:  P30       Z=F
  01: 2.1861   F
  02: 1--      Exponent of 10
  03: 66       Z Loc : Slope 12

32:  P30       Z=F
  01: 4.4642   F
  02: 0        Exponent of 10
  03: 106      Z Loc : Offset 12

33:  P30       Z=F
  01: 0        F
  02: 3        Exponent of 10
  03: 146      Z Loc : Elev 12
```

Piezometer/Well #13: Transducer S/N 941189

```
34:  P30       Z=F
  01: 1.3743   F
  02: 1--      Exponent of 10
  03: 67       Z Loc : Slope 13

35:  P30       Z=F
  01: 3.3305   F
  02: 0        Exponent of 10
  03: 107      Z Loc : Offset 13

36:  P30       Z=F
  01: 0        F
  02: 3        Exponent of 10
  03: 147      Z Loc : Elev 13
```

Piezometer/Well #1: Transducer S/N 941196

```
37:  P30        Z=F
  01: 1.3589    F
  02: 1--       Exponent of 10
  03: 68        Z Loc : Slope 1

38:  P30        Z=F
  01: 4.1418    F
  02: 0         Exponent of 10
  03: 108       Z Loc : Offset 1

39:  P30        Z=F
  01: 0         F
  02: 3         Exponent of 10
  03: 148       Z Loc : Elev 1
```

Piezometer/Well #2: Transducer S/N 941212

```
40:  P30        Z=F
  01: 1.5701    F
  02: 1--       Exponent of 10
  03: 69        Z Loc : Slope 2

41:  P30        Z=F
  01: 3.8375    F
  02: 0         Exponent of 10
  03: 109       Z Loc : Offset 2

42:  P30        Z=F
  01: 0         F
  02: 3         Exponent of 10
  03: 149       Z Loc : Elev 2
```

Piezometer/Well #3: Transducer S/N 941211

```
43:  P30        Z=F
  01: 1.3639    F
  02: 1--       Exponent of 10
  03: 70        Z Loc : Slope 3

44:  P30        Z=F
  01: 2.6824    F
  02: 0         Exponent of 10
  03: 110       Z Loc : Offset 3

45:  P30        Z=F
  01: 0         F
  02: 3         Exponent of 10
  03: 150       Z Loc : Elev 3
```

*** READ TRANSDUCERS ON MULTIPLEXER #1 ***

```
46:  P86        Do
  01: 41        Set high Port 1
```

```
47:  P87        Beginning of Loop
  01: 0000      Delay
  02: 5         Loop Count

48:  P86        Do
  01: 72        Pulse Port 2

49:  P8         Excite,Delay,Volt(DIFF)
  01: 1         Rep
  02: 3         25 mV slow Range
  03: 1         IN Chan
  04: 1         Excite all reps w/EXchan 1
  05: 10        Delay (units=.01sec)
  06: 770       mV Excitation
  07: 161       Loc : Res Volts
  08: .01       Mult
  09: 0.0000    Offset

50:  P8         Excite,Delay,Volt(DIFF)
  01: 1         Rep
  02: 3         25 mV slow Range
  03: 2         IN Chan
  04: 1         Excite all reps w/EXchan 1
  05: 10        Delay (units=.01sec)
  06: 770       mV Excitation
  07: 162       Loc : DucerVolt
  08: .5        Mult
  09: 0.0000    Offset

51:  P38        Z=X/Y
  01: 162       X Loc
  02: 161       Y Loc
  03: 163       Z Loc :

52:  P36        Z=X*Y
  01: 163       X Loc
  02: 41--      Y Loc
  03: 164       Z Loc : MtrsofH2O

53:  P35        Z=X-Y
  01: 164       X Loc
  02: 81--      Y Loc
  03: 165       Z Loc : NormMtH2O

54:  P33        Z=X+Y
  01: 165       X Loc
  02: 121--     Y Loc
  03: 1--       Z Loc : WaterEl 1

55:  P95        End

56:  P86        Do
  01: 51        Set low Port 1

*** READ TRANSDUCERS ON MULTIPLEXER #2 ***
```

```
57:  P86       Do
  01: 43       Set high Port 3

58:  P87       Beginning of Loop
  01: 0000     Delay
  02: 10       Loop Count

59:  P86       Do
  01: 72       Pulse Port 2

60:  P8        Excite,Delay,Volt(DIFF)
  01: 1        Rep
  02: 3        25 mV slow Range
  03: 4        IN Chan
  04: 3        Excite all reps w/EXchan 3
  05: 10       Delay (units=.01sec)
  06: 770      mV Excitation
  07: 161      Loc : Res Volts
  08: .01      Mult
  09: 0.0000   Offset

61:  P8        Excite,Delay,Volt(DIFF)
  01: 1        Rep
  02: 3        25 mV slow Range
  03: 5        IN Chan
  04: 3        Excite all reps w/EXchan 3
  05: 10       Delay (units=.01sec)
  06: 770      mV Excitation
  07: 162      Loc : DucerVolt
  08: .5       Mult
  09: 0.0000   Offset

62:  P38       Z=X/Y
  01: 162      X Loc
  02: 161      Y Loc
  03: 163      Z Loc :

63:  P36       Z=X*Y
  01: 163      X Loc
  02: 61--     Y Loc
  03: 164      Z Loc : MtrsofH2O

64:  P35       Z=X-Y
  01: 164      X Loc
  02: 101--    Y Loc
  03: 165      Z Loc : NormMtH2O

65:  P33       Z=X+Y
  01: 165      X Loc
  02: 141--    Y Loc
  03: 17--     Z Loc : WaterEl 2

66:  P95       End
```

```
67:  P86        Do
  01: 53        Set low Port 3

READ POWER SUPPLY VOLTAGE & TEMPERATURE

68:  P10        Battery Voltage
  01: 33        Loc : BattVolts

69:  P17        Module Temperature
  01: 34        Loc : CR10 Temp

*** SEND DATA TO FINAL STORAGE ***

70:  P78        Resolution
  01: 1         High Resolution

71:  P86        Do
  01: 10        Set high Flag 0 (output)

72:  P80        Set Active Storage Area
  01: 1         Final Storage Area 1
  02: 69        Array ID or location

73:  P77        Real Time
  01: 110       Day,Hour-Minute

74:  P70        Sample
  01: 5         Reps
  02: 1         Loc

75:  P70        Sample
  01: 10        Reps
  02: 17        Loc

76:  P70        Sample
  01: 2         Reps
  02: 33        Loc

77:  P77        Real Time
  01: 1000      Year

BACK UP DATA TO STORAGE MODULE

78:  P96        Serial Output
  01: 71        SM192/SM716/CSM1

79:  P86        Do
  01: 20        Set low Flag 0 (output)

80:  P          End Table 1


*      2        Table 2 Programs
  01: 0.0000    Sec. Execution Interval
```

```
01:  P        End Table 2

*     3       Table 3 Subroutines

01:  P        End Table 3

*     A       Mode 10 Memory Allocation
  01: 170     Input Locations
  02: 64      Intermediate Locations
  03: 0.0000  Final Storage Area 2

*     C       Mode 12 Security
  01: 0       LOCK 1
  02: 0       LOCK 2
  03: 0000    LOCK 3
```

 Input Location Assignments (with comments):

Key:
T=Table Number
E=Entry Number
L=Location Number

T:	E:	L:		
1:	54:	1:	Z Loc	: WaterEl 1
1:	65:	17:	Z Loc	: WaterEl 2
1:	68:	33:	Loc	: BattVolts
1:	69:	34:	Loc	: CR10 Temp
1:	1:	41:	Z Loc	: Slope 7
1:	4:	42:	Z Loc	: Slope 8
1:	7:	43:	Z Loc	: Slope 9
1:	10:	44:	Z Loc	: Slope 10
1:	13:	45:	Z Loc	: Slope 11
1:	16:	61:	Z Loc	: Slope 4
1:	19:	62:	Z Loc	: Slope 5
1:	22:	63:	Z Loc	: Slope 6
1:	25:	64:	Z Loc	: Slope 14
1:	28:	65:	Z Loc	: Slope 15
1:	31:	66:	Z Loc	: Slope 12
1:	34:	67:	Z Loc	: Slope 13
1:	37:	68:	Z Loc	: Slope 1
1:	40:	69:	Z Loc	: Slope 2
1:	43:	70:	Z Loc	: Slope 3
1:	2:	81:	Z Loc	: Offset 7
1:	5:	82:	Z Loc	: Offset 8
1:	8:	83:	Z Loc	: Offset 9
1:	11:	84:	Z Loc	: Offset 10
1:	14:	85:	Z Loc	: Offset 11
1:	17:	101:	Z Loc	: Offset 4
1:	20:	102:	Z Loc	: Offset 5
1:	23:	103:	Z Loc	: Offset 6
1:	26:	104:	Z Loc	: Offset 14
1:	29:	105:	Z Loc	: Offset 15
1:	32:	106:	Z Loc	: Offset 12
1:	35:	107:	Z Loc	: Offset 13
1:	38:	108:	Z Loc	: Offset 1
1:	41:	109:	Z Loc	: Offset 2
1:	44:	110:	Z Loc	: Offset 3
1:	3:	121:	Z Loc	: Elev 7
1:	6:	122:	Z Loc	: Elev 8
1:	9:	123:	Z Loc	: Elev 9
1:	12:	124:	Z Loc	: Elev 10
1:	15:	125:	Z Loc	: Elev 11
1:	18:	141:	Z Loc	: Elev 4
1:	21:	142:	Z Loc	: Elev 5
1:	24:	143:	Z Loc	: Elev 6
1:	27:	144:	Z Loc	: Elev 14
1:	30:	145:	Z Loc	: Elev 15
1:	33:	146:	Z Loc	: Elev 12
1:	36:	147:	Z Loc	: Elev 13
1:	39:	148:	Z Loc	: Elev 1
1:	42:	149:	Z Loc	: Elev 2
1:	45:	150:	Z Loc	: Elev 3

 Input Location Assignments (cont.):

```
1: 49:161:  Loc : Res Volts
1: 60:161:  Loc : Res Volts
1: 50:162:  Loc : DucerVolt
1: 61:162:  Loc : DucerVolt
1: 51:163:  Z Loc :
1: 62:163:  Z Loc :
1: 52:164:  Z Loc : MtrsofH2O
1: 63:164:  Z Loc : MtrsofH2O
1: 53:165:  Z Loc : NormMtH2O
1: 64:165:  Z Loc : NormMtH2O
```

SNOWPRO

Snow Monitoring CR10 Datalogger Program

The current Snow Monitoring System (SMS) CR10 datalogger program is presented below. The first six ages contain general comments and information. This includes a record of program updates, wiring and perpherial address information, and an instrument input/final memory location record. The program instructions, with comments, start on page 7.

Program: SNOW monitoring program (archived as SNOW7)

(this program was first downloaded Dec 20, 1994)

Added code for first snow density plate loadcells
(for now, one reading every ten minutes. May try
average of five readings later...)

Added SDS offsets for tower, pit 1, pit 5

OLD UPDATES:
Added 2 locations for snow density estimates.

RMY direction is only being taken at pit 1, until
the measurement is debugged.

Added wind velocity STD DIV after YEAR stamp at end
These values will NOT be included in database for
now.

Move year stamp to end of array.
Created 8 more fields, 2 for heat transfer plates,
6 for snow density plates.
10 minute execution interval
10 second wind measurements
removed extra data at end of standard array
(still has wind vector P69 at end, w/zero offset)
added 116 ID for 10 minute readings
every two hours, ID is set to 111

first data set with rearranged temp probe
reorganized final storage (w/ zero dividers)
added in temp probes offsets
added in m/s conversion for wind velocities
added in solar conversions
Duplicate P1/P2, INT8, SW8A count commands removed
removed SDS 15 1-min averages
set SDS offsets to zero (created table with updates below)
added P53 commands (need to fill in offsets)
P71-final storage writing reorganized

Table 1 has a 10 sec. execution interval, with RM direction and counts & MET counts taken every time. Final storage and all other data is taken every ten minutes, including averages of ten second data

snowmelt gauge thawing control logic (Table 2)
SDS averaging scheme (5 readings)
RMY direction averaging (10-sec minute readings every 10 minutes)
RMY counts every 10 sec

MET counts every 10 sec

Multiplexer Port Usage:

CP MUX: 1 1H: HMP35C #1 temp
1L: Ex Chan 1
2H: HMP35C #1 RH
2L:

2 1H: HMP35C #2 temp
1L: Ex Chan 1
2H: HMP35C #2 RH

3 1H: HMP35C #3 temp
1L: Ex Chan 1
2H: HMP35C #3 RH
2L:

4 1H: RM Young wind direction

```
=PASTE()
=SELECT("R2C9")
=FORMULA("=IF(RC[-6]>0,if(rc[-6]<0.8,rc[-6],r[-1]c),R[-1]C)")
=COPY()
=SELECT("R2C10:R2C12")
=PASTE()
=SELECT("R3C9:R2001C12")
=PASTE()
=SELECT("R2C8:R2001C8")
=COPY()
=SELECT("R2C14")
=PASTE()
=HLINE(6)
=SELECT("R2C9:R5C12")
=COPY()
=SELECT("R2C15")
=PASTE()
=SELECT("R6C15")
=FORMULA("=IF(RC[-6]>AVERAGE(R[-4]C[-6]:R[-1]C[-6])*0.8,IF(RC[-6]<AVERAGE(R[1]C[-6]:R[4]C[-6])*1.2,RC[-6],R[-1]C
=COPY()
=SELECT("R6C16:R6C18")
=PASTE()
=SELECT("R7C15:R2001C18")
=PASTE()
=SELECT("R1C15")
=FORMULA("'Probe1")
=SELECT("R1C16")
=FORMULA("'Probe2")
=SELECT("R1C17")
=FORMULA("'Probe3")
=SELECT("R1C18")
=FORMULA("'Probe4")
=SELECT("R1C14:R2001C18")
=COPY()
=CREATE.OBJECT(5,"R11C20",3.75,9,"R22C25",38.25,12,1,TRUE)
=CHART.WIZARD(TRUE,"TR5FLUX6.TXT!R1C14:R2001C18",7,2,2,1,1,1,"TRENCH 5 - FLUXMETER 6","JULIAN DAY","S
=UNHIDE("TR5FLUX6.TXT Chart 1")
=WINDOW.MAXIMIZE()
=SELECT("S1")
=PATTERNS(0,1,1,3,2,1,1,3,FALSE)
=SELECT("S2")
=PATTERNS(0,2,3,3,2,1,1,4,FALSE)
=SELECT("S3")
=PATTERNS(0,3,7,3,2,1,1,5,FALSE)
=SELECT("S4")
=PATTERNS(0,4,5,3,2,1,1,6,FALSE)
=Setup_Page()
=SELECT("Axis 1")
=PATTERNS(1,1,1,1,4,1,4)
=SCALE(0,0.5,0.1,0.05,TRUE,FALSE,FALSE,FALSE)
=GRIDLINES(FALSE,FALSE,TRUE,FALSE)
```

8: Eppley Labs pyranometer #1
9: Eppley Labs pyranometer #2
10: Eppley Labs pyrgeometer
11: REBS snow surface temperature
12-14: snow density plate #1 loadcells

TR-1 MUX: 1-9: 107 TPs
10: RM Young wind direction
11-13: snow density plate #2 loadcells

TR-3 MUX: 1-9: 107 TPs
10: RM Young wind direction

TR-5 MUX: 1-8: 107 TPs
9: RM Young wind direction

Device Addresses:

SDM-SW8A: 00
SDM-CD16: 01
SDM-INT8: 02
SDS TOWER: 03
SDS TR-1: 04
SDS TR-3: 05
SDS TR-4: 06
SDS TR-5: 07

INT8 program debugging record:

>3/16 2/0000/2222/0000/7777/ 500/17--/0.098/0.0000
3/17 02/0000/0022/0000/0022/1000/17--/1.000/0.0000
(assume all 4 ports are being used)

Excitation Channel Usage:
1: HMP35C temps, 107 TPs
2: HMP35C RHs
3:

Control Port Usage:
1: SW8A, INT, Snow depth sensor (reset)
2: SW8A, INT, Snow depth sensor (clock)
3: SW8A, INT, Snow depth sensor (dataline)
4: Reset CP Multiplexer
5: Reset TR-1 Multiplexer

```
=ECHO(TRUE)
=IF(Print_Plots_on_Printer)
=  PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=ELSE()
=  DIALOG.BOX(OPTIONS_MENU)
=  IF(PrintorContinue=1)
=    PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=  END.IF()
=END.IF()
=FILE.CLOSE(FALSE)
=FILE.CLOSE(FALSE)
=ECHO(FALSE)
=RETURN()


=ECHO(FALSE)
=IF(FILE.EXISTS("C:\SOIL\TR1LDCEL.TXT"))
=  OPEN("C:\soil\tr1ldcel.txt")
=ELSE()
=  ALERT("File: 'C:\SOIL\TR1LDCEL.TXT' does not exist.")
=  RETURN()
=END.IF()
=SELECT("R2C2:R2001C2")
=COPY()
=SELECT("R2C8")
=PASTE()
=SELECT("R2C9")
=FORMULA("=IF(RC[-6]>-5,if(rc[-6]<5,rc[-6],r[-1]c),R[-1]C)")
=COPY()
=SELECT("R2C10:R2C12")
=PASTE()
=SELECT("R3C9:R2001C12")
=PASTE()
=HLINE(6)
=SELECT("R2C9:R5C12")
=COPY()
=SELECT("R1C9")
=FORMULA("'Load Cell 1")
=SELECT("R1C10")
=FORMULA("'Load Cell 2")
=SELECT("R1C11")
=FORMULA("'Load Cell 3")
=SELECT("R1C8:R2001C11")
=COPY()
=CREATE.OBJECT(5,"R11C20",3.75,9,"R22C25",38.25,12,1,TRUE)
=CHART.WIZARD(TRUE,"TR1ldcel.TXT!R1C8:R2001C11",7,2,2,1,1,1,"TRENCH 1 - Load Cells","JULIAN DAY"
=UNHIDE("TR1ldcel.TXT Chart 1")
=WINDOW.MAXIMIZE()
=SELECT("S1")
=PATTERNS(0,1,1,3,2,1,1,3,FALSE)
=SELECT("S2")
```

6: Reset TR-3 Multiplexer
7: Reset TR-5 Multiplexer
8: Clock all Multiplexers

Pulse Input Channel Usage:
P1: TR-1 RM Young
P2: tower RM Young

Internal/Output Array Definitions:

1-5: snowmelt (rain gauges)
6-10: snow depth SDS
11-14: RM Young wind directions
15-18: RM Young wind speeds
19-21: MET wind speeds

22: upward Epply pyranometer
23: downward Epply pyranometer
24: upward Epply pyrgeometer
25: (empty - downward pyrgeometer?)
26: REBS radiometer

27-29: HMP35C relative humidities
30-32: HMP35C temps

33-39: TR-1 snow temps
40: TR-1 atmospheric temp
41-42: TR-1 soil temps

43-49: TR-3 snow temps
50: TR-3 atmospheric temp
51-52: TR-3 soil temps
53: TR-3 rain gauge temp

54-60: TR-5 snow temps
61: TR-5 atmospheric temp
62: TR-5 rain gauge temp

63-64: heat transfer plates (to be installed)
65-67: loadcells for snow density plate #1
68-70: loadcells for snow density plate #2
71-72: snow density estimates based on loadcells

73-97: readings used in averages of SDS, loadcells

```
=PATTERNS(0,2,3,3,2,1,1,4,FALSE)
=SELECT("S3")
=PATTERNS(0,3,7,3,2,1,1,5,FALSE)
=SELECT("Axis 1")
=PATTERNS(1,1,1,1,4,1,4)
=SCALE(TRUE,TRUE,TRUE,TRUE,-5,FALSE,FALSE,FALSE)
=GRIDLINES(FALSE,FALSE,TRUE,FALSE)
=Setup_Page()
=ECHO(TRUE)
=IF(Print_Plots_on_Printer)
=  PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=ELSE()
=  DIALOG.BOX(OPTIONS_MENU)
=  IF(PrintorContinue=1)
=    PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=  END.IF()
=END.IF()
=FILE.CLOSE(FALSE)
=FILE.CLOSE(FALSE)
=ECHO(FALSE)
=RETURN()


=ECHO(FALSE)
=IF(FILE.EXISTS("C:\SOIL\TR2LDCEL.TXT"))
=  OPEN("C:\soil\TR2ldcel.txt")
=ELSE()
=  ALERT("File: 'C:\SOIL\TR2LDCEL.TXT' does not exist.")
=  RETURN()
=END.IF()
=SELECT("R2C2:R2001C2")
=COPY()
=SELECT("R2C8")
=PASTE()
=SELECT("R2C9")
=FORMULA("=IF(RC[-6]>-5,if(rc[-6]<5,rc[-6],r[-1]c),R[-1]C)")
=COPY()
=SELECT("R2C10:R2C12")
=PASTE()
=SELECT("R3C9:R2001C12")
=PASTE()
=HLINE(6)
=SELECT("R2C9:R5C12")
=COPY()
=SELECT("R1C9")
=FORMULA("'Load Cell 1")
=SELECT("R1C10")
=FORMULA("'Load Cell 2")
=SELECT("R1C11")
=FORMULA("'Load Cell 3")
=SELECT("R1C8:R2001C11")
```

Instrument Map (CR10 intermediate memory locations):

	Tower	TR-1	TR-3	TR-4	TR-5
snow melt gauge	1	2	3	4	5
snow depth sensor	6	7	8	9	10
RMY wind directions	11	12	13		14
RMY wind velocities	15	16	17		18
MET wind velocities	19,20,21				
upward pyranomter	22				
downward pyranometer	23				
upward pyrgeometer	24				
(downward pyrgeometer 25 - not installed)					
REBS radiometer	26				
HMP35C temps	27,28,29				
HMP35C RHs	30,31,32				

temperature probes:

on the ground	33	43	54
10 cm above ground	34	44	55
20 cm above ground	35	45	56
30 cm above ground	36	46	57
40 cm above ground	37	47	58
50 cm above ground	38	48	59
60 cm/snow surface	39	49	60
atmospheric (2m above snow)	40	50	61
10 cm below surface	41	51	
	42	52	
rain gauge	53	62	

heat transfer plates: 63,64
loadcells for snow density plate #1: 65,66,67
loadcells for snow density plate #2: 68,69,70
snow denisty estimates based on loadcells: 71,73

25 SDS readings used for average value: 73-97
(also used for temp storage of loadcell averages)

```
=COPY()
=SELECT("R1C9")
=FORMULA("'Load Cell 1")
=SELECT("R1C10")
=FORMULA("'Load Cell 2")
=SELECT("R1C11")
=FORMULA("'Load Cell 3")
=SELECT("R1C8:R2001C11")
=COPY()
=CREATE.OBJECT(5,"R11C20",3.75,9,"R22C25",38.25,12,1,TRUE)
=CHART.WIZARD(TRUE,"TR3ldcel.TXT!R1C8:R2001C11",7,2,2,1,1,1,"TRENCH 3 - Load Cells","JULIAN DAY"
=UNHIDE("TR3ldcel.TXT Chart 1")
=WINDOW.MAXIMIZE()
=SELECT("S1")
=PATTERNS(0,1,1,3,2,1,1,3,FALSE)
=SELECT("S2")
=PATTERNS(0,2,3,3,2,1,1,4,FALSE)
=SELECT("S3")
=PATTERNS(0,3,7,3,2,1,1,5,FALSE)
=SELECT("Axis 1")
=PATTERNS(1,1,1,1,4,1,4)
=SCALE(TRUE,TRUE,TRUE,TRUE,-5,FALSE,FALSE,FALSE)
=GRIDLINES(FALSE,FALSE,TRUE,FALSE)
=Setup_Page()
=ECHO(TRUE)
=IF(Print_Plots_on_Printer)
=  PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=ELSE()
=  DIALOG.BOX(OPTIONS_MENU)
=  IF(PrintorContinue=1)
=    PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=  END.IF()
=END.IF()
=FILE.CLOSE(FALSE)
=FILE.CLOSE(FALSE)
=ECHO(FALSE)
=RETURN()


=ECHO(FALSE)
=IF(FILE.EXISTS("C:\SOIL\TR4LDCEL.TXT"))
=  OPEN("C:\soil\TR4ldcel.txt")
=ELSE()
=  ALERT("File: 'C:\SOIL\TR4LDCEL.TXT' does not exist.")
=  RETURN()
=END.IF()
=SELECT("R2C2:R2001C2")
=COPY()
=SELECT("R2C8")
=PASTE()
=SELECT("R2C9")
```

```
*    1      Table 1 Programs

Start table every ten seconds, but main body is executed
every 10 minutes....

 01: 10      Sec. Execution Interval

Take RMY wind direction readings every 10 seconds, then
averaged every ten minutes at end of Table 1

Take pit 1 RMY wind direction....


01:  P86     Do
 01: 45      Set high Port 5

02:  P87     Beginning of Loop
 01: 0000    Delay
 02: 11      Loop Count

03:  P86     Do
 01: 78      Pulse Port 8

04:  P95     End

05:  P4      Excite,Delay,Volt(SE)
 01: 1       Rep
 02: 5       2500 mV slow Range
 03: 3       IN Chan
 04: 1       Excite all reps w/EXchan 1
 05: 20      Delay (units .01sec)
 06: 2500    mV Excitation
 07: 12      Loc :
 08: .142    Mult
 09: 0.0000  Offset

06:  P86     Do
 01: 55      Set low Port 5
==================================================================
take tower RMY vel. 10-sec counts

07:  P3      Pulse
 01: 1       Rep
 02: 1       Pulse Input Chan
```

```
=FORMULA("=IF(RC[-6]>-5,if(rc[-6]<5,rc[-6],r[-1]c),R[-1]C)")
=COPY()
=SELECT("R2C10:R2C12")
=PASTE()
=SELECT("R3C9:R2001C12")
=PASTE()
=HLINE(6)
=SELECT("R2C9:R5C12")
=COPY()
=SELECT("R1C9")
=FORMULA("'Load Cell 1")
=SELECT("R1C10")
=FORMULA("'Load Cell 2")
=SELECT("R1C11")
=FORMULA("'Load Cell 3")
=SELECT("R1C8:R2001C11")
=COPY()
=CREATE.OBJECT(5,"R11C20",3.75,9,"R22C25",38.25,12,1,TRUE)
=CHART.WIZARD(TRUE,"TR4ldcel.TXT!R1C8:R2001C11",7,2,2,1,1,1,"TRENCH 4 - Load Cells","JULIAN DAY"
=UNHIDE("TR4ldcel.TXT Chart 1")
=WINDOW.MAXIMIZE()
=SELECT("S1")
=PATTERNS(0,1,1,3,2,1,1,3,FALSE)
=SELECT("S2")
=PATTERNS(0,2,3,3,2,1,1,4,FALSE)
=SELECT("S3")
=PATTERNS(0,3,7,3,2,1,1,5,FALSE)
=SELECT("Axis 1")
=PATTERNS(1,1,1,1,4,1,4)
=SCALE(TRUE,TRUE,TRUE,TRUE,-5,FALSE,FALSE,FALSE)
=GRIDLINES(FALSE,FALSE,TRUE,FALSE)
=Setup_Page()
=ECHO(TRUE)
=IF(Print_Plots_on_Printer)
=  PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=ELSE()
=  DIALOG.BOX(OPTIONS_MENU)
=  IF(PrintorContinue=1)
=    PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=  END.IF()
=END.IF()
=FILE.CLOSE(FALSE)
=FILE.CLOSE(FALSE)
=ECHO(FALSE)
=RETURN()


=ECHO(FALSE)
=IF(FILE.EXISTS("C:\SOIL\TR5LDCEL.TXT"))
=  OPEN("C:\soil\TR5ldcel.txt")
=ELSE()
```

03: 1 Low level AC
04: 15 Loc :
05: .0098 Mult (based on 0.0980/T(sec))
06: 0 Offset

take TR-1 RMY vel. 10-sec counts

08: P3 Pulse
01: 1 Rep
02: 2 Pulse Input Chan
03: 1 Low level AC
04: 16 Loc :
05: .0098 Mult (based on 0.0980/T(sec))
06: 0 Offset

(CONFIRM MULTIPLIER and ports that are wired)
Take RMY 10-sec readings

09: P101 SDM-INT8
01: 2 Address
02: 0000 Input config; channels 8,7,6,5
03: 2222 Chan4321=LLrise/LLrise/LLrise/LLrise/
04: 0000 Function; channels 8,7,6,5
05: 7700 Chan4321=Counts/Counts/none/none/
06: 0 Execution interval averaging
07: 17-- Loc :
08: 0.098 Mult
09: 0.0000 Offset

Take MET 10-sec readings

10: P102 SDM-SW8A
01: 3 Reps
02: 00 Address
03: 2 Counts function
04: 6 Chan
05: 19-- Loc :
06: .0800 Mult (based on 0.800/T(sec))
07: 0.447 Offset

```
=  ALERT("File: 'C:\SOIL\TR5LDCEL.TXT' does not exist.")
=  RETURN()
=END.IF()
=SELECT("R2C2:R2001C2")
=COPY()
=SELECT("R2C8")
=PASTE()
=SELECT("R2C9")
=FORMULA("=IF(RC[-6]>-5,if(rc[-6]<5,rc[-6],r[-1]c),R[-1]C)")
=COPY()
=SELECT("R2C10:R2C12")
=PASTE()
=SELECT("R3C9:R2001C12")
=PASTE()
=HLINE(6)
=SELECT("R2C9:R5C12")
=COPY()
=SELECT("R1C9")
=FORMULA("'Load Cell 1")
=SELECT("R1C10")
=FORMULA("'Load Cell 2")
=SELECT("R1C8:R2001C11")
=COPY()
=CREATE.OBJECT(5,"R11C20",3.75,9,"R22C25",38.25,12,1,TRUE)
=CHART.WIZARD(TRUE,"TR5ldcel.TXT!R1C8:R2001C10",7,2,2,1,1,1,"TRENCH 5 - Load Cells","JULIAN DAY"
=UNHIDE("TR5ldcel.TXT Chart 1")
=WINDOW.MAXIMIZE()
=SELECT("S1")
=PATTERNS(0,1,1,3,2,1,1,3,FALSE)
=SELECT("S2")
=PATTERNS(0,2,3,3,2,1,1,4,FALSE)
=SELECT("Axis 1")
=PATTERNS(1,1,1,1,4,1,4)
=SCALE(TRUE,TRUE,TRUE,TRUE,-5,FALSE,FALSE,FALSE)
=GRIDLINES(FALSE,FALSE,TRUE,FALSE)
=Setup_Page()
=ECHO(TRUE)
=IF(Print_Plots_on_Printer)
=  PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=ELSE()
=  DIALOG.BOX(OPTIONS_MENU)
=  IF(PrintorContinue=1)
=    PRINT(1,,,1,FALSE,FALSE,1,FALSE,1,-4)
=  END.IF()
=END.IF()
=FILE.CLOSE(FALSE)
=FILE.CLOSE(FALSE)
=ECHO(FALSE)
=RETURN()
```

Start other readings every 10 minutes

```
11:  P92      If time is
 01: 0        minutes into a
 02: 10       minute interval
 03: 30       Then Do

12:  P10      Battery Voltage
 01: 100      Loc :
```

take snowmelt gauge readings

```
13:  P102     SDM-SW8A
 01: 5        Reps
 02: 0        Address
 03: 2        Counts function
 04: 1        Chan
 05: 1--      Loc :
 06: 1        Mult
 07: 0        Offset
```

take SDS readings. Take five readings of each, then
average them.

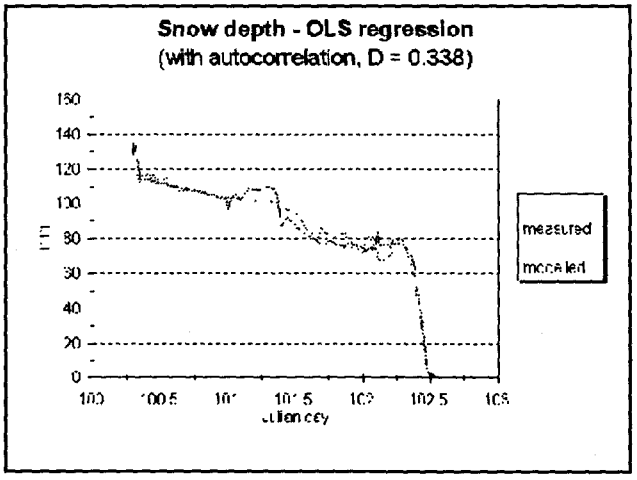
```
14:  P87      Beginning of Loop
 01: 1        Delay
 02: 5        Loop Count

15:  P108     User Special(TOWER SDS)
 01: 03       Address
 02: 50       Ref Temp Loc:  (TR-3 atmospheric)
 03: 73--     Loc :
 04: -1       Mult
 05: 1426.5   Offset

16:  P108     User Special(TR-1 SDS)
 01: 10       Address
 02: 40       Ref Temp Loc:  (TR-1 atmospheric)
 03: 78--     Loc:
 04: -1       Mult
 05: 1374.3   Offset

17:  P108     User Special(TR-3 SDS)
 01: 11       Address
```

DEFAULT


Snow depth - OLS regression
(with autocorrelation, D = 0.338)
150
140
120
100
80
60
40
20
0
100
100.5
101
101.5
102
102.5
103
measured
modeled

02: 50 Ref Temp Loc: (TR-3 atmospheric)
03: 83-- Loc:
04: -1 Mult
05: 0 Offset

18: P108 User Special(TR-4 SDS)
01: 33 Address
02: 50 Ref Temp Loc: (TR-3 atmospheric)
03: 88-- Loc:
04: -1 Mult
05: 0 Offset

19: P108 User Special (TR-5 SDS)
01: 13 Address
02: 61 Ref Temp Loc: (TR-5 atmospheric)
03: 93-- Loc:
04: -1 Multipler
05: 1350.8 Offset

20: P95 End

take SDS averages

21: P51 Spatial Average
01: 5 Swath
02: 73 First Loc
03: 6 Avg Loc :

22: P51 Spatial Average
01: 5 Swath
02: 78 First Loc
03: 7 Avg Loc :

23: P51 Spatial Average
01: 5 Swath
02: 83 First Loc
03: 8 Avg Loc :

24: P51 Spatial Average
01: 5 Swath
02: 88 First Loc
03: 9 Avg Loc :

25: P51 Spatial Average
01: 5 Swath

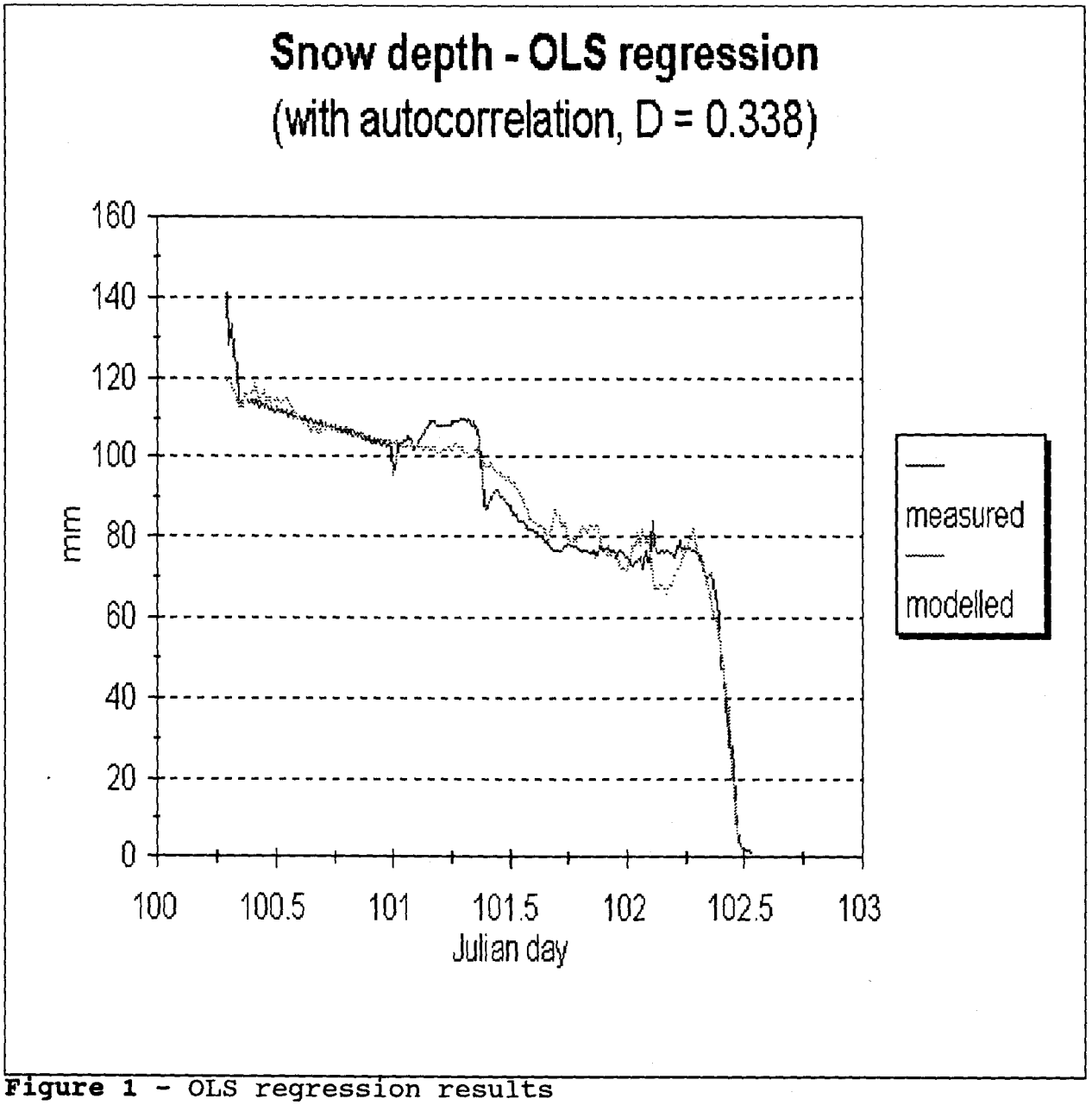


Figure 1 - OLS regression results

```
 02: 93      First Loc
 03: 10      Avg Loc :


start tower MUX readings==================================

take HMP35C temperature and RH measurements

26:  P86     Do
 01: 44      Set high Port 4

27:  P86     Do
 01: 78      Pulse Port 8

take level 1 temperature

28:  P11     Temp 107 Probe
 01: 1       Rep
 02: 1       IN Chan
 03: 1       Excite all reps w/EXchan 1
 04: 30      Loc :
 05: 1       Mult
 06: 0.0000  Offset

29:  P86     Do
 01: 78      Pulse Port 8

take level 1 relative humidity reading

30:  P4      Excite,Delay,Volt(SE)
 01: 1       Rep
 02: 5       2500 mV slow Range
 03: 1       IN Chan
 04: 2       Excite all reps w/EXchan 2
 05: 15      Delay (units .01sec)
 06: 2500    mV Excitation
 07: 27      Loc :
 08: .1      Mult
 09: 0.0000  Offset

31:  P86     Do
 01: 78      Pulse Port 8
```

Preliminary Model

A preliminary model was developed using all the data (including all wind and soil temperature parameters) described above. This provided a 'worst-case' model since no corrections for multicollinearity and autocorrelation were made. It also provided an initial evaluation of the influence of the independent parameters on the dependent snow measurements, degree of autocorrelation, and the presence of multicollinearity.

Regression of the meteorological parameters on snowmelt resulted in a R^2 of 0.534 and significant t-tests for IN, OUT, NET, and SOIL2. A regression on snow depth resulted in a R^2 of 0.900 and significant t-tests for IN, OUT, LONG, NET, TEMP, RH, WIND, SOIL1, and SOIL2. Based upon these results only, these models would be encouraging.

However, both models showed signs of autocorrelation and multicollinearity. The Durbin-Watson D-statistics strongly rejected the null hypothesis of no autocorrelation. Multicollinearity was confirmed by variance inflation factors near 100 (WIND2 and WIND3) and condition numbers near 30.

First, multicollinearity was confirmed by regression each wind parameters on each of the others. In all cases, this resulted in a R^2 of 0.93 or higher. The same procedure was done with the soil temperatures. SOIL1 regressed on SOIL2 resulted in a R^2 of 0.93. The issue of similar diurnal trends in parameters producing multicollinearity will be addressed in the 'Parameter Interaction' section below.

Treating Multicollinearity

One symptom of multicollinearity is inflated R^2 values. Another is instable regression results. The first step in removing the multicollinearity was deciding which single wind and soil temperature parameter to include in the models. Based on physical reasoning, assumptions can be made about the relative importance and influence of these parameters. Wind is the driving force behind sensible and latent heat transfer at the snow-atmosphere interface. Therefore, it was hypothesized that the wind measurements nearest this interface would more strongly correlate with snowmelt rates. Similarly, it was assumed that the soil temperature nearest the snow-ground interface would be a more accurate inference to the heat transfer between the snow and soil.

These hypotheses were tested by regressing each parameter individually against the dependent variable MELT. As expected, the regression of WIND1 resulted in the highest R^2 and t-test values. Only the t-test for WIND1 was statistically significant at $\alpha = 0.05$. While the R^2 for WIND1 was approximately three times greater than the others, its value of 0.016 is small enough to question the usefulness of the results. Both of the soil

take level 2 temperature measurements

```
32:  P11      Temp 107 Probe
 01: 1       Rep
 02: 1       IN Chan
 03: 1       Excite all reps w/EXchan 1
 04: 31       Loc :
 05: 1       Mult
 06: 0       Offset

33:  P86      Do
 01: 78      Pulse Port 8
```

take level 2 relative humidity readings

```
34:  P4       Excite,Delay,Volt(SE)
 01: 1       Rep
 02: 5       2500 mV slow Range
 03: 1       IN Chan
 04: 2       Excite all reps w/EXchan 2
 05: 15       Delay (units .01sec)
 06: 2500     mV Excitation
 07: 28       Loc :
 08: .1      Mult
 09: 0       Offset

35:  P86      Do
 01: 78      Pulse Port 8
```

take level 3 temperature measurement

```
36:  P11      Temp 107 Probe
 01: 1       Rep
 02: 1       IN Chan
 03: 1       Excite all reps w/EXchan 1
 04: 32       Loc :
 05: 1       Mult
 06: 0       Offset

37:  P86      Do
 01: 78      Pulse Port 8
```

falling on mature snow. Furthermore, given such thin snowpacks it is assumed that the snowpack remains homogeneous. Data collected helps support this assumption. The graphs on the next three pages show that snowmelt (no y-axis) was measured near the beginning of the three datasets. This snowmelt is strong evidence that the snowpack had quickly reached the mature stage.

Initial statistical modelling was started with the PC version of SAS. When the site license of that software package expired in mid-stream, SPSS (ver 6.1 for Windows) was selected for the completion of this project. Comments on t-tests are based upon $\alpha = 0.05$.

Model Design

The snowmelt model was development in an iterative fashion. The general strategy was to examine several issues separately. Several challenges were expected due to modelling time-series data with ordinary least squares (OLS) techniques. The most difficult challenge was autocorrelation. Two models that eliminated autocorrelation will be discussed, both of which have serious drawbacks. It is hoped that the insight provided by the other exploratory models developed is valid, despite their autocorrelation problems.

The degree of autocorrelation was assessed with the Durbin-Watson D-statistic. Multicollinearity was detected with variance inflation factors and condition numbers. Since several parameters have diurnal trends (atmospheric and soil temperatures and shortwave solar components) parameter interaction and combinations were explored.

In the model descriptions the following parameter abbreviations will be used:

MELT	measured snowmelt
DEPTH	measured snow depth
IN	incoming shortwave solar energy
OUT	reflected shortwave solar energy
LONG	incoming longwave solar energy
NET	net solar energy
TEMP	atmospheric temperature @ 2 m
RH	relative humidity @ 2 m
WIND1	wind velocity @ 0.5 m
WIND2	wind velocity @ 2 m
WIND3	wind velocity @ 5 m
WINDP	wind velocity @ 2 m (other location)
SOIL1	soil temperature at -10 cm
SOIL2	soil temperature at -20 cm

take level 3 relative humidity reading

```
38:  P4      Excite,Delay,Volt(SE)
 01: 1       Rep
 02: 5       2500 mV slow Range
 03: 1       IN Chan
 04: 2       Excite all reps w/EXchan 2
 05: 15      Delay (units .01sec)
 06: 2500    mV Excitation
 07: 29      Loc :
 08: .1      Mult
 09: 0       Offset

39:  P86     Do
 01: 78      Pulse Port 8
```

take upward Epply pyranometer reading

```
40:  P2      Volt (DIFF)
 01: 1       Rep
 02: 2       7.5 mV slow Range
 03: 2       IN Chan
 04: 22      Loc :
 05: 108.1   Mult
 06: 0       Offset

41:  P86     Do
 01: 78      Pulse Port 8
```

take downward Epply pyranometer reading

```
42:  P2      Volt (DIFF)
 01: 1       Rep
 02: 2       7.5 mV slow Range
 03: 2       IN Chan
 04: 23      Loc :
 05: 112.4   Mult
 06: 0       Offset

43:  P86     Do
 01: 78      Pulse Port 8
```

take upward Eppley pyrgeometer reading

temperatures are measured 10 cm and 20 cm below the ground surface. Wind velocity is measured at several locations including at the weather tower at three heights: 0.5 m, 2 m and 5 m.

Data from three snowfall events were prepared for this modelling exercise. Fourteen centimeters of snow fell during each of the three events. The three melt events produced a total of 16.3, 17.7 and 18.1 liters per square meter respectively. All event datasets begin at the time of maximum snowfall (end of snow storm) and end when one centimeter of snow remained. The snowmelt event used for model development (referred to as 'event 1') occurred April 10-12, 1994. The dataset used starts at approximately 6:00 am on April 10, and ends at noon on April 12. Data was measured every ten minutes, and n = 216. The other two snowfall events were selected for model verification. Event 2 begins January 29, at 8:20 pm, and ends February 7, at 1:50 pm. Event 3 begins February 12, at 1:50 am, and ends at noon on February 15. Measurements for both events 1 and 2 were taken at fifteen minute intervals, and n = 846 and 333 respectively. The issue of different measurement intervals will be discussed in the 'Model Verification' section.

Except for the event 1 snow depth, the data are completely unfiltered. Snow depth is measured with a ultrasonic depth gauge. Data from snow depth sensors are often very noisy due to winds, blowing snow and non-level surfaces. Snowmelt is measured with a 1 m^2 circular pan which drains into a subsurface rain gauge. The unit for measured snowmelt used in this report is 'tips of snowmelt gauge.' When the gauges are fully calibrated, this unit will be converted directly to mm/hr of meltwater.

The meteorological parameters will be used as the model's independent variables. Measured snowmelt and snow depth will be used separately as the model's dependent variables. While both snowmelt and snow depth are indices for the rate of snowmelt, snowmelt is the preferable index. Snowmelt has the important advantage of translating directly into water input into the soil.

Changes in snow depth can be caused not only by snowmelt entering the ground, but by wind compaction, snow metamorphism, evaporation, and sublimation. Despite this greater complexity, snow depth can be an important snowmelt rate index if an assumption about snow density can be made. This assumption is that the snow density quickly increases from fresh snow values (80-120 kg/m^3) to 'mature' values (500 kg/m^3). Snow at this mature density is at the point of phase change, the transition point between snow crystals and meltwater. As snow passes through this phase change, the meltwater is pulled by gravity through the remaining snowpack and exits the snowpack system relatively quickly.

Conditions at RFP made this a reasonable assumption. All of the snowfall events recorded since December 16, 1993 have been isolated events, with a maximum snowfall of 19.5 cm. Isolated events prevent the occurrence of layers forming due to fresh snow

44: P2 Volt (DIFF)
01: 1 Rep
02: 2 7.5 mV slow Range
03: 2 IN Chan
04: 24 Loc :
05: 270.3 Mult
06: 0 Offset

45: P86 Do
01: 78 Pulse Port 8

take REBS net radiometer reading

46: P2 Volt (DIFF)
01: 1 Rep
02: 4 250 mV slow Range
03: 2 IN Chan
04: 26 Loc :
05: 12.9 Mult
06: 0 Offset

Take tower snow density plate loadcell readings

47: P86 Do
01: 78 Pulse Port 8

48: P6 Full Bridge
01: 1 Rep
02: 2 7.5 mV slow Range
03: 1 IN Chan
04: 1 Excite all reps w/EXchan 1
05: 2500 mV Excitation
06: 65 Loc :
07: 1 Mult
08: -0.006 Offset

49: P86 Do
01: 78 Pulse Port 8

50: P6 Full Bridge
01: 1 Rep
02: 2 7.5 mV slow Range
03: 1 IN Chan
04: 1 Excite all reps w/EXchan 1
05: 2500 mV Excitation

The Development of a Linear Regression Model for Snowmelt - Draft
Jim Moffitt - Soil Study Team

The following report documents initial statistical modelling of the snowmelt data. It documents modelling work from November 1 - December 7, 1994.

Research Question

The goal of the following statistical analysis is to study the effect eight meteorological parameters have on snowmelt rates. The role of snowmelt in the fate and transport of actinides in soils surrounding the Rocky Flats Plant (RFP) is being investigated as part of a comprehensive environmental remediation study. A critical part of this study is to measure and model the movement of precipitation through the soil. A snowmelt model will be developed to assess the timing and magnitude of the water input from snow. This information will help determine if the contaminants in the soil are mobile and a threat to the underlying groundwater.

Two types of models are being developed to predict the contribution of extreme snowmelt events in producing flow through the soil: process-driven and statistical. Process-driven models take into account heat transfer theory, aerodynamic formulae and snow metamorphism. These processes are coupled with heat and mass balances to address evaporation, sublimation, changing snow density, and snowmelt rates.

This report focuses on the development of a deterministic, linear regression model. Methods and assumptions of model development will be discussed. Finally, its predictive capability will be compared with two different snowmelt events.

Description of Data

Field data for this study is collected with a system which attempts to account for the complete water budget of the top meter of soil. The system consists of both subsurface and above-ground data collection. Subsurface instrumentation includes groundwater piezometers, two methods of soil moisture measurement (Time Domain Reflectometry probes and tensiometers), soil temperatures, and apparatus which allows both free-flowing and immobile soil water to be collected and sampled for chemical analysis. The above-ground instrumentation measures parameters that characterize rainfall, evaporation and snowmelt.

The parameters being measured for snowmelt model input include solar energy components, wind velocity, atmospheric and soil temperatures, and relative humidity. The parameters used for snowmelt model verification are snow depth and snowmelt.

The solar energy components include incoming and reflected shortwave solar radiation, incoming longwave solar radiation, and net solar radiation. These measurements are made from a weather tower at a height of 5 m. Relative humidity and atmospheric temperature measurements are made at a height of 2 m. Soil

The Development of a Linear Regression Model for Snowmelt

Final Project - APPM 5580

December 8, 1994

Jim Moffitt

06: 66 Loc :
07: 1 Mult
08: 0.004 Offset

51: P86 Do
01: 78 Pulse Port 8

52: P6 Full Bridge
01: 1 Rep
02: 2 7.5 mV slow Range
03: 1 IN Chan
04: 1 Excite all reps w/EXchan 1
05: 2500 mV Excitation
06: 67 Loc :
07: 1 Mult
08: 0.0000 Offset

53: P86 Do
01: 54 Set low Port 4

END TOWER MUX READINGS

START TR-1 MUX READINGS==========

54: P86 Do
01: 45 Set high Port 5

55: P87 Beginning of Loop
01: 0000 Delay
02: 10 Loop Count

56: P86 Do
01: 78 Pulse Port 8

57: P11 Temp 107 Probe
01: 1 Rep
02: 1 IN Chan
03: 1 Excite all reps w/EXchan 1
04: 33-- Loc :
05: 1 Mult
06: 0.0000 Offset

58: P95 End (temp loop)

PLATE #2 LOADCELL CODE HERE

```
59: P86     Do
 01: 55     Set low Port 5
```

END TR-1 MUX READINGS

START TR-3 MUX READINGS

```
60: P86     Do
 01: 46     Set high Port 6

61: P87     Beginning of Loop
 01: 0000   Delay
 02: 11     Loop Count

62: P86     Do
 01: 78     Pulse Port 8

63: P11     Temp 107 Probe
 01: 1      Rep
 02: 1      IN Chan
 03: 1      Excite all reps w/EXchan 1
 04: 43--   Loc :
 05: 1      Mult
 06: 0      Offset

64: P95     End (temp loop)

65: P86     Do
 01: 56     Set low Port 6
```

END TR-3 MUX readings

START TR-5 MUX READINGS==========

```
66: P86     Do
 01: 47     Set high Port 7

67: P87     Beginning of Loop
 01: 0000   Delay
 02: 9      Loop Count
```

& 3 based on the initial OLS model. Since the time intervals were different, the model predictions were adjusted accordingly. The original model was based upon ten minute intervals, the data for events 2 & 3 were collected on fifteen minute intervals. The model predictions were multiplied by 1.5. This action assumes that the relationship between the measuremed parameters and snowmelt vary linearily with time. Both the snowmelt models are extremely erratic, have periods of negative snowmelt rates, and show little diurnal trends.

The snow depth models appear better. The model follows the trends well. The model produced a R^2 of 0.80 for event 2, and 0.29 for event 3. If the last day of event 3 is omitted, the R^2 increases to 0.86.

The next three show the results of the autoregression model. The model fit very well for event 2. The results for event 3 resulted in over and under prediction of snowmelt. The excellent fit of the graph on page 40 is the result of constraining the model to 'no-negative' snowmelt. Again, since these models are dependent on previous actual measurements, these excellence results are not a big surprise.

The next two graphs show the results of the SHORTS snowmelt model. This model did a very poor job of snowmelt prediction. Surprisingly, the model did not even reproduce the diurnal trends of the snowmelt.

Finally, temperature model prediction were generated for events 2 and 3. The next graph show the model results for event 2. The diurnal trends are matched, but the model under predicted. The 'corrected' version of this model is shown on the following page. The corrections are a constant offset and not allowing melt at night. This version matched the measured snowmelt timing and magnitude well. While this model is promising, it is dependent on the selected offset, which is a major disadvantage. The final two graphs are of the TEMP models prediction of event 3. The same offset is used and appears valid since it resulted in no negative snowmelt. While the timing is reasonably matched, the magnitude of snowmelt is under predicted.

Conclusions

The solar components were the parameters which most frequently appeared as significant in the regression models. This is important information for two reasons. First, it agrees with what has been determined with previous process-driven snowmelt models. Secondly, solar data is collected (or can be calculated) globally, and thus allows the scale of snowmelt modelling to be expanded.

The 'verification' graphs provide ideas on how to improve the modelling results of the regression models. The models could be constrained by 'rules' based on physical reasoning. For example, increases in snow depth could be prevented (assuming

```
68:  P86      Do
 01: 78      Pulse Port 8

69:  P11      Temp 107 Probe
 01: 1       Rep
 02: 1       IN Chan
 03: 1       Excite all reps w/EXchan 1
 04: 54--    Loc :
 05: 1       Mult
 06: 0       Offset

70:  P95      End

71:  P86      Do
 01: 57      Set low Port 7
```

==========

adjust temperature probe readings with cal. offsets

```
72:  P53      Scaling Array (A*loc +B)
 01: 33      Start Loc :
 02: 1       A1
 03: -.18298 B1 TR-1 0 cm
 04: 1       A2
 05: .04596  B2 TR-1 1
 06: 1       A3
 07: -.01064 B3 TR-1 2
 08: 1       A4
 09: .09727  B4 TR-1 3

73:  P53      Scaling Array (A*loc +B)
 01: 37      Start Loc :
 02: 1       A1
 03: -.1735  B1 TR-1 4
 04: 1       A2
 05: -.01529 B2 TR-1 5
 06: 1       A3
 07: .08885  B3 TR-1 6
 08: 1       A4
 09: -.06371 B4 TR-1 atmos

74:  P53      Scaling Array (A*loc +B)
 01: 41      Start Loc :
 02: 1       A1
 03: .21617  B1 TR-1 -10cm
```

result in increased snow depth. Increased snow depth due to increased relative humidity occurs only during snowfall, which never happened during the dataset periods.

To help compare the models and summarize the results Table 9 was developed. It illustrates the range and consistency of the coefficient estimates. Table 9 reflects a degree of consistency in the OLS models. The solar components, soil temperature and wind speed parameter frequently appear as statistically significant in predicting snowmelt rates. The signs of the IN and SOIL coefficients are opposite from what is expected. This casts serious doubts on the usefulness of the models with negative IN coefficients. There may be an explanation for the

Table 9 - Summary of snowmelt models

	Orig OLS	Shorts	Day time	25% sample	Temp	Auto regress
IN	-0.036	1.142	-0.079	-	-	-
OUT	0.117	$x10^{-4}$	0.184	-	-	0.122
LONG	0.123	0.173	0.235	0.257	-	-
NET	-	-	0.071	-0.074	-	-
TEMP	-	-	-	3.31	1.83	-
SOIL	-17.30	-15.94	-20.6	-34.52	-	-
RH	-	-	-	-	-	-
WIND	-5.02	-3.97	-5.50	-7.72	-	-
Adj R^2	0.49	0.57	0.46	0.73	0.18	-

SOIL coefficient. The soil temperature steadily declined for two days until after the snowmelt spike at the end. At this time the soil temperature quickly increased. The snowpack probably acted as an effective insulating layer. As the snow quickly disappeared, the soil temperatures quickly increased. This would result in a negative coefficient, and may be a good reason to remove SOIL from future model specifications.

Four of the developed models were used to model the data from events 2 & 3. The original OLS, the autoregression, the shortwave interaction, and the temperature models were selected. The OLS and regression were selected based upon their event 1 goodness-to-fit. The other two were selected based upon their simplicity.

The next four graphs show the model predictions for events 2

04: 1 A2
05: -.07923 B2 TR-1 -20cm
06: 1 A3
07: .14470 B3 TR-3 0cm
08: 1 A4
09: .28372 B4 TR-3 1

75: P53 Scaling Array (A*loc +B)
01: 45 Start Loc :
02: 1 A1
03: -.38725 B1 TR-3 2
04: 1 A2
05: .05764 B2 TR-3 3
06: 1 A3
07: .11822 B3 TR-3 4
08: 1 A4
09: .22583 B4 TR-3 5

76: P53 Scaling Array (A*loc +B)
01: 49 Start Loc :
02: 1 A1
03: .04744 B1 TR-3 6
04: 1 A2
05: .15120 B2 TR-3 atmos
06: 1 A3
07: .14418 B3 TR-3 -10cm
08: 1 A4
09: .11995 B4 TR-3 -20cm

77: P53 Scaling Array (A*loc +B)
01: 53 Start Loc :
02: 1 A1
03: 0.0000 B1 TR-3 rain guage
04: 1 A2
05: -.0327 B2 TR-5 0cm
06: 1 A3
07: -.12468 B3 TR-5 1
08: 1 A4
09: .00173 B4 TR-5 2

78: P53 Scaling Array (A*loc +B)
01: 57 Start Loc :
02: 1 A1
03: .02616 B1 TR-5 3
04: 1 A2

variance in the data. This allows the model to be simplified and reduces multicollinearity.

An experienced regression modeler would probably apply this analysis tool early in the modelling exercise. I, however, first tried it after the above models were developed. Factor analysis identified IN (55.3%) and LONG (25.1%) as contributing 80.4% of the dataset's variance. Given the autocorrelation in the snow data, this would have provided a non-biased indication of the important parameters to specify in a model.

Model Selection and Verification

Beyond curve fitting, the validity of the developed models can be assessed by the signs of the parameter coefficients. Do they make physical sense? For example, if a model results in decreasing atmospheric temperature producing increased snowmelt rates, then it is a result of pure statistical chance, not physical relationships. Table 8 illustrates the effects on the dependent variables expected due to changes in the independent variables. For example, increased shortwave radiation is expected to increase snowmelt rates and decrease snow depth. Increased relative humidity, on the other hand, could effect snowmelt several ways. It could mean that it is snowing (decreased snowmelt), raining (increased snowmelt), or the snow could be evaporating due to intense melting.

Table 8

Parameter ---->	IN		OUT		LONG		NET		RH	
Δ parameter	-	+	-	+	-	+	-	+	-	+
Δ snowmelt rate	-	+	-+	-+	-	+	-	+	-+	-+
Δ snow depth		-		-		-		-		-+

Parameter ---->	TEMP		SOIL		WIND		MELT		DEPTH	
Δ parameter	-	+	-	+	-	+	-	+	-	+
Δ snowmelt rate	-	+	-	+	-+	-+			+	-
Δ snow depth		-		-		-+		-		

Table 8 helps illustrate why the snow depth models tended to have better goodness-of-fit. Snow depth is constrained mainly in the negative direction. Only positive changes in RH and WIND can

05: .01322 B2 TR-5 4
06: 1 A3
07: -.31349 B3 TR-5 5
08: 1 A4
09: -.31135 B4 TR-5 6

79: P53 Scaling Array (A*loc +B)
01: 61 Start Loc :
02: 1 A1
03: -.08749 B1 TR-5 atmos
04: 1 A2
05: 0.0000 B2 TR-5 rain gauge
06: 1 A3
07: 0 B3 empty Loc:
08: 1 A4
09: 0 B4 empty Loc:

80: P86 Do
01: 10 Set high Flag 0 (output)

81: P80 Set Active Storage Area
01: 1 Final Storage Area 1
02: 116 Array ID or location

82: P92 If time is (if 90 min interval, set ID to 111)
01: 0 minutes into a
02: 90 minute interval
03: 30 Then Do

83: P80 Set Active Storage Area
01: 1 Final Storage Area 1
02: 111 Array ID or location

84: P95 End (if two hour interval)

85: P77 Real Time
01: 0110 Day,Hour-Minute

86: P70 Sample snowmelt pans, SDS, RMY DIR
01: 14 Reps
02: 1-- Loc

offered by SPSS were used to develop a snowmelt model. The results are summarized in Table 7.

Table 7 - Summary of Autoregressive Models

Algorithm	rho	Adj-R^2	D-stat	Sig parameters, coefficient
Exact Max-Likelihood	0.829	--	--	LONG 0.1228
Cochran-Orcutt	0.832	0.055	1.716	LONG 0.1218
Prais-Winsten	0.832	0.055	1.715	LONG 0.1221

The graph on the following page shows the results of the Exact Maximum Likelihood method (the other two produced similar results). While the model fits the measured values extremely well, this fact reveals the major drawback that autoregressive models have when applied to datasets with short measurement intervals. Each new prediction takes into account the residual from the previous time step. If the subject matter was economic forecasting, with a quarterly or annually time interval, this poses no problem. With a time interval of ten minutes, however, this 'forecast' capability is useless. This would be equivalent to forecasting the price of a stock ten minutes from now. Any modelling equation which has a measured dependent parameter on the right hand side (or its residual) will have this critical disadvantage. What is needed is a robust model which given snowpack and weather parameters, can model snowmelt independently from snowmelt measurements.

Now for the good news. Autoregression models can provide a more accurate picture of significant parameters, and thus their coefficients. For the snowmelt model, this news was not so good. All three algorithms were consistent in selecting only the longwave solar radiation (LONG) as being statistically significant. It seems this result is due to this particular dataset, and not a strong physical relationship between longwave radiation and snowmelt rates.

Principal Components

Factor analysis, using principal analysis, was used to study the variance each parameter introduces to the model. Factor analysis allows the complete dataset to be reduced to a smaller amount of parameters by identifying the ones responsible for the

```
87:  P71      Average the P1/P2 RMY 1-min counts
 01: 2       Reps
 02: 15--    Loc

88:  P71      Average the RMY 10-sec counts
 01: 2       Reps
 02: 17--    Loc

89:  P71      Average the MET 10-sec counts
 01: 3       Reps
 02: 19--    Loc

90:  P70      Sample rest of standard body
 01: 41      Reps   (5 solars, 6 HMP35Cs, 30 107TPs)
 02: 22--    Loc

91:  P87      Beginning of Loop
 01: 0000    Delay
 02: 2       Loop Count

92:  P70      Sample (store 5555 in fields for ht/density plates)
 01: 1       Reps
 02: 99      Loc

93:  P95      End

94:  P70      Sample snow density plate #1 loadcells
 01: 3       Reps
 02: 65--    Loc

95:  P87      Beginning of Loop
 01: 0000    Delay
 02: 5       Loop Count

96:  P70      Sample
 01: 1       Reps
 02: 99      Loc

97:  P95      End

98:  P70      Sample the system voltage
 01: 1       Reps
 02: 100     Loc

99:  P77      Real Time
```

Table 6 - Results of 25% Random Sample

MELT	R^2	D stat	F value	t-test significant
Sample #1	0.52	1.55	7.79	NET OUT
Sample #2	0.73	1.83	16.95	NET LONG TEMP SOIL1 WIND1
Sample #3	0.33	2.15	4.73	NET
DEPTH	**R^2**	**D stat**	**F value**	**t-test significant**
Sample #1	0.98	1.58	321.6	IN NET OUT TEMP SOIL1
Sample #2	0.97	1.49	200.6	IN NET OUT TEMP SOIL1
Sample #3	0.96	1.35	135.4	NET OUT SOIL1 RH

Based upon these results, the snowmelt sample #2 and snow depth sample #1 were selected to evaluate the model's effectiveness. Graphs on the next two pages show the goodness-of-fit for these two models. Both models consistently under predicted the snowmelt and depth. Since there appeared to be a constant offset, this offset was used to 'correct' the model. This allowed the model's ability to predict the snowmelt rate trends to be assessed. Since both estimated constants were found to be statistically significant, this needed correction reflects poorly on the model's success.

The snow depth random sample model fit was very good. The R^2 for this model compared to the complete set of data remained high at 0.94. However, the autocorrelation was not removed. Random sampling did remove autocorrelation for the snowmelt model. Comparing the goodness-of-fit of this model with the original data reduced the R^2 from 0.73 to 0.32. This model did not reproduce the snowmelt rate trends well and is of questionable usefulness.

Autoregression

Autoregressive techniques were investigated to handle the strong autocorrelation of the snow data. The models developed assumed a first-order autocorrelation. The three algorithms

```
 01: 1000    Year

100: P82     Standard Deviation of wind velocities
 01: 7      Reps
 02: 15      Sample Loc

101: P96     Serial Output
 01: 71      SM192/SM716/CSM1

102: P95     End (if into 15 minute period)

103: P       End Table 1
```

==========

```
*    2       Table 2 Programs
 01: 30      Sec. Execution Interval
```

store 0 in SDM-CD16 ON/OFF locations (101-105)

```
01:  P87     Beginning of Loop
 01: 0       Delay
 02: 5       Loop Count

02:  P30     Z=F
 01: 0.0000  F
 02: 00      Exponent of 10
 03: 101--   Z Loc :

03:  P95     End
```

turn OFF SDM-CD16 switches

```
04:  P104    SDM-CD16
 01: 5       Reps
 02: 01      Address
 03: 101     Loc
```

start temperature checking, start heating if neccesary

Treating Autocorrelation

Conditions of autocorrelation produce biased standard error estimates and violate a classical OLS assumption. This assumption is that there is no correlation between sample errors. The violation of this assumption results in overly inflated significance of coefficients estimates. Samples from time series data can be expected to be autocorrelated.

Three methods were tried to remove the condition of autocorrelation: first-differences, random sampling and autoregression. Autoregression results will be discussed in the next section. The regression of first-differences on MELT failed to remove the autocorrelation. First-difference regression on DEPTH did remove the autocorrelation condition, but resulted in a R^2 of only 0.0237.

Random sampling proved slightly more successful. Approximately 20 sets of 50% samples are taken. Each set was regressed and the Durbin-Watson statistic generated. The following tables summarizes the regression results for the three sets with the highest D-statistic.

Table 5 - Results of 50% Random Sample

MELT	Adj R^2	D stat	F value	t-test significant
Sample #1	0.61	0.78	22.63	IN OUT WIND1
Sample #2	0.57	1.03	20.13	OUT LONG TEMP SOIL1 WIND1
Sample #3	0.48	0.96	11.71	OUT SOIL1 WIND1
DEPTH	**Adj R^2**	**D stat**	**F value**	**t-test significant**
Sample #1	0.94	0.78	187.4	NET LONG OUT RH SOIL1 TEMP1
Sample #2	0.95	0.61	290.8	IN NET LONG OUT RH SOIL1
Sample #3	0.94	0.51	221.1	NET LONG OUT RH SOIL1

The snowmelt models were consistent only in specifying the OUT solar component as statistically significant in determining melt rates. The snow depth models were consistent in specifying NET, LONG, OUT, RH and SOIL1. If enough samples were taken, it is possible that the models would have converged on a stable set of parameters. No more samples were taken due to the low D-statistics.

It was clear that 50% samples was not adequate to remove the autocorrelation in the data. Therefore, 25% samples were tried next. Approximately 20 sets of the 25% samples were taken. Table 2 summarizes the regression results for the three datasets which showed the least signs of autocorrelation.

control logic: First check if either TR-3 or TR-5 temps are below zero. Preliminary data shows that the TR-5 snowmelt gauge is subject to greater temp fluctuations (both colder and warmer). It will be assumed that TR-3 better characterizes the other three snowmelt gauge locations due to similar topography (only TR-5 is near the hill top). Therefore, TR-5 temps will control the heating of its gauge only, while TR-3 will dictate what heating takes place at the tower, TR-1 & TR-4.

If the snowmelt gauges are below freezing, the heat will be turned on only if the atmospheric temp is above freezing (thus causing potential snowmelt to migrate down snowpack).

check if TR-3 snowmelt gauge temperature is below 0

```
05: P89     If X<=>F
 01: 53     X Loc (TR-3 snowmelt gauge temperature)
 02: 4      <
 03: 0      F    (freezing point)
 04: 30     Then Do
```

check if TR-3 atmospheric temperature is above 0

```
06: P89     If X<=>F
 01: 50     X Loc (TR-3 atmospheric temperature)
 02: 3      >=
 03: 0.0000 F
 04: 30     Then Do
```

if both cases are true, turn SDM-CD16 ON/OFF switches for tower, TR-1, TR-3 & TR-4 ON

```
07: P87     Beginning of Loop
 01: 0      Delay
 02: 4      Loop Count

08: P30     Z=F
 01: 1      F
 02: 0      Exponent of 10
 03: 101--  Z Loc :

09: P95     End (loop)
```

would take no more that two measurement intervals (twenty minutes) to reach the snowmelt gauges.

Table 4 summarizes the regression results. These results mainly reflect the high degree of autocorrelation in the data. They could also be interpreted as confirming that the models are corrected specified.

Table 4 - Lag Effects

	lags	Adj R2	t-test significant
Snowmelt	1	0.51	LONG OUT SOIL1 WIND1
	2	0.51	IN OUT WIND1
Snow depth	1	0.94	LONG IN OUT NET TEMP RH
	2	0.93	IN NET TEMP RH WIND1

Temperature Model

A model using only atmospheric temperature was developed next. Up until the seventies, the snowmelt models used only atmospheric temperature data to predict snowmelt rates. This method is referred to as 'degree-day' models. While these simple models are extremely inaccurate for 'real-time' modelling, they perform reasonably well for averaged time periods of a month or more on seasonal snowpacks. More importantly, this method relies solely on one of the most extensively measured weather parameters, atmospheric temperature. The performance of such a model will be assessed for snowmelt events that last on the order of a few days.

Given the simplicity of this model, it was developed for each of the three events. Table 5 summarizes the results. It appears that temperature models are not appropriate for short events.

Table 5 - Temperature models

	adj R^2	temp coefficient
event 1	0.18	1.83
event 2	0.20	0.64
event 3	0.36	1.83

10: P95 End (if atm >= 0)

11: P95 End (if RG < 0)

check if TR-5 snowmelt gauge temperature is below 0

12: P89 If X<=>F
01: 62 X Loc
02: 4 <
03: 0.000 F
04: 30 Then Do

check if TR-5 atmospheric temperature is above 0

13: P89 If X<=>F
01: 61 X Loc
02: 3 >=
03: 0.0000 F
04: 30 Then Do

if both cases are true, turn TR-5 SDM-CD16 ON/OFF
switch ON

14: P30 Z=F
01: 1 F
02: 00 Exponent of 10
03: 105 Z Loc :

15: P95 End (if atm >= 0)

16: P95 End (if RG < 0)

trigger SDM-CD16, turn on specified ports

17: P104 SDM-CD16
01: 5 Reps
02: 01 Address
03: 101 Loc

18: P End Table 2
Page 19 Table 3

original OLS model plus shortwaves	0.62	SHORTS IN OUT LONG

The following graph (next page) show the results of the three models in Table 2. The third model (original OLS model with the 'SHORTS' interaction term) had the highest adjusted R^2 value. While is matches the melt spike well, it consistently over predicts elsewhere. The second model is more promising. Its adjusted R^2 is considerably better than the original OLS model. It matches the measured trends well and has the advantage of being very simple.

Day Time Model

The next step was to include only the time period during daylight hours (6:00 am - 6:00 pm). The reason for this is that 81% of the event 1 melting occurred during these hours. The results from this model are summarized in Table 3.

The following two graphs show the results. Since the original OLS snow depth model (using all data) produced an adjusted R^2 of 0.95, it is not surprising that this day time

Table 3 - Results of 'day time' model

	Adj R^2	t-test significant
Snowmelt	0.46	IN OUT LONG NET WIND1
Snow depth	0.97	OUT LONG NET RH SOIL1

model retains a close fit. It was a surprise that the goodness-of-fit of day time snowmelt model deteriorated. While diurnal trends were retained, the magnitude of the snowmelt rate was poorly match. If an offset was introduced (the constant was not statistical significant), the model would poorly match either the first two or the last snowmelt period.

Lag Effects

Since the snow melting at the top of the snowpack is required to flow through the snowpack to reach the snowmelt gauge, lag effects were examined. Regression analysis was performed to assess the effects of parameter measurements from previous time steps on current measurements of snowmelt/depth. Given the thinness of the snowpack, it was assumed that snowmelt

10 Memory Allocation

01: 150 Input Locations
02: 150 Intermediate Locations
03: 0.0000 Final Storage Area 2

* C Mode 12 Security

01: 0000 LOCK 1
02: 0000 LOCK 2
03: 0000 LOCK 3

temperatures were regressed on the snowmelt measurements with inconclusive results. Since the R^2 values were even smaller (0.0009-0.0084), SOIL1 was selected for model development due to the physical reasoning stated above.

Regression results using only one wind velocity and soil temperature resulted in greatly decreased multicollinearity. It should be noted that during event 1 only the shortwave solar components showed diurnal trends. In more typical datasets (see event 2), removing multicollinearity may pose a more difficult problem. The variance inflation factors were decreased to a maximum of 25. The condition numbers were reduced to a maximum of 14, a 50% reduction. All of the models that follow include only one wind velocity (WIND1) and one soil temperature parameter (SOIL1).

Table 1 - Results of OLS regression model

	Adj R^2	D stat	F value	t-test significant
Snowmelt	0.49	0.49	26.36	IN OUT LONG SOIL1 WIND1
Snow depth	0.95	0.34	515.8	IN OUT LONG NET TEMP RH WIND1

The graphs on the next two pages show the goodness-to-fit of these two models. The snow depth model very closely matches the measured values. The fit of the snowmelt is not as good. It follows the diurnal trend well, but the melting 'spike' at the end is dampened. Integration of the spike revealed that the model predicted 13% more meltwater during this period.

Parameter Interaction

During the period of event 1, only the shortwave components (IN and OUT) have diurnal trends. During snowmelt, atmospheric and soil temperatures and net radiation typically show this same trend. A regression model with the two shortwave components multiplied together was tried to assess their interaction. Table 2 summarizes the regression results.

Table 2 - Results of shortwave interaction snowmelt model

Snowmelt	Adj R^2	t-test significant
Shortwave only	0.50	SHORTS
Shortwaves with other OLS sig vars	0.57	SHORTS LONG SOIL1 WIND1

Lysimeter Instrument Manufacturer Specification Sheets

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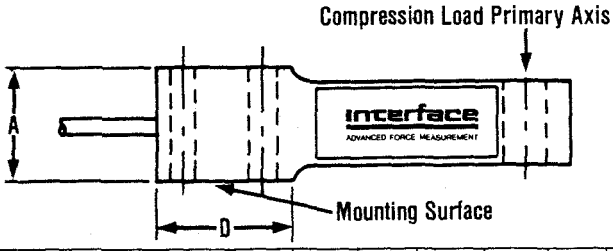
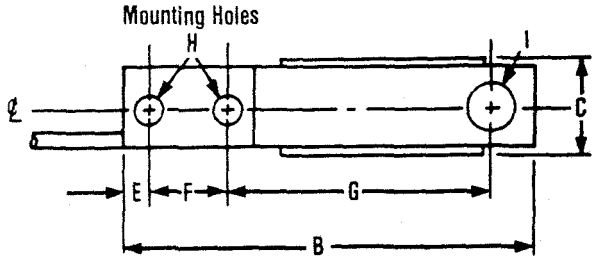




DIMENSION		A	B	C	D	E	F	G	H	I	MOUNTING SCREWS: SCREW SIZE	MOUNTING SCREWS: LENGTH (min)	MOUNTING SCREWS: MIN. SCREW GRADE	MOUNTING SCREWS: SCREW TORQUE	LOAD SCREWS: SIZE	LOAD SCREWS: MIN. ULTIMATE STRENGTH REQUIRED*
SSB-50, 100, 250	IN	1	2-3/8	7/8	1	1/4	.50	1.31	11/64	11/64	8-32	1-1/4	5	36 in. lb.	#8	SSB-50 12,000 PSI SSB-100 24,000 PSI SSB-250 60,000 PSI
	mm	25	60	22	25	6.4	12.7	33.3	4.4	4.4	4			4.1 N•m.		
SSB-500	IN	1	3-7/8	1-1/4	1-1/4	1/4	.75	2.50	9/32	13/32	1/4	1-3/8	5	120 in. lb.	3/8	20,000 PSI
	mm	25	98	32	32	6.4	19.0	63.5	7.1	10.3	6			13.7 N•m.		
SSB-1000	IN	1-1/2	5	1-1/4	1-3/4	3/8	1.00	3.25	13/32	13/32	3/8	2-1/8	5	35 ft. lb.	3/8	40,000 PSI
	mm	38	127	32	44	9.5	25.4	82.6	10.3	10.3	9			48 N•m.		

Mounting Instructions: Fasten securely to a flat rigid surface with screws and torques per table.

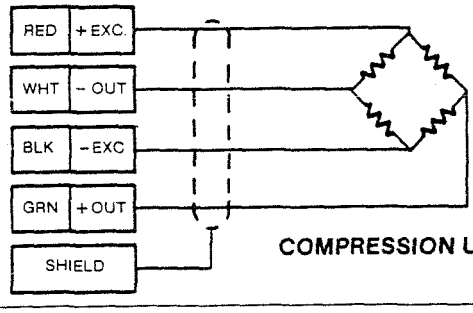
Mounting surface to be machined, finish 125 ✓ or better, flat within .001 T.I.R.

* For 300% Ultimate Load Capacity

ELECTRICAL INFORMATION

SSB Series capacities 1000 lbs. and under are provided with a 4-conductor shielded cable (AWG 28) 10 ft. (3m) long.

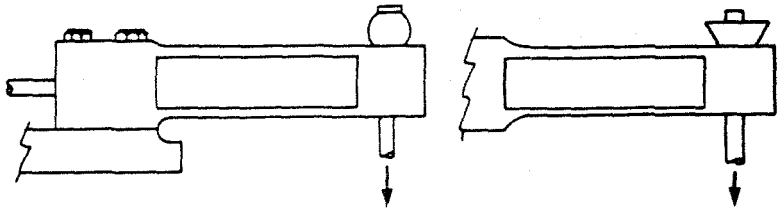
Wiring Color Code complies with ISA S37.8 "Specifications and Tests for Strain Gage Force Transducers" and SMA Load Cell Terminology.



COMPRESSION UPSCALE

APPLICATION NOTES

1. The Sealed SuperBeam load cell is specifically designed for outdoor use and can be used in scale pits, batching plants or other locations directly exposed to weather. They are made of Anodized High Strength Aluminum Alloy.
2. Please exercise caution while handling and installing these load cells. Application of a force equaling more than 150% of rated capacity (For example, more than 75 lbs. on SSB-50) will result in irreparable damage.



TYPICAL INSTALLATION & ATTACHMENTS

PERFORMANCE DATA

Input Resistance — Ohms . . . . . 350 + 40/-3.5

Output Resistance — Ohms . . . . . *350 ± 3.5*

Recommended Excitation — VDC 10

Non-Linearity — % Rated Output . . . . . < ± 0.03

Hysteresis — % Rated Output . . . . . < ± 0.02

Temp. Range, Compensated — °F (-15 to 65°C). . . 0 to 150

Temperature effect on zero — % Rated Output/100°F (55.6 °C) . . . . . ± 0.15

Zero Balance — % Rated Output . . . . . < ± 1

SEALED SUPERBEAM LOAD CELL

Model: SSB-MA-500 Date: 07-14-1994

Capacity: 500 LBS. Serial: C60136

Output, Compression mV/V: 3.000

INTERFACE, INC.
7401 E. Butherus Dr.
Scottsdale, Arizona 85260 U.S.A.
Telephone: (602) 948-5555 • Fax: (602) 948-1924
Telex: 825-882

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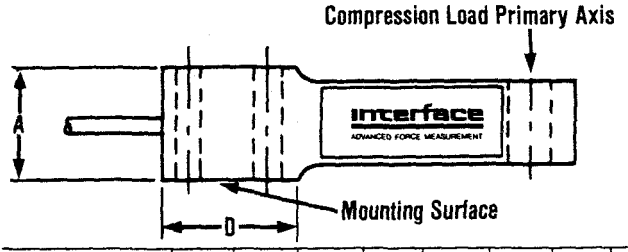

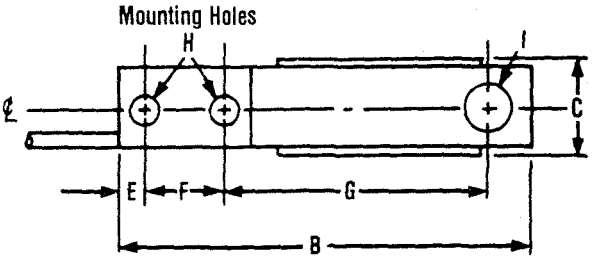

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SSB-50, 100, 250	IN	1	2-3/8	7/8	1	1/4	.50	1.31	11/64	11/64	8-32	1-1/4	5	36 in. lb.	#8	SSB-50 12,000 PSI SSB-100 24,000 PSI SSB-250 60,000 PSI
	mm	25	60	22	25	6.4	12.7	33.3	4.4	4.4	4			4.1 N•m.		
SSB-500	IN	1	3-7/8	1-1/4	1-1/4	1/4	.75	2.50	9/32	13/32	1/4	1-3/8	5	120 in. lb.	3/8	20,000 PSI
	mm	25	98	32	32	6.4	19.0	63.5	7.1	10.3	6			13.7 N•m.		
SSB-1000	IN	1-1/2	5	1-1/4	1-3/4	3/8	1.00	3.25	13/32	13/32	3/8	2-1/8	5	35 ft. lb.	3/8	40,000 PSI
	mm	38	127	32	44	9.5	25.4	82.6	10.3	10.3	9			48 N•m.		

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* For 300% Ultimate Load Capacity

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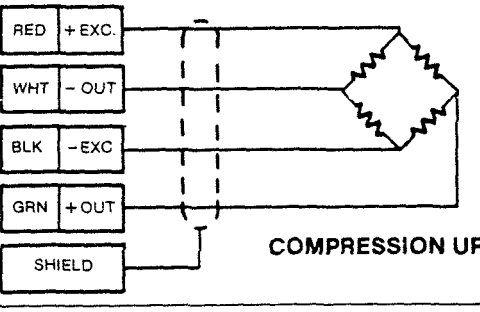

Red GN 262.5Ω
Red WH 262.5Ω
Bl Gr 262.5Ω
Bl WH 262.5Ω

COMPRESSION UPSCALE

APPLICATION NOTES

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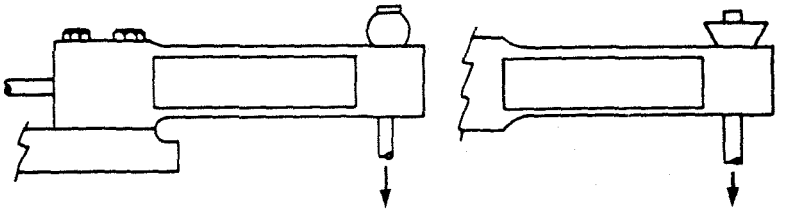

TYPICAL INSTALLATION & ATTACHMENTS

PERFORMANCE DATA

Input Resistance — Ohms	350 + 40/-3.5
Output Resistance — Ohms	350 ± 3.5
Recommended Excitation — VDC	10
Non-Linearity — % Rated Output	< ± 0.03
Hysteresis — % Rated Output	< ± 0.02
Temp. Range, Compensated — °F (-15 to 65°C)	0 to 150
Temperature effect on zero — % Rated Output/100°F (55.6 °C)	± 0.15
Zero Balance — % Rated Output	< ± 1

SEALED SUPERBEAM LOAD CELL

Model: SSB-MA-500 Date: 06-18-94

Capacity: 500 LBS Serial: C60158

Output, Compression mV/V: 2.999

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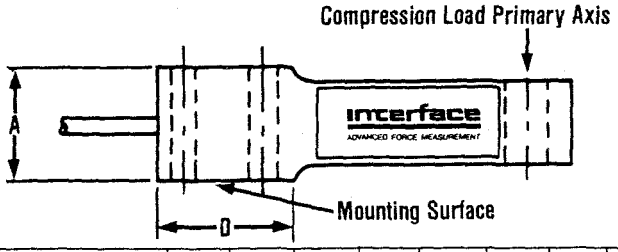
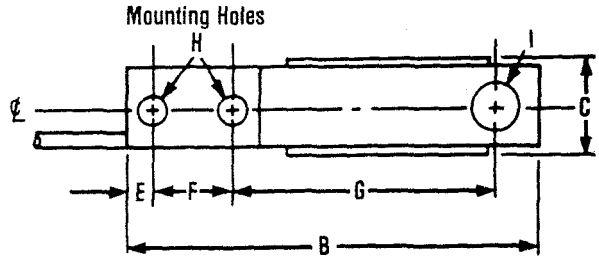




DIMENSION		A	B	C	D	E	F	G	H	I	MOUNTING SCREWS: SCREW SIZE	MOUNTING SCREWS: LENGTH (min)	MOUNTING SCREWS: MIN. SCREW GRADE	MOUNTING SCREWS: SCREW TORQUE	LOAD SCREWS: SIZE	LOAD SCREWS: MIN. ULTIMATE STRENGTH REQUIRED*	
SSB-50, 100, 250	IN	1	2-3/8	7/8	1	1/4	.50	1.31	11/64	11/64	8-32	1-1/4	5	36 in. lb.	#8	SSB-50	12,000 PSI
																SSB-100	24,000 PSI
	mm	25	60	22	25	6.4	12.7	33.3	4.4	4.4	4			4.1 N•m.		SSB-250	60,000 PSI
SSB-500	IN	1	3-7/8	1-1/4	1-1/4	1/4	.75	2.50	9/32	13/32	1/4	1-3/8	5	120 in. lb.	3/8	20,000 PSI	
	mm	25	98	32	32	6.4	19.0	63.5	7.1	10.3	6			13.7 N•m.			
SSB-1000	IN	1-1/2	5	1-1/4	1-3/4	3/8	1.00	3.25	13/32	13/32	3/8	2-1/8	5	35 ft. lb.	3/8	40,000 PSI	
	mm	38	127	32	44	9.5	25.4	82.6	10.3	10.3	9			48 N•m.			

Mounting Instructions: Fasten securely to a flat rigid surface with screws and torques per table.

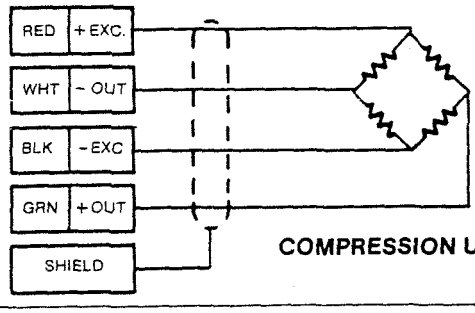
Mounting surface to be machined, finish 125 ✓ or better, flat within .001 T.I.R.

* For 300% Ultimate Load Capacity

ELECTRICAL INFORMATION

SSB Series capacities 1000 lbs. and under are provided with a 4-conductor shielded cable (AWG 28) 10 ft. (3m) long.

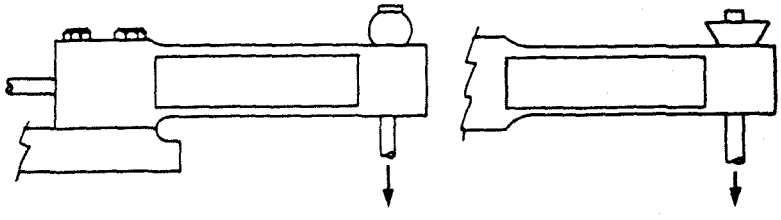
Wiring Color Code complies with ISA S37.8 "Specifications and Tests for Strain Gage Force Transducers" and SMA Load Cell Terminology.



COMPRESSION UPSCALE

APPLICATION NOTES

1. The Sealed SuperBeam load cell is specifically designed for outdoor use and can be used in scale pits, batching plants or other locations directly exposed to weather. They are made of Anodized High Strength Aluminum Alloy.
2. Please exercise caution while handling and installing these load cells. Application of a force equaling more than 150% of rated capacity (For example, more than 75 lbs. on SSB-50) will result in irreparable damage.



TYPICAL INSTALLATION & ATTACHMENTS

PERFORMANCE DATA

Input Resistance — Ohms . . . . . 350 + 40/-3.5

Output Resistance — Ohms . . . . . 350 ± 3.5

Recommended Excitation — VDC 10

Non-Linearity — % Rated Output . . . . . < ± 0.03

Hysteresis — % Rated Output . . . . . < ± 0.02

Temp. Range, Compensated — °F (-15 to 65°C). . . 0 to 150

Temperature effect on zero — % Rated Output/100°F (55.6 °C) . . . . . ± 0.15

Zero Balance — % Rated Output . . . . . < ± 1

SEALED SUPERBEAM LOAD CELL

Model: SSB-MA-500 Date: 07-06-1994

Capacity: 500 LBS Serial: C60164

Output, Compression mV/V: 3.000

INTERFACE, INC.
7401 E. Butherus Dr.
Scottsdale, Arizona 85260 U.S.A.
Telephone: (602) 948-5555 • Fax: (602) 948-1924
Telex: 825-882

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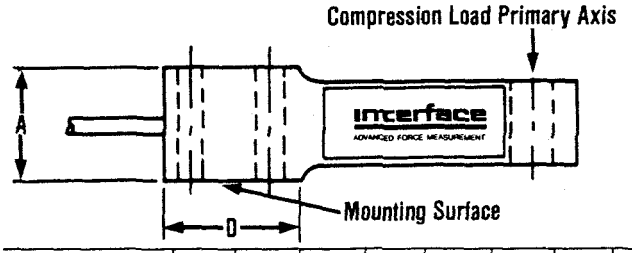
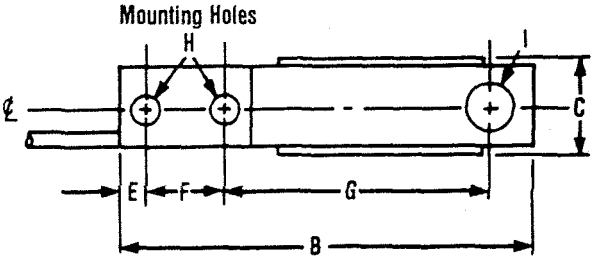
ADVANCED FORCE MEASUREMENT

CALIBRATION CERTIFICATE
INSTALLATION INFORMATION

INSTALLATION DIMENSIONS





DIMENSION		A	B	C	D	E	F	G	H	I	MOUNTING SCREWS: SCREW SIZE	MOUNTING SCREWS: LENGTH (min)	MOUNTING SCREWS: MIN. SCREW GRADE	MOUNTING SCREWS: SCREW TORQUE	LOAD SCREWS: SIZE	LOAD SCREWS: MIN. ULTIMATE STRENGTH REQUIRED*
SSB-50, 100, 250	IN	1	2-3/8	7/8	1	1/4	.50	1.31	11/64	11/64	8-32	1-1/4	5	36 in. lb.	#8	SSB-50 12,000 PSI SSB-100 24,000 PSI SSB-250 60,000 PSI
	mm	25	60	22	25	6.4	12.7	33.3	4.4	4.4	4			4.1 N•m.		
SSB-500	IN	1	3-7/8	1-1/4	1-1/4	1/4	.75	2.50	9/32	13/32	1/4	1-3/8	5	120 in. lb.	3/8	20,000 PSI
	mm	25	98	32	32	6.4	19.0	63.5	7.1	10.3	6			13.7 N•m.		
SSB-1000	IN	1-1/2	5	1-1/4	1-3/4	3/8	1.00	3.25	13/32	13/32	3/8	2-1/8	5	35 ft. lb.	3/8	40,000 PSI
	mm	38	127	32	44	9.5	25.4	82.6	10.3	10.3	9			48 N•m.		

Mounting Instructions: Fasten securely to a flat rigid surface with screws and torques per table.

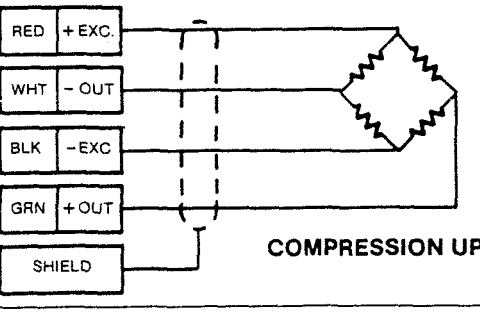
Mounting surface to be machined, finish 125 or better, *flat within .001 T.I.R.*

* For 300% Ultimate Load Capacity

ELECTRICAL INFORMATION

SSB Series capacities 1000 lbs. and under are provided with a 4-conductor shielded cable (AWG 28) 10 ft. (3m) long.

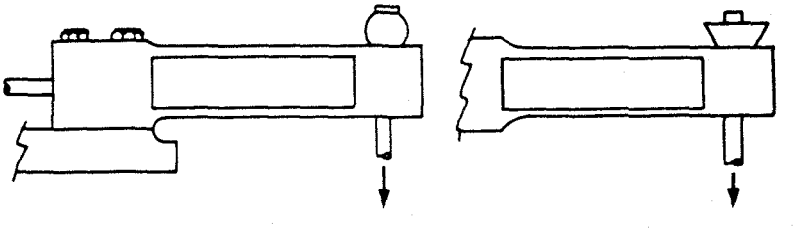
Wiring Color Code complies with ISA S37.8 "Specifications and Tests for Strain Gage Force Transducers" and SMA Load Cell Terminology.



COMPRESSION UPSCALE

APPLICATION NOTES

1. The Sealed SuperBeam load cell is specifically designed for outdoor use and can be used in scale pits, batching plants or other locations directly exposed to weather. They are made of Anodized High Strength Aluminum Alloy.
2. Please exercise caution while handling and installing these load cells. Application of a force equaling more than 150% of rated capacity (For example, more than 75 lbs. on SSB-50) will result in irreparable damage.



TYPICAL INSTALLATION & ATTACHMENTS

PERFORMANCE DATA

Input Resistance — Ohms ..... 350 + 40/-3.5

Output Resistance — Ohms .....350 ± 3.5

Recommended Excitation — VDC 10

Non-Linearity — % Rated Output .....<±0.03

Hysteresis — % Rated Output .....<±0.02

Temp. Range, Compensated — °F (-15 to 65°C)... 0 to 150

Temperature effect on zero —
% Rated Output/100°F (55.6 °C) .....±0.15

Zero Balance — % Rated Output .....<±1

SEALED SUPERBEAM LOAD CELL

Model: SSB-MA-500 Date: 06-18-94

Capacity: 500 LBS Serial: C60155

Output, Compression mV/V: 3.001

INTERFACE, INC.
7401 E. Butherus Dr.
Scottsdale, Arizona 85260 U.S.A.
Telephone: (602) 948-5555 • Fax: (602) 948-1924
Telex: 825-882

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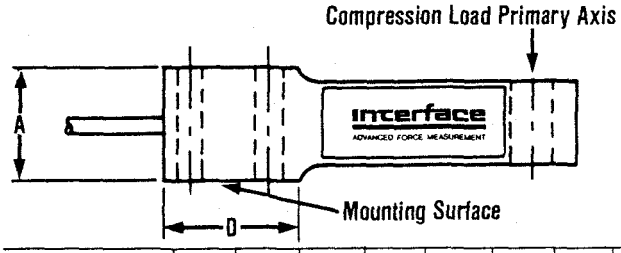
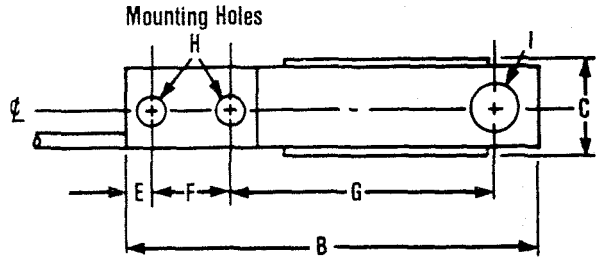
ADVANCED FORCE MEASUREMENT

CALIBRATION CERTIFICATE
INSTALLATION INFORMATION

INSTALLATION DIMENSIONS





DIMENSION		A	B	C	D	E	F	G	H	I	MOUNTING SCREWS: SCREW SIZE	MOUNTING SCREWS: LENGTH (min)	MOUNTING SCREWS: MIN. SCREW GRADE	MOUNTING SCREWS: SCREW TORQUE	LOAD SCREWS: SIZE	LOAD SCREWS: MIN. ULTIMATE STRENGTH REQUIRED*
SSB-50, 100, 250	IN	1	2-3/8	7/8	1	1/4	.50	1.31	11/64	11/64	8-32	1-1/4	5	36 in. lb.	#8	SSB-50 12,000 PSI SSB-100 24,000 PSI SSB-250 60,000 PSI
	mm	25	60	22	25	6.4	12.7	33.3	4.4	4.4	4			4.1 N•m.		
SSB-500	IN	1	3-7/8	1-1/4	1-1/4	1/4	.75	2.50	9/32	13/32	1/4	1-3/8	5	120 in. lb.	3/8	20,000 PSI
	mm	25	98	32	32	6.4	19.0	63.5	7.1	10.3	6			13.7 N•m.		
SSB-1000	IN	1-1/2	5	1-1/4	1-3/4	3/8	1.00	3.25	13/32	13/32	3/8	2-1/8	5	35 ft. lb.	3/8	40,000 PSI
	mm	38	127	32	44	9.5	25.4	82.6	10.3	10.3	9			48 N•m.		

Mounting Instructions: Fasten securely to a flat rigid surface with screws and torques per table.

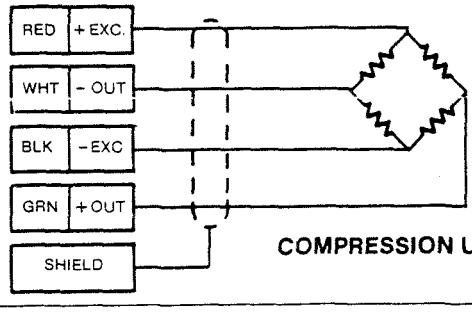
Mounting surface to be machined, finish 125 ✓ or better, flat within .001 T.I.R.

* For 300% Ultimate Load Capacity

ELECTRICAL INFORMATION

SSB Series capacities 1000 lbs. and under are provided with a 4-conductor shielded cable (AWG 28) 10 ft. (3m) long.

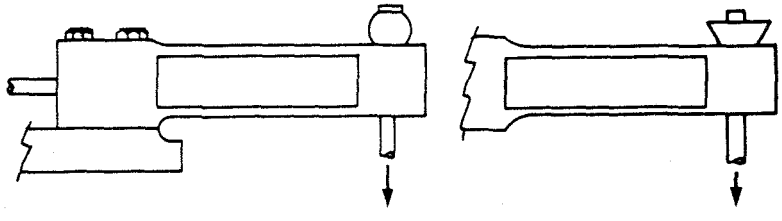
Wiring Color Code complies with ISA S37.8 "Specifications and Tests for Strain Gage Force Transducers" and SMA Load Cell Terminology.



COMPRESSION UPSCALE

APPLICATION NOTES

1. The Sealed SuperBeam load cell is specifically designed for outdoor use and can be used in scale pits, batching plants or other locations directly exposed to weather. They are made of Anodized High Strength Aluminum Alloy.
2. Please exercise caution while handling and installing these load cells. Application of a force equaling more than 150% of rated capacity (For example, more than 75 lbs. on SSB-50) will result in irreparable damage.



TYPICAL INSTALLATION & ATTACHMENTS

PERFORMANCE DATA

Input Resistance — Ohms	350 + 40/-3.5
Output Resistance — Ohms	350 ± 3.5
Recommended Excitation — VDC	10
Non-Linearity — % Rated Output	< ± 0.03
Hysteresis — % Rated Output	< ± 0.02
Temp. Range, Compensated — °F (-15 to 65°C)	0 to 150
Temperature effect on zero — % Rated Output/100°F (55.6 °C)	± 0.15
Zero Balance — % Rated Output	< ± 1

SEALED SUPERBEAM LOAD CELL

Model: SSB-MA-500 Date: 07-06-1994

Capacity: 500 LBS Serial: C62206

Output, Compression mV/V: 3.001

INTERFACE, INC.
7401 E. Butherus Dr.
Scottsdale, Arizona 85260 U.S.A.
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Telex: 825-882

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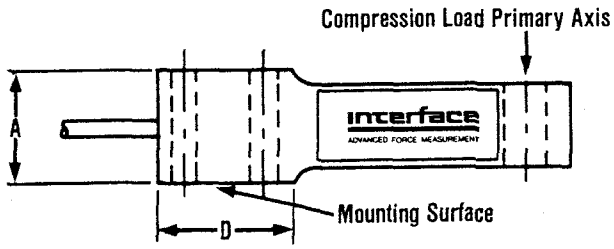
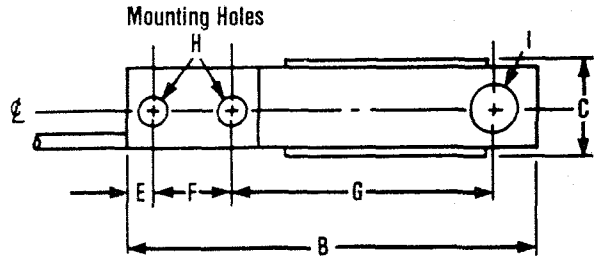
CALIBRATION CERTIFICATE
INSTALLATION INFORMATION

INSTALLATION DIMENSIONS





DIMENSION		A	B	C	D	E	F	G	H	I	MOUNTING SCREWS: SCREW SIZE	MOUNTING SCREWS: LENGTH (min)	MOUNTING SCREWS: MIN. SCREW GRADE	MOUNTING SCREWS: SCREW TORQUE	LOAD SCREWS: SIZE	LOAD SCREWS: MIN. ULTIMATE STRENGTH REQUIRED*
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	mm	25	60	22	25	6.4	12.7	33.3	4.4	4.4	4			4.1 N•m.		
SSB-500	IN	1	3-7/8	1-1/4	1-1/4	1/4	.75	2.50	9/32	13/32	1/4	1-3/8	5	120 in. lb.	3/8	20,000 PSI
	mm	25	98	32	32	6.4	19.0	63.5	7.1	10.3	6			13.7 N•m.		
SSB-1000	IN	1-1/2	5	1-1/4	1-3/4	3/8	1.00	3.25	13/32	13/32	3/8	2-1/8	5	35 ft. lb.	3/8	40,000 PSI
	mm	38	127	32	44	9.5	25.4	82.6	10.3	10.3	9			48 N•m.		

Mounting Instructions: Fasten securely to a flat rigid surface with screws and torques per table.

Mounting surface to be machined, finish 125 or better, flat within .001 T.I.R.

* For 300% Ultimate Load Capacity

ELECTRICAL INFORMATION

SSB Series capacities 1000 lbs. and under are provided with a 4-conductor shielded cable (AWG 28) 10 ft. (3m) long.

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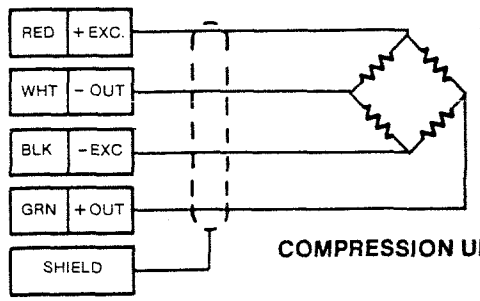

COMPRESSION UPSCALE

APPLICATION NOTES

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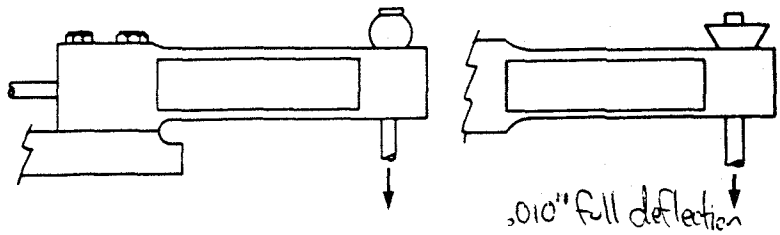

TYPICAL INSTALLATION & ATTACHMENTS

PERFORMANCE DATA

Input Resistance — Ohms	350 + 40/-3.5
Output Resistance — Ohms	350 ± 3.5
Recommended Excitation — VDC	10
Non-Linearity — % Rated Output	< ± 0.03
Hysteresis — % Rated Output	< ± 0.02
Temp. Range, Compensated — °F (-15 to 65°C)	0 to 150
Temperature effect on zero — % Rated Output/100°F (55.6 °C)	±0.15
Zero Balance — % Rated Output	< ±1

SEALED SUPERBEAM LOAD CELL

Model: SSB-MA-500 Date: 07-06-199

Capacity: 500 LBS Serial: C62205

Output, Compression mV/V: 3.001

INTERFACE, INC.
7401 E. Butherus Dr.
Scottsdale, Arizona 85260 U.S.A.
Telephone: (602) 948-5555 • Fax: (602) 948-1924
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Co./Dept. E G+G	Co. Inter Face
Phone # 303-966-6544	Phone # 1-800-947-5598
Fax # 303-966-6533	Fax # 602-948-1924

interface
ADVANCED FORCE MEASUREMENT

8

"INFO FROM INTERFACE" No. 35B

SUBJECT: MULTIPLE LOAD CELL INSTALLATIONS

Many load cell applications require the use of multiple cells, ranging in most cases from 3 to 8 per installation. Instruments vary in their ability to power multiple load cells, and compatibility for a given installation should be verified by consulting the instrument specification sheet.

Our parallel load cell installation diagram (see reverse side) shows the most common method of hooking up a multiple load cell system. Standardized output load cells are recommended for all multiple load cell installations. The trim pots are used for final adjustment of corner sensitivity and are adjusted as follows:

a. Set up systems in final mechanical configuration and wire as shown in installation diagram with all span resistors set at zero.

b. Apply a known weight sequentially over each load cell, and note which provides the lowest reading on the indicator.

c. Again apply the known weight over each load cell and adjust the trim pot for that particular cell, so that the indicator reads the same as the lowest value obtained in Step b.

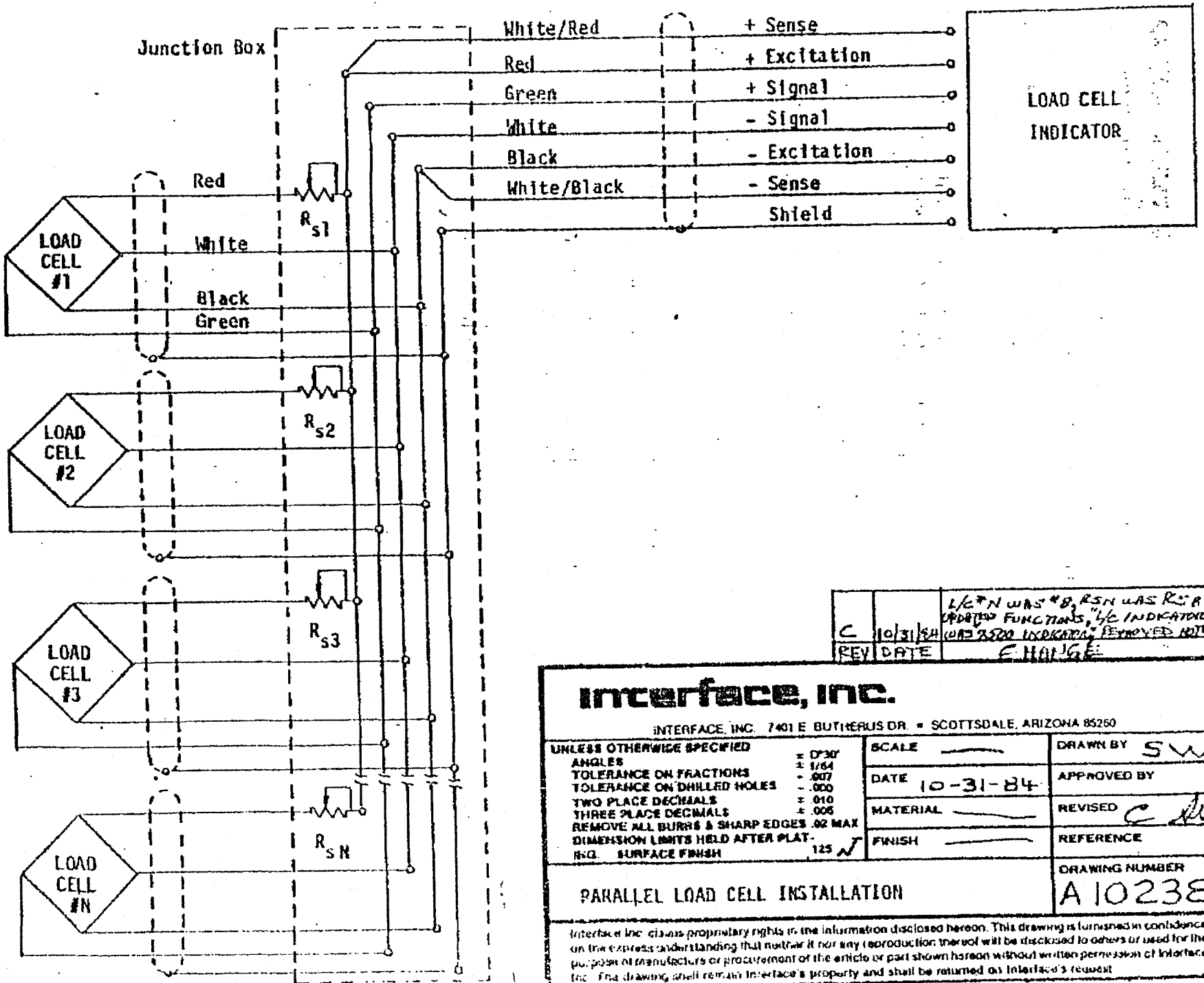
d. It may be necessary to perform Step c several times before all readings are identical. If particular care is taken to place the weight directly over the cell (if possible) or in the same position relative to the cell each time an indicator reading is taken, the number of adjustment readings will be minimized.

e. The system should now be zeroed and the span adjusted.

Other applications such as tank and hopper installations which are not as demanding accuracy-wise as regular scales, are most often handled by making use of standardized output cells without using the trim pots.

This information should get you through most of the basic multiple load cell installation requirements. We, of course, welcome the opportunity to work with you and your customer when required to provide as much additional guidance as we can for specific requirements.

SALES DEPARTMENT - INTERFACE, INC.
FMT/mm
6/89


Junction Box
White/Red
Red
Green
White
Black
White/Black
+ Sense
+ Excitation
+ Signal
- Signal
- Excitation
- Sense
Shield
LOAD CELL INDICATOR
Red
White
Black
Green
LOAD CELL #1
LOAD CELL #2
LOAD CELL #3
LOAD CELL #N
R_{s1}
R_{s2}
R_{s3}
R_{sN}
C
10/31/84
L/C #N WAS #8, RSN WAS RSB UPDATED FUNCTIONS, "L/C INDICATOR" WAS 2500 INDICATOR, REMOVED NOTES
REV
DATE
CHANGE
interface, inc.
INTERFACE, INC. 7401 E BUTHERUS DR. • SCOTTSDALE, ARIZONA 85260
UNLESS OTHERWISE SPECIFIED
ANGLES ± 0°30'
TOLERANCE ON FRACTIONS ± 1/64
TOLERANCE ON DRILLED HOLES ± .007
TWO PLACE DECIMALS ± .000
THREE PLACE DECIMALS ± .010
REMOVE ALL BURRS & SHARP EDGES .02 MAX
DIMENSION LIMITS HELD AFTER PLATING. SURFACE FINISH 125
SCALE
DATE 10-31-84
MATERIAL
FINISH
DRAWN BY SW
APPROVED BY
REVISED C
REFERENCE
DRAWING NUMBER A10238
PARALLEL LOAD CELL INSTALLATION
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LOAD BUTTONS

DIMENSIONS IN INCHES

MODEL	MATERIAL	THD/DIA	APPLICATION	A	B	C	D	R	FIG
LB-106	H.T. STEEL	1/4-28	SM-10 THRU 250, SSM-50 THRU 250	7/16	1/2	5/8	1/2	2	1
LB-109	H.T. STEEL	1/2-20	SM-500, 1000 SSM-500 THRU 3000	15/16	1 1/16	1 5/16	1	4	1
LB-110	H.T. STEEL	5/8-18	SSM-5000	15/16	1 1/16	1 5/16	1	4	1
LB-101	H.T. STEEL	5/8-18	1110 & 1210-300 THRU 10K	15/16	1 1/16	1 9/32	1	4	1
LB-102	H.T. STEEL	1 1/4-12	1120 & 1220-25K, 50K	1 1/2	1 3/4	1 9/16	11/16	6	1
LB-103	H.T. STEEL	1 3/4-12	1132 & 1232-100K	2 1/8	2 1/2	3 3/4	2 1/8	12	1
LB-104	H.T. STEEL	2 3/4-8	1140 & 1240-200K	3 1/2	4	5	3 1/8	12	1
LB-111	H.T. STEEL	.395	SSB-500, 1000	3/4	.395	3/4	1/2	4	2
LB-107	H.T. STEEL	1.185	SSB-2.5K THRU 10K	1.185	-	1	-	6	3

METRIC SIZES

LB-101M	H.T. STEEL	M16x2	1110 & 1210-5kN TO 50kN	15/16	1 1/16	1 9/32	1	4	1
LB-102M	H.T. STEEL	M33x2	1120 & 1220-100kN, 250kN	1 1/2	1 3/4	1 9/16	11/16	6	1
LB-103M	H.T. STEEL	M42x2	1132 & 1232-450kN	2 1/8	2 1/2	3 3/4	2 1/8	12	1
LB-104M	H.T. STEEL	M72x2	1140 & 1240-900kN	3 1/2	4	5	3 1/8	12	1

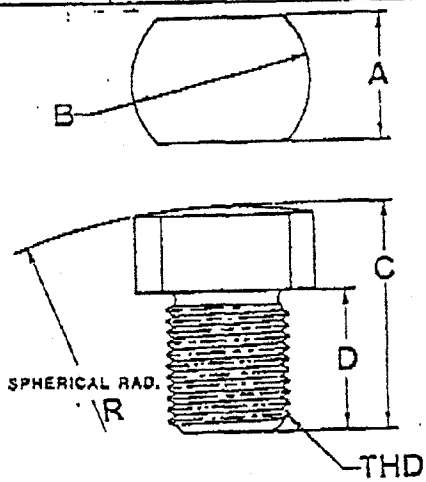

FIG. 1

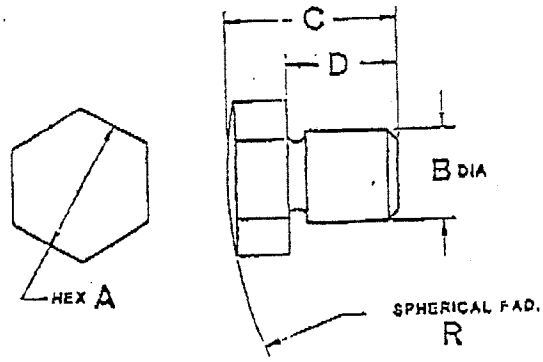

FIG. 2

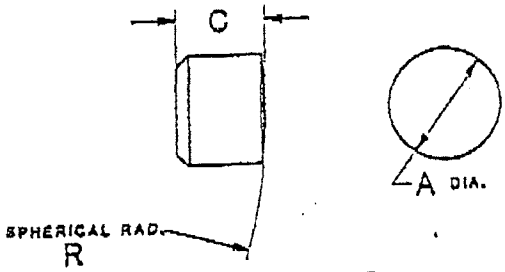

FIG. 3

INTERFACE,INC.,7401 E.BUTHERUS DR.,SCOTTSDALE,AZ 85260 USA(602)948-5555 FAX(602)948-1924

ACCESSORY PRICE LIST

TOP PLATES

TP-101	$95.00
TP-102	$110.00
TP-103	$195.00
TP-104	$295.00
TP-301	$195.00
TP-302	$230.00
TP-303	$360.00

BOTTOM PLATES

BP101-11	$100.00
BP101-12	$100.00
BP101-21	$100.00
BP101-22	$100.00
BP101-3	$100.00
BP102-11	$105.00
BP102-12	$105.00
BP102-21	$105.00
BP102-22	$105.00
BP102-3	$105.00
BP103-11	$350.00
BP103-12	$350.00
BP103-21	$250.00
BP103-22	$250.00
BP103-3	$170.00
BP104-11	$600.00
BP104-12	$600.00
BP104-21	$600.00
BP104-22	$600.00
BP104-3	$350.00
BP108-11	$100.00
BP108-12	$100.00
BP108-21	$100.00
BP108-22	$100.00
BP108-3	$100.00
BP302-11	$230.00
BP302-12	$230.00
BP302-21	$230.00
BP302-22	$230.00
BP302-3	$230.00
BP303-11	$360.00
BP303-12	$360.00
BP303-21	$360.00
BP303-22	$360.00
BP303-3	$300.00
BP308-11	$195.00
BP308-12	$195.00
BP308-21	$195.00
BP308-22	$195.00
BP308-3	$195.00

LOAD BUTTONS

LB-101	$40.00
LB-102	$110.00
LB-103	$170.00
LB-104	$310.00
LB-106	$20.00
LB-107	$30.00
LB-109	$30.00
LB-110	$40.00
LB-111	$40.00
LB-101M	$40.00
LB-102M	$110.00
LB-103M	$170.00
LB-104M	$310.00

THREAD ADAPTORS

TA-102	$20.00
TA-103	$20.00
TA-106	$125.00
THD-101	$125.00
THD-105	$1,100.00
THD-106	$900.00
THD-112	$150.00
THD-113	$350.00
THD-114	$650.00
THD-115	$500.00
THD-143	$350.00
THD-144	$290.00
THD-153	$225.00
THD-163	$250.00

CALIBRATION ADAPTORS

CA-101	$100.00
CA-102	$250.00
CA-103	$350.00
CA-104	$595.00
CA-105	$490.00

ROD END BEARINGS

REB-101	$75.00
REB-102	$250.00
REB-104	$16.00
REB-105	$27.00
REB-106	$54.00

JAM NUTS

JN-101	$1.00
JN-102	$1.00
JN-103	$1.50
JN-104	$1.50
JN-105	$60.00
JN-106	$70.00
JN-107	$90.00
JN-201	$1.00
JN-202	$1.00
JN-203	$5.00
JN-204	$60.00
JN-205	$60.00
JN-206	$70.00
JN-207	$90.00

CLEVISES

CLV-101	$215.00
CLV-102	$295.00
CLV-104	$45.00
CLV-105	$45.00
CLV-106	$125.00

INTERFACE,INC.,7401 E. BUTHERUS DR.,SCOTTSDALE, AZ 85260 USA(602)948-5555 FAX(602)948-1924

Micrometeorological Station Manufacturer Specification Sheets

RADIATION AND ENERGY BALANCE SYSTEMS, INC. *(REBS)*
P.O. Box 15512, Seattle, WA 98115-0512, (206) 624-7221

HEAT FLOW TRANSDUCER (HFT-3.1)
INSTRUCTION MANUAL. REV. 2, 6/92

Serial Number H943021 Date 1/10/94

Calibration factor 37.9 $Wm^{-2}mV^{-1}$

SPECIFICATIONS

Nominal calibration factor:	40 $Wm^{-2}mV^{-1}$
Nominal resistance:	2 ohms
Nominal Size:	38.56mm diameter x 3.93mm thick
Thermal conductivity:	1.22 $Wm^{-1}K^{-1}$
Cable:	shielded 2-conductor, 6m long

INTRODUCTION

The heat flow transducer is designed to measure heat flow in soils. The thermopile is encapsulated in high thermal conductivity epoxy to prevent ground potential pickup. Additional features include: high output; low resistance; temperature independent; no power required; and linear calibration.

INSTALLATION

The heat flow transducer should be installed level in the soil. Make sure that there is good thermal contact between the soil and the top and bottom of the transducer. It is not advisable to place the transducer too close to the soil surface. This may impede moisture migration and the soil above it may dry quicker than adjacent soil. Resulting heat flow measurements would not be representative of the adjacent soil.

WIRING

The wiring convention is that the black wire is positive with respect to the other insulated wire when the transducer side with the white dot is on top and energy is flowing downward through the transducer.

COMPUTING HEAT FLOW

Heat flow is computed from the thermopile voltage (Vt) by:

$$HF(Wm^{-2}) = Vt(mV) * \text{calibration factor}.$$

CALIBRATION

The heat flow transducer was calibrated in a water saturated glass bead medium (WSGB) having a thermal conductivity of 0.906 $Wm^{-1}\ {}^{o}C^{-1}$. The medium is located between hot and cold constant temperature baths. Heat transfer through the WSGB was determined from the temperature gradient across the WSGB. The heat flow transducer calibration factor is correct for the calibration medium. Measured heat flows may need to be corrected if the transducer is used in a medium having a different thermal conductivity.

The heat flow transducer calibration factor should remain unchanged. However, the manufacturer recommends annual recalibration to insure high quality data. Inquiries concerning these services may be directed to the manufacturer.

WARRANTY POLICY

Radiation & Energy Balance Systems, Inc. (REBS) warrants its products to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment, subject to the following conditions.

REBS's obligation under this warranty is limited to repairing or replacing (at REBS's option) products which have been returned prepaid to REBS. REBS will return warranted equipment by surface carrier prepaid. This warranty shall not apply to any REBS products which have been subjected to misuse, neglect, accidents of nature or shipping damage. Batteries are not warranted.

Under no circumstances will REBS reimburse the claimant for costs incurred in removing and/or reinstalling equipment at a test site. This warranty and REBS's obligation thereunder, is in lieu of all other warranties, expressed or implied, including warranties of suitability and fitness for a particular purpose. REBS is not liable for consequential damages.

FACTORY REPAIR

Products may not be returned without prior authorization by REBS. Repair charges: $50.00/hour (minimum charge $50.00).→

RADIATION AND ENERGY BALANCE SYSTEMS, INC. *(REBS)*
P.O. Box 15512, Seattle, WA 98115-0512, (206) 624-7221
HEAT FLOW TRANSDUCER (HFT-3.1)
INSTRUCTION MANUAL. REV. 2, 6/92

Serial Number H943121 Date 5/13/94

Calibration factor 43.0 $Wm^{-2}mV^{-1}$

SPECIFICATIONS

Nominal calibration factor:	40 $Wm^{-2}mV^{-1}$
Nominal resistance:	2 ohms
Nominal Size:	38.56mm diameter x 3.93mm thick
Thermal conductivity:	1.22 $Wm^{-1}K^{-1}$
Cable:	shielded 2-conductor, 6m long

INTRODUCTION

The heat flow transducer is designed to measure heat flow in soils. The thermopile is encapsulated in high thermal conductivity epoxy to prevent ground potential pickup. Additional features include: high output; low resistance; temperature independent; no power required; and linear calibration.

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FACTORY REPAIR

Products may not be returned without prior authorization by REBS. Repair charges: $50.00/hour (minimum charge $50.00).→

Class A Evaporation Pan Manufacturer Specification Sheets

NovaLynx Corporation
Model 255-100 (3003) Evaporation Gauge
Instruction Manual

1.0 INTRODUCTION

1.1 Description

The Model 255-100 Analog Output Evaporation Gauge was designed to accurately measure the changing water level in an evaporation pan and provide an electrical signal proportional to the water level from which the evaporation rate can be determined. Although it can be used with a wide variety of evaporation systems, it is normally used with a standard Class A, National Weather Service evaporation pan. The gauge consists of a float, pulley, and counterweight attached to a precision 1000 ohm (or optional 5000 ohm) potentiometer, all mounted in a protective enclosure.

1.2 Specifications

Electrical output range: 0-9.73″ = 0-5 Vdc
Water level range: 0-8.0″ = 0-4.11 Vdc
Height: 27-1/2″
Diameter: 8″
Weight: 7-1/2 lbs
Cable: 50' of 22 GA cable
Connector: 3 pin MS-type
Float: 5″ diameter
Counterweight: 4 oz
Water input port: 1/2″ NP coupling, female
Base dimensions: 16″ triangle with leveling screws
Total resolution: 0.0382″ with 8-bit converter in DataLynx data logger

Potentiometer
Accuracy: 1%
Rotation: continuous
Resistance: 1000 ohms, standard (5000 ohms, optional)
Operating temperature: -50° to +125° F
Linearity: 0.25%
Power: 5 Vdc reg

2.0 INSTALLATION

2.1 After carefully unpacking all components, inspect for damage that may have occurred in shipment. Do not discard any packing material until you are certain there is no damage and all items are accounted for, including accessories. In the event of damage during shipment, a claim for loss should be filed with carrier at the receiving location. This does not apply to shipments via Parcel Post or UPS. In this case you should contact NovaLynx for instructions on handling the claim.

2.2 Remove the top cap and remove the float, chain, and counterweight which are packed in the housing for shipping.

2.3 The gauge is connected to the pan by using 1/2" diameter pipe. Flexible tubing is acceptable provided it is not subject to deterioration. The gauge should be placed far enough away from the pan so that it will not cast a shadow on the pan that could have an effect on the evaporation process.

2.4 Level gauge by placing a level on the housing in front of the gear and adjusting the leveling screws on the triangular base until the unit is level.

2.5 After connecting the gauge to the pan and securing all electrical connections, fill evaporation pan with 8" of water and carefully check all joints for leaks.

2.6 The pulley and the potentiometer housing have been marked with indicators that line up when the potentiometer is approximately at the breakpoint between zero and 1000 ohms (or 5000 ohms) resistance. To obtain the exact breakpoint for zeroing or base setting, use an ohmmeter across the white and red wires or use the actual readout device that will be used with the unit when in operation.

2.7 The float chain should be placed on the pulley so that the float rests on the top of the water (8" in the evaporation pan) when the pulley is at the breakpoint. For operation, the float chain is placed on the pulley so that a falling level of water will cause clockwise (as seen from the front of the pulley) motion in the pulley and a decrease in resistance in the potentiometer output. Refer to the assembly diagram.

2.8 Carefully secure housing cover into place with allen screws.

3.0 OPERATION

The potentiometer produces a resistance output in relation to the position of the float and can be monitored on site with a data logger or strip chart recorder.

4.0 TROUBLESHOOTING

4.1 Always disconnect the reporting/recording device from power or troubleshoot immediately whenever any of the following conditions are observed: the cable has been damaged, the gauge does not appear to operate normally or exhibits a marked change in performance, the gauge has been dropped or damaged, or if moisture damage has occurred to the circuits.

4.2 If the gauge does not register correctly, first check the connections. Check the potentiometer with a voltmeter. Be sure the reporting/recording device has been powered-up correctly. If the reporting/recording device uses batteries for its primary source of power, check that the batteries have sufficient voltage to power the device.

4.3 Check the sensor cable connections both at the gauge and at the control unit. Cable shorts can cause lack of readings. If a connection is found to be loose, tighten into place and check to see if the problem has been corrected.

5.0 WARRANTY

NovaLynx warrants that its products are free from defects in material and workmanship under normal use and service for a period of one year from date of shipment from factory. NovaLynx's obligations under this warranty are limited to, at NovaLynx's option: (i) replacing; or (ii) repairing; any products determined to be defective. In no case shall NovaLynx's liability exceed product's original purchase price. This warranty does not apply to any equipment that has been repaired or altered, except by NovaLynx, or which has been subjected to misuse, negligence, or accident. *It is expressly agreed that this warranty will be in lieu of all warranties of fitness and in lieu of the warranty of merchantability.*

If an instrument appears to be defective within the warranty period, you may return it to NovaLynx freight prepaid for inspection. NovaLynx will, at it's option, repair or replace the defective unit and return it to you freight prepaid.

6.0 FACTORY SERVICE

If it becomes necessary to return this instrument to the factory for service, either during or after the warranty period, call NovaLynx (916-477-5226) and obtain a return authorization. Carefully pack the instrument to prevent damage during shipment. Include a letter with a description of the problem, your telephone number, and your return shipping address. Whenever possible, a cost estimate for the repair and the time required will be given at the time of your call.

NOVALYNX CORPORATION
P.O. Box 240
431-G Crown Point Circle
Grass Valley, CA 95945
(916)477-5226

01/92

NO	REVISION	DATE	DWN	APP'D
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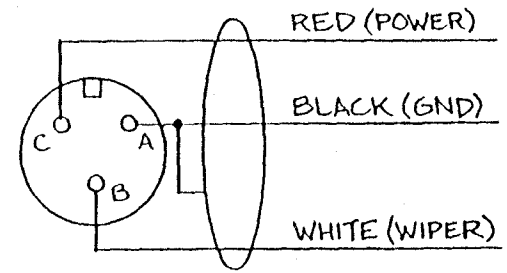
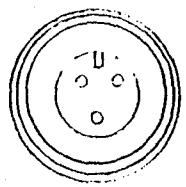
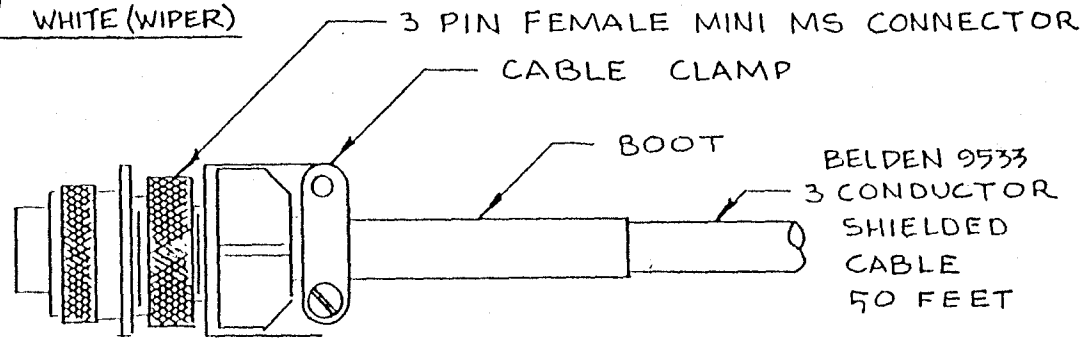
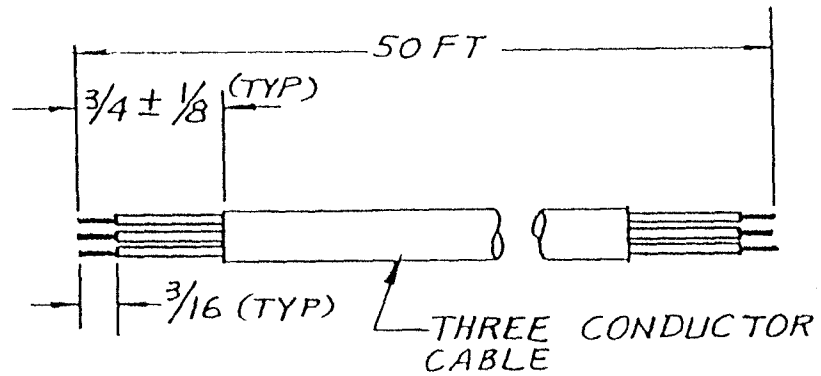






NOTE: CONNECT BLACK TO A
WHITE TO B
RED TO C



DataLynx Instruments

SCALE: 1:1	APPROVED BY:	DRAWN BY DJH
DATE: 5:86	DB	REVISED

255-100
CONNECTOR CABLE

DRAWING NUMBER
A103137-1

8½ X 11 PRINTED ON NO. 1000H CLEARPRINT

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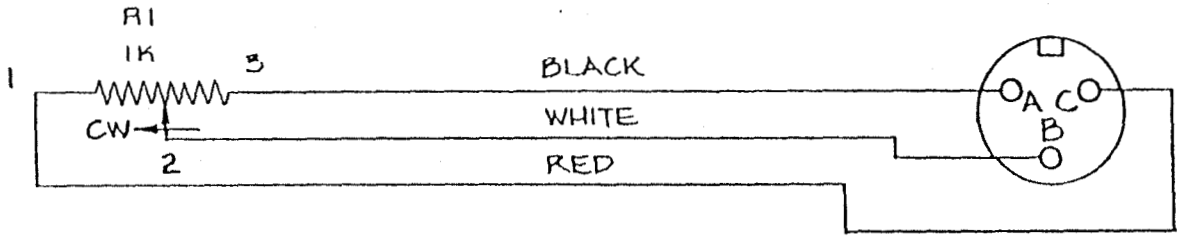
2	ECO#688	8/21/90	DAK	[illegible]



3 PIN MALE MINI BULKHEAD CONNECTOR
#MS-3102A-10SL-3P

NOTE:
CLOCKWISE DIRECTION INDICATED IS FOR GEAR BOX MOUNTED POTENTIOMETER

CABLE - BELDEN #9533, 3 COND.
SHIELDED CABLE, 8" LONG

DataLynx Instruments

SCALE: FULL	APPROVED BY	DRAWN BY
DATE: 5:84		PAUL

255-100
INTERNAL WIRING DIAGRAM

DRAWING NUMBER
A103000-2

NATIONAL NO. 188A-8½X11

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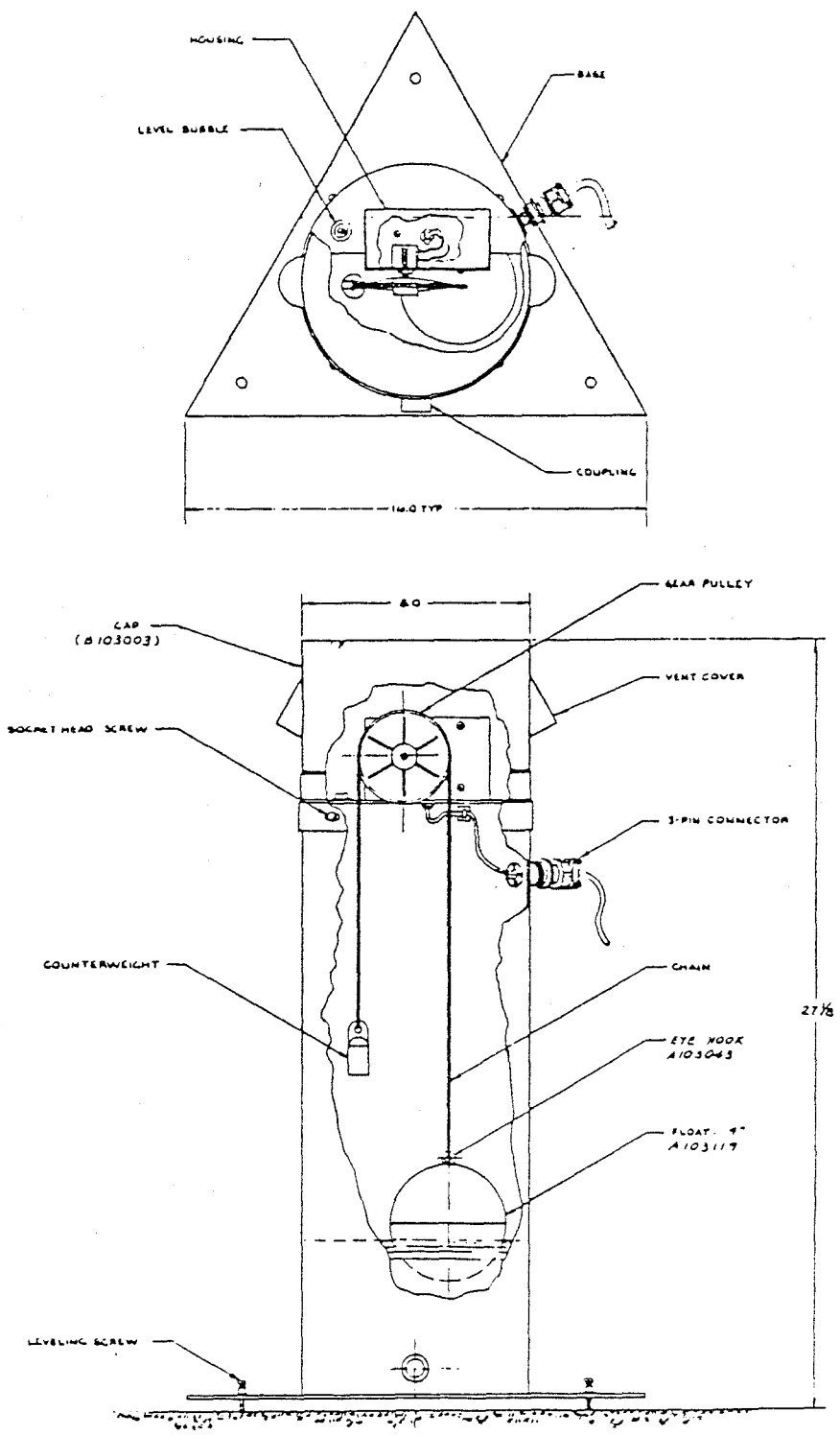


NOTE. REFER TO DRAWING NO A103000 FOR WIRING INSTRUCTIONS

DataLynx

Assembly Diagram

C102352

DATALYNX INSTRUMENTS
Model 255-200 Evaporation Pan
Model 255-210 Still Well
Model 255-214 Hook Gauge

Instruction Manual

1.0 INTRODUCTION

The equipment used for evaporation measurements includes the following: an evaporation pan, a micrometer hook gauge and stilling well (or a fixed point gauge and appropriate measuring tube), an anemometer for measuring wind movement over the pan, and an 8" non-recording precipitation gauge and measuring stick. Additional equipment, in some cases, might include a recording-type precipitation gauge, a thermometer to provide maximum, minimum, and current temperatures of the water in the pan, maximum and minimum thermometers for air temperatures, and/or a hygrothermograph or psychrometer for air temperature and humidity. A suitable shelter must be provided for the temperature and humidity sensors. A water storage tank may be necessary to provide a reserve supply of water for the pan.

Observations are made of the amount of water loss from the pan, anemometer reading, and water temperature in accordance with the instructions in this manual. Observations of air temperature and precipitation are also made. At some evaporation stations additional observations are required, such as dry and wet bulb temperatures and soil temperature and moisture content.

2.0 SITING GUIDELINES

The site for the equipment should be level, sodded, and free from obstructions. It should be representative of the principal natural agricultural soils and vegetation conditions of the area. At locations where the normal climate and soil do not permit the maintenance of a sod cover, the ground cover should be maintained as near as possible to the natural cover common to the area. Under no conditions should the evaporation pan or the instrument shelter be placed on concrete, asphalt, or over a layer of crushed rock. Obstructions, such as shrubs, trees, or buildings should not be closer than four times the height of the object above the pan. Weeds and grass should be mowed to keep them below the level of the pan. The exposure should be free from obstructions that cast shadows over the pan during any part of the day other than brief periods near sunrise and sunset. Avoid locations near ponds, swamps of not more than a few miles in diameter (particularly if they are temporary in nature), lawns or other areas that receive frequent sprinkling or irrigation. At reservoirs (flood control, water supply, irrigation project), a site on the upwind side of the lake or reservoir is preferable, based on the prevailing direction of the strongest winds. Locate the equipment a sufficient distance from spillways and other bodies of water to minimize chances for water to be blown into the pan by strong winds. The site should be surrounded by a fence to protect the equipment and to prevent animals from drinking the water. A steel link fence, 9 or 11 gauge, a minimum of 4' high, with steel posts set in concrete, is

suggested. If the area has problems with small animals or rodents, it may be necessary to bury a barrier and place 18" to 24" of chicken wire (galvanized) along the bottom of the fence.

3.0 EQUIPMENT

3.1 Evaporation Pan

The evaporation pan is cylindrical, with inside dimensions of 10" deep and 47-1/2" diameter. When a micrometer hook gauge is used for measuring water levels, two short lines painted on the inside of the pan, 2" and 3" below the rim, will assist in maintaining the proper water level. The ground should be filled sufficiently to level the pan support and to keep the pan above the level of surface water in rainy weather. Earth fill should be used around the support to anchor it. It should be tamped firmly between the top members to within 1/2" of the top of the support, leaving an air space between the bottom of the pan and the fill to facilitate inspection of the pan for leaks. The pan should be centered on the platform. During inspections the platform level should be checked and corrected if needed.

Inspect the pan carefully for leaks at least once a month. Report the finding of any leaks on the observation form for the month. Report both the date the leak was discovered and the date the pan was repaired or replaced.

Because the temperature characteristics of all evaporation pans must be identical, they must not be painted. Clean the pan as frequently as necessary to keep it free from sediment, algae, and oil films. Any of these contaminants will materially affect the rate of evaporation.

The pan should be emptied by siphoning or dipping the water out. Under no circumstances should the pan be lifted and emptied if any significant amount of liquid remains in the pan.

During months when freezing is likely, empty, clean, and store the pan. The pan should be stored indoors, if possible. If it is left in the fenced enclosure, it should be turned upside down and secured to the platform.

The growth of algae can be discouraged by the addition of small amounts of copper sulfate to the water. Any existing algae must be removed by thorough cleaning.

3.2 Stilling Well for Hook Gauges

The cylindrical well provides an undisturbed water surface around the hook gauge and, in addition, provides a support for the gauge. The well consists of a cylinder of brass, monel, or other non-corrosive metal. Less electrolytic action will occur if the metal is the same as that of the pan. The outside dimensions of the well are 8" high and 3-1/2" diameter. To dampen oscillations in the well, a .375" diameter stainless steel rod is threaded into a hole in the center of the base plate and extends up into the cylinder 7-1/2". The base is provided with leveling screws. Place the stilling well in the pan about one foot from the north edge. Level the top rim of the well using the three leveling screws in its base and a spirit level. The well should rest firmly on the bottom of the pan, which must be free from "buckling" to maintain a level position of the well. Clean the stilling well occasionally and remove any

sediment. When cleaning or adjustments are required (stilling well, pan, etc.), record hook gauge readings taken before and after any such actions.

3.3 Micrometer Hook Gauge

A micrometer hook gauge is used to indicate changes in the level of water in the evaporation pan. The gauge consists of a hook on the end of a stem that is graduated to 1/10" over a range of several inches. The stem is constructed with double threads throughout its range of adjustment. The threads have a pitch of 1/10". A three-legged spider and adjusting nut assembly supports the hook and provides for adjustment of the height of the hook when the gauge is installed on the stilling well. The adjusting nut is threaded to screw on the stem of the hook. After assembly, the gauge is placed on the stilling well with the three legs of the spider resting on the top rim of the well and the hook centered in the well. The stem should then be vertical. The adjusting nut is free to turn within the spider so that it may be conveniently used to adjust the height of the hook. The relative height of the hook in the well is indicated by the scales on the gauge.

Keep the hook gauge clean and lightly oil the threads on the stem with a single drop of light viscosity machine oil about twice a year. Carefully remove any excess oil with a clean cloth, to prevent oil from being transferred to the water surface. Before oiling, clean the gauge thoroughly with kerosene or a petroleum-based solvent. When the gauge is assembled after cleaning, determine that the threads of the stem and the adjusting nut are properly matched by turning the adjusting nut counterclockwise (as viewed from the top) until the top of the nut coincides with one of the graduations of the stem. If the scale has been properly assembled, the index line on the ring of the spider will coincide with the 0 (zero) on the circular scale. If it does not coincide, unscrew the adjusting nut and reassemble the gauge by matching the alternate combination of threads.

3.4 Fixed Point Gauge

The fixed point gauge consists of a pointed 1/8" rod mounted in a tube of noncorrosive metal, 2-1/2" to 3-1/2" in diameter and about 10" long. This tube is attached to a metal base of sufficient size and weight so that its position in the pan is not likely to be changed by the wind. The pointed rod is affixed within the tube to the center of the base so that the point will be 7-1/2" above the bottom of the pan when in position. Two small openings approximately 1/8" in diameter are placed in the sides of the tube near the base, on opposite sides, to permit the flow of water from or into the stilling well and at the same time restrict surging action of water at the point of measurement. Place the gauge about one foot from the north edge of the pan.

A cylindrical measuring tube or replacement graduate 15" deep with a cross sectional area 1/100th that of the evaporation pan is used to measure the amount of water necessary to replace that lost from the pan by evaporation. The inside diameter of this tube should be 4.8" for use with a 48" evaporation pan (inside dimension) and 4.75" for a 47-1/2" evaporation pan. The transparent tubes are graduated at 1" intervals to permit an accuracy of 0.01".

3.5 Water Storage Tank

Where it is necessary to transport water some distance, a tank or other covered receptacle should be located near the site. A tank having a capacity of at least 30 gallons usually provides an adequate reserve of water. The storage tank should be thoroughly cleaned at the beginning of each season. The water placed in the tank should be completely free of oil. At the end of the season, the tank should be emptied and secured to prevent freeze and wind damage.

4.0 EVAPORATION READINGS

4.1 Hook Gauge

At the time of each observation, place the gauge on the stilling well and adjust the hook in the well until the point is below the surface of the water. Slowly turn the adjusting nut clockwise until the point just pierces the water surface. Reflection of the sky in the water will assist in determining when the point first breaks through the surface. Remove the gauge from the well and read the scales. The figures on the stem represent whole inches, and the intermediate graduations represent tenths of an inch. The figures on the circular scale represent hundredths of an inch, and the intermediate graduations represent thousandths. Whenever an observation is taken, the scale on the stem is read to tenths of an inch, as indicated by the first graduation at or above the top of the knurled adjusting nut. The circular scale on the adjusting nut is read to the nearest hundredth of an inch at the index. Both scales are added and the sum represents the gauge reading. For example: A scale reading of 25 on the stem indicates 2.5", a scale reading between 30 and 31 on the circular scale indicates a value between .03" and .04", or 0.03" as determined to the nearest hundredth. The gauge reading is therefore 2.5" + 0.03" = 2.53". Enter the readings obtained as above in the appropriate spaces on the observation forms.

Precipitation causes unavoidable inaccuracies in measurements and condensation of water (dew) may occasionally cause the water level to be slightly higher than that of the previous observation. Subtract precipitation gauge readings to correct evaporation measurements.

Experiments have shown that the height of the rim of the pan above the water surface affects the rate of evaporation. In order for the records from all stations to be comparable, the pan should be filled to a level 2" below the rim, and refilled (at a regular observation) when the water has receded 1", i.e. to the 3" line. When heavy rains threaten to overflow the pan or raise the water beyond the range of the hook gauge, remove enough water to lower the level to within the 2" to 3" range.

Cleaning the pan or adjusting the water level should be done immediately following an observation. Read the gauge level and enter the readings on the forms in use. For example, whenever heavy rains require the removal of water to prevent overflowing the pan, enter the gauge readings made immediately before and after the change and also enter the time, date, and nature of the change as a remark.

On the last day of the month, and whenever the stilling well is leveled or otherwise adjusted, measure the height of the rim of the pan above the water level to the nearest

tenth of an inch and enter height value and the time of the measurement on the permanent record form as a remark. This reading provides a check on the maintenance of proper level in the pan. The measurements should be taken at the time of reading the hook gauge. The measuring stick for the non-recording precipitation gauge may be used for these measurements by multiplying the reading by 10.

4.2 Fixed Point Gauge

At the time of observation, add or remove water from the pan until the tip of the fixed point coincides with the surface of the water in the well. As the water approaches the tip of the point, pour slowly to prevent overfilling, allowing time for water to flow into the well. When water must be added, fill transparent plastic tube to zero mark before pouring into evaporation pan. When water must be removed, using the transparent plastic tube, care must be taken to determine amount. For instance, if enough water is removed to reach the "5" marking on the transparent plastic tube, the actual amount removed would be measured from the bottom of the tube and would be 15 - 5 = 10, which is equivalent to an inch.

5.0 WARRANTY

All instruments are warranted for one year, unless specified otherwise, against defects in materials or workmanship. Instruments abused, improperly used or installed, or altered by others may cancel warranty. If an instrument appears to be defective within the warranty period, you may return it to DataLynx freight prepaid for inspection. DataLynx will, at it's option, repair or replace the defective unit and return it to you freight prepaid.

6.0 FACTORY SERVICE

If it becomes necessary to return this instrument to the factory for service, either during or after the warranty period, call DataLynx (916-477-5226) and obtain a return authorization. Carefully pack the instrument to prevent damage during shipment. Include a letter with a description of the problem, your telephone number, and your return shipping address. Whenever possible, a cost estimate for the repair and the time required will be given at the time of your call.

NOVALYNX CORPORATION
431-G CROWN POINT CIRCLE
PO BOX 240
GRASS VALLEY CA 95945

(916)477-5226

3/90

HUMIDITY PROBE HMP 35AD

The HMP 35AD Humidity Probe is designed to be used with measurement systems and devices, such as dataloggers, recorders, controllers, displays, weather stations and laboratory equipment. Cable connections are shown in Figure 1, calibration potentiometers in Figure 2.

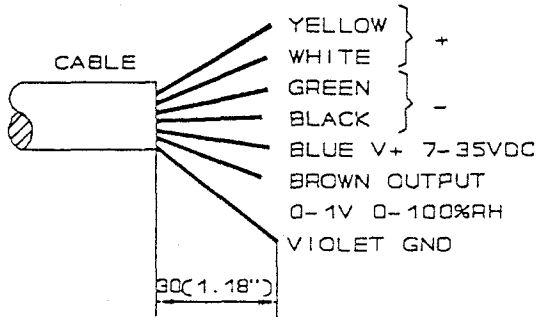


Fig. 1 Cable connections

ONE-POINT HUMIDITY CALIBRATION

When checking the calibration of the transmitters, use Vaisala's One-Point Calibrator HMK 20. Use the one-point calibration potentiometer to calibrate the transmitter. The checking period is e.g. 1 year according to the operating conditions and the required accuracy of the measurement. If salt method calibration is preferred for the HMP 35AD, use HMK 11 Humidity Meter Calibrator with LiCl (12 %RH) and NaCl (75 %RH) salt solutions. More detailed information in HMK 11 Operating Instructions.

REPLACEMENT OF THE HUMICAP® SENSOR OR THE MEMBRANE FILTER

Remove the damaged sensor and insert a new one. Recalibrate the transmitter. Replace a dirty membrane filter to ensure a maximum lifetime for the sensor. Do not attempt to clean the filter.

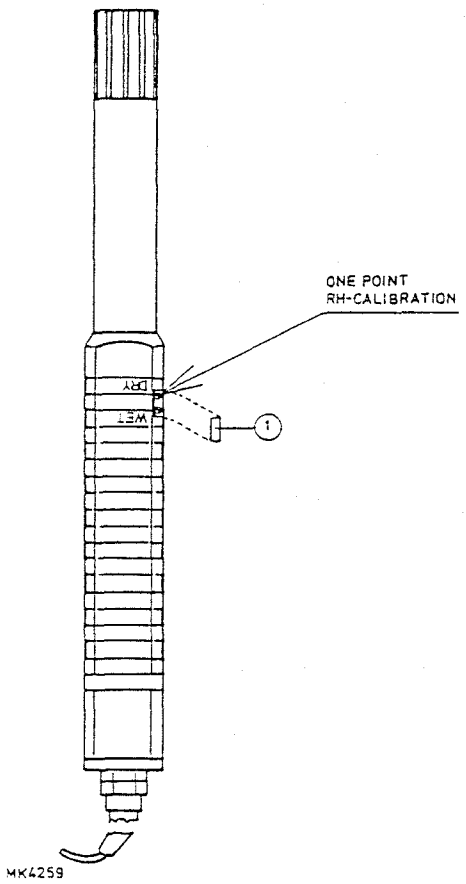


Fig. 2 Calibration potentiometers

GUARANTEE

Vaisala issues a guarantee for the material and workmanship of this product under normal operating conditions for one year from the date of delivery. Exceptional operating conditions, damage due to careless handling or misapplication will void the guarantee.

TECHNICAL DATA

Mechanics

Sensor protection	membrane filter 0.2 µm (part no. 2787)
Housing material	ABS plastic
Housing classification	IP 55 (NEMA 3S)
Dimensions	length 235 mm, probe head Ø 18.5 mm
Cable length	1.5 m (5 ft)
Weight	180 g

Electronics

Supply voltage	7 ... 35 VDC
Recommended external load for outputs	≥ 10 kΩ
Current consumption	≤ 4 mA
Operating temperature range	-20 ... +60 °C (-4 ... +140 °F)

Relative humidity

Sensor	HUMICAP® H (part no. 0062)
Measuring range	0 ... 100 %RH
Output signal	0.002 ... 1 VDC ≙ 0.2 ... 100 %RH
Accuracy at +20 °C (including calibration inaccuracy, linearity and repeatability)	
against high-quality standards	±1 %RH
against salt solutions (DIN 50 008)	±2 %RH (0 ... 90 %RH) ±3 %RH (90 ... 100 %RH)
Temperature coefficient	±0.04 %RH/°C
Typical long-term stability	better than 1 %RH per year
Response time (at +20 °C, 90 % response)	15 s with membrane filter

Temperature

Sensor	two-terminal IC AD590 LH
Measuring range	-40 ... +80 °C
Output signal	1 µA/K, linear
Accuracy (at +25 °C)	±1 °C

MANUAL FOR
NOVALYNX MULTI-PLATE RADIATION SHIELD
FOR TEMPERATURE AND HUMIDITY PROBES

MODEL 230-281

TABLE OF CONTENTS

1.0 INTRODUCTION

2.0 SPECIFICATIONS

3.0 INSTALLATION

4.0 MAINTENANCE

5.0 WARRANTY

RELEASE DATE: FEB 15, 1993

MULTI-PLATE SHIELD
MODEL 230-281

1.0 INTRODUCTION

1.1 Novalynx Corporation recommends the use of solar radiation shields whenever temperature and humidity sensors are to be installed in the field either onto a tower or mast and exposed to direct sunlight and precipitation. One of the solar radiation shields provided by Novalynx Corp. is the Multi-plate Self Aspirated Shield.

1.2 The multi-plate shield is, as its name implies, constructed of 3 anodized aluminum plates and a mounting arm. The plates are shaped to give maximum airflow around the probe while at the same time reducing direct exposure to sunlight. The plates also help prevent direct contact of the probe from rain and snow except under certain extreme conditions. Sensor exposure to sunlight and contact by rain or snow can give rise to errors in the air temperature and humidity measurements.

1.3 The self aspirated shield can provide protection for sensors located at non-powered remote locations. The shield is shaped to allow natural air convection to occur around the probe so that the air being measured inside the shield is a good representation of the air outside the shield. Of course, on a very still day, the aspiration of the probe inside the shield will be less than if the wind were blowing. The effects of the wind upon the temperature probe ventilation can be seen by comparison tests using a shield in both still air and in moving air under controlled conditions. Under low wind conditions, less than 0.5 m/s, and with a solar angle of 70 degrees above the horizon, the temperature error due to poor aspiration can be as great as 7 degrees. Error correction methods can be employed using graphs and related data such as the sun's angle on the horizon, and the wind speed.

1.4 Refer to the drawings at the end of this manual for detailed views of the shield and the sensor location inside the shield.

2.0 SPECIFICATIONS

2.1

Height.....	8.3"
Diameter of Plates.....	3.50"
Thickness of Plates.....	0.08"
Sensor Clearance.....	0.75" Dia x 4.3" Long
Sensor Mounting.....	Threaded Fitting or Clamp
Tower Mounting.....	U-bolt with plate for up to 1" Dia
Weight.....	0.45kg 1.01bs
Shipping Weight.....	0.68kg 1.5bs

3.0 INSTALLATION

3.1 The shield is designed for mounting onto a 1 inch diameter tower leg or mast. The shield is clamped onto the supporting pipe using a u-bolt and clamping plate provided with the shield.

3.2 Before attaching the shield onto the supporting pipe, install the sensor. This is especially important for situations where the shield is to be mounted above the ground to avoid unnecessary trips up and down the tower. For some sensors, the mounting adapter consists of a threaded, fitting. Other sensors are adapted to the shield mounting plate as required. With the sensor installed, the sensing end of the probe should be within 1 inch of the top of the shield. The probe should never touch the top of the shield. Generally, all sensors and shields provided by Novalynx Corp. will be matched and prepared prior to shipment to the user. Usually, the shield is shipped with the sensor installed to minimize packing materials and to speed the installation. The sensor may be removed from the shield for inspection and testing if desired.

3.3 Attach the shield to the tower or mast using the u-bolt and clamp assembly that is located on the shield mounting arm. Select a location on the tower that is free of shadows, preferably on the south side of the tower for the Northern hemisphere. Try to avoid placing the shield beneath guy wires and over-head objects that are subject to dripping during rain storms. Tighten the u-bolt taking care to avoid over-tightening the u-bolt which may cause damage to the threads or deform the tower leg. Check to ensure that the shield is vertically level to maximize sun screening of the sensor.

3.4 Upon completing the installation of the shield, route the sensor cables down the nearest tower leg or the mast using cable ties and grips to fasten the cable to the mast and to relieve strain that is placed upon the cable due to its weight and gravitational forces. The cable must be fastened securely to prevent wind whipping which can severely damage the outer jacket of the cable. Wire ties should be spaced down the tower every three to four feet. Use only stainless steel cable ties or ties that are resistant to ultra-violet radiation. Wire grips should be used wherever a sensor cable or groups of cables reach the end of a horizontal support and begin to hang down the tower leg. The wire grip will reduce damage due to the cable strain.

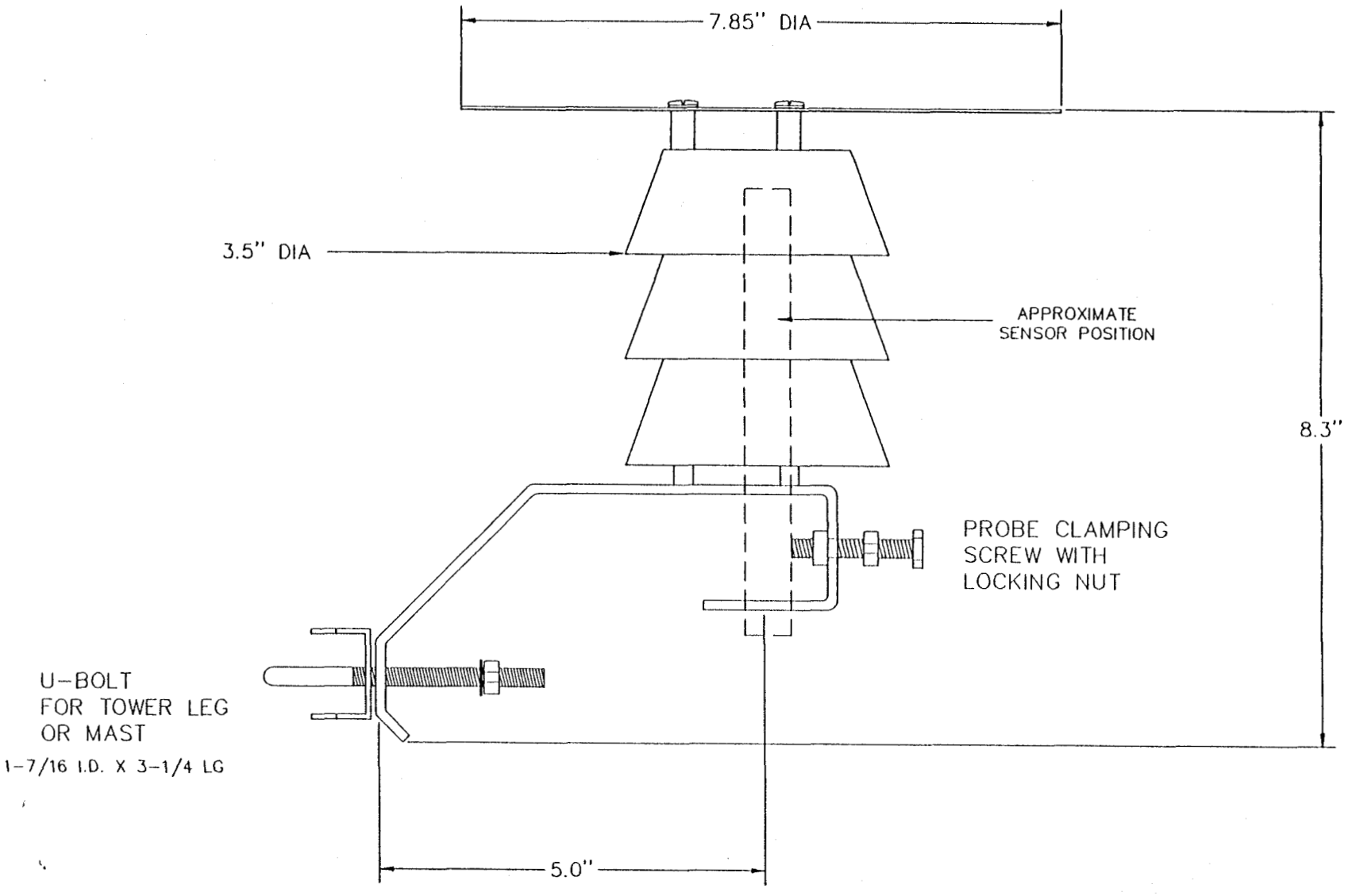
3.5 The ends of the sensor cables should be placed into weather proof or weather resistant junction boxes for termination at the base of the tower if possible.

4.0 MAINTENANCE

4.1 Inspect the shield installation on a regular basis to detect loose hardware or the need for cleaning. Do not let spider webs or leaves and other debris collect in between the shield plates. Keep the surfaces of the plates clean and free of dust and dirt which can absorb heat. Replace any shield components which may become damaged due to storm action or long term exposure to the sun. Contact Novalynx Corp. for assistance in obtaining replacement parts and service.

5.0 WARRANTY

5.1 The shield is covered by the standard Novalynx Corp. warranty.



LYNX CORPORATION			C
TITLE OUTLINE DIMENSION DRAWING SOLAR RADIATION SHIELD			
MOD. USAGE 230-281			SHEET 1 OF 1
BY RGN	SCALE FULL	DWG. NO. 921108	
DATE 11-11-92			

DataLynx Instruments
Model 230-201 Temperature Sensor
Model 210-600 Water Temperature Sensor

Instruction Manual

1.0 Introduction

1.1 General Description

The Model 230-201 Temperature Sensor is a two-terminal integrated circuit transducer that provides a linear output current proportional to the absolute temperature. The sensor acts as a high impedance constant current regulator. Laser trimming of the chips' thin film resistors is used to calibrate the output. It is supplied with 25' of cable but can be used with longer lengths. Because of its high impedance current it is insensitive to voltage drop over long lines.

1.2 Optional Accessories

- Solar radiation shields
- Instrument shelters
- Recorders or displays

1.3 Specifications

Range: -40° to +140° F (-40° to +60° C)
Output: linear
1 μA/°K for supply voltages between +4 and +30 V
298.2 μA at +25° C
Accuracy: ± 0.4° C or 0.8° F
Linearity: ± 0.3° C or 0.6° F
Size: 0.375" diameter x 2.5" long
Cable: 25' of 2-conductor cable standard, longer lengths available
Weight/shipping: 6 oz/1 lb

2.0 Installation

2.1 Unpacking

After carefully unpacking, inspect for damage that may have occurred in shipment. Do not discard any packing material until you are certain there is no damage and all items are accounted for, including accessories. In the event of damage during shipment, a claim for loss should be filed with carrier at the receiving location. This does not apply to shipments via Parcel Post or UPS. In this case you should contact NovaLynx for instructions on handling the claim.

2.2 Assembly

The sensor requires no special installation other than consideration for the particular measurement required. This sensor can be used to record temperatures in ambient air, water, soil, or any medium that is not corrosive. When recording air temperature, the probe is normally protected from direct sun by locating it in a shield or shelter. Various models are offered by NovaLynx. The probe should be kept away from thermal drafts such as heating ducts and air conditioning vents unless that is the condition to be measured. After installing the probe, route the cable to the recorder or display instrument. If it is a permanent installation, secure the cable in place with plastic cable ties or weatherproof tape to prevent wear or fraying.

2.3 Wiring

Model 230-201

Black	=	Ground
White	=	Signal
Red	=	+8 to +20 Vdc

Model 210-600

Black	=	+8 to 20 Vdc
White	=	Signal
Ground	=	Ground

3.0 Operation

Operation is essentially automatic and requires no on-site supervision.

3.1 Maintenance & Troubleshooting

If probe does not measure correctly:

1. Check power to output device to ensure connection.
2. If output device uses batteries for primary source of power, check (1) for sufficient voltage, (2) that batteries are securely in place, and (3) that battery terminals are clean and provide solid contact.
3. Check cable for continuity.
4. To check the sensor, connect it in series with a 12 Vdc battery and a current meter with the negative side of the battery connected to the negative lead of the current meter, the positive side of the battery connected to the red wire of the temperature sensor, and the white wire of the temperature sensor connected to the positive lead of the current meter. With the meter on the 1 mA or 2 mA range setting, observe the current. The measurement should correspond to the ambient temperature; the higher the temperature the higher the current reading. Refer to sensor curve drawing for values. If the sensor does not respond as described, it needs to be replaced.
6. If problem continues, see warranty instructions to return to NovaLynx.

4.0 Warranty

NovaLynx warrants that its products are free from defects in material and workmanship under normal use and service for a period of one year from date of shipment from factory. NovaLynx's obligations under this warranty are limited to, at NovaLynx's option: (i) replacing; or (ii) repairing; any products determined to be defective. In no case shall NovaLynx's liability exceed product's original purchase price. This warranty does not apply to any equipment that has been repaired or altered, except by NovaLynx, or which has been subjected to misuse, negligence, or

accident. *It is expressly agreed that this warranty will be in lieu of all warranties of fitness and in lieu of the warranty of merchantability.*

If an instrument appears to be defective within the warranty period, you may return it to NovaLynx freight prepaid for inspection. NovaLynx will, at it's option, repair or replace the defective unit and return it to you freight prepaid.

Factory Service

If it becomes necessary to return this instrument to the factory for service, either during or after the warranty period, call NovaLynx (916-477-5226) and obtain a return authorization. Carefully pack the instrument to prevent damage during shipment. Include a letter with a description of the problem, your telephone number, and your return shipping address. Whenever possible, a cost estimate for the repair and the time required will be given at the time of your call.

NOVALYNX CORPORATION
P.O. Box 240
431-G Crown Point Circle
Grass Valley, CA 95945
(916)477-5226

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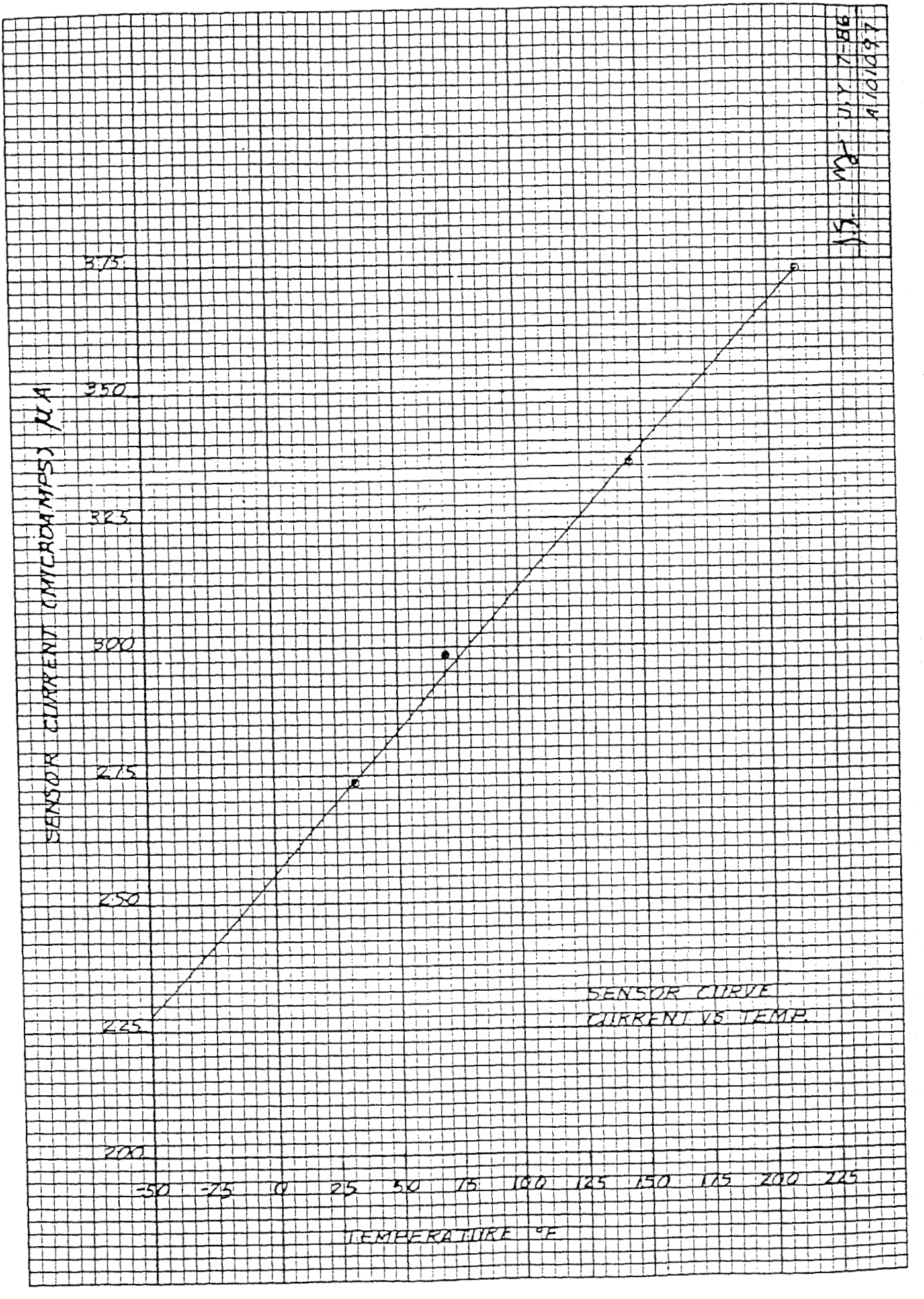
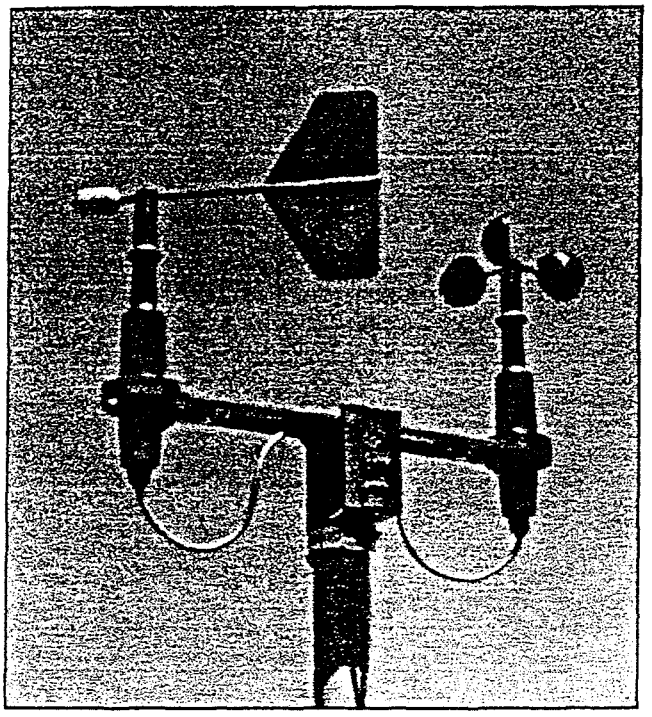

J.S. 7-86
A101097
SENSOR CURRENT (MICROAMPS) μA
375
350
325
300
275
250
225
200
-50
-25
0
25
50
75
100
125
150
175
200
225
TEMPERATURE °F
SENSOR CURVE
CURRENT VS TEMP.

MODEL 03002
WIND SENTRY
INCLUDES MODELS 03102 & 03302



WIND SPEED SPECIFICATION SUMMARY:

Range	0 to 50 m/s (112 mph), gust survival 60 m/s (134 mph)
Sensor	12 cm diameter cup wheel assembly, 40 mm diameter hemispherical cups
Turning Factor	75 cm (2.46 ft)
Distance Constant (63% recovery)	2.3 m (7.5 ft)
Threshold	1.1 m/s (2.5 mph)
Transducer	Stationary coil, 1350 ohm nominal resistance
Transducer Output	AC sine wave signal induced by rotating magnet on cup wheel shaft 100 mV p-p at 60 rpm. 6V p-p at 3600 rpm.
Output Frequency	1 cycle per cup wheel revolution. 0.75 m/s per Hz

WIND DIRECTION (AZIMUTH) SPECIFICATION SUMMARY:

Range	360° mechanical, 352° electrical (8° open)
Sensor	Balanced vane, 16 cm turning radius.
Damping Ratio	0.2
Delay Distance (50% recovery)	0.5 m (1.6 ft)
Threshold	1.3 m/s (2.9 mph) at 10° displacement 1.9 m/s (4.2 mph) at 5° displacement
Transducer	Precision conductive plastic potentiometer, 10K ohm ±20% resistance 1.0% linearity, life expectancy 50 million revolutions Rated 1 watt at 40°C, 0 watts at 125°C
Transducer Excitation Requirement	Regulated DC voltage, 15 VDC max
Transducer Output	Analog DC voltage proportional to wind direction angle with regulated excitation voltage applied across potentiometer

INTRODUCTION

The Wind Sentry Anemometer and Vane measure horizontal wind speed and wind direction. The small size, simplicity, and corrosion resistant construction provide a professional quality instrument at a modest cost. The cup wheel and vane shafts use stainless steel precision instrument grade ball bearings which are lubricated with a wide temperature range high quality instrument oil. Standard bearings have light contacting seals to exclude contamination and help retain lubricant for longer service life. Optional shielded bearings are supplied on some special models to provide lower anemometer threshold.

Cup wheel rotation produces an AC sine wave voltage signal with frequency directly proportional to wind speed. This AC signal is induced in a stationary coil by a two pole ring magnet mounted on the cup wheel shaft. One complete sine wave cycle is produced for each cup wheel revolution.

Wind vane position is transmitted by a 10K ohm precision conductive plastic potentiometer which requires a regulated excitation voltage. With a constant voltage applied to the potentiometer, the output signal is an analog voltage directly proportional to azimuth angle.

The sensor mounts on a standard 1 inch pipe, outside diameter 34mm (1.34") and is supplied with a crossarm and junction box for cable connections. The crossarm mounting is secured to the pipe by a stainless steel band clamp. Wind Sentry anemometers and windvanes are available separately with similar mounting and junction box. A variety of devices are available for signal conditioning, display, and recording of wind speed and direction. The Wind Sentry will also interface directly with many popular data loggers.

INITIAL CHECK-OUT

When the Wind Sentry is unpacked, check it carefully for any signs of shipping damage. Place the cup wheel on the anemometer shaft and secure it by tightening the set screw on the side of the hub. The instrument is aligned, balanced, and fully calibrated before shipment; however, it should be checked both mechanically and electrically before installation. The vane and cup wheel should easily rotate 360° without friction. Check vane balance by holding the instrument so the vane surface is horizontal. It should have near neutral torque without any particular tendency to rotate. A slight imbalance will not degrade performance.

The wind direction potentiometer requires a stable DC excitation voltage. Do not exceed 15 volts. When the potentiometer wiper is in the 8° deadband region, the output signal is "floating" and may show varying or unpredictable values. Azimuth signal conditioning electronics should properly process this condition. (All YOUNG signal conditioning electronics meet these requirements.) Avoid a short circuit between the azimuth signal line and either the excitation or ground reference lines. Although there is a current limiting resistor in series with the wiper for protection, damage to the potentiometer may occur if a short circuit condition exists.

Before installation, connect the Wind Sentry to a signal conditioning device and check for proper wind speed and direction values. Make electrical connections to the sensor cables supplied with the instrument as shown in the wiring diagram. Positioning the vane over the center of a sheet of paper with 35° or 45° cross markings allows easy visual alignment of the vane. To check wind speed, temporarily remove the cup wheel and connect a Model 18810 Anemometer Drive to the cup wheel shaft. Details appear in the CALIBRATION section.

INSTALLATION

Proper placement of the instrument is very important. Eddies from trees, buildings, or other structures can greatly influence wind speed and direction observations. To get meaningful data for most applications, locate the instrument well above or upwind of such obstructions. As a general rule, the air flow around a structure is disturbed to twice the height of the structure upwind, six times the height downwind, and twice the height of the structure above ground. For some observations it may not be practical or necessary to meet these guidelines.

Initial installation is most easily done with two people during the vane alignment step; one to adjust the instrument position and the other to observe the indicating device.

To install the Wind Sentry, follow these steps:

1. MOUNT WIND SENTRY
   a) Connect sensor cable to Wind Sentry junction box.
   b) Place Wind Sentry on mounting post. Do Not tighten band clamp yet.
   c) Connect sensor cable to indicator.

2. ALIGN VANE
   a) Select a known azimuth reference point on the horizon.
   b) Sighting down vane centerline, point counterweight toward azimuth reference on horizon.
   c) While holding vane in position, slowly turn base until indicator displays proper value.
   d) Tighten mounting post band clamp.

CALIBRATION

The Wind Sentry is fully calibrated before shipment and should require no adjustments. Recalibration may be necessary after some maintenance operations. Periodic calibration checks are desirable and may be necessary where the instrument is used in programs which require auditing of sensor performance.

For wind direction calibration, the following method can yield an accuracy of ±5° or better if carefully done. Begin by connecting the instrument to a signal conditioning circuit which has some way to indicate azimuth value. This may be an indicator which displays azimuth values in angular degrees or simply a voltmeter monitoring the output. Hold or mount the instrument so the vane center of rotation is over the center of a sheet of paper which has 30° or 45° crossmarkings. Position the instrument so the mounting crossarm is oriented north-south with the vane on the north and the anemometer on the south. With the counterweight pointing directly at the anemometer the azimuth signal should correspond to 180° or due south. Looking from above, visually align the vane with each of the crossmarkings and observe the indicator display. It should correspond to vane position within 5°. If not, it may be necessary to adjust the relative position of the vane skirt and shaft. See step 3 in the MAINTENANCE section under potentiometer replacement.

It is important to note that while full scale azimuth on signal conditioning electronics may be 360°, full scale azimuth signal from the instrument is 352°. The signal conditioning electronics must be adjusted accordingly. For example, in a circuit where 0 to 1.00 VDC represents 0° to 360°, the output must be adjusted for 0.978 VDC when the instrument is at 352° full scale. (352°/360° X 1.00 volts = 0.978 volts)

Wind speed calibration is determined by the cup wheel turning factor and the output characteristics of the transducer. Calibration formulas showing cup wheel rpm and frequency output vs. wind speed are included in this manual. These formulas are accurate to within 2 percent.

To calibrate wind system electronics using an actual signal from the instrument, temporarily remove the cup wheel and connect a Model 18810 Anemometer Drive to the cup wheel shaft. Calculate wind speed by applying the appropriate calibration formula to the motor rpm and adjust the signal conditioning electronics for proper value. For example, with the cup wheel shaft turning at 1800 rpm trim the indicator to display 22.7 meters per second. (0.01250 X 1800 + 0.2 = 22.7)

MAINTENANCE

Given proper care, the Wind Sentry should provide years of service. Because of its durable, corrosion resistant construction, the instrument requires little maintenance. The only components likely to require replacement due to normal wear are the precision ball bearings and the azimuth potentiometer. Replacement of these components should only be performed by a qualified instrument technician. If service facilities are not available, return the instrument to the factory. Refer to the accompanying drawings to become familiar with part names and locations. Maximum torque on all set screws is 80 oz-in.

POTENTIOMETER REPLACEMENT:

The potentiometer has a life expectancy of fifty million revolutions. As it becomes worn, the element usually begins to produce noisy signals or become non-linear. When the signal noise or non-linearity become unacceptable, replace the potentiometer as follows:

1. REMOVE POTENTIOMETER
   a) Remove three screws which secure upper and lower sections of main housing.
   b) Carefully remove upper housing exposing wiring connections to circuit board.
   c) Unsolder potentiometer wires from circuit board. Note color coding.
   d) Using a knife blade or similar instrument, loosen potentiometer assembly from upper housing and slide it out.

2. INSTALL NEW POTENTIOMETER
   a) Slide new potentiometer cell into upper housing. Be sure to engage cell key into housing notch.
   b) Solder potentiometer wires to circuit board. Observe color code.
   c) Join two sections of main housing. Secure with screws removed in step 1a.

3. ALIGN VANE
   a) Connect excitation voltage and signal conditioning electronics to instrument according to wiring diagram.
   b) Loosen set screw in side of vane hub.
   c) Position instrument so crossarm is oriented north-south with vane on north side. Orient vane to a known angular reference.(See CALIBRATION section.)
   d) While holding vane in reference position, slowly turn vane skirt until signal conditioning system indicates proper value.
   e) Tighten set screw on side of vane hub. Do not exceed 80 oz-in torque.

ANEMOMETER FLANGE BEARING REPLACEMENT:

If anemometer bearings become noisy or wind speed threshold increases above an acceptable level, replace the bearings. Check bearing condition by hanging an ordinary paper clip (0.5 gm) on the outside edge of one cup while the instrument is held in a horizontal position. The cup should rotate downward. Failure to rotate due to the weight of the paper clip indicates anemometer bearings need replacement. Repeat this test at different positions to check full bearing rotation. Replace bearings as follows:

1. REMOVE BEARINGS
   a) Loosen set screw on side of cup wheel hub. Remove cup wheel.
   b) Remove three screws which hold two sections of main housing.
   c) Carefully separate upper and lower housing. Remove coil transducer assembly from upper housing. Do not disconnect from circuit board.
   d) Loosen screw and remove ring magnet on end of shaft inside upper housing.
   e) Slide shaft and skirt assembly out of both upper and lower bearings.
   f) Using knife blade under bearing flange, carefully remove upper bearing.
   g) Using a pencil, gently push out lower bearing from above.

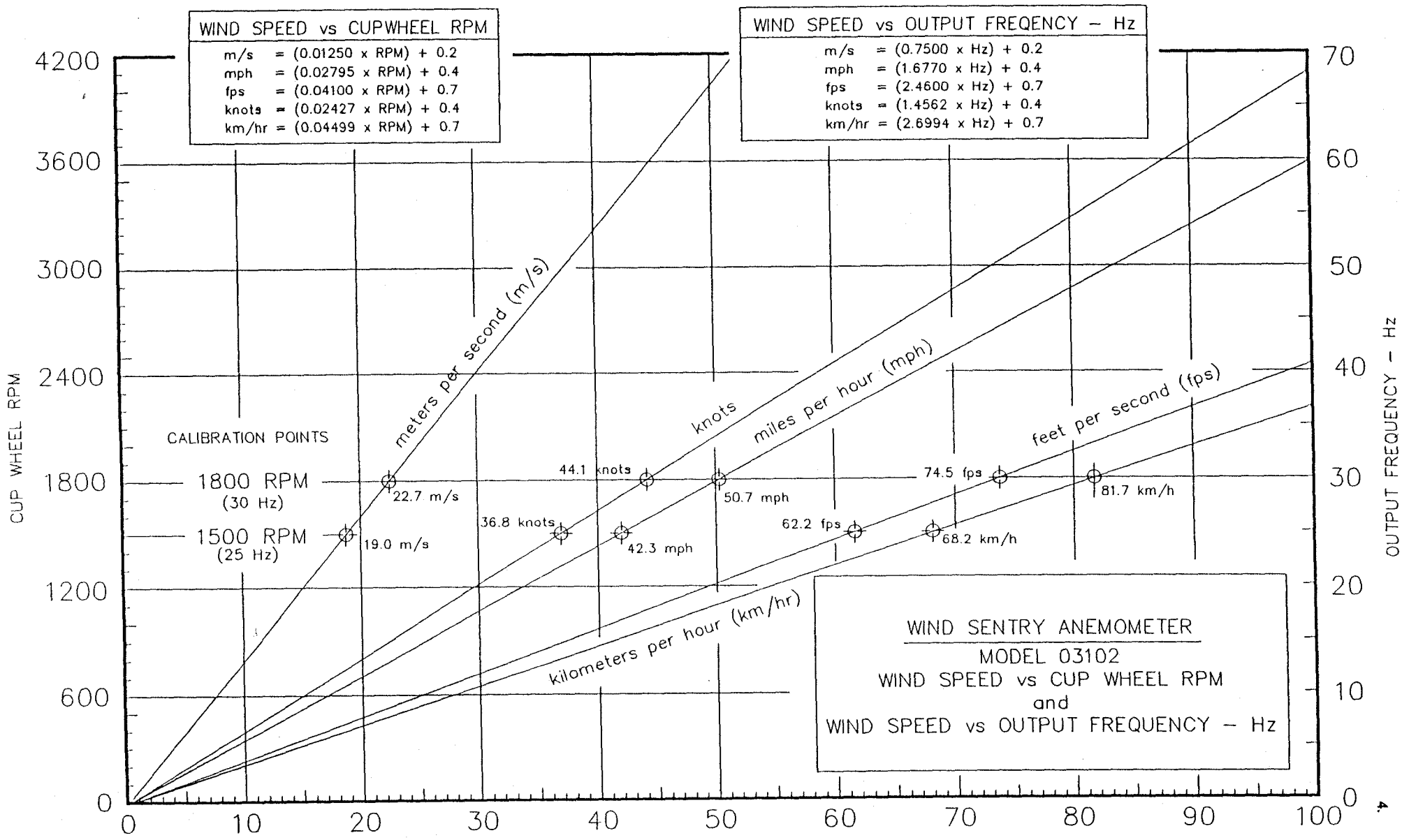
2. INSTALL NEW BEARINGS
   a) Insert new upper bearing. Use care not to apply excessive pressure.
   b) Slide cup wheel shaft through upper bearing.
   c) Slide lower bearing on shaft inside upper housing.
   d) Using ring magnet assembly, push lower bearing into its seat in upper housing.
   e) Secure ring magnet to shaft using screw removed in step 1d. Use a small amount of sealant on screw to prevent it from loosening.
   f) Join two housing sections. Secure using three screws removed in step 1b.
   g) Place cup wheel on shaft. Tighten set screw on side of hub. Do not exceed 80 oz-in torque.

VANE FLANGE BEARING REPLACEMENT:

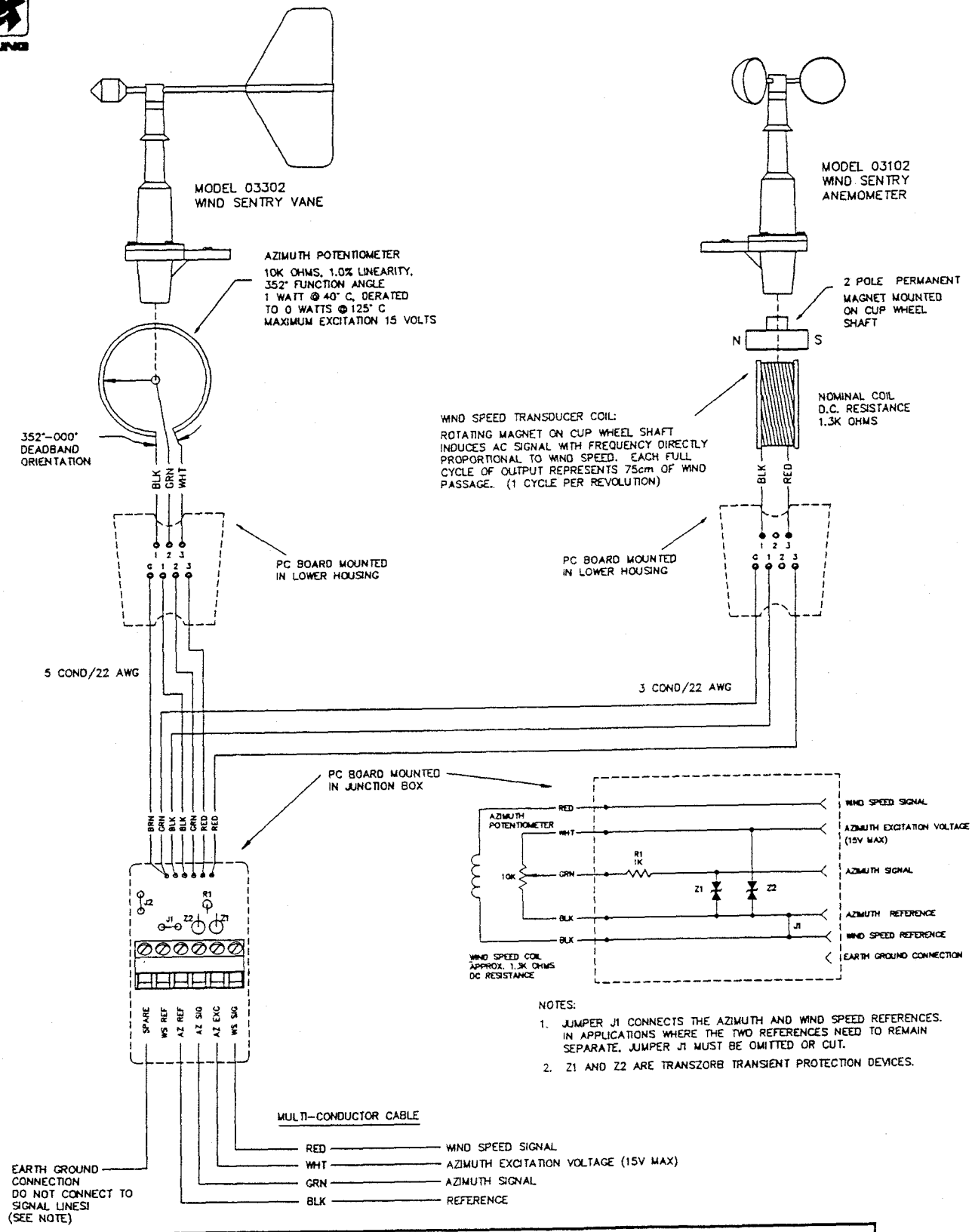
If vane bearings become noisy or if wind direction threshold increases above an acceptable level, replace the bearings. Check bearing condition by adding two ordinary paper clips (0.5 gm each) to the back edge of the vane fin while the instrument and vane are held in a horizontal position. Gently release the vane. It should rotate downward. Failure to do so indicates the bearings need replacement. Repeat this test at various positions to check full bearing rotation.

Since this procedure is similar to anemometer bearing replacement, only the major steps are shown here:

1. REMOVE BEARINGS (Remove coupling disc - same as ring magnet)
2. INSTALL NEW BEARINGS
3. ALIGN VANE (See CALIBRATION section)


WIND SPEED vs CUPWHEEL RPM
m/s = (0.01250 x RPM) + 0.2
mph = (0.02795 x RPM) + 0.4
fps = (0.04100 x RPM) + 0.7
knots = (0.02427 x RPM) + 0.4
km/hr = (0.04499 x RPM) + 0.7
WIND SPEED vs OUTPUT FREQENCY – Hz
m/s = (0.7500 x Hz) + 0.2
mph = (1.6770 x Hz) + 0.4
fps = (2.4600 x Hz) + 0.7
knots = (1.4562 x Hz) + 0.4
km/hr = (2.6994 x Hz) + 0.7
CUP WHEEL RPM
OUTPUT FREQUENCY – Hz
CALIBRATION POINTS
1800 RPM
(30 Hz)
1500 RPM
(25 Hz)
meters per second (m/s)
knots
miles per hour (mph)
feet per second (fps)
kilometers per hour (km/hr)
22.7 m/s
19.0 m/s
44.1 knots
36.8 knots
50.7 mph
42.3 mph
74.5 fps
62.2 fps
81.7 km/h
68.2 km/h
WIND SENTRY ANEMOMETER
MODEL 03102
WIND SPEED vs CUP WHEEL RPM
and
WIND SPEED vs OUTPUT FREQUENCY – Hz
WIND SPEED: meters per second, miles per hour, feet per second, knots, kilometers per hour
A03110.DWG
JAN 92

MODEL 03002 WIND SENTRY ANEMOMETER AND VANE W/J-BOX



NOTES:

1. JUMPER J1 CONNECTS THE AZIMUTH AND WIND SPEED REFERENCES. IN APPLICATIONS WHERE THE TWO REFERENCES NEED TO REMAIN SEPARATE, JUMPER J1 MUST BE OMITTED OR CUT.
2. Z1 AND Z2 ARE TRANSZORB TRANSIENT PROTECTION DEVICES.

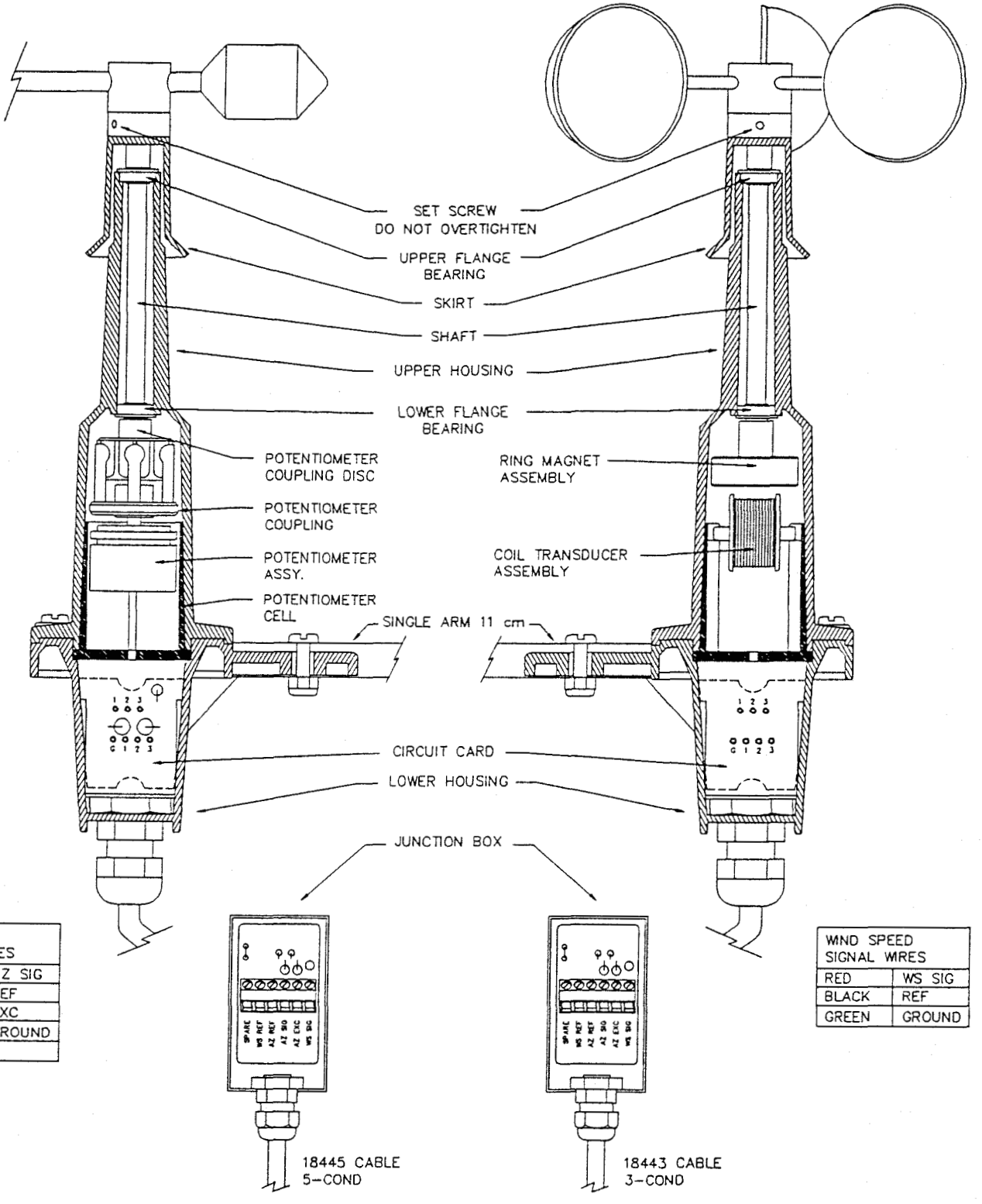
NOTE:
THE EARTH GROUND TERMINAL MUST BE CONNECTED TO EARTH GROUND TO PROVIDE A STATIC DISCHARGE PATH. CONNECT THIS TERMINAL TO AN EARTH GROUND IN THE PROXIMITY OF THE SENSOR.

MODEL 03002	DWG A	PRD 08-90
WIND SENTRY CABLE & WIRING DIAGRAM	DWN KL	DWG 01-92
	CHK EC	W03002
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

YOUNG

MODEL 03302
WIND SENTRY VANE

MODEL 03102
WIND SENTRY ANEMOMETER



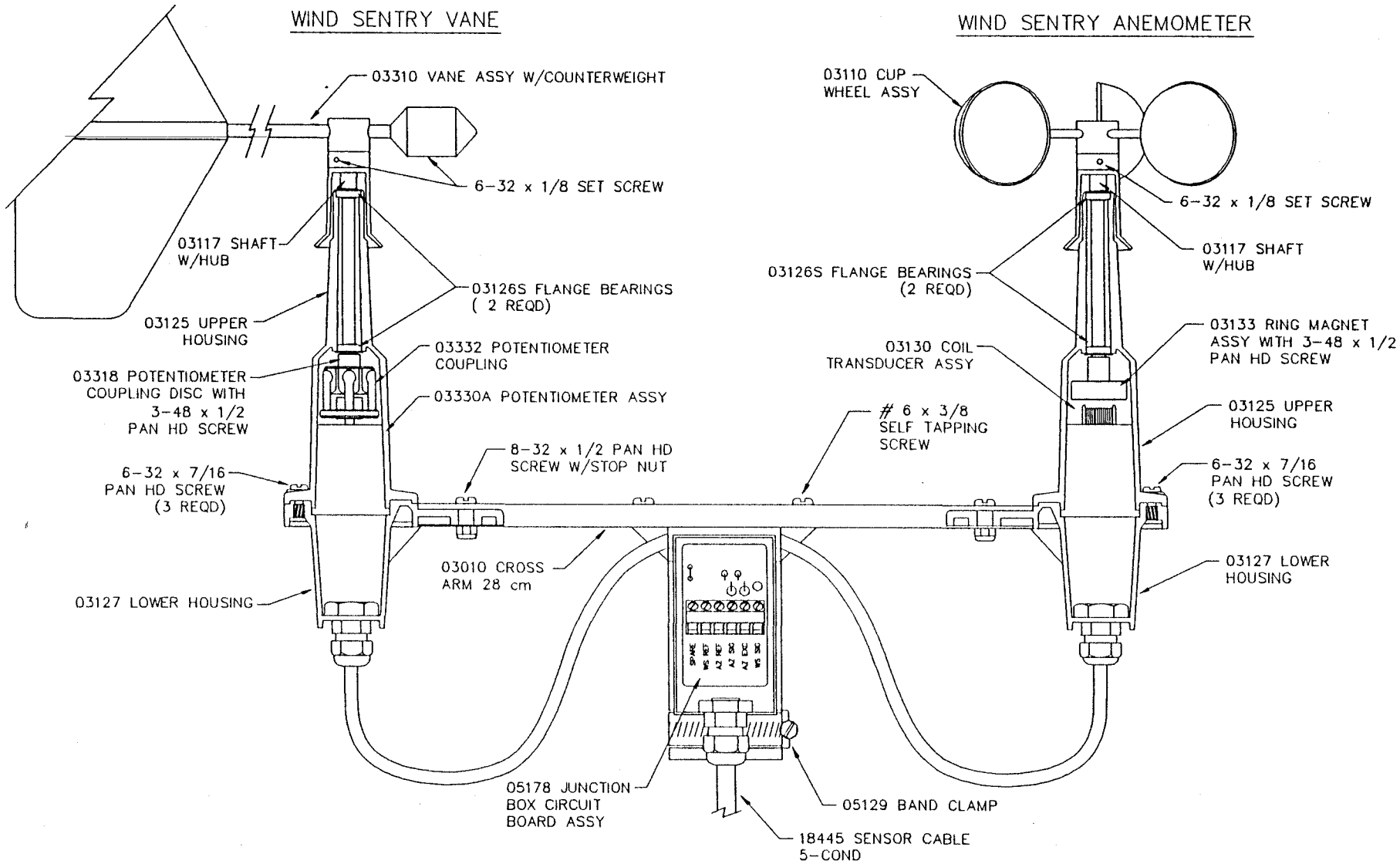
AZIMUTH SIGNAL WIRES	
GREEN	AZ SIG
BLK	REF
RED	EXC
BRN	GROUND

WIND SPEED SIGNAL WIRES	
RED	WS SIG
BLACK	REF
GREEN	GROUND

MODELS 03302/03102 WIND SENTRY	DWG A	PRD 12-92
CUP WHEEL ANEMOMETER AND VANE	DWN KL	DWG 01-92
SECTION VIEW	CHK	S03002
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

MODEL 03002 WIND SENTRY

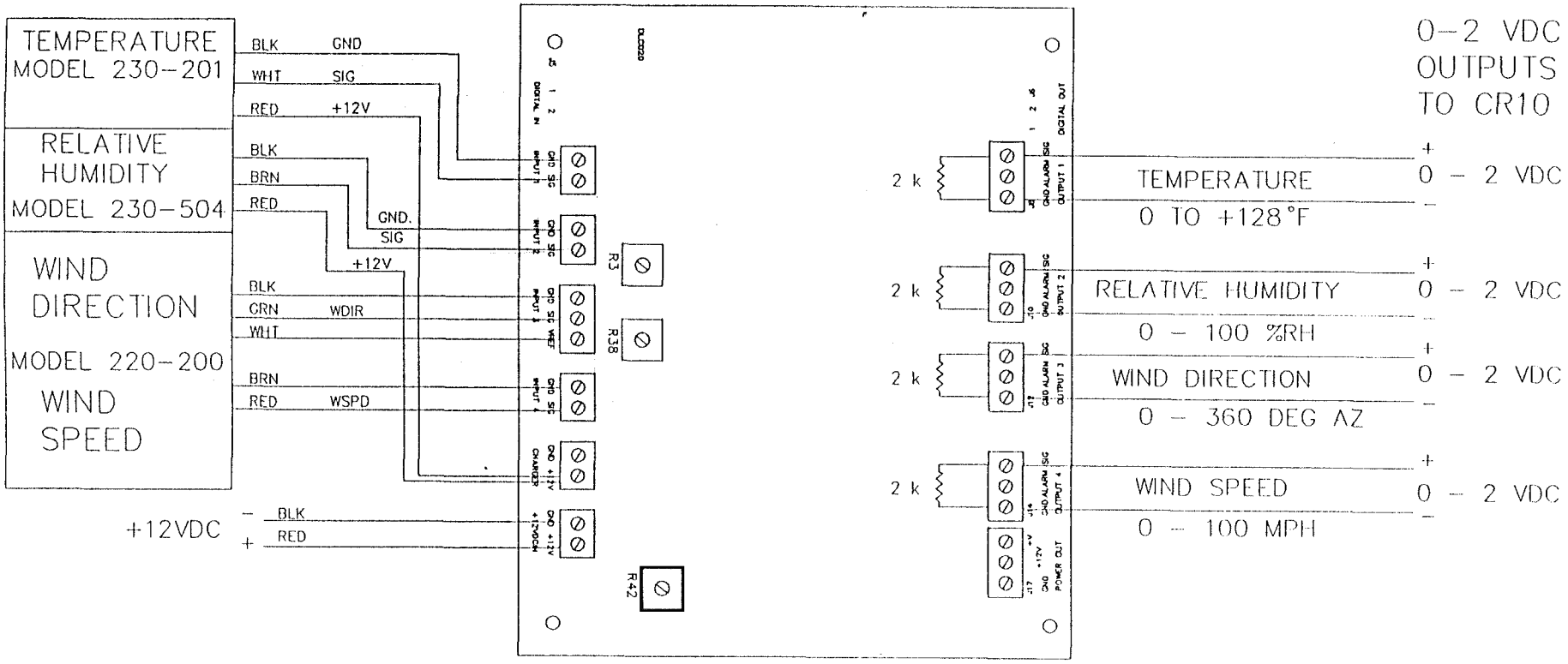
ANEMOMETER & VANE SYSTEM



MODEL 03002 WIND SENTRY	DWG A	PRD 12-91
VANE/ANEMOMETER	DWN KL	DWG 01-92
REPLACEMENT PARTS	CHK	M03002
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

SENSORS

UNIVERSAL SIGNAL CONDITIONING BOARD.
MODEL 395-104



NOTES: 1. ALL OUTPUTS ARE 0–1 mA WITH A 2K OHM LOAD RESISTOR TO PRODUCE 0–2 VDC OUTPUTS FOR CR10.

TRANSLATOR BOARD MODIFIED FOR SPEED, DIRECTION, TEMPERATURE, & HUMIDITY.

BOARD MODIFIED FOR WOODWARD-CLYDE

TITLE	SYSTEM WIRING DIAGRAM WSPD, WDIR, TEMP, RH BOARD
MOD USAGE	395-104
SHEET 1 OF 1	
BY	RGN
SCALE	NONE
DWG NO	931129
DATE	11-23-93

INSTRUCTION MANUAL

TCAV Averaging Soil Thermocouple Probe

Campbell Scientific, Inc.

TCAV
AVERAGING SOIL THERMOCOUPLE PROBE
INSTRUCTION MANUAL

June 13, 1990

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WARRANTY

The **TCAV - AVERAGING SOIL THERMOCOUPLE PROBE** is warranted against defects in materials and workmanship. This warranty applies for twelve months from date of shipment. We will repair or replace products which prove to be defective during the warranty period provided they are returned prepaid to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return warranted equipment by surface carrier prepaid. No other warranty is expressed or implied. CAMPBELL SCIENTIFIC, INC. is not liable for consequential damages.

Products may not be returned without prior authorization. To obtain a Returned Materials Authorization (RMA), contact CAMPBELL SCIENTIFIC, INC., phone (801) 753-2342. An RMA number will be issued in order to facilitate Repair Personnel in identifying an instrument upon arrival. Please write this number clearly on the outside of the shipping container.

CAMPBELL SCIENTIFIC, INC. does not accept collect calls.

Non-warranty products returned for repair should be accompanied by a purchase order to cover the repair.

CAMPBELL SCIENTIFIC, INC.

P.O. Box 551
Logan, UT 84321
Phone (801) 753-2342
TLX 453058
FAX 801-752-3268

9525 41st Avenue
Edmonton, Alberta T6E 5X7
CANADA
Phone (403) 461-5158
TLX 037-2966 (EDM)
FAX 403-450-2531

14-20 Field Street
Shepshed, Leics. LE12 9AL
ENGLAND
Phone 01144509601141
TLX 94016393 (CAMP G)
FAX 01144509601091

TCAV - AVERAGING SOIL THERMOCOUPLE PROBE

1. DESCRIPTION

The TCAV is a temperature probe which parallels 4 thermocouple junctions into one. One channel is required to measure the output voltage which represents the average temperature of the four junctions. The TCAV is most often used to obtain the average temperature of a soil layer for use in calculating stored energy.

The probe is constructed with type E thermocouple wire (chromel-constantan) and can be measured with one of the datalogger thermocouple measurement instructions, 13 or 14. Instruction 14, which uses the differential voltage measurement, should be used to reduce noise and ground loop problems.

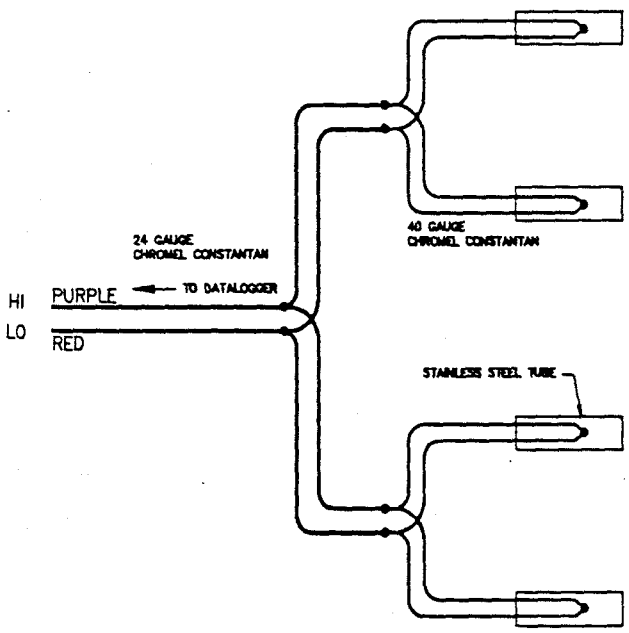

FIGURE 1. TCAV Thermocouple Probe

2. USING THE TCAV WITH SOIL HEAT FLUX PLATES

The TCAV is used in conjunction with soil heat flux plates to calculate the heat flux at the surface of the soil. The plates are buried at a fixed depth of between 5 and 8 cm to reduce errors due to vapor transport of heat.

2.1 INSTALLATION

The TCAV and two heat flux plates are typically installed as in Figure 2. The TCAV is constructed so two thermocouples can be used to obtain the average temperature of the soil layer above one heat flux plate and the other two above the second plate. The thermocouple pairs may be up to two meters apart.

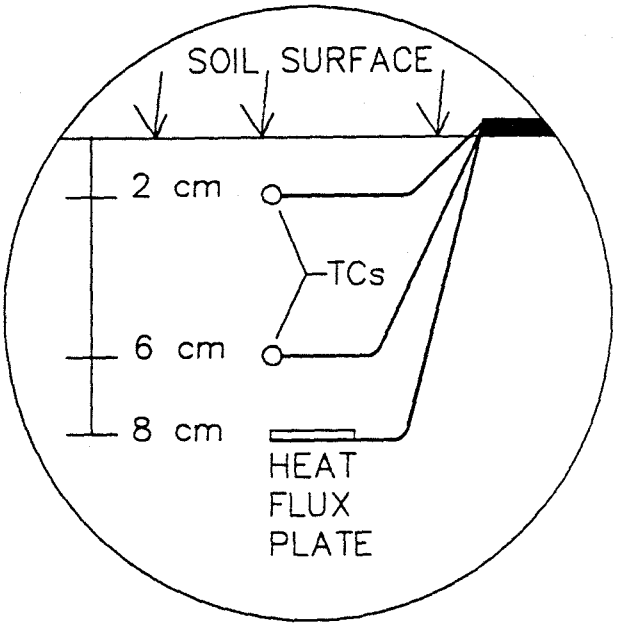

FIGURE 2. Placement of Thermocouples and Heat Flux Plates

The location of the two heat flux plates/thermocouples should be chosen to be representative of the area under study. If the ground cover is extremely varied, it could be necessary to have additional sensors to provide a valid average.

Use a shovel to cut a vertical slice in the soil and remove the soil to one side of the cut. Try to keep the soil that is removed intact so that it can be replaced with as little disruption as possible.

The sensors are installed in the undisturbed face. The depths are measured from the top of the soil. A horizontal cut is made with a knife to install a heat flux plate. The stainless steel tubes encasing the thermocouple junctions are pressed into the soil, keeping the tubes

horizontal. (When removing the thermocouples, grip the tubing, not the thermocouple wire.)

To minimize thermal conduction down the sensor lead wires, wrap them around the edge of the hole keeping the leads at the same level as the sensor for as long as possible. Replace the soil in the same position as it was. Do not run the leads directly to the surface.

2.2 CALCULATING SOIL HEAT FLUX

The soil heat flux at the surface is calculated by adding the measured flux at a fixed depth (in this case 8 cm) to the energy stored in the layer above the heat flux plates. The heat capacity of the soil and the change in temperature over the output interval are required to calculate the average stored energy, S (W m^{-2}):

$$S = (T_i - T_{i-1}) * D * Cs / t$$

Where:

T_i is the current temperature (^oC),
T_{i-1} is previous temperature (^oC),
D is depth to heat flux plate (m),
Cs is the soil heat capacity (J m^{-3} $^oC^{-1}$),and
T is the time interval (s).

One method of calculating Cs is to add the specific heat of the dry mineral soil, Csd, to that of the soil water, Cw (4190 J kg^{-1} $^oC^{-1}$). The values used for Csd and Cw are on a mass basis (J kg^{-1} $^oC^{-1}$). Cs, the heat capacity of the moist soil on a volume basis (J m^{-3} $^oC^{-1}$) is:

$$Cs = BD * (Csd + W * Cw)$$

This calculation requires site specific inputs for bulk density (BD, kg m^{-3}), mass basis water content (W, kg water/kg soil), and Csd, the specific heat of the dry soil. 840 J kg^{-1} $^oC^{-1}$ is a reasonable value for Csd for most mineral soils (Hanks and Ashcroft, Applied Soil Physics, Published by Springer-Verlag, New York, 1980).

Calibration of the Time Domain Reflectometry Cables for the Evapotranspiration Study

The calibration of ET TDR cables 31, 32, 33, and 34 is located in file 9518WAT.VAZ; calibration of ET TDR cables 35, 36, 37, and 38 is located in 9519WAT.VAZ. These files are stored with similar files as described in the section Time Domain Reflectometry Calibration Data.

ET TDR Cable Calibration

Cable Number	$T_{1.1}$	$T_{1.2}$	T_2	Travel Time (ns)	Water Content	Temper-ature (Celsius)
31	4.56	5.28	18.34	13.06	.525	14.5
32	4.73	5.44	18.65	13.21	.531	14.5
33	4.60	5.38	18.44	13.01	.525	14.5
34	4.65	5.32	18.58	13.26	.533	14.5
35	4.76	5.49	18.62	13.13	.528	16.0
36	4.55	5.30	18.46	13.16	.529	16.0
37	4.50	5.26	18.37	13.11	.527	16.0
38	4.52	5.26	18.55	13.29	.534	16.0

ALPHA WIRE CORPORATION
CUSTOMER SPECIFICATION FOR
HEAT-SHRINKABLE TUBING

FIT-221
FILE NUMBER:1925E
EFFECTIVE: 11-18-85
REPLACES:----------

SPECIFICATION NO. FIT-221

SCOPE

This specification covers an electrical insulating, heat-shrinkable tubing. The tubing shall be fabricated from thermally-stabilized, modified polyolefin and shall be crosslinked by irradiation. It shall be homogeneous and essentially free from flaws, pinholes, defects, cracks, seams, and inclusions.

Applicable Specifications

Extruded Insulating Tubing	UL Standard 224* CSA Standard C22.2 No. 198*
Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked	MIL-I-23053/5A Class 1 & 2

Physical Properties

Operating temperature range	-55°C to 135°C
Shrinkage ratio	Approximately 2:1 at 121°C
Dimensions	Shall conform to table I
Tensile strength	1800 psi
Ultimate elongation	400%
Longitudinal shrinkage	± 3%
Secant modulus	2.5×10^4 psi
Specific gravity	1.35
Heat shock (4 Hrs at 250°C)	No dripping, flowing, or cracking
Low temperature flexibility 4 hours at -55°C	No cracking
Copper stability 168 hours at 160°C Ultimate elongation	200%

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 2
To Walt "Mitch" Michman | From Debbie
Co. 3M Stoller Co. | Co. Alpha
Dept. Trailer #T891M | Phone #
Fax # 303-9[illegible]-6533 | Fax #

Electrical

Dielectric strength	500 volts/mil
Volume resistivity	10^{14} ohm/cm

Chemical

Corrosive effect 16 hours at 175°C	Non-corrosive
Flammability Colors Clear	 Self-extinguishing Not flame retardant
Water absorption 24 hours at 25°C	0.5% maximum

****

TABLE I

Alpha Part Number	Minimum Supplied I.D. Inches	Minimum Supplied I.D. mm	Maximum Recovered I.D. Inches	Maximum Recovered I.D. mm	Nominal Recovered Wall Thickness Inches	Nominal Recovered Wall Thickness mm
FIT-221-3/64	0.046	1,17	0.023	0,58	0.016	0,41
FIT-221-1/16	0.063	1,60	0.031	0,78	0.017	0,43
FIT-221-3/32	0.093	2,36	0.046	1,17	0.020	0,50
FIT-221-1/8	0.125	3,18	0.062	1,58	0.020	0,50
FIT-221-3/16	0.187	4,75	0.093	2,36	0.020	0,50
FIT-221-1/4	0.250	6,35	0.125	3,18	0.025	0,63
FIT-221-3/8	0.375	9,53	0.187	4,75	0.025	0,63
FIT-221-1/2	0.500	12,70	0.250	6,35	0.025	0,63
FIT-221-3/4	0.750	19,10	0.375	9,53	0.030	0,76
FIT-221-1	1.000	25,40	0.500	12,70	0.035	0,88
FIT-221-1-1/2	1.500	38,10	0.750	19,10	0.040	1,02
FIT-221-2	2.000	50,80	1.000	25,40	0.050	1,27
FIT-221-3	3.000	76,20	1.500	38,10	0.050	1,27
FIT-221-4	4.000	101,60	2.000	50,80	0.055	1,40

* No UL Recognition, CSA Certification on clear tubing

Rain Simulation Studies

Trench 3 - 3 Series & 2 Dry Runs

Location G

10 ft x 6 ft		11/7/94	7/1/94	7/1/94	7/7/94	7/8/94	7/8/94	7/18/94	7/19/94	7/19/94	7/22/94	7/28/94
	Time	Dry	Wet	Very Wet	Dry	Wet	Very Wet	Dry	Wet	V. Wet	Dry	Dry
	(min)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)
	5	10	20	15	0	0	15	0	0	5	5	5
	10	40	45	65	0	0	15	0	5	5	0	0
	15	40	35	60	0	0	20	0	0	45	0	0
	20	30	90	80	0	20	40	0	5	5	0	0
	25	30	100	100	0	10	60	0	60	0	5	0
	30	40	100	65	0	**45**	90	0	30	50	40	0
	35	40	70	75	0	25	**1000**	0	20	0	10	0
	40	40	95	90	0	30	1000	0	0	0	10	0
	45	40	85	70	0	40	1000	0	0	**90**	0	0
	50	40	85	90	0	30	1000	0	50	590	65	0
	55	40	85	80	0	20	1000	0	20	780	10	0
	60	35	NA	NA		40	**290**	60	10	1000	0	0
	65	5				**15**		**190**	**0**	1000	**0**	0
	70	0										
Total Vol		430	810	790	0	275	5530	250	200	3570	145	5
Ave. Vol per		39.09	73.64	71.82	0.00	21.15	425.38	19.23	15.38	274.62	11.15	0.38
5 Min Int												

Location F

10 ft x 6 ft		11/7/94	7/1/94	7/1/94	7/7/94	7/8/94	7/8/94	7/18/94	7/19/94	7/19/94	7/22/94	7/28/94
	Time	Dry	Wet	Very Wet	Dry	Wet	Very Wet	Dry	Wet	Very Wet	Dry	Dry
	(min)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)
	5	30	10	20	0	5	15	30	0	5	15	0
	10	20	10	0	10	40	35	60	0	5	5	0
	15	40	20	15	50	20	60	25	0	20	10	10
	20	25	40	25	40	30	40	25	5	25	0	25
	25	30	50	30	40	25	75	20	10	35	5	50
	30	35	40	10	35	30	55	20	25	20	15	25
	35	30	40	30	37	30	**290**	15	30	35	10	20
	40	35	20	30	43	45	1000	25	30	55	5	0
	45	35	40	20	48	45	1000	10	10	**1000**	25	30
	50	40	30	25	45	45	1000	20	10	1000	15	20
	55	40	30	25	45	45	1000	10	20	1000	5	30
	60	40	NA	NA	20	65	**1000**	20	15	1000	0	30
	65	0				**35**		**30**	**5**		**15**	5
	70	0										
Total Vol		400	330	230	413	460	5570	310	160	4200	125	245
Ave. Vol per		36.36364	30.00	20.91	34.42	35.38	464.17	23.85	12.31	350.00	9.62	18.85
5 min int												

Rain Simulation Studies

Trench 2 - 3 Series & 2 Dry Runs

Location E														
3 ft x 5 ft		**11/7/94**	**7/1/94**	**7/1/94**		**7/7/94**	**7/8/94**	**7/8/94**		**7/18/94**	**7/19/94**	**7/19/94**		**7/22/94**	**7/28/94**
	Time	**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Dry**
	(min)	**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**
	5	10	5	190		5	5	5		10	0	0		10	5
	10	15	75	360		45	0	5		20	0	0		0	0
	15	30	**130**	280		60	0	10		10	0	0		0	0
	20	20	180	340		50	0	15		5	0	0		5	0
	25	25	190	390		40	5	**415**		0	0	0		0	0
	30	20	230	310		30	0	1000		0	0	0		5	0
	35	20	240	370		30	15	1000		5	5	70		0	0
	40	25	220	410		25	10	1000		0	0	**430**		0	0
	45	25	270	420		40	10	1000		0	0	340		0	5
	50	20	310	450		35	0	1000		0	0	1000		10	0
	55	30	310	430		30	5	1000		0	0	1000		0	0
	60	20	NA	NA		20	0	**500**		0	0	1000		0	0
	65	0				**10**	**0**			**5**	**0**			**5**	0
	70	5													
Total Vol		240	2160	3950		420	50	6950		55	5	3840		35	10
Ave. Vol per		21.82	196.36	359.09		32.31	3.85	579.17		4.23	0.38	320.00		2.69	0.77
5 Min Int															
Location D															
1 ft x 1ft		**11/7/94**	**7/1/94**	**7/1/94**		**7/7/94**	**7/8/94**	**7/8/94**		**7/18/94**	**7/19/94**	**7/19/94**		**7/22/94**	**7/28/94**
	Time	**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Dry**
	(min)	**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**
	5	0	0	30		0	0	5		0	0	10		10	0
	10	10	20	60		0	0	10		0	0	10		15	5
	15	70	10	50		0	0	5		10	0	5		20	5
	20	70	10	50		0	0	5		10	0	20		15	10
	25	100	20	80		0	20	15		10	5	10		5	0
	30	90	15	80		0	10	10		0	0	15		5	20
	35	105	25	100		0	10	0		5	5	10		0	0
	40	105	10	80		0	15	15		0	5	10		5	0
	45	100	40	70		0	5	**145**		0	0	10		0	5
	50	105	20	90		0	10	365		5	0	0		5	10
	55	115	20	75		15	15	**105**		0	5	15		0	5
	60	90	NA	NA		30	5			10	5	5		0	10
	65	15				**40**	**5**			**0**	**0**			**5**	0
	70	5													
Total Vol		870	190	765		85	95	680		50	25	120		85	70
Ave. Vol per		79.09	17.27	69.55		6.54	7.31	61.82		3.85	1.92	10.00		6.54	5.38
5 min int															

Rain Simulation Studies

Trench 2 - 3 Series & 2 Dry Runs

Location C														
1 ft x 1ft		**6/30/94**	**7/1/94**	**7/1/94**		**7/7/94**	**7/8/94**	**7/8/94**		**7/18/94**	**7/19/94**	**7/19/94**		**7/22/94**	**7/28/94**
	Time	**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Dry**
	(min)	**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**
	5	no	30	40		40	10	20		50	0	0		10	5
	10	working	45	80		40	30	30		0	0	0		20	0
	15	110	65	80		20	15	20		0	0	10		20	0
	20	125	60	70		20	30	**295**		0	5	5		25	0
	25	120	50	90		15	15	605		0	0	**135**		15	0
	30	90	30	90		15	15	700		0	0	470		0	0
	35	110	40	**130**		15	15	775		0	0	550		0	5
	40	110	30	150		15	20	475		5	0	750		0	0
	45	110	60	180		20	20	800		10	0	870		5	0
	50	110	40	270		15	10	810		0	0	900		0	5
	55	80	80	310		15	**110**	830		10	10	1000		0	5
	60	na	na	NA		5	260	**400**		5	0	1000		5	5
	After					**5**	**100**			**0**	**0**			10	0
Total Vol		965	530	1490		240	650	5760		80	15	5690		110	25
Ave. Vol per		87.72727	48.18	135.45		18.46	50.00	480.00		6.15	1.15	474.17		8.46	1.92
5 min int															
Location B															
3ft x 5ft		**11/7/94**	**7/1/94**	**7/1/94**		**7/7/94**	**7/8/94**	**7/8/94**		**7/18/94**	**7/19/94**	**7/19/94**		**7/22/94**	**7/28/94**
	Time	**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Dry**
	(min)	**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**
	5	10	0	10		10	5	2		0	0	5		5	40
	10	5	0	20		50	0	**163**		0	0	0		0	0
	15	5	10	60		50	0	505		0	0	**1000**		5	5
	20	0	10	80		30	5	580		0	5	1000		0	0
	25	5	20	100		0	35	1000		0	5	1000		0	0
	30	5	20	130		10	35	1000		0	5	1000		0	0
	35	15	30	230		10	40	1000		0	5	1000		0	5
	40	5	20	330		20	50	1000		0	0	1000		0	0
	45	5	20	**760**		20	**730**	1000		0	20	1000		0	0
	50	5	20	1000		20	450	1000		0	**760**	1000		**1000**	0
	55	5	20	1000		15	350	**860**		0	855	1000		1000	0
	60	5	NA	NA		15	663			**0**	830	1000		1000	0
	65	5				**5**	**37**				**850**			1000	10
	70	0													
Total Vol		65	170	3720		255	2400	8110		0	1655	9005		2010	50
Ave. Vol per		5.91	15.45	338.18		19.62	184.62	737.27		0.00	127.31	750.42		154.62	3.85
5 min int															

Rain Simulation Studies

Trench 2 - 3 Series & 2 Dry Runs

Location A														
10 ft x 35 ft										**7/18/94**	**7/19/94**	**7/19/94**		**7/22/94**	**7/28/94**
	Time									**Dry**	**Wet**	**Very Wet**		**Dry**	**Dry**
	(min)									**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**
	5									100	10	1000		0	0
	10									130	70	1000		5	0
	15									120	80	1000		0	0
	20									130	95	1000		0	0
	25									110	110	1000		5	0
	30									110	**355**	1000		0	0
	35									110	1000	1000		0	0
	40									130	1000	1000		**1000**	0
	45									110	1000	1000		1000	0
	50									100	1000	1000		1000	0
	55									110	1000	1000		9000	0
	60									100	1000	1000		10000	430
	60									**185**	**1000**			5gal +	1000
Total Vol										1545	7720	12000		exceeded	1430
														measurement	
Ave. Vol per										118.85	593.85	1000.00		capacity	119.17
5 min int															

Rain Simulation Studies							
Trench 3 - 2 Dry Runs							
Location E							
3 ft x 5 ft							
	Time	**Dry**	**Dry**				
		(ml)	**(ml)**				
	5	0	10				
	10	30	15				
	15	50	30				
	20	70	20				
	25	85	25				
	30	90	20				
	35	100	20				
	40	100	25				
	45	105	25				
	50	120	20				
	55	140	30				
	60	135	20				
	65	50	0				
	70	5	5				
Location D							
3 ft x 5 ft							
	Time	**Dry**	**Dry**				
		(ml)	**(ml)**				
	5	0	5				
	10	10	5				
	15	70	0				
	20	70	5				
	25	100	0				
	30	90	0				
	35	105	0				
	40	105	0				
	45	100	0				
	50	105	0				
	55	115	0				
	60	90	0				
	65	15	0				
	70	5	0				

Rain Simulation Studies

Trench 3 - 2 Dry Runs

Location C

10 ft x 6 ft

not working

Location B

10 ft x 6 ft

Time	Dry (ml)	Dry (ml)
5	10	5
10	5	0
15	5	5
20	0	0
25	5	10
30	5	10
35	15	20
40	5	10
45	5	25
50	5	15
55	5	10
60	5	20
65	5	5
70	0	5

Location A

10 ft x 35 ft

Time	Dry (ml)	Dry (ml)
5	35	0
10	100	0
15	175	0
20	185	80
25	160	40
30	400	30
35	195	30
40	175	20
45	345	10
50	145	30
55	220	20
60	440	20
65	125	0
70	145	0

Rain Simulation Studi			**imulations**				
Trench 3 - 2 Dry Ru			**Runs**				
Location G							
1 ft x 1 ft							
	Time	**Dry**	**Dry**				
		(ml)	**(ml)**				
	5	15	10				
	10	35	40				
	15	10	40				
	20	20	30				
	25	15	30				
	30	25	40				
	35	20	40				
	40	10	40				
	45	30	40				
	50	20	40				
	55	25	40				
	60	25	35				
	65	0	5				
	70	0	0				
Location F							
1 ft x 1 ft							
	Time	**Dry**	**Dry**				
		(ml)	**(ml)**				
	5	5	30				
	10	75	20				
	15	70	40				
	20	60	25				
	25	70	30				
	30	70	35				
	35	70	30				
	40	70	35				
	45	70	35				
	50	80	40				
	55	60	40				
	60	80	40				
	65	25	0				
	70	0	0				

Piezometer Data

for Trench 2

Date	Time	Run	1	2	3	Old
			Inches	Inches	Inches	Inches
6/30/94	8:05	I -1A	N/A	N/A	N/A	84
	9:25	I -1B	N/A	N/A	N/A	84
7/1/94	10:30	I -2A	163	66.5	77	82
	12:00	I -2B	160	114.5	130.5	70
	3:11	I -3B	160	46.5	61.5	46
7/7/94	6:35	II -1A	97.5	70.5	77.5	76
	9:05	II - 1B	97.5	55.5	72.5	58
7/8/94	6:33	II - 2A	85.5	60.5	60	65
	11:24	II - 2B	83	32	49	34
	1:30	II - 3B	81.5	13.5	26	14
7/18/94	7:01	III - 1A	73.5	68.5	75	75
	9:00	III - 1B	75.5	60	73	63.5
7/19/94	6:47	III - 2A	70.5	58	63.5	64
	8:46	III - 2B	70.5	30.5	59.5	35
	12:04	III - 3B	69	7	25	8.5
7/22/94	7:20	IV - 1A	76.5	57.5	63	63
	9:09	IV - 1B	76.5	26.5	55	31
7/28/94	8:24	V - 1A	90.5	63	69	69
	10:03	V - 1B	89.5	59.5	77	53

Measurements were taken before automation of the system

All values are the distance from ground surface to the water table

The Roman numeral indicates the series

The first number after the hyphen corresponds to

1- Dry run

2 - Wet run

3- Very Wet run

The letter indicates when relative to the rain simulation the information was taken

A- Prior to Simulation

B- After SImulation

```
Program: EVAPAN
Flag Usage:
Input Channel Usage:
Excitation Channel Usage:
Control Port Usage:
Pulse Input Channel Usage:
Output Array Definitions:


*      1        Table 1 Programs
  01: 10        Sec. Execution Interval

01:  P86        Do
  01: 41        Set high Port 1

02:  P86        Do
  01: 72        Pulse Port 2

03:  P86        Do
  01: 72        Pulse Port 2

04:  P86        Do
  01: 72        Pulse Port 2

05:  P22        Excitation with Delay
  01: 1         EX Chan
  02: 0         Delay w/EX (units=.01sec)
  03: 100       Delay after EX (units=.01sec)
  04: 0         mV Excitation

06:  P86        Do
  01: 72        Pulse Port 2

07:  P2         Volt (DIFF)
  01: 1         Rep
  02: 15        2500 mV fast Range
  03: 1         IN Chan
  04: 16        Loc [:WIND SPD ]
  05: .05       Mult
  06: 0         Offset

08:  P89        If X<=>F
  01: 16        X Loc WIND SPD
  02: 3         >=
  03: 0         F
  04: 30        Then Do

09:  P89        If X<=>F
  01: 16        X Loc WIND SPD
  02: 4         <
  03: 120       F
  04: 30        Then Do
```

```
10:  P33        Z=X+Y
  01: 17        X Loc SPD TOTAL
  02: 16        Y Loc WIND SPD
  03: 17        Z Loc [:SPD TOTAL]

11:  P32        Z=Z+1
  01: 18        Z Loc [:SPD COUNT]

12:  P95        End

13:  P95        End

14:  P86        Do
  01: 51        Set low Port 1

15:  P92        If time is
  01: 0         minutes into a
  02: 1         minute interval
  03: 30        Then Do

16:  P86        Do
  01: 41        Set high Port 1

17:  P86        Do
  01: 72        Pulse Port 2

18:  P2         Volt (DIFF)
  01: 1         Rep
  02: 15        2500 mV fast Range
  03: 1         IN Chan
  04: 4         Loc [:WATR TEMP]
  05: .064      Mult
  06: 0         Offset

19:  P89        If X<=>F
  01: 4         X Loc WATR TEMP
  02: 3         >=
  03: 0         F
  04: 30        Then Do

20:  P89        If X<=>F
  01: 4         X Loc WATR TEMP
  02: 4         <
  03: 120       F
  04: 30        Then Do

21:  P33        Z=X+Y
  01: 4         X Loc WATR TEMP
  02: 5         Y Loc WAT TOTAL
  03: 5         Z Loc [:WAT TOTAL]

22:  P32        Z=Z+1
  01: 6         Z Loc [:WAT COUNT]
```

```
23:  P95       End

24:  P95       End

25:  P86       Do
  01: 72       Pulse Port 2

26:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 8        Loc [:REL HUM  ]
  05: .05      Mult
  06: 0        Offset

27:  P89       If X<=>F
  01: 8        X Loc REL HUM
  02: 3        >=
  03: 0        F
  04: 30       Then Do

28:  P89       If X<=>F
  01: 8        X Loc REL HUM
  02: 4        <
  03: 101      F
  04: 30       Then Do

29:  P33       Z=X+Y
  01: 8        X Loc REL HUM
  02: 9        Y Loc HUM TOTAL
  03: 9        Z Loc [:HUM TOTAL]

30:  P32       Z=Z+1
  01: 10       Z Loc [:HUM COUNT]

31:  P95       End

32:  P95       End

33:  P86       Do
  01: 72       Pulse Port 2

34:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 12       Loc [:WIND DIR ]
  05: .18      Mult
  06: 0        Offset
```

```
35:  P89       If X<=>F
  01: 12       X Loc WIND DIR
  02: 3        >=
  03: 0        F
  04: 30       Then Do

36:  P89       If X<=>F
  01: 12       X Loc WIND DIR
  02: 4        <
  03: 361      F
  04: 30       Then Do

37:  P33       Z=X+Y
  01: 12       X Loc WIND DIR
  02: 13       Y Loc DIR TOTAL
  03: 13       Z Loc [:DIR TOTAL]

38:  P32       Z=Z+1
  01: 14       Z Loc [:DIR COUNT]

39:  P95       End

40:  P95       End

41:  P86       Do
  01: 51       Set low Port 1

42:  P11       Temp 107 Probe
  01: 1        Rep
  02: 3        IN Chan
  03: 1        Excite all reps w/EXchan 1
  04: 20       Loc [:AIR TEMP ]
  05: 1.8      Mult
  06: 32       Offset

43:  P89       If X<=>F
  01: 20       X Loc AIR TEMP
  02: 3        >=
  03: 0        F
  04: 30       Then Do

44:  P89       If X<=>F
  01: 20       X Loc AIR TEMP
  02: 4        <
  03: 120      F
  04: 30       Then Do

45:  P33       Z=X+Y
  01: 20       X Loc AIR TEMP
  02: 21       Y Loc AIR TOTAL
  03: 21       Z Loc [:AIR TOTAL]

46:  P32       Z=Z+1
  01: 22       Z Loc [:AIR COUNT]
```

```
47:  P95       End

48:  P95       End

49:  P95       End

50:  P92       If time is
  01: 59       minutes into a
  02: 60       minute interval
  03: 30       Then Do

51:  P86       Do
  01: 41       Set high Port 1

52:  P86       Do
  01: 72       Pulse Port 2

53:  P86       Do
  01: 72       Pulse Port 2

54:  P86       Do
  01: 72       Pulse Port 2

55:  P86       Do
  01: 72       Pulse Port 2

56:  P22       Excitation with Delay
  01: 1        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 100      Delay after EX (units=.01sec)
  04: 0        mV Excitation

57:  P86       Do
  01: 72       Pulse Port 2

58:  P1        Volt (SE)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 24       Loc [:59 EVAP  ]
  05: .00392   Mult
  06: 0        Offset

59:  P86       Do
  01: 51       Set low Port 1

60:  P95       End

61:  P92       If time is
  01: 0        minutes into a
  02: 60       minute interval
  03: 30       Then Do
```

```
62:  P17       Module Temperature
  01: 1        Loc [:CR10 TEMP]

63:  P53       Scaling Array (A*loc +B)
  01: 1        Start Loc [:CR10 TEMP]
  02: 1.8      A1
  03: 32       B1
  04: 0.0000   A2
  05: 0.0000   B2
  06: 0.0000   A3
  07: 0.0000   B3
  08: 0.0000   A4
  09: 0.0000   B4

64:  P10       Battery Voltage
  01: 2        Loc [:Batt Volt]

65:  P86       Do
  01: 41       Set high Port 1

66:  P86       Do
  01: 72       Pulse Port 2

67:  P86       Do
  01: 72       Pulse Port 2

68:  P86       Do
  01: 72       Pulse Port 2

69:  P86       Do
  01: 72       Pulse Port 2

70:  P22       Excitation with Delay
  01: 1        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 100      Delay after EX (units=.01sec)
  04: 0        mV Excitation

71:  P86       Do
  01: 72       Pulse Port 2

72:  P1        Volt (SE)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 25       Loc [:60 EVAP  ]
  05: .00392   Mult
  06: 0        Offset

73:  P86       Do
  01: 51       Set low Port 1
```

```
74:  P33        Z=X+Y
  01: 24        X Loc 59 EVAP
  02: 25        Y Loc 60 EVAP
  03: 3         Z Loc [:EVAP PAN ]

75:  P37        Z=X*F
  01: 3         X Loc EVAP PAN
  02: .5        F
  03: 3         Z Loc [:EVAP PAN ]

76:  P38        Z=X/Y
  01: 5         X Loc WAT TOTAL
  02: 6         Y Loc WAT COUNT
  03: 7         Z Loc [:FINAL WTR]

77:  P38        Z=X/Y
  01: 9         X Loc HUM TOTAL
  02: 10        Y Loc HUM COUNT
  03: 11        Z Loc [:FINAL HUM]

78:  P38        Z=X/Y
  01: 13        X Loc DIR TOTAL
  02: 14        Y Loc DIR COUNT
  03: 15        Z Loc [:FINAL DIR]

79:  P38        Z=X/Y
  01: 17        X Loc SPD TOTAL
  02: 18        Y Loc SPD COUNT
  03: 19        Z Loc [:FINAL SPD]

80:  P38        Z=X/Y
  01: 21        X Loc AIR TOTAL
  02: 22        Y Loc AIR COUNT
  03: 23        Z Loc [:FINAL AIR]

81:  P37        Z=X*F
  01: 5         X Loc WAT TOTAL
  02: 0         F
  03: 5         Z Loc [:WAT TOTAL]

82:  P37        Z=X*F
  01: 6         X Loc WAT COUNT
  02: 0         F
  03: 6         Z Loc [:WAT COUNT]

83:  P37        Z=X*F
  01: 9         X Loc HUM TOTAL
  02: 0         F
  03: 9         Z Loc [:HUM TOTAL]

84:  P37        Z=X*F
  01: 10        X Loc HUM COUNT
  02: 0         F
  03: 10        Z Loc [:HUM COUNT]
```

```
85:  P37       Z=X*F
  01: 13       X Loc DIR TOTAL
  02: 0        F
  03: 13       Z Loc [:DIR TOTAL]

86:  P37       Z=X*F
  01: 14       X Loc DIR COUNT
  02: 0        F
  03: 14       Z Loc [:DIR COUNT]

87:  P37       Z=X*F
  01: 17       X Loc SPD TOTAL
  02: 0        F
  03: 17       Z Loc [:SPD TOTAL]

88:  P37       Z=X*F
  01: 18       X Loc SPD COUNT
  02: 0        F
  03: 18       Z Loc [:SPD COUNT]

89:  P37       Z=X*F
  01: 21       X Loc AIR TOTAL
  02: 0        F
  03: 21       Z Loc [:AIR TOTAL]

90:  P37       Z=X*F
  01: 22       X Loc AIR COUNT
  02: 0        F
  03: 22       Z Loc [:AIR COUNT]

91:  P86       Do
  01: 10       Set high Flag 0 (output)

92:  P80       Set Active Storage Area
  01: 1        Final Storage Area 1
  02: 123      Array ID or location

93:  P77       Real Time
  01: 1110     Year,Day,Hour-Minute

94:  P70       Sample
  01: 3        Reps
  02: 1        Loc CR10 TEMP

95:  P70       Sample
  01: 1        Reps
  02: 7        Loc FINAL WTR

96:  P70       Sample
  01: 1        Reps
  02: 11       Loc FINAL HUM
```

```
97:  P70       Sample
  01: 1        Reps
  02: 15       Loc FINAL DIR

98:  P70       Sample
  01: 1        Reps
  02: 19       Loc FINAL SPD

99:  P70       Sample
  01: 1        Reps
  02: 23       Loc FINAL AIR

100: P96       Serial Output
  01: 71       SM192/SM716/CSM1

101: P95       End

102: P         End Table 1


*     2        Table 2 Programs
  01: 0.0000   Sec. Execution Interval

01:  P         End Table 2


*     3        Table 3 Subroutines

01:  P         End Table 3


*     A        Mode 10 Memory Allocation
  01: 28       Input Locations
  02: 64       Intermediate Locations
  03: 0.0000   Final Storage Area 2


*     C        Mode 12 Security
  01: 0        LOCK 1
  02: 0        LOCK 2
  03: 0000     LOCK 3
```

 Input Location Assignments (with comments):

Key:
T=Table Number
E=Entry Number
L=Location Number

T:	E:	L:	
1:	62:	1:	Loc [:CR10 TEMP]
1:	63:	1:	Start Loc [:CR10 TEMP]
1:	64:	2:	Loc [:Batt Volt]
1:	74:	3:	Z Loc [:EVAP PAN]
1:	75:	3:	Z Loc [:EVAP PAN]
1:	18:	4:	Loc [:WATR TEMP]
1:	21:	5:	Z Loc [:WAT TOTAL]
1:	81:	5:	Z Loc [:WAT TOTAL]
1:	22:	6:	Z Loc [:WAT COUNT]
1:	82:	6:	Z Loc [:WAT COUNT]
1:	76:	7:	Z Loc [:FINAL WTR]
1:	26:	8:	Loc [:REL HUM]
1:	29:	9:	Z Loc [:HUM TOTAL]
1:	83:	9:	Z Loc [:HUM TOTAL]
1:	30:	10:	Z Loc [:HUM COUNT]
1:	84:	10:	Z Loc [:HUM COUNT]
1:	77:	11:	Z Loc [:FINAL HUM]
1:	34:	12:	Loc [:WIND DIR]
1:	37:	13:	Z Loc [:DIR TOTAL]
1:	85:	13:	Z Loc [:DIR TOTAL]
1:	38:	14:	Z Loc [:DIR COUNT]
1:	86:	14:	Z Loc [:DIR COUNT]
1:	78:	15:	Z Loc [:FINAL DIR]
1:	7:	16:	Loc [:WIND SPD]
1:	10:	17:	Z Loc [:SPD TOTAL]
1:	87:	17:	Z Loc [:SPD TOTAL]
1:	11:	18:	Z Loc [:SPD COUNT]
1:	88:	18:	Z Loc [:SPD COUNT]
1:	79:	19:	Z Loc [:FINAL SPD]
1:	42:	20:	Loc [:AIR TEMP]
1:	45:	21:	Z Loc [:AIR TOTAL]
1:	89:	21:	Z Loc [:AIR TOTAL]
1:	46:	22:	Z Loc [:AIR COUNT]
1:	90:	22:	Z Loc [:AIR COUNT]
1:	80:	23:	Z Loc [:FINAL AIR]
1:	58:	24:	Loc [:59 EVAP]
1:	72:	25:	Loc [:60 EVAP]

Page 11 Input Location Labels:

1:CR10 TEMP	8:REL HUM	15:FINAL DIR	22:AIR COUNT
2:Batt Volt	9:HUM TOTAL	16:WIND SPD	23:FINAL AIR
3:EVAP PAN	10:HUM COUNT	17:SPD TOTAL	24:59 EVAP
4:WATR TEMP	11:FINAL HUM	18:SPD COUNT	25:60 EVAP
5:WAT TOTAL	12:WIND DIR	19:FINAL SPD	26:_____
6:WAT COUNT	13:DIR TOTAL	20:AIR TEMP	27:_____
7:FINAL WTR	14:DIR COUNT	21:AIR TOTAL	28:_____

```
Program:EVAPAN02
Flag Usage:
Input Channel Usage:
Excitation Channel Usage:
Control Port Usage:
Pulse Input Channel Usage:
Output Array Definitions:

     LOCATION     IDENTIFICATION
       1        ARRAY ID NUMBER 123



*      1        Table 1 Programs
  01: 60        Sec. Execution Interval

01:  P86        Do
  01: 41        Set high Port 1

02:  P86        Do
  01: 72        Pulse Port 2

03:  P22        Excitation with Delay
  01: 2         EX Chan
  02: 0000      Delay w/EX (units=.01sec)
  03: 10        Delay after EX (units=.01sec)
  04: 0.0000    mV Excitation

04:  P86        Do
  01: 72        Pulse Port 2

05:  P22        Excitation with Delay
  01: 2         EX Chan
  02: 0         Delay w/EX (units=.01sec)
  03: 10        Delay after EX (units=.01sec)
  04: 0.0000    mV Excitation

06:  P86        Do
  01: 72        Pulse Port 2

07:  P22        Excitation with Delay
  01: 2         EX Chan
  02: 0         Delay w/EX (units=.01sec)
  03: 10        Delay after EX (units=.01sec)
  04: 0         mV Excitation

08:  P86        Do
  01: 72        Pulse Port 2

09:  P22        Excitation with Delay
  01: 2         EX Chan
  02: 0000      Delay w/EX (units=.01sec)
  03: 10        Delay after EX (units=.01sec)
  04: 0.0000    mV Excitation
```

```
10:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 16       Loc [:WIND SPD ]
  05: .05      Mult
  06: 0        Offset

11:  P89       If X<=>F
  01: 16       X Loc WIND SPD
  02: 3        >=
  03: 0        F
  04: 30       Then Do

12:  P89       If X<=>F
  01: 16       X Loc WIND SPD
  02: 4        <
  03: 120      F
  04: 30       Then Do

13:  P33       Z=X+Y
  01: 17       X Loc SPD TOTAL
  02: 16       Y Loc WIND SPD
  03: 17       Z Loc [:SPD TOTAL]

14:  P32       Z=Z+1
  01: 18       Z Loc [:SPD COUNT]

15:  P95       End

16:  P95       End

17:  P86       Do
  01: 51       Set low Port 1

18:  P92       If time is
  01: 0        minutes into a
  02: 1        minute interval
  03: 30       Then Do

19:  P86       Do
  01: 41       Set high Port 1

20:  P86       Do
  01: 72       Pulse Port 2

21:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 4        Loc [:WATR TEMP]
  05: .064     Mult
  06: 0        Offset
```

```
22:  P89        If X<=>F
  01: 4         X Loc WATR TEMP
  02: 3         >=
  03: 0         F
  04: 30        Then Do

23:  P89        If X<=>F
  01: 4         X Loc WATR TEMP
  02: 4         <
  03: 120       F
  04: 30        Then Do

24:  P33        Z=X+Y
  01: 4         X Loc WATR TEMP
  02: 5         Y Loc WAT TOTAL
  03: 5         Z Loc [:WAT TOTAL]

25:  P32        Z=Z+1
  01: 6         Z Loc [:WAT COUNT]

26:  P95        End

27:  P95        End

28:  P86        Do
  01: 72        Pulse Port 2

29:  P22        Excitation with Delay
  01: 2         EX Chan
  02: 0000      Delay w/EX (units=.01sec)
  03: 10        Delay after EX (units=.01sec)
  04: 0.0000    mV Excitation

30:  P2         Volt (DIFF)
  01: 1         Rep
  02: 15        2500 mV fast Range
  03: 1         IN Chan
  04: 8         Loc [:REL HUM  ]
  05: .05       Mult
  06: 0         Offset

31:  P89        If X<=>F
  01: 8         X Loc REL HUM
  02: 3         >=
  03: 0         F
  04: 30        Then Do

32:  P89        If X<=>F
  01: 8         X Loc REL HUM
  02: 4         <
  03: 101       F
  04: 30        Then Do
```

```
33:  P33       Z=X+Y
  01: 8        X Loc REL HUM
  02: 9        Y Loc HUM TOTAL
  03: 9        Z Loc [:HUM TOTAL]

34:  P32       Z=Z+1
  01: 10       Z Loc [:HUM COUNT]

35:  P95       End

36:  P95       End

37:  P86       Do
  01: 72       Pulse Port 2

38:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 12       Loc [:WIND DIR ]
  05: .18      Mult
  06: 0        Offset

39:  P89       If X<=>F
  01: 12       X Loc WIND DIR
  02: 3        >=
  03: 0        F
  04: 30       Then Do

40:  P89       If X<=>F
  01: 12       X Loc WIND DIR
  02: 4        <
  03: 361      F
  04: 30       Then Do

41:  P33       Z=X+Y
  01: 12       X Loc WIND DIR
  02: 13       Y Loc DIR TOTAL
  03: 13       Z Loc [:DIR TOTAL]

42:  P32       Z=Z+1
  01: 14       Z Loc [:DIR COUNT]

43:  P95       End

44:  P95       End

45:  P86       Do
  01: 51       Set low Port 1
```

```
46:  P11       Temp 107 Probe
  01: 1        Rep
  02: 3        IN Chan
  03: 1        Excite all reps w/EXchan 1
  04: 20       Loc [:AIR TEMP ]
  05: 1.8      Mult
  06: 32       Offset

47:  P89       If X<=>F
  01: 20       X Loc AIR TEMP
  02: 3        >=
  03: 0        F
  04: 30       Then Do

48:  P89       If X<=>F
  01: 20       X Loc AIR TEMP
  02: 4        <
  03: 120      F
  04: 30       Then Do

49:  P33       Z=X+Y
  01: 20       X Loc AIR TEMP
  02: 21       Y Loc AIR TOTAL
  03: 21       Z Loc [:AIR TOTAL]

50:  P32       Z=Z+1
  01: 22       Z Loc [:AIR COUNT]

51:  P95       End

52:  P95       End

53:  P95       End

54:  P92       If time is
  01: 59       minutes into a
  02: 60       minute interval
  03: 30       Then Do

55:  P86       Do
  01: 41       Set high Port 1

56:  P86       Do
  01: 72       Pulse Port 2

57:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

58:  P86       Do
  01: 72       Pulse Port 2
```

```
59:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

60:  P86       Do
  01: 72       Pulse Port 2

61:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

62:  P86       Do
  01: 72       Pulse Port 2

63:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation

64:  P86       Do
  01: 72       Pulse Port 2

65:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

66:  P1        Volt (SE)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 24       Loc [:59 EVAP  ]
  05: .00392   Mult
  06: 0        Offset

67:  P86       Do
  01: 51       Set low Port 1

68:  P95       End

69:  P92       If time is
  01: 0        minutes into a
  02: 60       minute interval
  03: 30       Then Do

70:  P17       Module Temperature
  01: 1        Loc [:CR10 TEMP]
```

```
71:  P53       Scaling Array (A*loc +B)
  01: 1        Start Loc [:CR10 TEMP]
  02: 1.8      A1
  03: 32       B1
  04: 0.0000   A2
  05: 0.0000   B2
  06: 0.0000   A3
  07: 0.0000   B3
  08: 0.0000   A4
  09: 0.0000   B4

72:  P10       Battery Voltage
  01: 2        Loc [:Batt Volt]

73:  P86       Do
  01: 41       Set high Port 1

74:  P86       Do
  01: 72       Pulse Port 2

75:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

76:  P86       Do
  01: 72       Pulse Port 2

77:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

78:  P86       Do
  01: 72       Pulse Port 2

79:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

80:  P86       Do
  01: 72       Pulse Port 2

81:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation
```

```
82:  P86       Do
  01: 72       Pulse Port 2

83:  P1        Volt (SE)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 25       Loc [:60 EVAP  ]
  05: .00392   Mult
  06: 0        Offset

84:  P86       Do
  01: 51       Set low Port 1

85:  P33       Z=X+Y
  01: 24       X Loc 59 EVAP
  02: 25       Y Loc 60 EVAP
  03: 3        Z Loc [:EVAP PAN ]

86:  P37       Z=X*F
  01: 3        X Loc EVAP PAN
  02: .5       F
  03: 3        Z Loc [:EVAP PAN ]

87:  P38       Z=X/Y
  01: 5        X Loc WAT TOTAL
  02: 6        Y Loc WAT COUNT
  03: 7        Z Loc [:FINAL WTR]

88:  P38       Z=X/Y
  01: 9        X Loc HUM TOTAL
  02: 10       Y Loc HUM COUNT
  03: 11       Z Loc [:FINAL HUM]

89:  P38       Z=X/Y
  01: 13       X Loc DIR TOTAL
  02: 14       Y Loc DIR COUNT
  03: 15       Z Loc [:FINAL DIR]

90:  P38       Z=X/Y
  01: 17       X Loc SPD TOTAL
  02: 18       Y Loc SPD COUNT
  03: 19       Z Loc [:FINAL SPD]

91:  P38       Z=X/Y
  01: 21       X Loc AIR TOTAL
  02: 22       Y Loc AIR COUNT
  03: 23       Z Loc [:FINAL AIR]

92:  P37       Z=X*F
  01: 5        X Loc WAT TOTAL
  02: 0        F
  03: 5        Z Loc [:WAT TOTAL]
```

```
93:  P37       Z=X*F
  01: 6        X Loc WAT COUNT
  02: 0        F
  03: 6        Z Loc [:WAT COUNT]

94:  P37       Z=X*F
  01: 9        X Loc HUM TOTAL
  02: 0        F
  03: 9        Z Loc [:HUM TOTAL]

95:  P37       Z=X*F
  01: 10       X Loc HUM COUNT
  02: 0        F
  03: 10       Z Loc [:HUM COUNT]

96:  P37       Z=X*F
  01: 13       X Loc DIR TOTAL
  02: 0        F
  03: 13       Z Loc [:DIR TOTAL]

97:  P37       Z=X*F
  01: 14       X Loc DIR COUNT
  02: 0        F
  03: 14       Z Loc [:DIR COUNT]

98:  P37       Z=X*F
  01: 17       X Loc SPD TOTAL
  02: 0        F
  03: 17       Z Loc [:SPD TOTAL]

99:  P37       Z=X*F
  01: 18       X Loc SPD COUNT
  02: 0        F
  03: 18       Z Loc [:SPD COUNT]

100: P37       Z=X*F
  01: 21       X Loc AIR TOTAL
  02: 0        F
  03: 21       Z Loc [:AIR TOTAL]

101: P37       Z=X*F
  01: 22       X Loc AIR COUNT
  02: 0        F
  03: 22       Z Loc [:AIR COUNT]

102: P86       Do
  01: 10       Set high Flag 0 (output)

103: P80       Set Active Storage Area
  01: 1        Final Storage Area 1
  02: 123      Array ID or location

104: P77       Real Time
  01: 1110     Year,Day,Hour-Minute
```

```
105: P70        Sample
  01: 3         Reps
  02: 1         Loc CR10 TEMP

106: P70        Sample
  01: 1         Reps
  02: 7         Loc FINAL WTR

107: P70        Sample
  01: 1         Reps
  02: 11        Loc FINAL HUM

108: P70        Sample
  01: 1         Reps
  02: 15        Loc FINAL DIR

109: P70        Sample
  01: 1         Reps
  02: 19        Loc FINAL SPD

110: P70        Sample
  01: 1         Reps
  02: 23        Loc FINAL AIR

111: P96        Serial Output
  01: 71        SM192/SM716/CSM1

112: P95        End

113: P          End Table 1


*     2         Table 2 Programs
  01: 0.0000    Sec. Execution Interval

01:   P         End Table 2


*     3         Table 3 Subroutines

01:   P         End Table 3


*     A         Mode 10 Memory Allocation
  01: 28        Input Locations
  02: 64        Intermediate Locations
  03: 0.0000    Final Storage Area 2


*     C         Mode 12 Security
  01: 0         LOCK 1
  02: 0         LOCK 2
  03: 0000      LOCK 3
```

 Input Location Assignments (with comments):

Key:
T=Table Number
E=Entry Number
L=Location Number

T:	E:	L:	
1:	70:	1:	Loc [:CR10 TEMP]
1:	71:	1:	Start Loc [:CR10 TEMP]
1:	72:	2:	Loc [:Batt Volt]
1:	85:	3:	Z Loc [:EVAP PAN]
1:	86:	3:	Z Loc [:EVAP PAN]
1:	21:	4:	Loc [:WATR TEMP]
1:	24:	5:	Z Loc [:WAT TOTAL]
1:	92:	5:	Z Loc [:WAT TOTAL]
1:	25:	6:	Z Loc [:WAT COUNT]
1:	93:	6:	Z Loc [:WAT COUNT]
1:	87:	7:	Z Loc [:FINAL WTR]
1:	30:	8:	Loc [:REL HUM]
1:	33:	9:	Z Loc [:HUM TOTAL]
1:	94:	9:	Z Loc [:HUM TOTAL]
1:	34:	10:	Z Loc [:HUM COUNT]
1:	95:	10:	Z Loc [:HUM COUNT]
1:	88:	11:	Z Loc [:FINAL HUM]
1:	38:	12:	Loc [:WIND DIR]
1:	41:	13:	Z Loc [:DIR TOTAL]
1:	96:	13:	Z Loc [:DIR TOTAL]
1:	42:	14:	Z Loc [:DIR COUNT]
1:	97:	14:	Z Loc [:DIR COUNT]
1:	89:	15:	Z Loc [:FINAL DIR]
1:	10:	16:	Loc [:WIND SPD]
1:	13:	17:	Z Loc [:SPD TOTAL]
1:	98:	17:	Z Loc [:SPD TOTAL]
1:	14:	18:	Z Loc [:SPD COUNT]
1:	99:	18:	Z Loc [:SPD COUNT]
1:	90:	19:	Z Loc [:FINAL SPD]
1:	46:	20:	Loc [:AIR TEMP]
1:	49:	21:	Z Loc [:AIR TOTAL]
1:	100:	21:	Z Loc [:AIR TOTAL]
1:	50:	22:	Z Loc [:AIR COUNT]
1:	101:	22:	Z Loc [:AIR COUNT]
1:	91:	23:	Z Loc [:FINAL AIR]
1:	66:	24:	Loc [:59 EVAP]
1:	83:	25:	Loc [:60 EVAP]

Page 12 Input Location Labels:

1:CR10 TEMP	8:REL HUM	15:FINAL DIR	22:AIR COUNT
2:Batt Volt	9:HUM TOTAL	16:WIND SPD	23:FINAL AIR
3:EVAP PAN	10:HUM COUNT	17:SPD TOTAL	24:59 EVAP
4:WATR TEMP	11:FINAL HUM	18:SPD COUNT	25:60 EVAP
5:WAT TOTAL	12:WIND DIR	19:FINAL SPD	26:_____
6:WAT COUNT	13:DIR TOTAL	20:AIR TEMP	27:_____
7:FINAL WTR	14:DIR COUNT	21:AIR TOTAL	28:_____

Program: EVAPAN03

Flag Usage:

Input Channel Usage:

Excitation Channel Usage:

Control Port Usage:
Control port 1 controls the Evaporation Pan MUX which controls water temperature, relative humidity wind direction, wind velocity, and evaporation pan depth. Control port 2 controls a 107B air temperature probe. Ports 3 and 4 are reserved for the temperature probe and load cell MUXes for lysimeter 1.
Ports 5 and 6 are reserved for the temperature probe and load cell MUXes for lysimeter 2.

Pulse Input Channel Usage:

Output Array Definitions:

LOCATION	IDENTIFICATION
1	ARRAY ID NUMBER 123
2	YEAR
3	JULIAN DAY
4	HOUR-MINUTE
5	CR10 TEMPERATURE
6	BATTERY VOLTAGE
7	EVAPORATION PAN DEPTH
8	WATER TEMPERATURE
9	RELATIVE HUMIDITY
10	WIND DIRECTION
11	WIND VELOCITY
12	AIR TEMPERATURE

```
*      1        Table 1 Programs
  01: 60        Sec. Execution Interval

01:  P86        Do
  01: 41        Set high Port 1

02:  P86        Do
  01: 72        Pulse Port 2

03:  P22        Excitation with Delay
  01: 2         EX Chan
  02: 0         Delay w/EX (units=.01sec)
  03: 10        Delay after EX (units=.01sec)
  04: 0         mV Excitation
```

```
04:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 4        Loc [:WATR TEMP]
  05: .064     Mult
  06: 0        Offset

05:  P89       If X<=>F
  01: 4        X Loc WATR TEMP
  02: 3        >=
  03: 0        F
  04: 30       Then Do

06:  P89       If X<=>F
  01: 4        X Loc WATR TEMP
  02: 4        <
  03: 120      F
  04: 30       Then Do

07:  P33       Z=X+Y
  01: 4        X Loc WATR TEMP
  02: 5        Y Loc WAT TOTAL
  03: 5        Z Loc [:WAT TOTAL]

08:  P32       Z=Z+1
  01: 6        Z Loc [:WAT COUNT]

09:  P95       End

10:  P95       End

11:  P86       Do
  01: 72       Pulse Port 2

12:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

13:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 8        Loc [:REL HUM  ]
  05: .05      Mult
  06: 0        Offset

14:  P89       If X<=>F
  01: 8        X Loc REL HUM
  02: 3        >=
  03: 0        F
  04: 30       Then Do
```

```
15:  P89       If X<=>F
  01: 8        X Loc REL HUM
  02: 4        <
  03: 101      F
  04: 30       Then Do

16:  P33       Z=X+Y
  01: 8        X Loc REL HUM
  02: 9        Y Loc HUM TOTAL
  03: 9        Z Loc [:HUM TOTAL]

17:  P32       Z=Z+1
  01: 10       Z Loc [:HUM COUNT]

18:  P95       End

19:  P95       End

20:  P86       Do
  01: 72       Pulse Port 2

21:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation

22:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 12       Loc [:WIND DIR ]
  05: .18      Mult
  06: 0        Offset

23:  P89       If X<=>F
  01: 12       X Loc WIND DIR
  02: 3        >=
  03: 0        F
  04: 30       Then Do

24:  P89       If X<=>F
  01: 12       X Loc WIND DIR
  02: 4        <
  03: 361      F
  04: 30       Then Do

25:  P33       Z=X+Y
  01: 12       X Loc WIND DIR
  02: 13       Y Loc DIR TOTAL
  03: 13       Z Loc [:DIR TOTAL]

26:  P32       Z=Z+1
  01: 14       Z Loc [:DIR COUNT]
```

```
27:  P95       End

28:  P95       End

29:  P86       Do
  01: 72       Pulse Port 2

30:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation

31:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 16       Loc [:WIND SPD ]
  05: .05      Mult
  06: 0        Offset

32:  P89       If X<=>F
  01: 16       X Loc WIND SPD
  02: 3        >=
  03: 0        F
  04: 30       Then Do

33:  P89       If X<=>F
  01: 16       X Loc WIND SPD
  02: 4        <
  03: 120      F
  04: 30       Then Do

34:  P33       Z=X+Y
  01: 17       X Loc SPD TOTAL
  02: 16       Y Loc WIND SPD
  03: 17       Z Loc [:SPD TOTAL]

35:  P32       Z=Z+1
  01: 18       Z Loc [:SPD COUNT]

36:  P95       End

37:  P95       End

38:  P86       Do
  01: 51       Set low Port 1
```

```
39:  P11       Temp 107 Probe
  01: 1        Rep
  02: 3        IN Chan
  03: 1        Excite all reps w/EXchan 1
  04: 20       Loc [:AIR TEMP ]
  05: 1.8      Mult
  06: 32       Offset

40:  P89       If X<=>F
  01: 20       X Loc AIR TEMP
  02: 3        >=
  03: 0        F
  04: 30       Then Do

41:  P89       If X<=>F
  01: 20       X Loc AIR TEMP
  02: 4        <
  03: 120      F
  04: 30       Then Do

42:  P33       Z=X+Y
  01: 20       X Loc AIR TEMP
  02: 21       Y Loc AIR TOTAL
  03: 21       Z Loc [:AIR TOTAL]

43:  P32       Z=Z+1
  01: 22       Z Loc [:AIR COUNT]

44:  P95       End

45:  P95       End

46:  P92       If time is
  01: 59       minutes into a
  02: 60       minute interval
  03: 30       Then Do

47:  P86       Do
  01: 41       Set high Port 1

48:  P86       Do
  01: 72       Pulse Port 2

49:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

50:  P86       Do
  01: 72       Pulse Port 2
```

```
51:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

52:  P86       Do
  01: 72       Pulse Port 2

53:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

54:  P86       Do
  01: 72       Pulse Port 2

55:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation

56:  P86       Do
  01: 72       Pulse Port 2

57:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

58:  P1        Volt (SE)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 24       Loc [:59 EVAP  ]
  05: .00392   Mult
  06: 0        Offset

59:  P86       Do
  01: 51       Set low Port 1

60:  P95       End

61:  P92       If time is
  01: 0        minutes into a
  02: 60       minute interval
  03: 30       Then Do

62:  P17       Module Temperature
  01: 1        Loc [:CR10 TEMP]
```

```
63:  P53       Scaling Array (A*loc +B)
  01: 1        Start Loc [:CR10 TEMP]
  02: 1.8      A1
  03: 32       B1
  04: 0.0000   A2
  05: 0.0000   B2
  06: 0.0000   A3
  07: 0.0000   B3
  08: 0.0000   A4
  09: 0.0000   B4

64:  P10       Battery Voltage
  01: 2        Loc [:Batt Volt]

65:  P86       Do
  01: 41       Set high Port 1

66:  P86       Do
  01: 72       Pulse Port 2

67:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

68:  P86       Do
  01: 72       Pulse Port 2

69:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

70:  P86       Do
  01: 72       Pulse Port 2

71:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

72:  P86       Do
  01: 72       Pulse Port 2

73:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation
```

```
74:  P86       Do
  01: 72       Pulse Port 2

75:  P1        Volt (SE)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 25       Loc [:60 EVAP  ]
  05: .00392   Mult
  06: 0        Offset

76:  P86       Do
  01: 51       Set low Port 1

77:  P33       Z=X+Y
  01: 24       X Loc 59 EVAP
  02: 25       Y Loc 60 EVAP
  03: 3        Z Loc [:EVAP PAN ]

78:  P37       Z=X*F
  01: 3        X Loc EVAP PAN
  02: .5       F
  03: 3        Z Loc [:EVAP PAN ]

79:  P38       Z=X/Y
  01: 5        X Loc WAT TOTAL
  02: 6        Y Loc WAT COUNT
  03: 7        Z Loc [:FINAL WTR]

80:  P38       Z=X/Y
  01: 9        X Loc HUM TOTAL
  02: 10       Y Loc HUM COUNT
  03: 11       Z Loc [:FINAL HUM]

81:  P38       Z=X/Y
  01: 13       X Loc DIR TOTAL
  02: 14       Y Loc DIR COUNT
  03: 15       Z Loc [:FINAL DIR]

82:  P38       Z=X/Y
  01: 17       X Loc SPD TOTAL
  02: 18       Y Loc SPD COUNT
  03: 19       Z Loc [:FINAL SPD]

83:  P38       Z=X/Y
  01: 21       X Loc AIR TOTAL
  02: 22       Y Loc AIR COUNT
  03: 23       Z Loc [:FINAL AIR]

84:  P37       Z=X*F
  01: 5        X Loc WAT TOTAL
  02: 0        F
  03: 5        Z Loc [:WAT TOTAL]
```

```
85:  P37       Z=X*F
  01: 6        X Loc WAT COUNT
  02: 0        F
  03: 6        Z Loc [:WAT COUNT]

86:  P37       Z=X*F
  01: 9        X Loc HUM TOTAL
  02: 0        F
  03: 9        Z Loc [:HUM TOTAL]

87:  P37       Z=X*F
  01: 10       X Loc HUM COUNT
  02: 0        F
  03: 10       Z Loc [:HUM COUNT]

88:  P37       Z=X*F
  01: 13       X Loc DIR TOTAL
  02: 0        F
  03: 13       Z Loc [:DIR TOTAL]

89:  P37       Z=X*F
  01: 14       X Loc DIR COUNT
  02: 0        F
  03: 14       Z Loc [:DIR COUNT]

90:  P37       Z=X*F
  01: 17       X Loc SPD TOTAL
  02: 0        F
  03: 17       Z Loc [:SPD TOTAL]

91:  P37       Z=X*F
  01: 18       X Loc SPD COUNT
  02: 0        F
  03: 18       Z Loc [:SPD COUNT]

92:  P37       Z=X*F
  01: 21       X Loc AIR TOTAL
  02: 0        F
  03: 21       Z Loc [:AIR TOTAL]

93:  P37       Z=X*F
  01: 22       X Loc AIR COUNT
  02: 0        F
  03: 22       Z Loc [:AIR COUNT]

94:  P86       Do
  01: 10       Set high Flag 0 (output)

95:  P80       Set Active Storage Area
  01: 1        Final Storage Area 1
  02: 123      Array ID or location

96:  P77       Real Time
  01: 1110     Year,Day,Hour-Minute
```

```
97:  P70        Sample
  01: 3         Reps
  02: 1         Loc CR10 TEMP

98:  P70        Sample
  01: 1         Reps
  02: 7         Loc FINAL WTR

99:  P70        Sample
  01: 1         Reps
  02: 11        Loc FINAL HUM

100: P70        Sample
  01: 1         Reps
  02: 15        Loc FINAL DIR

101: P70        Sample
  01: 1         Reps
  02: 19        Loc FINAL SPD

102: P70        Sample
  01: 1         Reps
  02: 23        Loc FINAL AIR

103: P96        Serial Output
  01: 71        SM192/SM716/CSM1

104: P95        End

105: P          End Table 1


*     2         Table 2 Programs
  01: 0.0000    Sec. Execution Interval

01:  P          End Table 2


*     3         Table 3 Subroutines

01:  P          End Table 3


*     A         Mode 10 Memory Allocation
  01: 28        Input Locations
  02: 64        Intermediate Locations
  03: 0.0000    Final Storage Area 2


*     C         Mode 12 Security
  01: 0         LOCK 1
  02: 0         LOCK 2
  03: 0000      LOCK 3
```

 Input Location Assignments (with comments):

Key:
T=Table Number
E=Entry Number
L=Location Number

```
T:  E:  L:
1: 62:  1:  Loc [:CR10 TEMP]
1: 63:  1:  Start Loc [:CR10 TEMP]
1: 64:  2:  Loc [:Batt Volt]
1: 77:  3:  Z Loc [:EVAP PAN ]
1: 78:  3:  Z Loc [:EVAP PAN ]
1:  4:  4:  Loc [:WATR TEMP]
1:  7:  5:  Z Loc [:WAT TOTAL]
1: 84:  5:  Z Loc [:WAT TOTAL]
1:  8:  6:  Z Loc [:WAT COUNT]
1: 85:  6:  Z Loc [:WAT COUNT]
1: 79:  7:  Z Loc [:FINAL WTR]
1: 13:  8:  Loc [:REL HUM  ]
1: 16:  9:  Z Loc [:HUM TOTAL]
1: 86:  9:  Z Loc [:HUM TOTAL]
1: 17: 10:  Z Loc [:HUM COUNT]
1: 87: 10:  Z Loc [:HUM COUNT]
1: 80: 11:  Z Loc [:FINAL HUM]
1: 22: 12:  Loc [:WIND DIR ]
1: 25: 13:  Z Loc [:DIR TOTAL]
1: 88: 13:  Z Loc [:DIR TOTAL]
1: 26: 14:  Z Loc [:DIR COUNT]
1: 89: 14:  Z Loc [:DIR COUNT]
1: 81: 15:  Z Loc [:FINAL DIR]
1: 31: 16:  Loc [:WIND SPD ]
1: 34: 17:  Z Loc [:SPD TOTAL]
1: 90: 17:  Z Loc [:SPD TOTAL]
1: 35: 18:  Z Loc [:SPD COUNT]
1: 91: 18:  Z Loc [:SPD COUNT]
1: 82: 19:  Z Loc [:FINAL SPD]
1: 39: 20:  Loc [:AIR TEMP ]
1: 42: 21:  Z Loc [:AIR TOTAL]
1: 92: 21:  Z Loc [:AIR TOTAL]
1: 43: 22:  Z Loc [:AIR COUNT]
1: 93: 22:  Z Loc [:AIR COUNT]
1: 83: 23:  Z Loc [:FINAL AIR]
1: 58: 24:  Loc [:59 EVAP  ]
1: 75: 25:  Loc [:60 EVAP  ]
```

Page 12 Input Location Labels:

1:CR10 TEMP	8:REL HUM	15:FINAL DIR	22:AIR COUNT
2:Batt Volt	9:HUM TOTAL	16:WIND SPD	23:FINAL AIR
3:EVAP PAN	10:HUM COUNT	17:SPD TOTAL	24:59 EVAP
4:WATR TEMP	11:FINAL HUM	18:SPD COUNT	25:60 EVAP
5:WAT TOTAL	12:WIND DIR	19:FINAL SPD	26:_____
6:WAT COUNT	13:DIR TOTAL	20:AIR TEMP	27:_____
7:FINAL WTR	14:DIR COUNT	21:AIR TOTAL	28:_____

Program: EVAPAN04

Flag Usage:

Input Channel Usage:

Excitation Channel Usage:

Control Port Usage:

Control port 1 controls the Evaporation Pan MUX which controls water temperature, relative humidity wind direction, wind velocity, and evaporation pan depth. Control port 2 controls a 107B air temperature probe. Ports 3 and 4 are reserved for the temperature probe and load cell MUXes for lysimeter 1.
Ports 5 and 6 are reserved for the temperature probe and load cell MUXes for lysimeter 2.

Pulse Input Channel Usage:

Output Array Definitions:

LOCATION	IDENTIFICATION
1	ARRAY ID NUMBER 123
2	YEAR
3	JULIAN DAY
4	HOUR-MINUTE
5	CR10 TEMPERATURE
6	BATTERY VOLTAGE
7	EVAPORATION PAN DEPTH
8	WATER TEMPERATURE
9	RELATIVE HUMIDITY
10	WIND DIRECTION
11	WIND VELOCITY
12	AIR TEMPERATURE

EVAPAN04 differs from EVAPAN03 at lines 58 and 75 The multiplication factor was changed from 0.00392 to 0.00487. This represents the circumference of the pot (9.73") divided by the max voltage output (2000 mvolts)

```
*      1        Table 1 Programs
  01: 60        Sec. Execution Interval

01:  P86        Do
  01: 41        Set high Port 1

02:  P86        Do
  01: 72        Pulse Port 2
```

```
03:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation

04:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 4        Loc [:WATR TEMP]
  05: .064     Mult
  06: 0        Offset

05:  P89       If X<=>F
  01: 4        X Loc WATR TEMP
  02: 3        >=
  03: 0        F
  04: 30       Then Do

06:  P89       If X<=>F
  01: 4        X Loc WATR TEMP
  02: 4        <
  03: 120      F
  04: 30       Then Do

07:  P33       Z=X+Y
  01: 4        X Loc WATR TEMP
  02: 5        Y Loc WAT TOTAL
  03: 5        Z Loc [:WAT TOTAL]

08:  P32       Z=Z+1
  01: 6        Z Loc [:WAT COUNT]

09:  P95       End

10:  P95       End

11:  P86       Do
  01: 72       Pulse Port 2

12:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

13:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 8        Loc [:REL HUM  ]
  05: .05      Mult
  06: 0        Offset
```

```
14:  P89       If X<=>F
  01: 8        X Loc REL HUM
  02: 3        >=
  03: 0        F
  04: 30       Then Do

15:  P89       If X<=>F
  01: 8        X Loc REL HUM
  02: 4        <
  03: 101      F
  04: 30       Then Do

16:  P33       Z=X+Y
  01: 8        X Loc REL HUM
  02: 9        Y Loc HUM TOTAL
  03: 9        Z Loc [:HUM TOTAL]

17:  P32       Z=Z+1
  01: 10       Z Loc [:HUM COUNT]

18:  P95       End

19:  P95       End

20:  P86       Do
  01: 72       Pulse Port 2

21:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation

22:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 12       Loc [:WIND DIR ]
  05: .18      Mult
  06: 0        Offset

23:  P89       If X<=>F
  01: 12       X Loc WIND DIR
  02: 3        >=
  03: 0        F
  04: 30       Then Do

24:  P89       If X<=>F
  01: 12       X Loc WIND DIR
  02: 4        <
  03: 361      F
  04: 30       Then Do
```

```
25:  P33       Z=X+Y
  01: 12       X Loc WIND DIR
  02: 13       Y Loc DIR TOTAL
  03: 13       Z Loc [:DIR TOTAL]

26:  P32       Z=Z+1
  01: 14       Z Loc [:DIR COUNT]

27:  P95       End

28:  P95       End

29:  P86       Do
  01: 72       Pulse Port 2

30:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation

31:  P2        Volt (DIFF)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 16       Loc [:WIND SPD ]
  05: .05      Mult
  06: 0        Offset

32:  P89       If X<=>F
  01: 16       X Loc WIND SPD
  02: 3        >=
  03: 0        F
  04: 30       Then Do

33:  P89       If X<=>F
  01: 16       X Loc WIND SPD
  02: 4        <
  03: 120      F
  04: 30       Then Do

34:  P33       Z=X+Y
  01: 17       X Loc SPD TOTAL
  02: 16       Y Loc WIND SPD
  03: 17       Z Loc [:SPD TOTAL]

35:  P32       Z=Z+1
  01: 18       Z Loc [:SPD COUNT]

36:  P95       End

37:  P95       End
```

```
38:  P86       Do
  01: 51       Set low Port 1

39:  P11       Temp 107 Probe
  01: 1        Rep
  02: 3        IN Chan
  03: 1        Excite all reps w/EXchan 1
  04: 20       Loc [:AIR TEMP ]
  05: 1.8      Mult
  06: 32       Offset

40:  P89       If X<=>F
  01: 20       X Loc AIR TEMP
  02: 3        >=
  03: 0        F
  04: 30       Then Do

41:  P89       If X<=>F
  01: 20       X Loc AIR TEMP
  02: 4        <
  03: 120      F
  04: 30       Then Do

42:  P33       Z=X+Y
  01: 20       X Loc AIR TEMP
  02: 21       Y Loc AIR TOTAL
  03: 21       Z Loc [:AIR TOTAL]

43:  P32       Z=Z+1
  01: 22       Z Loc [:AIR COUNT]

44:  P95       End

45:  P95       End

46:  P92       If time is
  01: 59       minutes into a
  02: 60       minute interval
  03: 30       Then Do

47:  P86       Do
  01: 41       Set high Port 1

48:  P86       Do
  01: 72       Pulse Port 2

49:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

50:  P86       Do
  01: 72       Pulse Port 2
```

```
51:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

52:  P86       Do
  01: 72       Pulse Port 2

53:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

54:  P86       Do
  01: 72       Pulse Port 2

55:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation

56:  P86       Do
  01: 72       Pulse Port 2

57:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

58:  P1        Volt (SE)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 24       Loc [:59 EVAP  ]
  05: .00487   Mult
  06: 0        Offset

59:  P86       Do
  01: 51       Set low Port 1

60:  P95       End

61:  P92       If time is
  01: 0        minutes into a
  02: 60       minute interval
  03: 30       Then Do

62:  P17       Module Temperature
  01: 1        Loc [:CR10 TEMP]
```

```
63:  P53       Scaling Array (A*loc +B)
  01: 1        Start Loc [:CR10 TEMP]
  02: 1.8      A1
  03: 32       B1
  04: 0.0000   A2
  05: 0.0000   B2
  06: 0.0000   A3
  07: 0.0000   B3
  08: 0.0000   A4
  09: 0.0000   B4

64:  P10       Battery Voltage
  01: 2        Loc [:Batt Volt]

65:  P86       Do
  01: 41       Set high Port 1

66:  P86       Do
  01: 72       Pulse Port 2

67:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

68:  P86       Do
  01: 72       Pulse Port 2

69:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

70:  P86       Do
  01: 72       Pulse Port 2

71:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0000     Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0.0000   mV Excitation

72:  P86       Do
  01: 72       Pulse Port 2

73:  P22       Excitation with Delay
  01: 2        EX Chan
  02: 0        Delay w/EX (units=.01sec)
  03: 10       Delay after EX (units=.01sec)
  04: 0        mV Excitation
```

```
74:  P86       Do
  01: 72       Pulse Port 2

75:  P1        Volt (SE)
  01: 1        Rep
  02: 15       2500 mV fast Range
  03: 1        IN Chan
  04: 25       Loc [:60 EVAP  ]
  05: .00487   Mult
  06: 0        Offset

76:  P86       Do
  01: 51       Set low Port 1

77:  P33       Z=X+Y
  01: 24       X Loc 59 EVAP
  02: 25       Y Loc 60 EVAP
  03: 3        Z Loc [:EVAP PAN ]

78:  P37       Z=X*F
  01: 3        X Loc EVAP PAN
  02: .5       F
  03: 3        Z Loc [:EVAP PAN ]

79:  P38       Z=X/Y
  01: 5        X Loc WAT TOTAL
  02: 6        Y Loc WAT COUNT
  03: 7        Z Loc [:FINAL WTR]

80:  P38       Z=X/Y
  01: 9        X Loc HUM TOTAL
  02: 10       Y Loc HUM COUNT
  03: 11       Z Loc [:FINAL HUM]

81:  P38       Z=X/Y
  01: 13       X Loc DIR TOTAL
  02: 14       Y Loc DIR COUNT
  03: 15       Z Loc [:FINAL DIR]

82:  P38       Z=X/Y
  01: 17       X Loc SPD TOTAL
  02: 18       Y Loc SPD COUNT
  03: 19       Z Loc [:FINAL SPD]

83:  P38       Z=X/Y
  01: 21       X Loc AIR TOTAL
  02: 22       Y Loc AIR COUNT
  03: 23       Z Loc [:FINAL AIR]

84:  P37       Z=X*F
  01: 5        X Loc WAT TOTAL
  02: 0        F
  03: 5        Z Loc [:WAT TOTAL]
```

```
85:  P37       Z=X*F
  01: 6        X Loc WAT COUNT
  02: 0        F
  03: 6        Z Loc [:WAT COUNT]

86:  P37       Z=X*F
  01: 9        X Loc HUM TOTAL
  02: 0        F
  03: 9        Z Loc [:HUM TOTAL]

87:  P37       Z=X*F
  01: 10       X Loc HUM COUNT
  02: 0        F
  03: 10       Z Loc [:HUM COUNT]

88:  P37       Z=X*F
  01: 13       X Loc DIR TOTAL
  02: 0        F
  03: 13       Z Loc [:DIR TOTAL]

89:  P37       Z=X*F
  01: 14       X Loc DIR COUNT
  02: 0        F
  03: 14       Z Loc [:DIR COUNT]

90:  P37       Z=X*F
  01: 17       X Loc SPD TOTAL
  02: 0        F
  03: 17       Z Loc [:SPD TOTAL]

91:  P37       Z=X*F
  01: 18       X Loc SPD COUNT
  02: 0        F
  03: 18       Z Loc [:SPD COUNT]

92:  P37       Z=X*F
  01: 21       X Loc AIR TOTAL
  02: 0        F
  03: 21       Z Loc [:AIR TOTAL]

93:  P37       Z=X*F
  01: 22       X Loc AIR COUNT
  02: 0        F
  03: 22       Z Loc [:AIR COUNT]

94:  P86       Do
  01: 10       Set high Flag 0 (output)

95:  P80       Set Active Storage Area
  01: 1        Final Storage Area 1
  02: 123      Array ID or location

96:  P77       Real Time
  01: 1110     Year,Day,Hour-Minute
```

```
97:  P70        Sample
  01: 3         Reps
  02: 1         Loc CR10 TEMP

98:  P70        Sample
  01: 1         Reps
  02: 7         Loc FINAL WTR

99:  P70        Sample
  01: 1         Reps
  02: 11        Loc FINAL HUM

100: P70        Sample
  01: 1         Reps
  02: 15        Loc FINAL DIR

101: P70        Sample
  01: 1         Reps
  02: 19        Loc FINAL SPD

102: P70        Sample
  01: 1         Reps
  02: 23        Loc FINAL AIR

103: P96        Serial Output
  01: 71        SM192/SM716/CSM1

104: P95        End

105: P          End Table 1


*     2         Table 2 Programs
  01: 0.0000    Sec. Execution Interval

01:  P          End Table 2


*     3         Table 3 Subroutines

01:  P          End Table 3


*     A         Mode 10 Memory Allocation
  01: 28        Input Locations
  02: 64        Intermediate Locations
  03: 0.0000    Final Storage Area 2


*     C         Mode 12 Security
  01: 0         LOCK 1
  02: 0         LOCK 2
  03: 0000      LOCK 3
```

 Input Location Assignments (with comments):

Key:
T=Table Number
E=Entry Number
L=Location Number

```
T:  E:  L:
1: 62:  1:  Loc [:CR10 TEMP]
1: 63:  1:  Start Loc [:CR10 TEMP]
1: 64:  2:  Loc [:Batt Volt]
1: 77:  3:  Z Loc [:EVAP PAN ]
1: 78:  3:  Z Loc [:EVAP PAN ]
1:  4:  4:  Loc [:WATR TEMP]
1:  7:  5:  Z Loc [:WAT TOTAL]
1: 84:  5:  Z Loc [:WAT TOTAL]
1:  8:  6:  Z Loc [:WAT COUNT]
1: 85:  6:  Z Loc [:WAT COUNT]
1: 79:  7:  Z Loc [:FINAL WTR]
1: 13:  8:  Loc [:REL HUM  ]
1: 16:  9:  Z Loc [:HUM TOTAL]
1: 86:  9:  Z Loc [:HUM TOTAL]
1: 17: 10:  Z Loc [:HUM COUNT]
1: 87: 10:  Z Loc [:HUM COUNT]
1: 80: 11:  Z Loc [:FINAL HUM]
1: 22: 12:  Loc [:WIND DIR ]
1: 25: 13:  Z Loc [:DIR TOTAL]
1: 88: 13:  Z Loc [:DIR TOTAL]
1: 26: 14:  Z Loc [:DIR COUNT]
1: 89: 14:  Z Loc [:DIR COUNT]
1: 81: 15:  Z Loc [:FINAL DIR]
1: 31: 16:  Loc [:WIND SPD ]
1: 34: 17:  Z Loc [:SPD TOTAL]
1: 90: 17:  Z Loc [:SPD TOTAL]
1: 35: 18:  Z Loc [:SPD COUNT]
1: 91: 18:  Z Loc [:SPD COUNT]
1: 82: 19:  Z Loc [:FINAL SPD]
1: 39: 20:  Loc [:AIR TEMP ]
1: 42: 21:  Z Loc [:AIR TOTAL]
1: 92: 21:  Z Loc [:AIR TOTAL]
1: 43: 22:  Z Loc [:AIR COUNT]
1: 93: 22:  Z Loc [:AIR COUNT]
1: 83: 23:  Z Loc [:FINAL AIR]
1: 58: 24:  Loc [:59 EVAP  ]
1: 75: 25:  Loc [:60 EVAP  ]
```

Page 12 Input Location Labels:

1:CR10 TEMP	8:REL HUM	15:FINAL DIR	22:AIR COUNT
2:Batt Volt	9:HUM TOTAL	16:WIND SPD	23:FINAL AIR
3:EVAP PAN	10:HUM COUNT	17:SPD TOTAL	24:59 EVAP
4:WATR TEMP	11:FINAL HUM	18:SPD COUNT	25:60 EVAP
5:WAT TOTAL	12:WIND DIR	19:FINAL SPD	26:_____
6:WAT COUNT	13:DIR TOTAL	20:AIR TEMP	27:_____
7:FINAL WTR	14:DIR COUNT	21:AIR TOTAL	28:_____

APPENDIX 11

Field CR7 Datalogger program code for system measurements. Code is contained in {drive}:\snbk94\appendix\programs\HRNSFLD2.DOC, TNS90.DOC, and TN90P23.DOC for monitoring of pits 2 and 3. Code for shutting down the datalogger is contained in {drive}:\snbk94\appendix\programs\ENDCR7.DOC.

APPENDIX 12

Laboratory CR7 datalogger program code for system testing, antifreeze calibration, and transducer calibration. Code is contained in {drive}:\snbk94\appendix\programs\P3TST.DOC, HRNSFLD2.DOC, and AFCAL*.DOC.

Class A Evaporation Pan Manufacturer Specification Sheets

NovaLynx Corporation
Model 255-100 (3003) Evaporation Gauge
Instruction Manual

1.0 INTRODUCTION

1.1 Description

The Model 255-100 Analog Output Evaporation Gauge was designed to accurately measure the changing water level in an evaporation pan and provide an electrical signal proportional to the water level from which the evaporation rate can be determined. Although it can be used with a wide variety of evaporation systems, it is normally used with a standard Class A, National Weather Service evaporation pan. The gauge consists of a float, pulley, and counterweight attached to a precision 1000 ohm (or optional 5000 ohm) potentiometer, all mounted in a protective enclosure.

1.2 Specifications

Electrical output range: 0-9.73″ = 0-5 Vdc
Water level range: 0-8.0″ = 0-4.11 Vdc
Height: 27-1/2″
Diameter: 8″
Weight: 7-1/2 lbs
Cable: 50' of 22 GA cable
Connector: 3 pin MS-type
Float: 5″ diameter
Counterweight: 4 oz
Water input port: 1/2″ NP coupling, female
Base dimensions: 16″ triangle with leveling screws
Total resolution: 0.0382″ with 8-bit converter in DataLynx data logger

Potentiometer
Accuracy: 1%
Rotation: continuous
Resistance: 1000 ohms, standard (5000 ohms, optional)
Operating temperature: -50° to +125° F
Linearity: 0.25%
Power: 5 Vdc reg

2.0 INSTALLATION

2.1 After carefully unpacking all components, inspect for damage that may have occurred in shipment. Do not discard any packing material until you are certain there is no damage and all items are accounted for, including accessories. In the event of damage during shipment, a claim for loss should be filed with carrier at the receiving location. This does not apply to shipments via Parcel Post or UPS. In this case you should contact NovaLynx for instructions on handling the claim.

2.2 Remove the top cap and remove the float, chain, and counterweight which are packed in the housing for shipping.

2.3 The gauge is connected to the pan by using 1/2″ diameter pipe. Flexible tubing is acceptable provided it is not subject to deterioration. The gauge should be placed far enough away from the pan so that it will not cast a shadow on the pan that could have an effect on the evaporation process.

2.4 Level gauge by placing a level on the housing in front of the gear and adjusting the leveling screws on the triangular base until the unit is level.

2.5 After connecting the gauge to the pan and securing all electrical connections, fill evaporation pan with 8″ of water and carefully check all joints for leaks.

2.6 The pulley and the potentiometer housing have been marked with indicators that line up when the potentiometer is approximately at the breakpoint between zero and 1000 ohms (or 5000 ohms) resistance. To obtain the exact breakpoint for zeroing or base setting, use an ohmmeter across the white and red wires or use the actual readout device that will be used with the unit when in operation.

2.7 The float chain should be placed on the pulley so that the float rests on the top of the water (8″ in the evaporation pan) when the pulley is at the breakpoint. For operation, the float chain is placed on the pulley so that a falling level of water will cause clockwise (as seen from the front of the pulley) motion in the pulley and a decrease in resistance in the potentiometer output. Refer to the assembly diagram.

2.8 Carefully secure housing cover into place with allen screws.

3.0 OPERATION

The potentiometer produces a resistance output in relation to the position of the float and can be monitored on site with a data logger or strip chart recorder.

4.0 TROUBLESHOOTING

4.1 Always disconnect the reporting/recording device from power or troubleshoot immediately whenever any of the following conditions are observed: the cable has been damaged, the gauge does not appear to operate normally or exhibits a marked change in performance, the gauge has been dropped or damaged, or if moisture damage has occurred to the circuits.

4.2 If the gauge does not register correctly, first check the connections. Check the potentiometer with a voltmeter. Be sure the reporting/recording device has been powered-up correctly. If the reporting/recording device uses batteries for its primary source of power, check that the batteries have sufficient voltage to power the device.

4.3 Check the sensor cable connections both at the gauge and at the control unit. Cable shorts can cause lack of readings. If a connection is found to be loose, tighten into place and check to see if the problem has been corrected.

5.0 WARRANTY

NovaLynx warrants that its products are free from defects in material and workmanship under normal use and service for a period of one year from date of shipment from factory. NovaLynx's obligations under this warranty are limited to, at NovaLynx's option: (i) replacing; or (ii) repairing; any products determined to be defective. In no case shall NovaLynx's liability exceed product's original purchase price. This warranty does not apply to any equipment that has been repaired or altered, except by NovaLynx, or which has been subjected to misuse, negligence, or accident. *It is expressly agreed that this warranty will be in lieu of all warranties of fitness and in lieu of the warranty of merchantability.*

If an instrument appears to be defective within the warranty period, you may return it to NovaLynx freight prepaid for inspection. NovaLynx will, at it's option, repair or replace the defective unit and return it to you freight prepaid.

6.0 FACTORY SERVICE

If it becomes necessary to return this instrument to the factory for service, either during or after the warranty period, call NovaLynx (916-477-5226) and obtain a return authorization. Carefully pack the instrument to prevent damage during shipment. Include a letter with a description of the problem, your telephone number, and your return shipping address. Whenever possible, a cost estimate for the repair and the time required will be given at the time of your call.

NOVALYNX CORPORATION
P.O. Box 240
431-G Crown Point Circle
Grass Valley, CA 95945
(916)477-5226

01/92

NO	REVISION	DATE	DWN	APP'D
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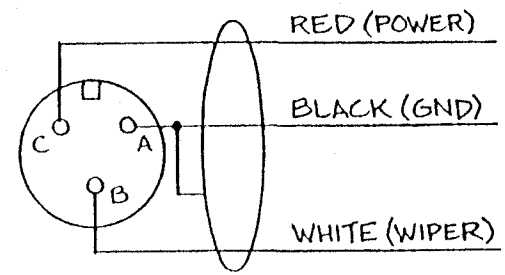
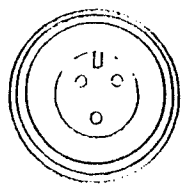
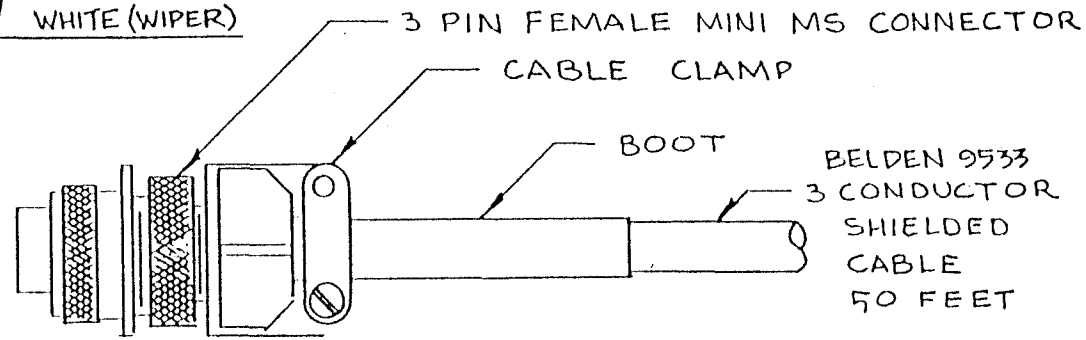
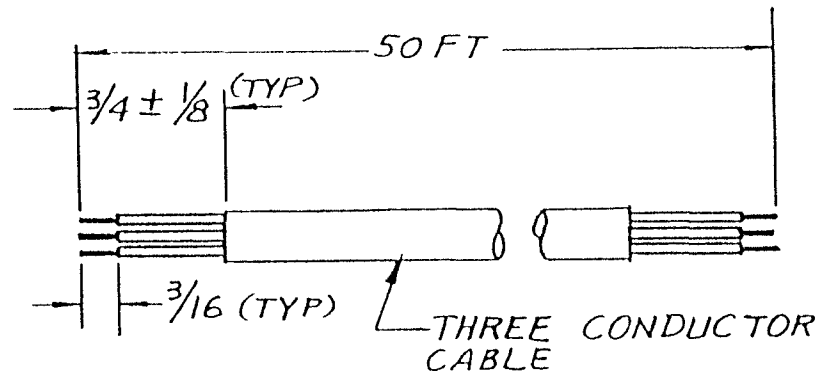






NOTE: CONNECT BLACK TO A
WHITE TO B
RED TO C



DataLynx Instruments

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255-100
CONNECTOR CABLE

DRAWING NUMBER
A103137-1

8½ X 11 PRINTED ON NO. 1000H CLEARPRINT •

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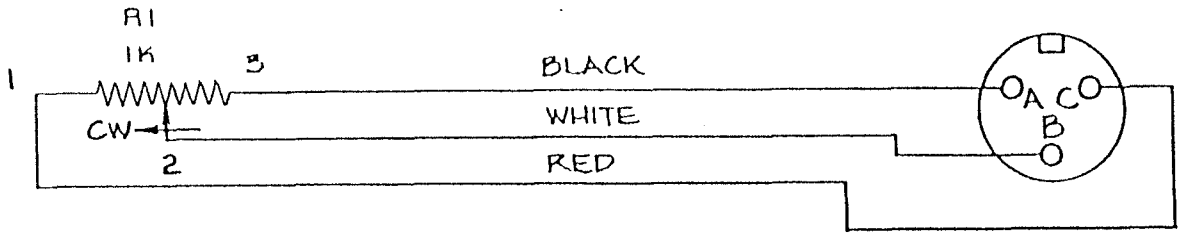
2	ECO#688	8/21/90	DAK	[illegible]



3 PIN MALE MINI BULK-HEAD CONNECTOR
#MS-3102A-10SL-3P

NOTE:
CLOCKWISE DIRECTION INDICATED IS FOR GEAR BOX MOUNTED POTENTIOMETER

CABLE - BELDEN #9533, 3 COND.
SHIELDED CABLE, 8" LONG

DataLynx Instruments

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255-100
INTERNAL WIRING DIAGRAM

DRAWING NUMBER
A103000-2

NATIONAL NO. 188A-8½X11

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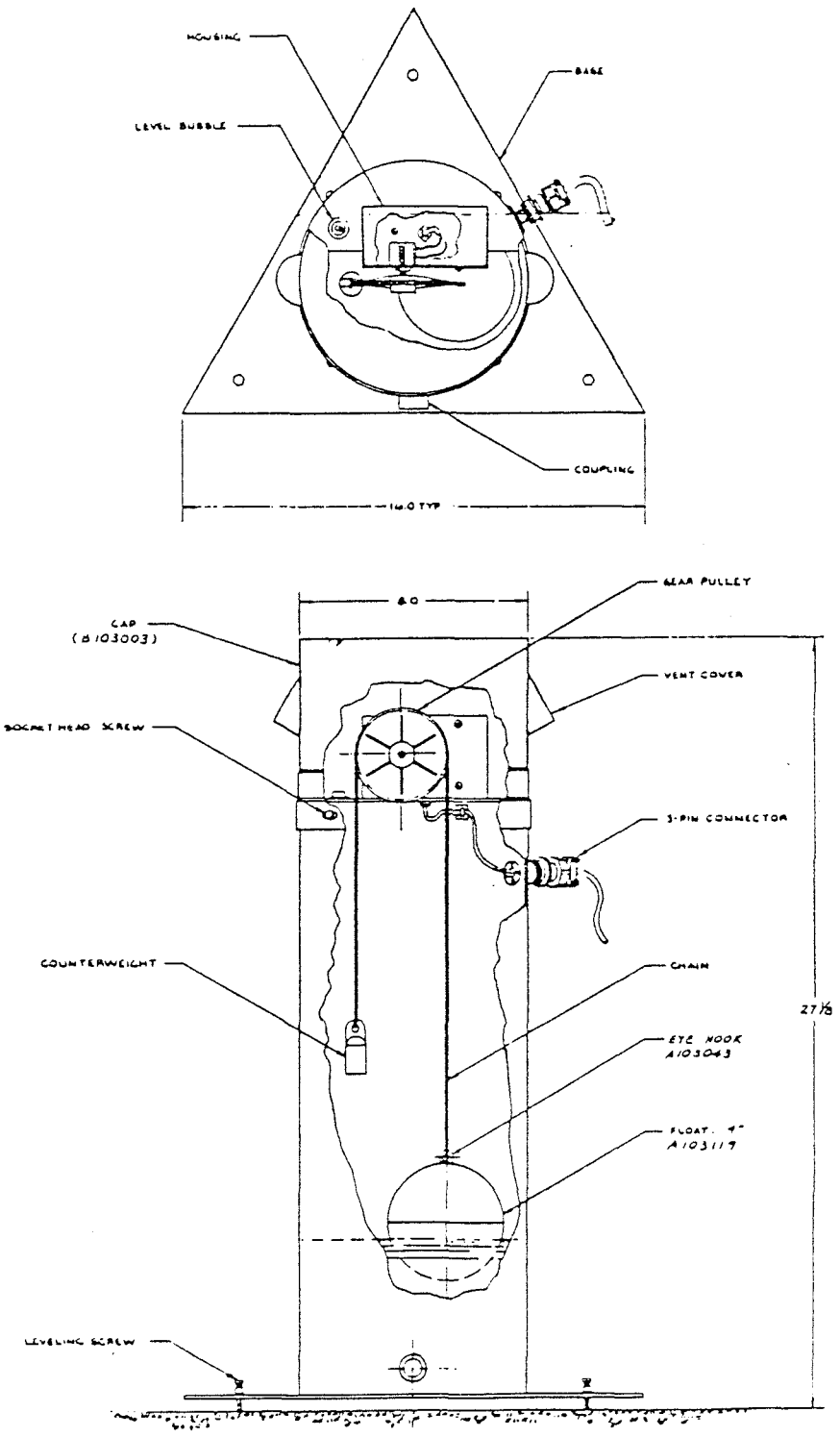


NOTE. REFER TO DRAWING NO A103000 FOR WIRING INSTRUCTIONS

DataLynx

Assembly Diagram

C102352

DATALYNX INSTRUMENTS
Model 255-200 Evaporation Pan
Model 255-210 Still Well
Model 255-214 Hook Gauge

Instruction Manual

1.0 INTRODUCTION

The equipment used for evaporation measurements includes the following: an evaporation pan, a micrometer hook gauge and stilling well (or a fixed point gauge and appropriate measuring tube), an anemometer for measuring wind movement over the pan, and an 8" non-recording precipitation gauge and measuring stick. Additional equipment, in some cases, might include a recording-type precipitation gauge, a thermometer to provide maximum, minimum, and current temperatures of the water in the pan, maximum and minimum thermometers for air temperatures, and/or a hygrothermograph or psychrometer for air temperature and humidity. A suitable shelter must be provided for the temperature and humidity sensors. A water storage tank may be necessary to provide a reserve supply of water for the pan.

Observations are made of the amount of water loss from the pan, anemometer reading, and water temperature in accordance with the instructions in this manual. Observations of air temperature and precipitation are also made. At some evaporation stations additional observations are required, such as dry and wet bulb temperatures and soil temperature and moisture content.

2.0 SITING GUIDELINES

The site for the equipment should be level, sodded, and free from obstructions. It should be representative of the principal natural agricultural soils and vegetation conditions of the area. At locations where the normal climate and soil do not permit the maintenance of a sod cover, the ground cover should be maintained as near as possible to the natural cover common to the area. Under no conditions should the evaporation pan or the instrument shelter be placed on concrete, asphalt, or over a layer of crushed rock. Obstructions, such as shrubs, trees, or buildings should not be closer than four times the height of the object above the pan. Weeds and grass should be mowed to keep them below the level of the pan. The exposure should be free from obstructions that cast shadows over the pan during any part of the day other than brief periods near sunrise and sunset. Avoid locations near ponds, swamps of not more than a few miles in diameter (particularly if they are temporary in nature), lawns or other areas that receive frequent sprinkling or irrigation. At reservoirs (flood control, water supply, irrigation project), a site on the upwind side of the lake or reservoir is preferable, based on the prevailing direction of the strongest winds. Locate the equipment a sufficient distance from spillways and other bodies of water to minimize chances for water to be blown into the pan by strong winds. The site should be surrounded by a fence to protect the equipment and to prevent animals from drinking the water. A steel link fence, 9 or 11 gauge, a minimum of 4' high, with steel posts set in concrete, is

suggested. If the area has problems with small animals or rodents, it may be necessary to bury a barrier and place 18" to 24" of chicken wire (galvanized) along the bottom of the fence.

3.0 EQUIPMENT

3.1 Evaporation Pan

The evaporation pan is cylindrical, with inside dimensions of 10" deep and 47-1/2" diameter. When a micrometer hook gauge is used for measuring water levels, two short lines painted on the inside of the pan, 2" and 3" below the rim, will assist in maintaining the proper water level. The ground should be filled sufficiently to level the pan support and to keep the pan above the level of surface water in rainy weather. Earth fill should be used around the support to anchor it. It should be tamped firmly between the top members to within 1/2" of the top of the support, leaving an air space between the bottom of the pan and the fill to facilitate inspection of the pan for leaks. The pan should be centered on the platform. During inspections the platform level should be checked and corrected if needed.

Inspect the pan carefully for leaks at least once a month. Report the finding of any leaks on the observation form for the month. Report both the date the leak was discovered and the date the pan was repaired or replaced.

Because the temperature characteristics of all evaporation pans must be identical, they must not be painted. Clean the pan as frequently as necessary to keep it free from sediment, algae, and oil films. Any of these contaminants will materially affect the rate of evaporation.

The pan should be emptied by siphoning or dipping the water out. Under no circumstances should the pan be lifted and emptied if any significant amount of liquid remains in the pan.

During months when freezing is likely, empty, clean, and store the pan. The pan should be stored indoors, if possible. If it is left in the fenced enclosure, it should be turned upside down and secured to the platform.

The growth of algae can be discouraged by the addition of small amounts of copper sulfate to the water. Any existing algae must be removed by thorough cleaning.

3.2 Stilling Well for Hook Gauges

The cylindrical well provides an undisturbed water surface around the hook gauge and, in addition, provides a support for the gauge. The well consists of a cylinder of brass, monel, or other non-corrosive metal. Less electrolytic action will occur if the metal is the same as that of the pan. The outside dimensions of the well are 8" high and 3-1/2" diameter. To dampen oscillations in the well, a .375" diameter stainless steel rod is threaded into a hole in the center of the base plate and extends up into the cylinder 7-1/2". The base is provided with leveling screws. Place the stilling well in the pan about one foot from the north edge. Level the top rim of the well using the three leveling screws in its base and a spirit level. The well should rest firmly on the bottom of the pan, which must be free from "buckling" to maintain a level position of the well. Clean the stilling well occasionally and remove any

sediment. When cleaning or adjustments are required (stilling well, pan, etc.), record hook gauge readings taken before and after any such actions.

3.3 Micrometer Hook Gauge

A micrometer hook gauge is used to indicate changes in the level of water in the evaporation pan. The gauge consists of a hook on the end of a stem that is graduated to 1/10" over a range of several inches. The stem is constructed with double threads throughout its range of adjustment. The threads have a pitch of 1/10". A three-legged spider and adjusting nut assembly supports the hook and provides for adjustment of the height of the hook when the gauge is installed on the stilling well. The adjusting nut is threaded to screw on the stem of the hook. After assembly, the gauge is placed on the stilling well with the three legs of the spider resting on the top rim of the well and the hook centered in the well. The stem should then be vertical. The adjusting nut is free to turn within the spider so that it may be conveniently used to adjust the height of the hook. The relative height of the hook in the well is indicated by the scales on the gauge.

Keep the hook gauge clean and lightly oil the threads on the stem with a single drop of light viscosity machine oil about twice a year. Carefully remove any excess oil with a clean cloth, to prevent oil from being transferred to the water surface. Before oiling, clean the gauge thoroughly with kerosene or a petroleum-based solvent. When the gauge is assembled after cleaning, determine that the threads of the stem and the adjusting nut are properly matched by turning the adjusting nut counterclockwise (as viewed from the top) until the top of the nut coincides with one of the graduations of the stem. If the scale has been properly assembled, the index line on the ring of the spider will coincide with the 0 (zero) on the circular scale. If it does not coincide, unscrew the adjusting nut and reassemble the gauge by matching the alternate combination of threads.

3.4 Fixed Point Gauge

The fixed point gauge consists of a pointed 1/8" rod mounted in a tube of noncorrosive metal, 2-1/2" to 3-1/2" in diameter and about 10" long. This tube is attached to a metal base of sufficient size and weight so that its position in the pan is not likely to be changed by the wind. The pointed rod is affixed within the tube to the center of the base so that the point will be 7-1/2" above the bottom of the pan when in position. Two small openings approximately 1/8" in diameter are placed in the sides of the tube near the base, on opposite sides, to permit the flow of water from or into the stilling well and at the same time restrict surging action of water at the point of measurement. Place the gauge about one foot from the north edge of the pan.

A cylindrical measuring tube or replacement graduate 15" deep with a cross sectional area 1/100th that of the evaporation pan is used to measure the amount of water necessary to replace that lost from the pan by evaporation. The inside diameter of this tube should be 4.8" for use with a 48" evaporation pan (inside dimension) and 4.75" for a 47-1/2" evaporation pan. The transparent tubes are graduated at 1" intervals to permit an accuracy of 0.01".

3.5 Water Storage Tank

Where it is necessary to transport water some distance, a tank or other covered receptacle should be located near the site. A tank having a capacity of at least 30 gallons usually provides an adequate reserve of water. The storage tank should be thoroughly cleaned at the beginning of each season. The water placed in the tank should be completely free of oil. At the end of the season, the tank should be emptied and secured to prevent freeze and wind damage.

4.0 EVAPORATION READINGS

4.1 Hook Gauge

At the time of each observation, place the gauge on the stilling well and adjust the hook in the well until the point is below the surface of the water. Slowly turn the adjusting nut clockwise until the point just pierces the water surface. Reflection of the sky in the water will assist in determining when the point first breaks through the surface. Remove the gauge from the well and read the scales. The figures on the stem represent whole inches, and the intermediate graduations represent tenths of an inch. The figures on the circular scale represent hundredths of an inch, and the intermediate graduations represent thousandths. Whenever an observation is taken, the scale on the stem is read to tenths of an inch, as indicated by the first graduation at or above the top of the knurled adjusting nut. The circular scale on the adjusting nut is read to the nearest hundredth of an inch at the index. Both scales are added and the sum represents the gauge reading. For example: A scale reading of 25 on the stem indicates 2.5", a scale reading between 30 and 31 on the circular scale indicates a value between .03" and .04", or 0.03" as determined to the nearest hundredth. The gauge reading is therefore 2.5" + 0.03" = 2.53". Enter the readings obtained as above in the appropriate spaces on the observation forms.

Precipitation causes unavoidable inaccuracies in measurements and condensation of water (dew) may occasionally cause the water level to be slightly higher than that of the previous observation. Subtract precipitation gauge readings to correct evaporation measurements.

Experiments have shown that the height of the rim of the pan above the water surface affects the rate of evaporation. In order for the records from all stations to be comparable, the pan should be filled to a level 2" below the rim, and refilled (at a regular observation) when the water has receded 1", i.e. to the 3" line. When heavy rains threaten to overflow the pan or raise the water beyond the range of the hook gauge, remove enough water to lower the level to within the 2" to 3" range.

Cleaning the pan or adjusting the water level should be done immediately following an observation. Read the gauge level and enter the readings on the forms in use. For example, whenever heavy rains require the removal of water to prevent overflowing the pan, enter the gauge readings made immediately before and after the change and also enter the time, date, and nature of the change as a remark.

On the last day of the month, and whenever the stilling well is leveled or otherwise adjusted, measure the height of the rim of the pan above the water level to the nearest

tenth of an inch and enter height value and the time of the measurement on the permanent record form as a remark. This reading provides a check on the maintenance of proper level in the pan. The measurements should be taken at the time of reading the hook gauge. The measuring stick for the non-recording precipitation gauge may be used for these measurements by multiplying the reading by 10.

4.2 Fixed Point Gauge

At the time of observation, add or remove water from the pan until the tip of the fixed point coincides with the surface of the water in the well. As the water approaches the tip of the point, pour slowly to prevent overfilling, allowing time for water to flow into the well. When water must be added, fill transparent plastic tube to zero mark before pouring into evaporation pan. When water must be removed, using the transparent plastic tube, care must be taken to determine amount. For instance, if enough water is removed to reach the "5" marking on the transparent plastic tube, the actual amount removed would be measured from the bottom of the tube and would be 15 - 5 = 10, which is equivalent to an inch.

5.0 WARRANTY

All instruments are warranted for one year, unless specified otherwise, against defects in materials or workmanship. Instruments abused, improperly used or installed, or altered by others may cancel warranty. If an instrument appears to be defective within the warranty period, you may return it to DataLynx freight prepaid for inspection. DataLynx will, at it's option, repair or replace the defective unit and return it to you freight prepaid.

6.0 FACTORY SERVICE

If it becomes necessary to return this instrument to the factory for service, either during or after the warranty period, call DataLynx (916-477-5226) and obtain a return authorization. Carefully pack the instrument to prevent damage during shipment. Include a letter with a description of the problem, your telephone number, and your return shipping address. Whenever possible, a cost estimate for the repair and the time required will be given at the time of your call.

NOVALYNX CORPORATION
431-G CROWN POINT CIRCLE
PO BOX 240
GRASS VALLEY CA 95945

(916)477-5226

3/90

HUMIDITY PROBE HMP 35AD

The HMP 35AD Humidity Probe is designed to be used with measurement systems and devices, such as dataloggers, recorders, controllers, displays, weather stations and laboratory equipment. Cable connections are shown in Figure 1, calibration potentiometers in Figure 2.

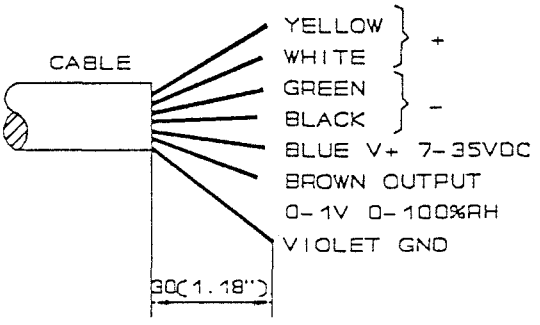


Fig. 1 Cable connections

ONE-POINT HUMIDITY CALIBRATION

When checking the calibration of the transmitters, use Vaisala's One-Point Calibrator HMK 20. Use the one-point calibration potentiometer to calibrate the transmitter. The checking period is e.g. 1 year according to the operating conditions and the required accuracy of the measurement. If salt method calibration is preferred for the HMP 35AD, use HMK 11 Humidity Meter Calibrator with LiCl (12 %RH) and NaCl (75 %RH) salt solutions. More detailed information in HMK 11 Operating Instructions.

REPLACEMENT OF THE HUMICAP® SENSOR OR THE MEMBRANE FILTER

Remove the damaged sensor and insert a new one. Recalibrate the transmitter. Replace a dirty membrane filter to ensure a maximum lifetime for the sensor. Do not attempt to clean the filter.

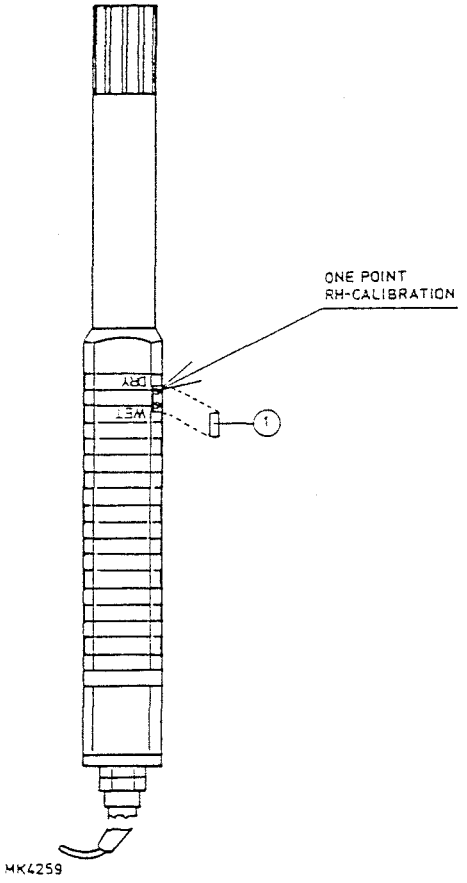


Fig. 2 Calibration potentiometers

GUARANTEE

Vaisala issues a guarantee for the material and workmanship of this product under normal operating conditions for one year from the date of delivery. Exceptional operating conditions, damage due to careless handling or misapplication will void the guarantee.

TECHNICAL DATA

Mechanics

Sensor protection	membrane filter 0.2 µm (part no. 2787)
Housing material	ABS plastic
Housing classification	IP 55 (NEMA 3S)
Dimensions	length 235 mm, probe head Ø 18.5 mm
Cable length	1.5 m (5 ft)
Weight	180 g

Electronics

Supply voltage	7 ... 35 VDC
Recommended external load for outputs	≥ 10 kΩ
Current consumption	≤ 4 mA
Operating temperature range	-20 ... +60 °C (-4 ... +140 °F)

Relative humidity

Sensor	HUMICAP® H (part no. 0062)
Measuring range	0 ... 100 %RH
Output signal	0.002 ... 1 VDC ≙ 0.2 ... 100 %RH
Accuracy at +20 °C (including calibration inaccuracy, linearity and repeatability)	
against high-quality standards	±1 %RH
against salt solutions (DIN 50 008)	±2 %RH (0 ... 90 %RH) ±3 %RH (90 ... 100 %RH)
Temperature coefficient	±0.04 %RH/°C
Typical long-term stability	better than 1 %RH per year
Response time (at +20 °C, 90 % response)	15 s with membrane filter

Temperature

Sensor	two-terminal IC AD590 LH
Measuring range	-40 ... +80 °C
Output signal	1 µA/K, linear
Accuracy (at +25 °C)	±1 °C

MANUAL FOR
NOVALYNX MULTI-PLATE RADIATION SHIELD
FOR TEMPERATURE AND HUMIDITY PROBES

MODEL 230-281

TABLE OF CONTENTS

1.0 INTRODUCTION

2.0 SPECIFICATIONS

3.0 INSTALLATION

4.0 MAINTENANCE

5.0 WARRANTY

RELEASE DATE: FEB 15, 1993

MULTI-PLATE SHIELD
MODEL 230-281

1.0 INTRODUCTION

1.1 Novalynx Corporation recommends the use of solar radiation shields whenever temperature and humidity sensors are to be installed in the field either onto a tower or mast and exposed to direct sunlight and precipitation. One of the solar radiation shields provided by Novalynx Corp. is the Multi-plate Self Aspirated Shield.

1.2 The multi-plate shield is, as its name implies, constructed of 3 anodized aluminum plates and a mounting arm. The plates are shaped to give maximum airflow around the probe while at the same time reducing direct exposure to sunlight. The plates also help prevent direct contact of the probe from rain and snow except under certain extreme conditions. Sensor exposure to sunlight and contact by rain or snow can give rise to errors in the air temperature and humidity measurements.

1.3 The self aspirated shield can provide protection for sensors located at non-powered remote locations. The shield is shaped to allow natural air convection to occur around the probe so that the air being measured inside the shield is a good representation of the air outside the shield. Of course, on a very still day, the aspiration of the probe inside the shield will be less than if the wind were blowing. The effects of the wind upon the temperature probe ventilation can be seen by comparison tests using a shield in both still air and in moving air under controlled conditions. Under low wind conditions, less than 0.5 m/s, and with a solar angle of 70 degrees above the horizon, the temperature error due to poor aspiration can be as great as 7 degrees. Error correction methods can be employed using graphs and related data such as the sun's angle on the horizon, and the wind speed.

1.4 Refer to the drawings at the end of this manual for detailed views of the shield and the sensor location inside the shield.

2.0 SPECIFICATIONS

2.1

Height.....	8.3"
Diameter of Plates.....	3.50"
Thickness of Plates.....	0.08"
Sensor Clearance.....	0.75" Dia x 4.3" Long
Sensor Mounting.....	Threaded Fitting or Clamp
Tower Mounting.....	U-bolt with plate for up to 1" Dia
Weight.....	0.45kg 1.0lbs
Shipping Weight.....	0.68kg 1.5bs

3.0 INSTALLATION

3.1 The shield is designed for mounting onto a 1 inch diameter tower leg or mast. The shield is clamped onto the supporting pipe using a u-bolt and clamping plate provided with the shield.

3.2 Before attaching the shield onto the supporting pipe, install the sensor. This is especially important for situations where the shield is to be mounted above the ground to avoid unnecessary trips up and down the tower. For some sensors, the mounting adapter consists of a threaded, fitting. Other sensors are adapted to the shield mounting plate as required. With the sensor installed, the sensing end of the probe should be within 1 inch of the top of the shield. The probe should never touch the top of the shield. Generally, all sensors and shields provided by Novalynx Corp. will be matched and prepared prior to shipment to the user. Usually, the shield is shipped with the sensor installed to minimize packing materials and to speed the installation. The sensor may be removed from the shield for inspection and testing if desired.

3.3 Attach the shield to the tower or mast using the u-bolt and clamp assembly that is located on the shield mounting arm. Select a location on the tower that is free of shadows, preferably on the south side of the tower for the Northern hemisphere. Try to avoid placing the shield beneath guy wires and over-head objects that are subject to dripping during rain storms. Tighten the u-bolt taking care to avoid over-tightening the u-bolt which may cause damage to the threads or deform the tower leg. Check to ensure that the shield is vertically level to maximize sun screening of the sensor.

3.4 Upon completing the installation of the shield, route the sensor cables down the nearest tower leg or the mast using cable ties and grips to fasten the cable to the mast and to relieve strain that is placed upon the cable due to its weight and gravitational forces. The cable must be fastened securely to prevent wind whipping which can severely damage the outer jacket of the cable. Wire ties should be spaced down the tower every three to four feet. Use only stainless steel cable ties or ties that are resistant to ultra-violet radiation. Wire grips should be used wherever a sensor cable or groups of cables reach the end of a horizontal support and begin to hang down the tower leg. The wire grip will reduce damage due to the cable strain.

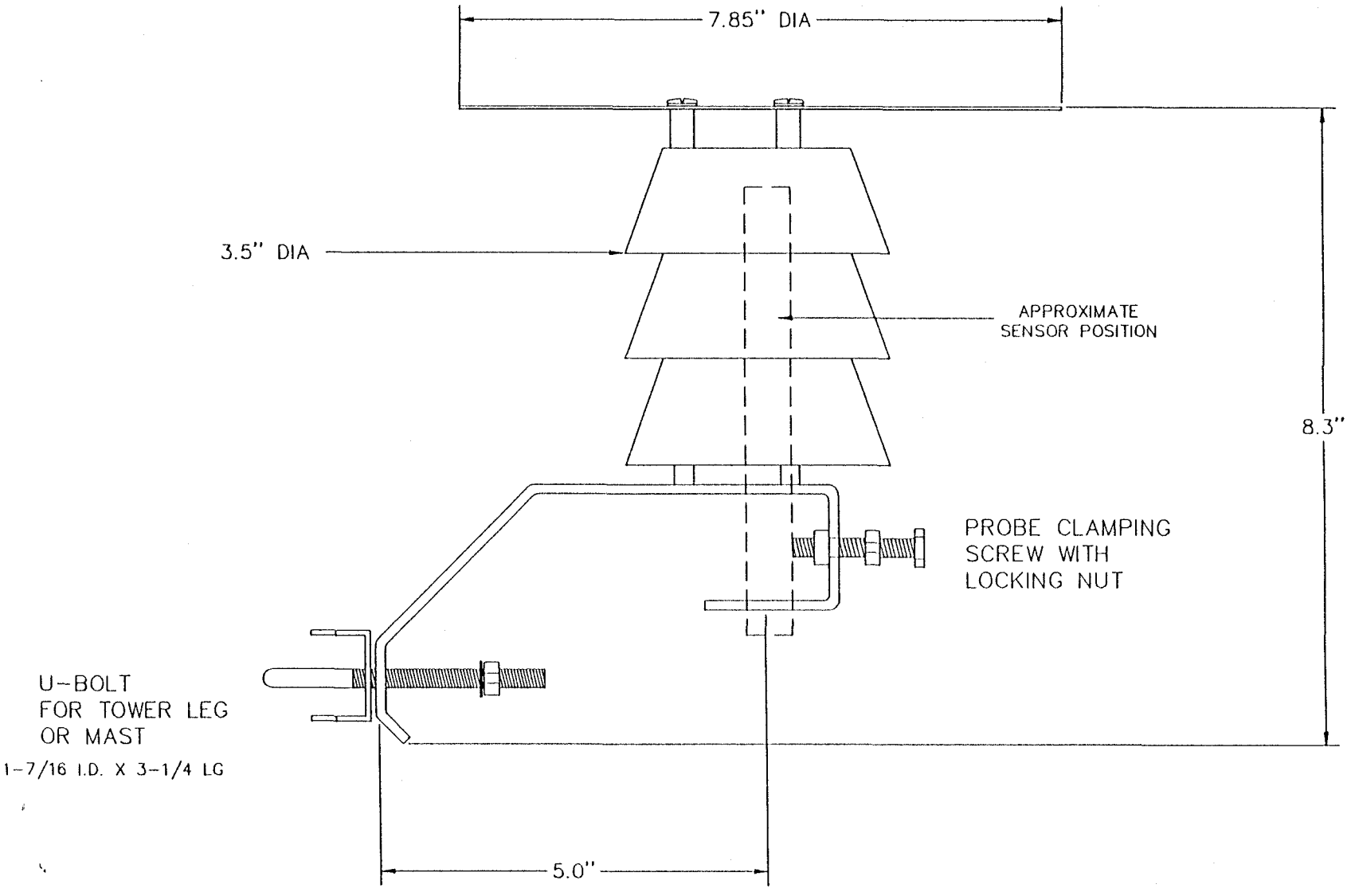
3.5 The ends of the sensor cables should be placed into weather proof or weather resistant junction boxes for termination at the base of the tower if possible.

4.0 MAINTENANCE

4.1 Inspect the shield installation on a regular basis to detect loose hardware or the need for cleaning. Do not let spider webs or leaves and other debris collect in between the shield plates. Keep the surfaces of the plates clean and free of dust and dirt which can absorb heat. Replace any shield components which may become damaged due to storm action or long term exposure to the sun. Contact Novalynx Corp. for assistance in obtaining replacement parts and service.

5.0 WARRANTY

5.1 The shield is covered by the standard Novalynx Corp. warranty.



LYNX CORPORATION			C
TITLE OUTLINE DIMENSION DRAWING SOLAR RADIATION SHIELD			
MOD. USAGE 230-281			SHEET 1 OF 1
BY RGN	SCALE FULL	DWG. NO. 921108	
DATE 11-11-92			

DataLynx Instruments
Model 230-201 Temperature Sensor
Model 210-600 Water Temperature Sensor

Instruction Manual

1.0 Introduction

1.1 General Description

The Model 230-201 Temperature Sensor is a two-terminal integrated circuit transducer that provides a linear output current proportional to the absolute temperature. The sensor acts as a high impedance constant current regulator. Laser trimming of the chips' thin film resistors is used to calibrate the output. It is supplied with 25' of cable but can be used with longer lengths. Because of its high impedance current it is insensitive to voltage drop over long lines.

1.2 Optional Accessories

- Solar radiation shields
- Instrument shelters
- Recorders or displays

1.3 Specifications

Range: -40° to +140° F (-40° to +60° C)
Output: linear
1 μA/°K for supply voltages between +4 and +30 V
298.2 μA at +25° C
Accuracy: ± 0.4° C or 0.8° F
Linearity: ± 0.3° C or 0.6° F
Size: 0.375" diameter x 2.5" long
Cable: 25' of 2-conductor cable standard, longer lengths available
Weight/shipping: 6 oz/1 lb

2.0 Installation

2.1 Unpacking

After carefully unpacking, inspect for damage that may have occurred in shipment. Do not discard any packing material until you are certain there is no damage and all items are accounted for, including accessories. In the event of damage during shipment, a claim for loss should be filed with carrier at the receiving location. This does not apply to shipments via Parcel Post or UPS. In this case you should contact NovaLynx for instructions on handling the claim.

2.2 Assembly

The sensor requires no special installation other than consideration for the particular measurement required. This sensor can be used to record temperatures in ambient air, water, soil, or any medium that is not corrosive. When recording air temperature, the probe is normally protected from direct sun by locating it in a shield or shelter. Various models are offered by NovaLynx. The probe should be kept away from thermal drafts such as heating ducts and air conditioning vents unless that is the condition to be measured. After installing the probe, route the cable to the recorder or display instrument. If it is a permanent installation, secure the cable in place with plastic cable ties or weatherproof tape to prevent wear or fraying.

2.3 Wiring

Model 230-201

Black	=	Ground
White	=	Signal
Red	=	+8 to +20 Vdc

Model 210-600

Black	=	+8 to 20 Vdc
White	=	Signal
Ground	=	Ground

3.0 Operation

Operation is essentially automatic and requires no on-site supervision.

3.1 Maintenance & Troubleshooting

If probe does not measure correctly:

1. Check power to output device to ensure connection.
2. If output device uses batteries for primary source of power, check (1) for sufficient voltage, (2) that batteries are securely in place, and (3) that battery terminals are clean and provide solid contact.
3. Check cable for continuity.
4. To check the sensor, connect it in series with a 12 Vdc battery and a current meter with the negative side of the battery connected to the negative lead of the current meter, the positive side of the battery connected to the red wire of the temperature sensor, and the white wire of the temperature sensor connected to the positive lead of the current meter. With the meter on the 1 mA or 2 mA range setting, observe the current. The measurement should correspond to the ambient temperature; the higher the temperature the higher the current reading. Refer to sensor curve drawing for values. If the sensor does not respond as described, it needs to be replaced.
6. If problem continues, see warranty instructions to return to NovaLynx.

4.0 Warranty

NovaLynx warrants that its products are free from defects in material and workmanship under normal use and service for a period of one year from date of shipment from factory. NovaLynx's obligations under this warranty are limited to, at NovaLynx's option: (i) replacing; or (ii) repairing; any products determined to be defective. In no case shall NovaLynx's liability exceed product's original purchase price. This warranty does not apply to any equipment that has been repaired or altered, except by NovaLynx, or which has been subjected to misuse, negligence, or

accident. *It is expressly agreed that this warranty will be in lieu of all warranties of fitness and in lieu of the warranty of merchantability.*

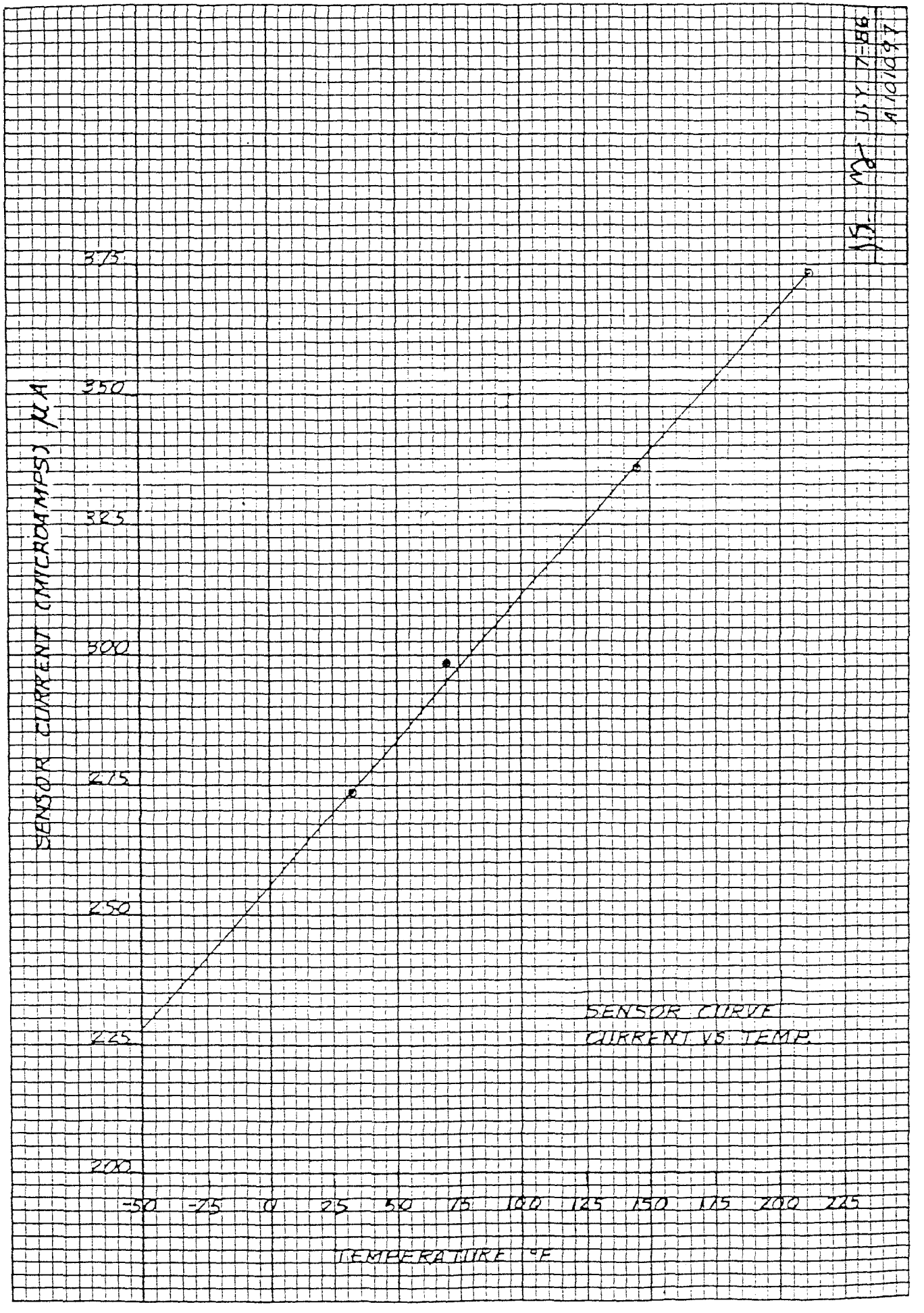
If an instrument appears to be defective within the warranty period, you may return it to NovaLynx freight prepaid for inspection. NovaLynx will, at it's option, repair or replace the defective unit and return it to you freight prepaid.

Factory Service

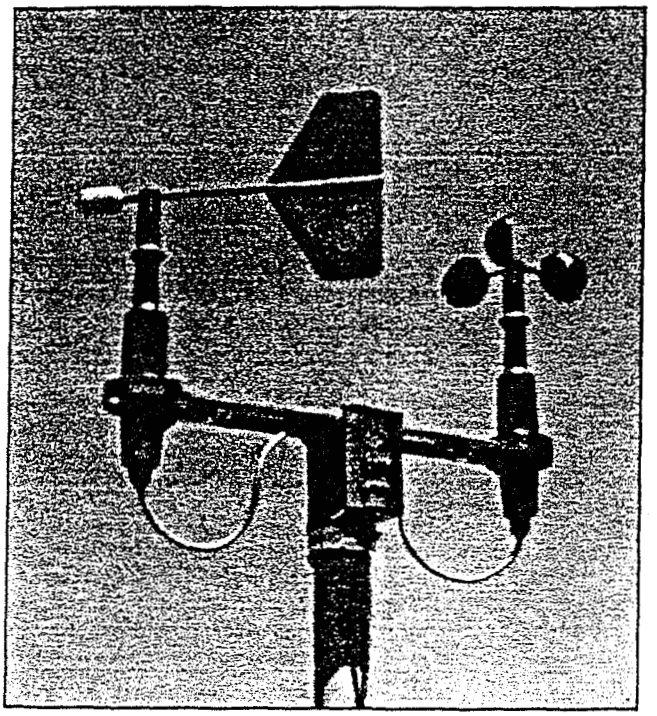
If it becomes necessary to return this instrument to the factory for service, either during or after the warranty period, call NovaLynx (916-477-5226) and obtain a return authorization. Carefully pack the instrument to prevent damage during shipment. Include a letter with a description of the problem, your telephone number, and your return shipping address. Whenever possible, a cost estimate for the repair and the time required will be given at the time of your call.

NOVALYNX CORPORATION
P.O. Box 240
431-G Crown Point Circle
Grass Valley, CA 95945
(916)477-5226

06/92


SENSOR CURRENT (MICROAMPS) μA
375
350
325
300
275
250
225
200
-50
-25
0
25
50
75
100
125
150
175
200
225
TEMPERATURE °F
SENSOR CURVE
CURRENT VS TEMP.

MODEL 03002
WIND SENTRY
INCLUDES MODELS 03102 & 03302



WIND SPEED SPECIFICATION SUMMARY:

Range	0 to 50 m/s (112 mph), gust survival 60 m/s (134 mph)
Sensor	12 cm diameter cup wheel assembly, 40 mm diameter hemispherical cups
Turning Factor	75 cm (2.46 ft)
Distance Constant (63% recovery)	2.3 m (7.5 ft)
Threshold	1.1 m/s (2.5 mph)
Transducer	Stationary coil, 1350 ohm nominal resistance
Transducer Output	AC sine wave signal induced by rotating magnet on cup wheel shaft 100 mV p-p at 60 rpm. 6V p-p at 3600 rpm.
Output Frequency	1 cycle per cup wheel revolution. 0.75 m/s per Hz

WIND DIRECTION (AZIMUTH) SPECIFICATION SUMMARY:

Range	360° mechanical, 352° electrical (8° open)
Sensor	Balanced vane, 16 cm turning radius.
Damping Ratio	0.2
Delay Distance (50% recovery)	0.5 m (1.6 ft)
Threshold	1.3 m/s (2.9 mph) at 10° displacement 1.9 m/s (4.2 mph) at 5° displacement
Transducer	Precision conductive plastic potentiometer, 10K ohm ±20% resistance 1.0% linearity, life expectancy 50 million revolutions Rated 1 watt at 40°C, 0 watts at 125°C
Transducer Excitation Requirement	Regulated DC voltage, 15 VDC max
Transducer Output	Analog DC voltage proportional to wind direction angle with regulated excitation voltage applied across potentiometer

INTRODUCTION

The Wind Sentry Anemometer and Vane measure horizontal wind speed and wind direction. The small size, simplicity, and corrosion resistant construction provide a professional quality instrument at a modest cost. The cup wheel and vane shafts use stainless steel precision instrument grade ball bearings which are lubricated with a wide temperature range high quality instrument oil. Standard bearings have light contacting seals to exclude contamination and help retain lubricant for longer service life. Optional shielded bearings are supplied on some special models to provide lower anemometer threshold.

Cup wheel rotation produces an AC sine wave voltage signal with frequency directly proportional to wind speed. This AC signal is induced in a stationary coil by a two pole ring magnet mounted on the cup wheel shaft. One complete sine wave cycle is produced for each cup wheel revolution.

Wind vane position is transmitted by a 10K ohm precision conductive plastic potentiometer which requires a regulated excitation voltage. With a constant voltage applied to the potentiometer, the output signal is an analog voltage directly proportional to azimuth angle.

The sensor mounts on a standard 1 inch pipe, outside diameter 34mm (1.34") and is supplied with a crossarm and junction box for cable connections. The crossarm mounting is secured to the pipe by a stainless steel band clamp. Wind Sentry anemometers and windvanes are available separately with similar mounting and junction box. A variety of devices are available for signal conditioning, display, and recording of wind speed and direction. The Wind Sentry will also interface directly with many popular data loggers.

INITIAL CHECK-OUT

When the Wind Sentry is unpacked, check it carefully for any signs of shipping damage. Place the cup wheel on the anemometer shaft and secure it by tightening the set screw on the side of the hub. The instrument is aligned, balanced, and fully calibrated before shipment; however, it should be checked both mechanically and electrically before installation. The vane and cup wheel should easily rotate 360° without friction. Check vane balance by holding the instrument so the vane surface is horizontal. It should have near neutral torque without any particular tendency to rotate. A slight imbalance will not degrade performance.

The wind direction potentiometer requires a stable DC excitation voltage. Do not exceed 15 volts. When the potentiometer wiper is in the 8° deadband region, the output signal is "floating" and may show varying or unpredictable values. Azimuth signal conditioning electronics should properly process this condition. (All YOUNG signal conditioning electronics meet these requirements.) Avoid a short circuit between the azimuth signal line and either the excitation or ground reference lines. Although there is a current limiting resistor in series with the wiper for protection, damage to the potentiometer may occur if a short circuit condition exists.

Before installation, connect the Wind Sentry to a signal conditioning device and check for proper wind speed and direction values. Make electrical connections to the sensor cables supplied with the instrument as shown in the wiring diagram. Positioning the vane over the center of a sheet of paper with 35° or 45° cross markings allows easy visual alignment of the vane. To check wind speed, temporarily remove the cup wheel and connect a Model 18810 Anemometer Drive to the cup wheel shaft. Details appear in the CALIBRATION section.

INSTALLATION

Proper placement of the instrument is very important. Eddies from trees, buildings, or other structures can greatly influence wind speed and direction observations. To get meaningful data for most applications, locate the instrument well above or upwind of such obstructions. As a general rule, the air flow around a structure is disturbed to twice the height of the structure upwind, six times the height downwind, and twice the height of the structure above ground. For some observations it may not be practical or necessary to meet these guidelines.

Initial installation is most easily done with two people during the vane alignment step; one to adjust the instrument position and the other to observe the indicating device.

To install the Wind Sentry, follow these steps:

1. MOUNT WIND SENTRY
   a) Connect sensor cable to Wind Sentry junction box.
   b) Place Wind Sentry on mounting post. Do Not tighten band clamp yet.
   c) Connect sensor cable to indicator.

2. ALIGN VANE
   a) Select a known azimuth reference point on the horizon.
   b) Sighting down vane centerline, point counterweight toward azimuth reference on horizon.
   c) While holding vane in position, slowly turn base until indicator displays proper value.
   d) Tighten mounting post band clamp.

CALIBRATION

The Wind Sentry is fully calibrated before shipment and should require no adjustments. Recalibration may be necessary after some maintenance operations. Periodic calibration checks are desirable and may be necessary where the instrument is used in programs which require auditing of sensor performance.

For wind direction calibration, the following method can yield an accuracy of ±5° or better if carefully done. Begin by connecting the instrument to a signal conditioning circuit which has some way to indicate azimuth value. This may be an indicator which displays azimuth values in angular degrees or simply a voltmeter monitoring the output. Hold or mount the instrument so the vane center of rotation is over the center of a sheet of paper which has 30° or 45° crossmarkings. Position the instrument so the mounting crossarm is oriented north-south with the vane on the north and the anemometer on the south. With the counterweight pointing directly at the anemometer the azimuth signal should correspond to 180° or due south. Looking from above, visually align the vane with each of the crossmarkings and observe the indicator display. It should correspond to vane position within 5°. If not, it may be necessary to adjust the relative position of the vane skirt and shaft. See step 3 in the MAINTENANCE section under potentiometer replacement.

It is important to note that while full scale azimuth on signal conditioning electronics may be 360°, full scale azimuth signal from the instrument is 352°. The signal conditioning electronics must be adjusted accordingly. For example, in a circuit where 0 to 1.00 VDC represents 0° to 360°, the output must be adjusted for 0.978 VDC when the instrument is at 352° full scale. (352°/360° X 1.00 volts = 0.978 volts)

Wind speed calibration is determined by the cup wheel turning factor and the output characteristics of the transducer. Calibration formulas showing cup wheel rpm and frequency output vs. wind speed are included in this manual. These formulas are accurate to within 2 percent.

To calibrate wind system electronics using an actual signal from the instrument, temporarily remove the cup wheel and connect a Model 18810 Anemometer Drive to the cup wheel shaft. Calculate wind speed by applying the appropriate calibration formula to the motor rpm and adjust the signal conditioning electronics for proper value. For example, with the cup wheel shaft turning at 1800 rpm trim the indicator to display 22.7 meters per second. (0.01250 X 1800 + 0.2 = 22.7)

MAINTENANCE

Given proper care, the Wind Sentry should provide years of service. Because of its durable, corrosion resistant construction, the instrument requires little maintenance. The only components likely to require replacement due to normal wear are the precision ball bearings and the azimuth potentiometer. Replacement of these components should only be performed by a qualified instrument technician. If service facilities are not available, return the instrument to the factory. Refer to the accompanying drawings to become familiar with part names and locations. Maximum torque on all set screws is 80 oz-in.

POTENTIOMETER REPLACEMENT:

The potentiometer has a life expectancy of fifty million revolutions. As it becomes worn, the element usually begins to produce noisy signals or become non-linear. When the signal noise or non-linearity become unacceptable, replace the potentiometer as follows:

1. REMOVE POTENTIOMETER
   a) Remove three screws which secure upper and lower sections of main housing.
   b) Carefully remove upper housing exposing wiring connections to circuit board.
   c) Unsolder potentiometer wires from circuit board. Note color coding.
   d) Using a knife blade or similar instrument, loosen potentiometer assembly from upper housing and slide it out.

2. INSTALL NEW POTENTIOMETER
   a) Slide new potentiometer cell into upper housing. Be sure to engage cell key into housing notch.
   b) Solder potentiometer wires to circuit board. Observe color code.
   c) Join two sections of main housing. Secure with screws removed in step 1a.

3. ALIGN VANE
   a) Connect excitation voltage and signal conditioning electronics to instrument according to wiring diagram.
   b) Loosen set screw in side of vane hub.
   c) Position instrument so crossarm is oriented north-south with vane on north side. Orient vane to a known angular reference.(See CALIBRATION section.)
   d) While holding vane in reference position, slowly turn vane skirt until signal conditioning system indicates proper value.
   e) Tighten set screw on side of vane hub. Do not exceed 80 oz-in torque.

ANEMOMETER FLANGE BEARING REPLACEMENT:

If anemometer bearings become noisy or wind speed threshold increases above an acceptable level, replace the bearings. Check bearing condition by hanging an ordinary paper clip (0.5 gm) on the outside edge of one cup while the instrument is held in a horizontal position. The cup should rotate downward. Failure to rotate due to the weight of the paper clip indicates anemometer bearings need replacement. Repeat this test at different positions to check full bearing rotation. Replace bearings as follows:

1. REMOVE BEARINGS
   a) Loosen set screw on side of cup wheel hub. Remove cup wheel.
   b) Remove three screws which hold two sections of main housing.
   c) Carefully separate upper and lower housing. Remove coil transducer assembly from upper housing. Do not disconnect from circuit board.
   d) Loosen screw and remove ring magnet on end of shaft inside upper housing.
   e) Slide shaft and skirt assembly out of both upper and lower bearings.
   f) Using knife blade under bearing flange, carefully remove upper bearing.
   g) Using a pencil, gently push out lower bearing from above.

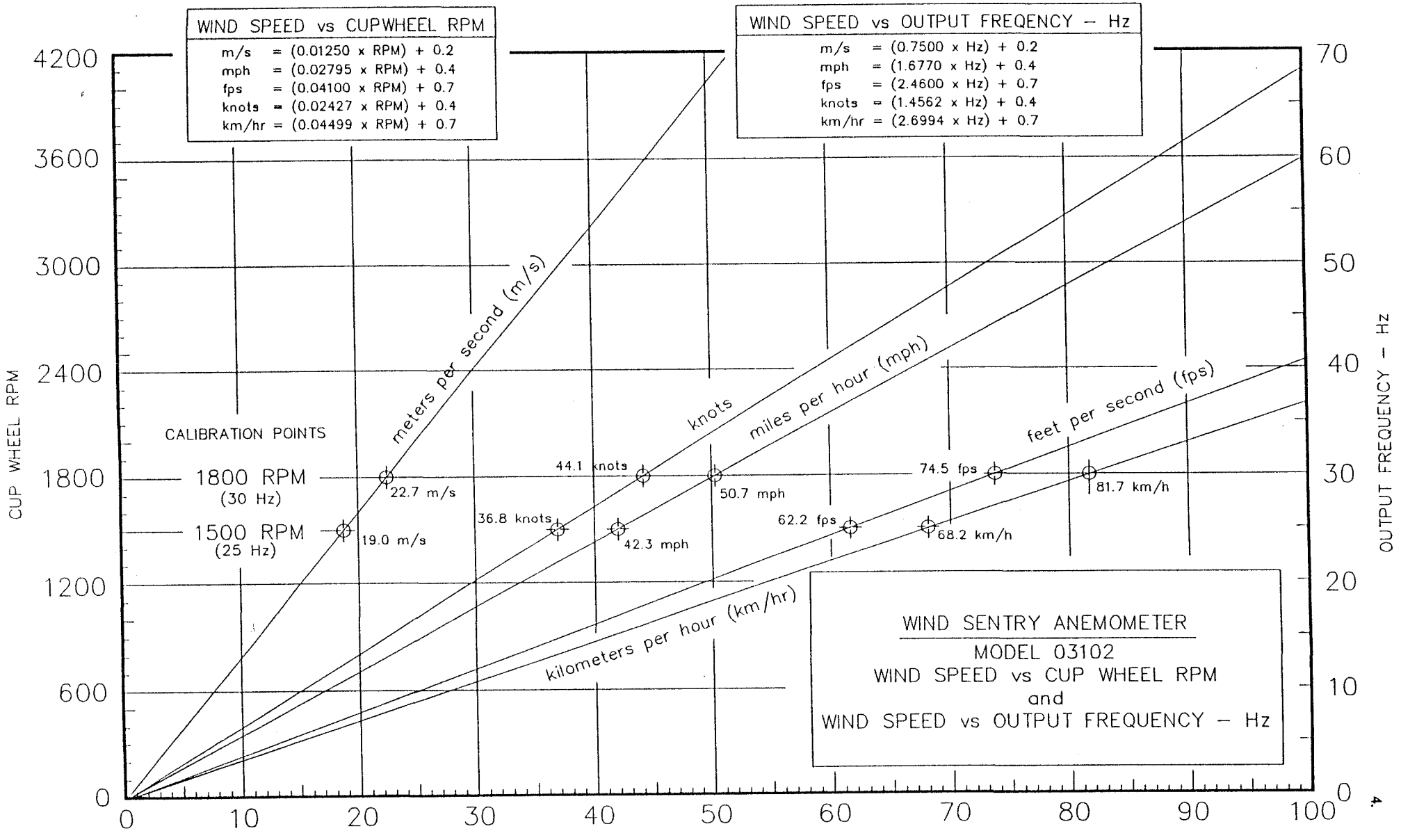
2. INSTALL NEW BEARINGS
   a) Insert new upper bearing. Use care not to apply excessive pressure.
   b) Slide cup wheel shaft through upper bearing.
   c) Slide lower bearing on shaft inside upper housing.
   d) Using ring magnet assembly, push lower bearing into its seat in upper housing.
   e) Secure ring magnet to shaft using screw removed in step 1d. Use a small amount of sealant on screw to prevent it from loosening.
   f) Join two housing sections. Secure using three screws removed in step 1b.
   g) Place cup wheel on shaft. Tighten set screw on side of hub. Do not exceed 80 oz-in torque.

VANE FLANGE BEARING REPLACEMENT:

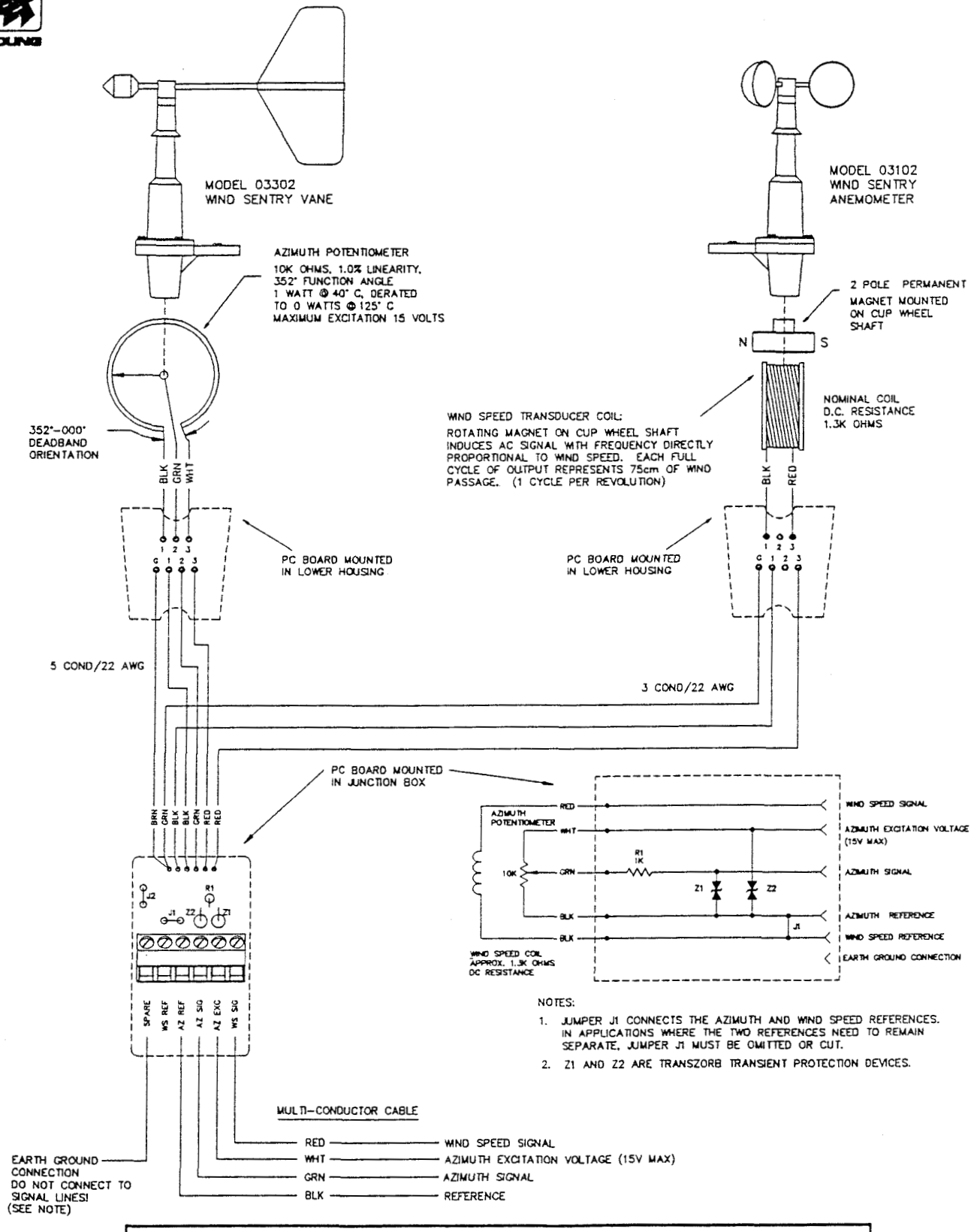
If vane bearings become noisy or if wind direction threshold increases above an acceptable level, replace the bearings. Check bearing condition by adding two ordinary paper clips (0.5 gm each) to the back edge of the vane fin while the instrument and vane are held in a horizontal position. Gently release the vane. It should rotate downward. Failure to do so indicates the bearings need replacement. Repeat this test at various positions to check full bearing rotation.

Since this procedure is similar to anemometer bearing replacement, only the major steps are shown here:

1. REMOVE BEARINGS (Remove coupling disc - same as ring magnet)
2. INSTALL NEW BEARINGS
3. ALIGN VANE (See CALIBRATION section)


WIND SPEED vs CUPWHEEL RPM
m/s = (0.01250 x RPM) + 0.2
mph = (0.02795 x RPM) + 0.4
fps = (0.04100 x RPM) + 0.7
knots = (0.02427 x RPM) + 0.4
km/hr = (0.04499 x RPM) + 0.7
WIND SPEED vs OUTPUT FREQENCY – Hz
m/s = (0.7500 x Hz) + 0.2
mph = (1.6770 x Hz) + 0.4
fps = (2.4600 x Hz) + 0.7
knots = (1.4562 x Hz) + 0.4
km/hr = (2.6994 x Hz) + 0.7
CUP WHEEL RPM
OUTPUT FREQUENCY – Hz
CALIBRATION POINTS
1800 RPM
(30 Hz)
1500 RPM
(25 Hz)
meters per second (m/s)
knots
miles per hour (mph)
feet per second (fps)
kilometers per hour (km/hr)
22.7 m/s
19.0 m/s
44.1 knots
36.8 knots
50.7 mph
42.3 mph
74.5 fps
62.2 fps
81.7 km/h
68.2 km/h
WIND SENTRY ANEMOMETER
MODEL 03102
WIND SPEED vs CUP WHEEL RPM
and
WIND SPEED vs OUTPUT FREQUENCY – Hz
WIND SPEED: meters per second, miles per hour, feet per second, knots, kilometers per hour
A03110.DWG
JAN 92

MODEL 03002 WIND SENTRY ANEMOMETER AND VANE W/J-BOX



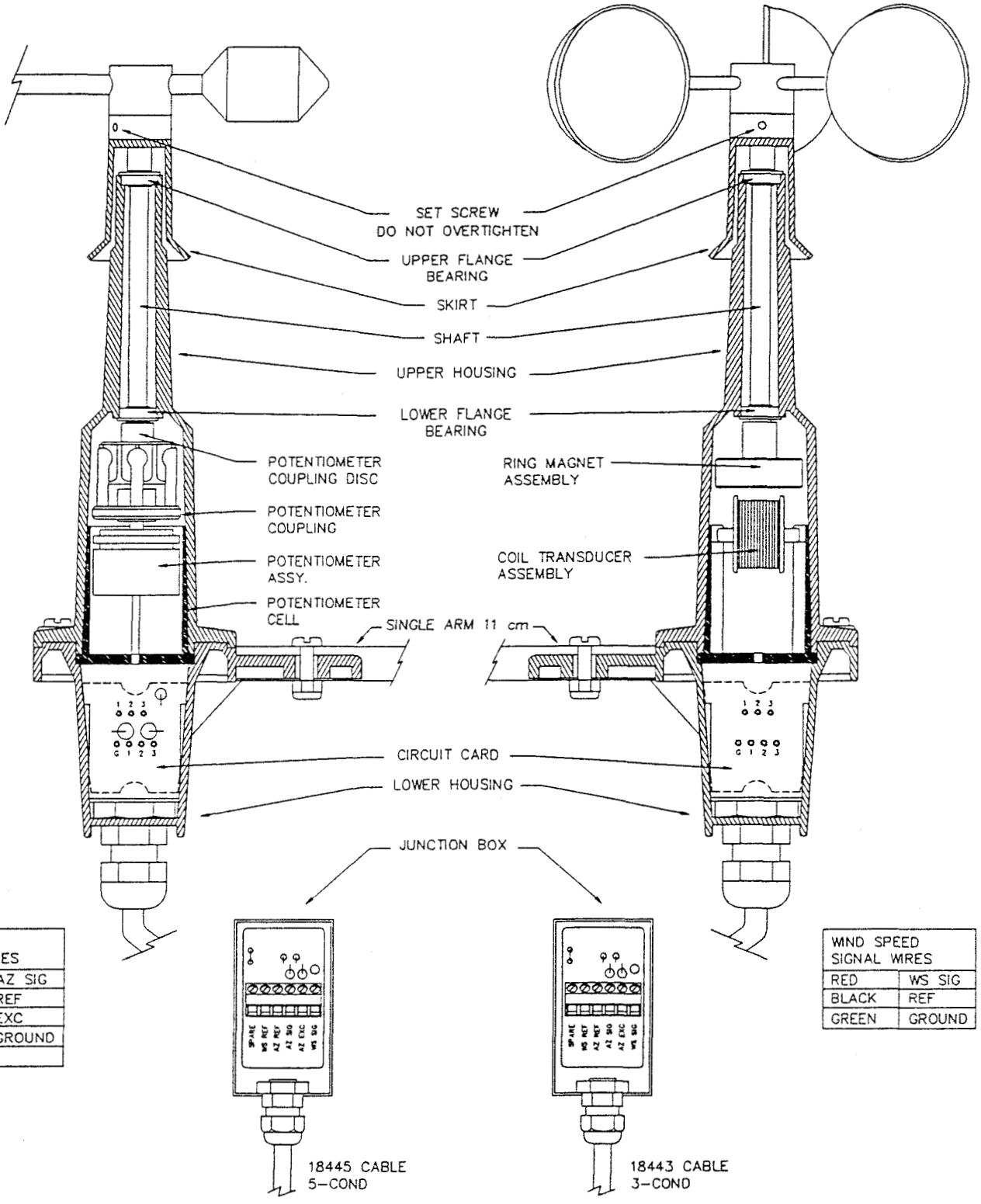
NOTE:
THE EARTH GROUND TERMINAL MUST BE CONNECTED TO EARTH GROUND TO PROVIDE A STATIC DISCHARGE PATH. CONNECT THIS TERMINAL TO AN EARTH GROUND IN THE PROXIMITY OF THE SENSOR.

MODEL 03002	DWG A	PRD 08-90
WIND SENTRY CABLE & WIRING DIAGRAM	DWN KL	DWG 01-92
	CHK EC	W03002
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

YOUNG

MODEL 03302
WIND SENTRY VANE

MODEL 03102
WIND SENTRY ANEMOMETER



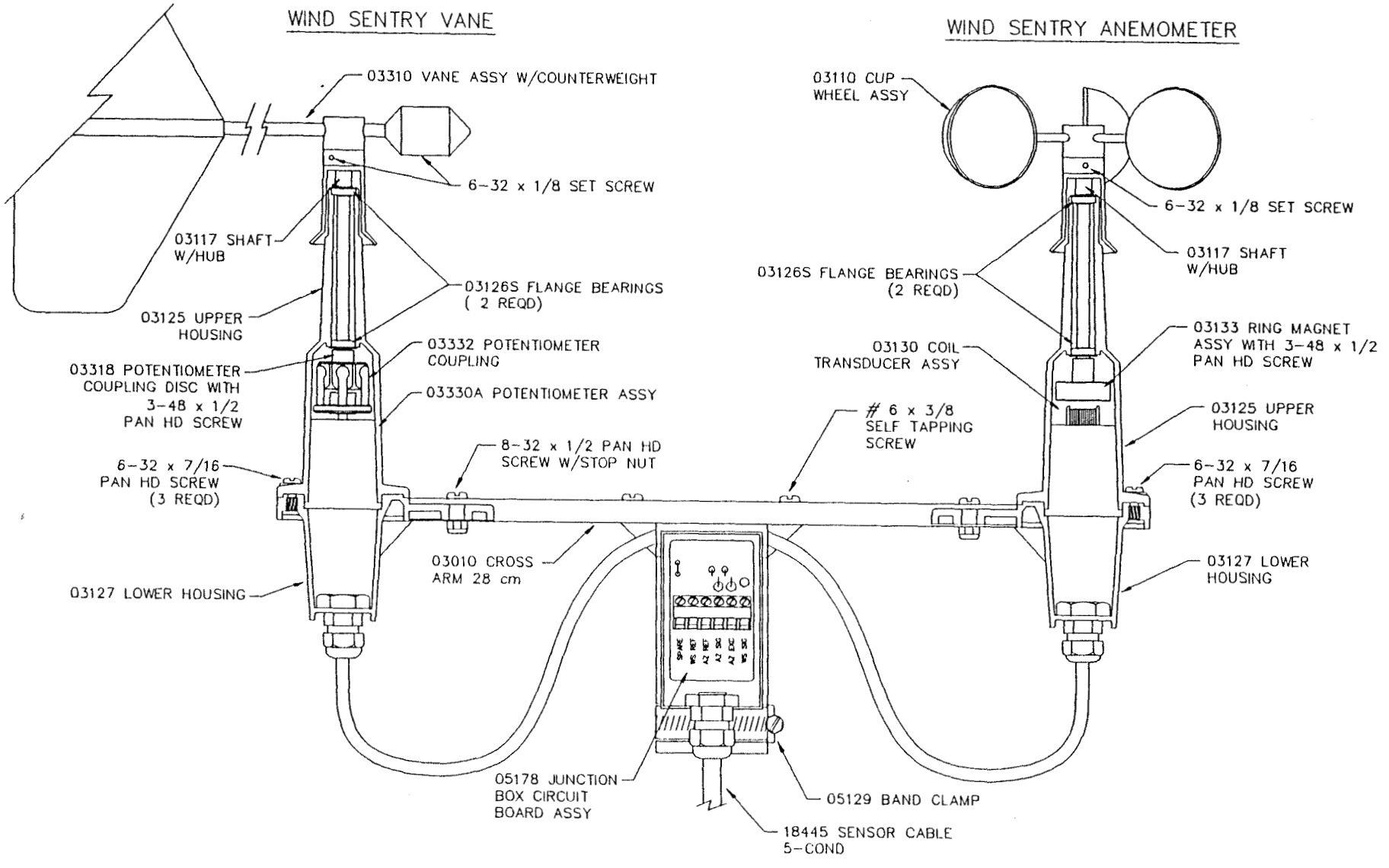
AZIMUTH SIGNAL WIRES	
GREEN	AZ SIG
BLK	REF
RED	EXC
BRN	GROUND

WIND SPEED SIGNAL WIRES	
RED	WS SIG
BLACK	REF
GREEN	GROUND

MODELS 03302/03102 WIND SENTRY	DWG A	PRD 12-92
CUP WHEEL ANEMOMETER AND VANE	DWN KL	DWG 01-92
SECTION VIEW	CHK	S03002
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

MODEL 03002 WIND SENTRY

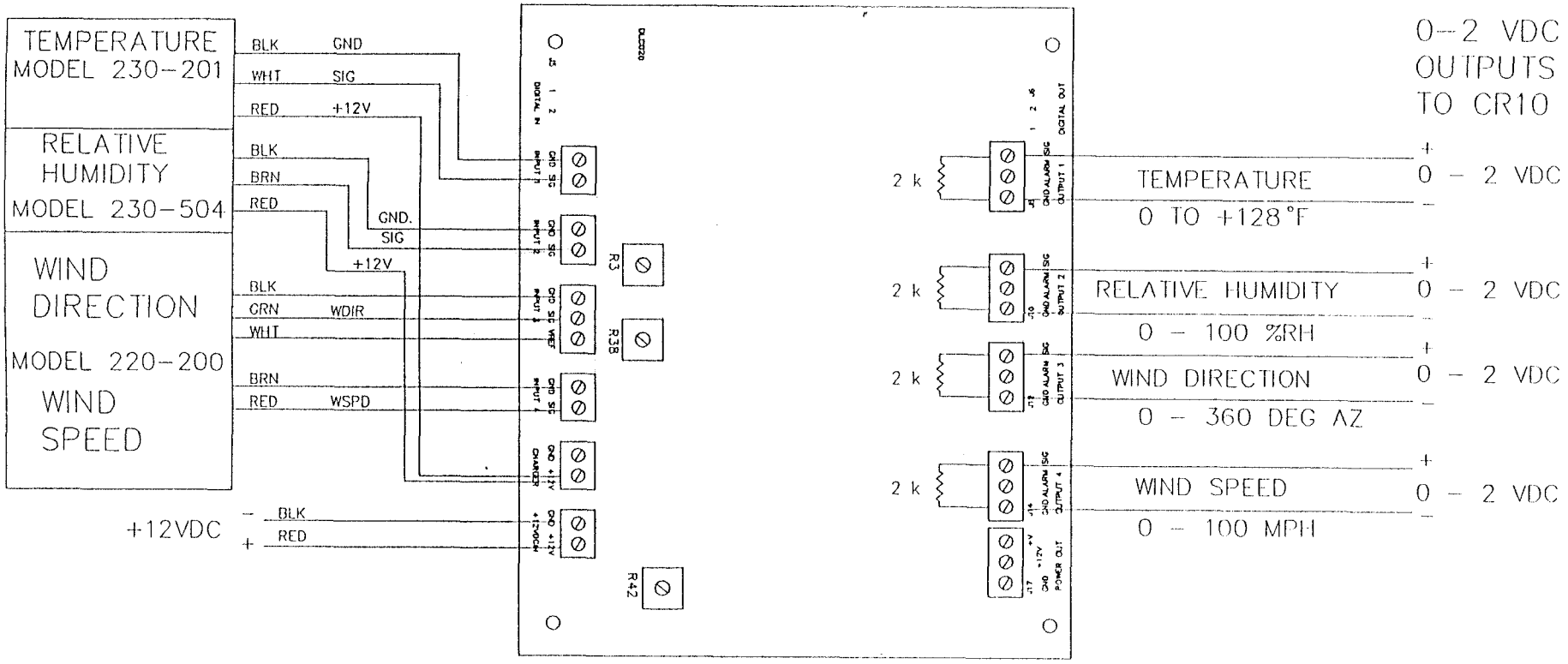
ANEMOMETER & VANE SYSTEM



MODEL 03002 WIND SENTRY	DWG A	PRD 12-91
VANE/ANEMOMETER	DWN KL	DWG 01-92
REPLACEMENT PARTS	CHK	M03002
R.M. YOUNG CO. TRAVERSE CITY, MI 49684 U.S.A. 616-946-3980		

SENSORS

UNIVERSAL SIGNAL CONDITIONING BOARD.
MODEL 395-104



NOTES: 1. ALL OUTPUTS ARE 0-1 mA WITH A 2K OHM LOAD RESISTOR TO PRODUCE 0-2 VDC OUTPUTS FOR CR10.

TRANSLATOR BOARD MODIFIED FOR SPEED, DIRECTION, TEMPERATURE, & HUMIDITY.

BOARD MODIFIED FOR WOODWARE-CLYDE

TITLE	SYSTEM WIRING DIAGRAM WSPD, WDIR, TEMP, RH BOARD
MOD USAGE	395-104
SHEET	1 OF 1
BY	RGN
SCALE	NONE
DWG NO	931129
DATE	11-23-93

INSTRUCTION MANUAL

TCAV Averaging Soil Thermocouple Probe

Campbell Scientific, Inc.

TCAV
AVERAGING SOIL THERMOCOUPLE PROBE
INSTRUCTION MANUAL

June 13, 1990

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WARRANTY

The **TCAV - AVERAGING SOIL THERMOCOUPLE PROBE** is warranted against defects in materials and workmanship. This warranty applies for twelve months from date of shipment. We will repair or replace products which prove to be defective during the warranty period provided they are returned prepaid to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return warranted equipment by surface carrier prepaid. No other warranty is expressed or implied. CAMPBELL SCIENTIFIC, INC. is not liable for consequential damages.

Products may not be returned without prior authorization. To obtain a Returned Materials Authorization (RMA), contact CAMPBELL SCIENTIFIC, INC., phone (801) 753-2342. An RMA number will be issued in order to facilitate Repair Personnel in identifying an instrument upon arrival. Please write this number clearly on the outside of the shipping container.

CAMPBELL SCIENTIFIC, INC. does not accept collect calls.

Non-warranty products returned for repair should be accompanied by a purchase order to cover the repair.

CAMPBELL SCIENTIFIC, INC.

P.O. Box 551
Logan, UT 84321
Phone (801) 753-2342
TLX 453058
FAX 801-752-3268

9525 41st Avenue
Edmonton, Alberta T6E 5X7
CANADA
Phone (403) 461-5158
TLX 037-2966 (EDM)
FAX 403-450-2531

14-20 Field Street
Shepshed, Leics. LE12 9AL
ENGLAND
Phone 01144509601141
TLX 94016393 (CAMP G)
FAX 01144509601091

TCAV - AVERAGING SOIL THERMOCOUPLE PROBE

1. DESCRIPTION

The TCAV is a temperature probe which parallels 4 thermocouple junctions into one. One channel is required to measure the output voltage which represents the average temperature of the four junctions. The TCAV is most often used to obtain the average temperature of a soil layer for use in calculating stored energy.

The probe is constructed with type E thermocouple wire (chromel-constantan) and can be measured with one of the datalogger thermocouple measurement instructions, 13 or 14. Instruction 14, which uses the differential voltage measurement, should be used to reduce noise and ground loop problems.

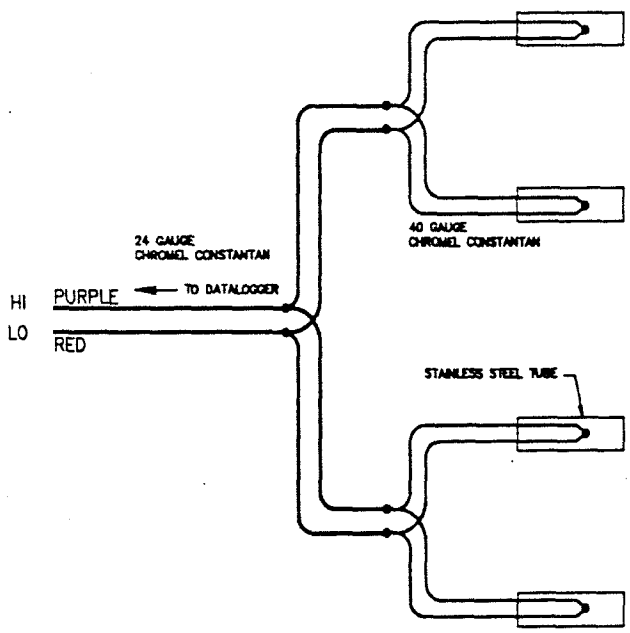


FIGURE 1. TCAV Thermocouple Probe

2. USING THE TCAV WITH SOIL HEAT FLUX PLATES

The TCAV is used in conjunction with soil heat flux plates to calculate the heat flux at the surface of the soil. The plates are buried at a fixed depth of between 5 and 8 cm to reduce errors due to vapor transport of heat.

2.1 INSTALLATION

The TCAV and two heat flux plates are typically installed as in Figure 2. The TCAV is constructed so two thermocouples can be used to obtain the average temperature of the soil layer above one heat flux plate and the other two above the second plate. The thermocouple pairs may be up to two meters apart.

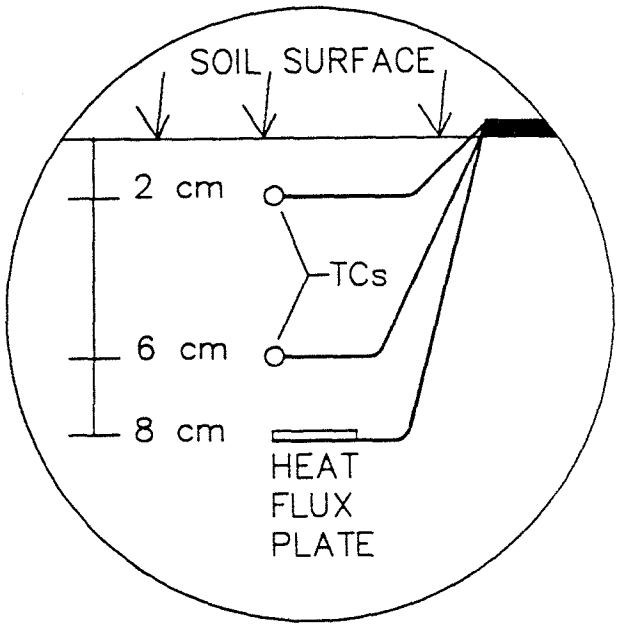


FIGURE 2. Placement of Thermocouples and Heat Flux Plates

The location of the two heat flux plates/thermocouples should be chosen to be representative of the area under study. If the ground cover is extremely varied, it could be necessary to have additional sensors to provide a valid average.

Use a shovel to cut a vertical slice in the soil and remove the soil to one side of the cut. Try to keep the soil that is removed intact so that it can be replaced with as little disruption as possible.

The sensors are installed in the undisturbed face. The depths are measured from the top of the soil. A horizontal cut is made with a knife to install a heat flux plate. The stainless steel tubes encasing the thermocouple junctions are pressed into the soil, keeping the tubes

horizontal. (When removing the thermocouples, grip the tubing, not the thermocouple wire.)

To minimize thermal conduction down the sensor lead wires, wrap them around the edge of the hole keeping the leads at the same level as the sensor for as long as possible. Replace the soil in the same position as it was. Do not run the leads directly to the surface.

2.2 CALCULATING SOIL HEAT FLUX

The soil heat flux at the surface is calculated by adding the measured flux at a fixed depth (in this case 8 cm) to the energy stored in the layer above the heat flux plates. The heat capacity of the soil and the change in temperature over the output interval are required to calculate the average stored energy, S (W m^{-2}):

$$S = (T_i - T_{i-1}) * D * Cs / t$$

Where:

T_i is the current temperature (^oC),
T_{i-1} is previous temperature (^oC),
D is depth to heat flux plate (m),
Cs is the soil heat capacity (J m^{-3} $^oC^{-1}$),and
T is the time interval (s).

One method of calculating Cs is to add the specific heat of the dry mineral soil, Csd, to that of the soil water, Cw (4190 J kg^{-1} $^oC^{-1}$). The values used for Csd and Cw are on a mass basis (J kg^{-1} $^oC^{-1}$). Cs, the heat capacity of the moist soil on a volume basis (J m^{-3} $^oC^{-1}$) is:

$$Cs = BD * (Csd + W * Cw)$$

This calculation requires site specific inputs for bulk density (BD, kg m^{-3}), mass basis water content (W, kg water/kg soil), and Csd, the specific heat of the dry soil. 840 J kg^{-1} $^oC^{-1}$ is a reasonable value for Csd for most mineral soils (Hanks and Ashcroft, Applied Soil Physics, Published by Springer-Verlag, New York, 1980).

Calibration of the Time Domain Reflectometry Cables for the Evapotranspiration Study

The calibration of ET TDR cables 31, 32, 33, and 34 is located in file 9518WAT.VAZ; calibration of ET TDR cables 35, 36, 37, and 38 is located in 9519WAT.VAZ. These files are stored with similar files as described in the section Time Domain Reflectometry Calibration Data.

ET TDR Cable Calibration

Cable Number	$T_{1.1}$	$T_{1.2}$	T_2	Travel Time (ns)	Water Content	Temper-ature (Celsius)
31	4.56	5.28	18.34	13.06	.525	14.5
32	4.73	5.44	18.65	13.21	.531	14.5
33	4.60	5.38	18.44	13.01	.525	14.5
34	4.65	5.32	18.58	13.26	.533	14.5
35	4.76	5.49	18.62	13.13	.528	16.0
36	4.55	5.30	18.46	13.16	.529	16.0
37	4.50	5.26	18.37	13.11	.527	16.0
38	4.52	5.26	18.55	13.29	.534	16.0

ALPHA WIRE CORPORATION
CUSTOMER SPECIFICATION FOR
HEAT-SHRINKABLE TUBING

FIT-221
FILE NUMBER:1925E
EFFECTIVE: 11-18-85
REPLACES:----------

SPECIFICATION NO. FIT-221

SCOPE

This specification covers an electrical insulating, heat-shrinkable tubing. The tubing shall be fabricated from thermally-stabilized, modified polyolefin and shall be crosslinked by irradiation. It shall be homogeneous and essentially free from flaws, pinholes, defects, cracks, seams, and inclusions.

Applicable Specifications

Extruded Insulating Tubing	UL Standard 224* CSA Standard C22.2 No. 198*
Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked	MIL-I-23053/5A Class 1 & 2

Physical Properties

Operating temperature range	-55°C to 135°C
Shrinkage ratio	Approximately 2:1 at 121°C
Dimensions	Shall conform to table I
Tensile strength	1800 psi
Ultimate elongation	400%
Longitudinal shrinkage	± 3%
Secant modulus	2.5×10^4 psi
Specific gravity	1.35
Heat shock (4 Hrs at 250°C)	No dripping, flowing, or cracking
Low temperature flexibility 4 hours at -55°C	No cracking
Copper stability 168 hours at 160°C Ultimate elongation	200%

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 2
To Walt "Mitch" Michaud | From Debbie
Co. 3M Stoller Co. | Co. Alpha
Dept. TRAILER #T891M | Phone #
Fax # 303-966-6533 | Fax #

Electrical

Dielectric strength	500 volts/mil
Volume resistivity	10^{14} ohm/cm

Chemical

Corrosive effect 16 hours at 175°C	Non-corrosive
Flammability Colors Clear	 Self-extinguishing Not flame retardant
Water absorption 24 hours at 25°C	0.5% maximum

****

TABLE I

Alpha Part Number	Minimum Supplied I.D. Inches	mm	Maximum Recovered I.D. Inches	mm	Nominal Recovered Wall Thickness Inches	mm
FIT-221-3/64	0.046	1,17	0.023	0,58	0.016	0,41
FIT-221-1/16	0.063	1,60	0.031	0,78	0.017	0,43
FIT-221-3/32	0.093	2,36	0.046	1,17	0.020	0,50
FIT-221-1/8	0.125	3,18	0.062	1,58	0.020	0,50
FIT-221-3/16	0.187	4,75	0.093	2,36	0.020	0,50
FIT-221-1/4	0.250	6,35	0.125	3,18	0.025	0,63
FIT-221-3/8	0.375	9,53	0.187	4,75	0.025	0,63
FIT-221-1/2	0.500	12,70	0.250	6,35	0.025	0,63
FIT-221-3/4	0.750	19,10	0.375	9,53	0.030	0,76
FIT-221-1	1.000	25,40	0.500	12,70	0.035	0,88
FIT-221-1-1/2	1.500	38,10	0.750	19,10	0.040	1,02
FIT-221-2	2.000	50,80	1.000	25,40	0.050	1,27
FIT-221-3	3.000	76,20	1.500	38,10	0.050	1,27
FIT-221-4	4.000	101,60	2.000	50,80	0.055	1,40

* No UL Recognition, CSA Certification on clear tubing

Rain Simulation Studies

Trench 3 - 3 Series & 2 Dry Runs

Location G

10 ft x 6 ft		11/7/94	7/1/94	7/1/94	7/7/94	7/8/94	7/8/94	7/18/94	7/19/94	7/19/94	7/22/94	7/28/94
	Time	Dry	Wet	Very Wet	Dry	Wet	Very Wet	Dry	Wet	V. Wet	Dry	Dry
	(min)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)
	5	10	20	15	0	0	15	0	0	5	5	5
	10	40	45	65	0	0	15	0	5	5	0	0
	15	40	35	60	0	0	20	0	0	45	0	0
	20	30	90	80	0	20	40	0	5	5	0	0
	25	30	100	100	0	10	60	0	60	0	5	0
	30	40	100	65	0	**45**	90	0	30	50	40	0
	35	40	70	75	0	25	**1000**	0	20	0	10	0
	40	40	95	90	0	30	1000	0	0	0	10	0
	45	40	85	70	0	40	1000	0	0	**90**	0	0
	50	40	85	90	0	30	1000	0	50	590	65	0
	55	40	85	80	0	20	1000	0	20	780	10	0
	60	35	NA	NA		40	**290**	60	10	1000	0	0
	65	5				**15**		**190**	**0**	1000	**0**	0
	70	0										
Total Vol		430	810	790	0	275	5530	250	200	3570	145	5
Ave. Vol per		39.09	73.64	71.82	0.00	21.15	425.38	19.23	15.38	274.62	11.15	0.38
5 Min Int												

Location F

10 ft x 6 ft		11/7/94	7/1/94	7/1/94	7/7/94	7/8/94	7/8/94	7/18/94	7/19/94	7/19/94	7/22/94	7/28/94
	Time	Dry	Wet	Very Wet	Dry	Wet	Very Wet	Dry	Wet	Very Wet	Dry	Dry
	(min)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)	(ml)
	5	30	10	20	0	5	15	30	0	5	15	0
	10	20	10	0	10	40	35	60	0	5	5	0
	15	40	20	15	50	20	60	25	0	20	10	10
	20	25	40	25	40	30	40	25	5	25	0	25
	25	30	50	30	40	25	75	20	10	35	5	50
	30	35	40	10	35	30	55	20	25	20	15	25
	35	30	40	30	37	30	**290**	15	30	35	10	20
	40	35	20	30	43	45	1000	25	30	55	5	0
	45	35	40	20	48	45	1000	10	10	**1000**	25	30
	50	40	30	25	45	45	1000	20	10	1000	15	20
	55	40	30	25	45	45	1000	10	20	1000	5	30
	60	40	NA	NA	20	65	**1000**	20	15	1000	0	30
	65	0				**35**		**30**	**5**		**15**	5
	70	0										
Total Vol		400	330	230	413	460	5570	310	160	4200	125	245
Ave. Vol per		36.36364	30.00	20.91	34.42	35.38	464.17	23.85	12.31	350.00	9.62	18.85
5 min int												

Rain Simulation Studies

Trench 2 - 3 Series & 2 Dry Runs

Location E														
3 ft x 5 ft		**11/7/94**	**7/1/94**	**7/1/94**		**7/7/94**	**7/8/94**	**7/8/94**		**7/18/94**	**7/19/94**	**7/19/94**		**7/22/94**	**7/28/94**
	Time	**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Dry**
	(min)	**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**
	5	10	5	190		5	5	5		10	0	0		10	5
	10	15	75	360		45	0	5		20	0	0		0	0
	15	30	**130**	280		60	0	10		10	0	0		0	0
	20	20	180	340		50	0	15		5	0	0		5	0
	25	25	190	390		40	5	**415**		0	0	0		0	0
	30	20	230	310		30	0	1000		0	0	0		5	0
	35	20	240	370		30	15	1000		5	5	70		0	0
	40	25	220	410		25	10	1000		0	0	**430**		0	0
	45	25	270	420		40	10	1000		0	0	340		0	5
	50	20	310	450		35	0	1000		0	0	1000		10	0
	55	30	310	430		30	5	1000		0	0	1000		0	0
	60	20	NA	NA		20	0	**500**		0	0	1000		0	0
	65	0				**10**	**0**			**5**	**0**			**5**	0
	70	5													
Total Vol		240	2160	3950		420	50	6950		55	5	3840		35	10
Ave. Vol per		21.82	196.36	359.09		32.31	3.85	579.17		4.23	0.38	320.00		2.69	0.77
5 Min Int															
Location D														
1 ft x 1ft		**11/7/94**	**7/1/94**	**7/1/94**		**7/7/94**	**7/8/94**	**7/8/94**		**7/18/94**	**7/19/94**	**7/19/94**		**7/22/94**	**7/28/94**
	Time	**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Dry**
	(min)	**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**
	5	0	0	30		0	0	5		0	0	10		10	0
	10	10	20	60		0	0	10		0	0	10		15	5
	15	70	10	50		0	0	5		10	0	5		20	5
	20	70	10	50		0	0	5		10	0	20		15	10
	25	100	20	80		0	20	15		10	5	10		5	0
	30	90	15	80		0	10	10		0	0	15		5	20
	35	105	25	100		0	10	0		5	5	10		0	0
	40	105	10	80		0	15	15		0	5	10		5	0
	45	100	40	70		0	5	**145**		0	0	10		0	5
	50	105	20	90		0	10	365		5	0	0		5	10
	55	115	20	75		15	15	**105**		0	5	15		0	5
	60	90	NA	NA		30	5			10	5	5		0	10
	65	15				**40**	**5**			**0**	**0**			**5**	0
	70	5													
Total Vol		870	190	765		85	95	680		50	25	120		85	70
Ave. Vol per		79.09	17.27	69.55		6.54	7.31	61.82		3.85	1.92	10.00		6.54	5.38
5 min int															

Rain Simulation Studies

Trench 2 - 3 Series & 2 Dry Runs

Location C														
1 ft x 1ft		**6/30/94**	**7/1/94**	**7/1/94**		**7/7/94**	**7/8/94**	**7/8/94**		**7/18/94**	**7/19/94**	**7/19/94**		**7/22/94**	**7/28/94**
	Time	**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Dry**
	(min)	**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**
	5	no	30	40		40	10	20		50	0	0		10	5
	10	working	45	80		40	30	30		0	0	0		20	0
	15	110	65	80		20	15	20		0	0	10		20	0
	20	125	60	70		20	30	**295**		0	5	5		25	0
	25	120	50	90		15	15	605		0	0	**135**		15	0
	30	90	30	90		15	15	700		0	0	470		0	0
	35	110	40	**130**		15	15	775		0	0	550		0	5
	40	110	30	150		15	20	475		5	0	750		0	0
	45	110	60	180		20	20	800		10	0	870		5	0
	50	110	40	270		15	10	810		0	0	900		0	5
	55	80	80	310		15	**110**	830		10	10	1000		0	5
	60	na	na	NA		5	260	**400**		5	0	1000		5	5
	After					**5**	**100**			**0**	**0**			10	0
Total Vol		965	530	1490		240	650	5760		80	15	5690		110	25
Ave. Vol per		87.72727	48.18	135.45		18.46	50.00	480.00		6.15	1.15	474.17		8.46	1.92
5 min int															
Location B															
3ft x 5ft		**11/7/94**	**7/1/94**	**7/1/94**		**7/7/94**	**7/8/94**	**7/8/94**		**7/18/94**	**7/19/94**	**7/19/94**		**7/22/94**	**7/28/94**
	Time	**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Wet**	**Very Wet**		**Dry**	**Dry**
	(min)	**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**	**(ml)**		**(ml)**	**(ml)**
	5	10	0	10		10	5	2		0	0	5		5	40
	10	5	0	20		50	0	**163**		0	0	0		0	0
	15	5	10	60		50	0	505		0	0	**1000**		5	5
	20	0	10	80		30	5	580		0	5	1000		0	0
	25	5	20	100		0	35	1000		0	5	1000		0	0
	30	5	20	130		10	35	1000		0	5	1000		0	0
	35	15	30	230		10	40	1000		0	5	1000		0	5
	40	5	20	330		20	50	1000		0	0	1000		0	0
	45	5	20	**760**		20	**730**	1000		0	20	1000		0	0
	50	5	20	1000		20	450	1000		0	**760**	1000		**1000**	0
	55	5	20	1000		15	350	**860**		0	855	1000		1000	0
	60	5	NA	NA		15	663			**0**	830	1000		1000	0
	65	5				**5**	**37**				**850**			1000	10
	70	0													
Total Vol		65	170	3720		255	2400	8110		0	1655	9005		2010	50
Ave. Vol per		5.91	15.45	338.18		19.62	184.62	737.27		0.00	127.31	750.42		154.62	3.85
5 min int															

Rain Simulation Studies

Location A — Trench 2 - 3 Series & 2 Dry Runs

10 ft x 35 ft		7/18/94	7/19/94	7/19/94		7/22/94	7/28/94
	Time	Dry	Wet	Very Wet		Dry	Dry
	(min)	(ml)	(ml)	(ml)		(ml)	(ml)
	5	100	10	1000		0	0
	10	130	70	1000		5	0
	15	120	80	1000		0	0
	20	130	95	1000		0	0
	25	110	110	1000		5	0
	30	110	**355**	1000		0	0
	35	110	1000	1000		0	0
	40	130	1000	1000		**1000**	0
	45	110	1000	1000		1000	0
	50	100	1000	1000		1000	0
	55	110	1000	1000		9000	0
	60	100	1000	1000		10000	430
	60	**185**	**1000**			5gal +	1000
Total Vol		1545	7720	12000		exceeded	1430
						measurement	
Ave. Vol per		118.85	593.85	1000.00		capacity	119.17
5 min int							

Rain Simulation Studies			
Trench 3 - 2 Dry Runs			
Location E			
3 ft x 5 ft			
	Time	**Dry**	**Dry**
		(ml)	**(ml)**
	5	0	10
	10	30	15
	15	50	30
	20	70	20
	25	85	25
	30	90	20
	35	100	20
	40	100	25
	45	105	25
	50	120	20
	55	140	30
	60	135	20
	65	50	0
	70	5	5
Location D			
3 ft x 5 ft			
	Time	**Dry**	**Dry**
		(ml)	**(ml)**
	5	0	5
	10	10	5
	15	70	0
	20	70	5
	25	100	0
	30	90	0
	35	105	0
	40	105	0
	45	100	0
	50	105	0
	55	115	0
	60	90	0
	65	15	0
	70	5	0

Rain Simulation Studies

Trench 3 - 2 Dry Runs

Location C

10 ft x 6 ft

not working

Location B

10 ft x 6 ft

Time	Dry (ml)	Dry (ml)
5	10	5
10	5	0
15	5	5
20	0	0
25	5	10
30	5	10
35	15	20
40	5	10
45	5	25
50	5	15
55	5	10
60	5	20
65	5	5
70	0	5

Location A

10 ft x 35 ft

Time	Dry (ml)	Dry (ml)
5	35	0
10	100	0
15	175	0
20	185	80
25	160	40
30	400	30
35	195	30
40	175	20
45	345	10
50	145	30
55	220	20
60	440	20
65	125	0
70	145	0

Rain Simulation Studi			**imulations**				
Trench 3 - 2 Dry Ru			**Runs**				
Location G							
1 ft x 1 ft							
	Time	**Dry**	**Dry**				
		(ml)	**(ml)**				
	5	15	10				
	10	35	40				
	15	10	40				
	20	20	30				
	25	15	30				
	30	25	40				
	35	20	40				
	40	10	40				
	45	30	40				
	50	20	40				
	55	25	40				
	60	25	35				
	65	0	5				
	70	0	0				
Location F							
1 ft x 1 ft							
	Time	**Dry**	**Dry**				
		(ml)	**(ml)**				
	5	5	30				
	10	75	20				
	15	70	40				
	20	60	25				
	25	70	30				
	30	70	35				
	35	70	30				
	40	70	35				
	45	70	35				
	50	80	40				
	55	60	40				
	60	80	40				
	65	25	0				
	70	0	0				

Piezometer Data

for Trench 2

Date	Time	Run	1	2	3	Old
			Inches	Inches	Inches	Inches
6/30/94	8:05	I -1A	N/A	N/A	N/A	84
	9:25	I -1B	N/A	N/A	N/A	84
7/1/94	10:30	I -2A	163	66.5	77	82
	12:00	I -2B	160	114.5	130.5	70
	3:11	I -3B	160	46.5	61.5	46
7/7/94	6:35	II -1A	97.5	70.5	77.5	76
	9:05	II - 1B	97.5	55.5	72.5	58
7/8/94	6:33	II - 2A	85.5	60.5	60	65
	11:24	II - 2B	83	32	49	34
	1:30	II - 3B	81.5	13.5	26	14
7/18/94	7:01	III - 1A	73.5	68.5	75	75
	9:00	III - 1B	75.5	60	73	63.5
7/19/94	6:47	III - 2A	70.5	58	63.5	64
	8:46	III - 2B	70.5	30.5	59.5	35
	12:04	III - 3B	69	7	25	8.5
7/22/94	7:20	IV - 1A	76.5	57.5	63	63
	9:09	IV - 1B	76.5	26.5	55	31
7/28/94	8:24	V - 1A	90.5	63	69	69
	10:03	V - 1B	89.5	59.5	77	53

Measurements were taken before automation of the system

All values are the distance from ground surface to the water table

The Roman numeral indicates the series

The first number after the hyphen corresponds to

1- Dry run

2 - Wet run

3- Very Wet run

The letter indicates when relative to the rain simulation the information was taken

A- Prior to Simulation

B- After SImulation

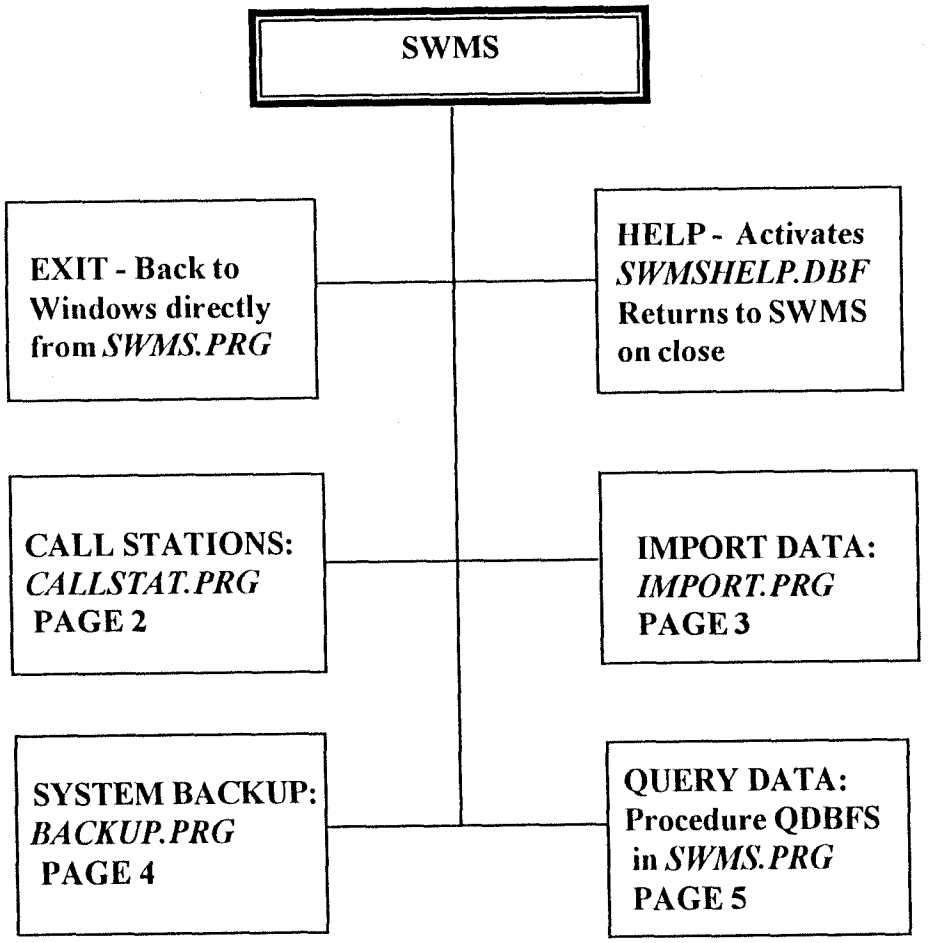
```
Program: EVAPAN
Flag Usage:
Input Channel Usage:
Excitation Channel Usage:
Control Port Usage:
Pulse Input Channel Usage:
Output Array Definitions:


*      1        Table 1 Programs
  01: 10        Sec. Execution Interval

01:  P86        Do
  01: 41        Set high Port 1

02:  P86        Do
  01: 72        Pulse Port 2

03:  P86        Do
  01: 72        Pulse Port 2

04:  P86        Do
  01: 72        Pulse Port 2

05:  P22        Excitation with Delay
  01: 1         EX Chan
  02: 0         Delay w/EX (units=.01sec)
  03: 100       Delay after EX (units=.01sec)
  04: 0         mV Excitation

06:  P86        Do
  01: 72        Pulse Port 2

07:  P2         Volt (DIFF)
  01: 1         Rep
  02: 15        2500 mV fast Range
  03: 1         IN Chan
  04: 16        Loc [:WIND SPD ]
  05: .05       Mult
  06: 0         Offset

08:  P89        If X<=>F
  01: 16        X Loc WIND SPD
  02: 3         >=
  03: 0         F
  04: 30        Then Do

09:  P89        If X<=>F
  01: 16        X Loc WIND SPD
  02: 4         <
  03: 120       F
  04: 30        Then Do
```

DIMENSIONS, WEIGHT AND RESISTANCE
OF ROUND COPPER AND ALUMINUM WIRE

WIRE SIZE	DIAMETER		D-C RESISTANCE AT 20°C (68°F) 100% CONDUCTIVITY COPPER		D-C RESISTANCE AT 20°C (68°F) 61.8% CONDUCTIVITY ALUMINUM		WEIGHT COPPER		WEIGHT ALUMINUM		WIRE SIZE
AWG.	NOM. INCH	CIRCULAR MILS	OHMS PER M FEET	OHMS PER LB.	OHMS PER M FEET	OHMS PER LB.	LB. PER M FEET	FEET PER LB.	LB. PER M FEET	FEET PER LB.	AWG
4/0	0.4600	211600	0.04901	0.00007652	0.07930	0.0004072	640.5	1.561	194.7	5.135	4/0
3/0	.4096	167800	.06182	.0001218	.1000	.0006482	507.8	1.969	154.4	6.478	3/0
2/0	.3648	133100	.07793	.0001935	.1261	.001030	402.8	2.482	122.5	8.163	2/0
1/0	.3249	105600	.09825	.0003075	.1590	.001637	319.5	3.130	97.14	10.29	1/0
1	.2893	83690	.1239	.0004891	.2005	.002603	253.3	3.947	77.02	12.98	1
2	.2576	66360	.1563	.0007781	.2529	.004141	200.9	4.978	61.08	16.37	2
3	.2294	52620	.1971	.001237	.3189	.006584	159.3	6.278	48.44	20.65	3
4	.2043	41740	.2485	.001967	.4021	.01047	126.3	7.915	38.40	26.04	4
5	.1819	33090	.3134	.003130	.5072	.01666	100.2	9.984	30.47	32.82	5
6	.1620	26240	.3952	.004975	.6395	.02647	79.44	12.59	24.15	41.41	6
7	.1443	20820	.4981	.007902	0.8060	.04206	63.03	15.87	19.16	52.19	7
8	.1285	16510	.6281	.01257	1.016	.06688	49.98	20.01	15.20	65.79	8
9	.1144	13090	.7925	.02000	1.282	.1065	39.62	25.24	12.05	82.99	9
10	.1019	10380	0.9988	.03180	1.616	.1691	31.43	31.82	9.56	105	10
11	.0907	8230	1.26	.0506	2.04	.269	24.9	40.2	7.57	132	11
12	.0808	6530	1.59	.0804	2.57	.428	19.8	50.6	6.02	166	12
13	.0720	5180	2.00	.127	3.24	0.679	15.7	63.7	4.77	210	13
14	.0641	4110	2.52	.203	4.08	1.08	12.4	80.4	3.77	265	14
15	.0571	3260	3.18	.322	5.15	1.72	9.87	101	3.00	333	15
16	.0508	2580	4.02	.514	6.50	2.74	7.81	128	2.37	422	16
17	.0453	2050	5.05	0.814	8.18	4.33	6.21	161	1.89	529	17
18	.0403	1620	6.39	1.30	10.3	6.91	4.92	203	1.50	666	18
19	.0359	1290	8.05	2.06	13.0	11.0	3.90	256	1.19	840	19
20	.0320	1020	10.1	3.27	16.4	17.4	3.10	323	0.943	1060	20
21	.0285	812	12.8	5.19	20.7	27.6	2.46	407	.748	1340	21
22	.0253	640	16.2	8.36	26.2	44.5	1.94	516	.590	1690	22
23	.0226	511	20.3	13.1	32.9	69.9	1.55	647	.471	2120	23
24	.0201	404	25.7	21.0	41.5	112	1.22	818	.371	2700	24
25	.0179	320	32.4	33.4	52.4	178	0.970	1030	.295	3390	25
26	.0159	253	41.0	53.6	66.4	285	.765	1310	.233	4290	26
27	.0142	202	51.4	84.3	83.2	449	.610	1640	.185	5410	27
28	.0126	159	65.3	136	106	724	.481	2080	.146	6850	28
29	.0113	128	81.2	210	131	1120	.387	2590	.118	8470	29
30	.0100	100	104	343	168	1830	.303	3300	.0921	10900	30
31	.0089	79.2	131	546	212	2910	.240	4170	.0730	13700	31
32	.0080	64.0	162	836	262	4450	.194	5160	.0590	16900	32
33	.0071	50.4	206	1350	333	7180	.153	6550	.0465	21500	33
34	.0063	39.7	261	2180	422	11600	.120	8320	.0365	27400	34
35	.0056	31.4	331	3480	536	18500	.0949	10500	.0289	34600	35
36	.0050	25.0	415	5480	671	29200	.0757	13200	.0230	43500	36
37	.0045	20.2	512	8360	—	—	.0613	16300	—	—	37
38	.0040	16.0	648	13400	—	—	.0484	20600	—	—	38
39	.0035	12.2	847	22800	—	—	.0371	27000	—	—	39
40	.0031	9.61	1080	37100	—	—	.0291	34400	—	—	40
41	.0028	7.84	1320	55700	—	—	.0237	42100	—	—	41
42	.0025	6.25	1660	87700	—	—	.0189	52900	—	—	42
43	.0022	4.84	2140	146000	—	—	.0147	68300	—	—	43
44	.0020	4.00	2590	214000	—	—	.0121	82600	—	—	44

DIMENSIONS, WEIGHT AND RESISTANCE
OF ROUND COPPER AND ALUMINUM WIRE

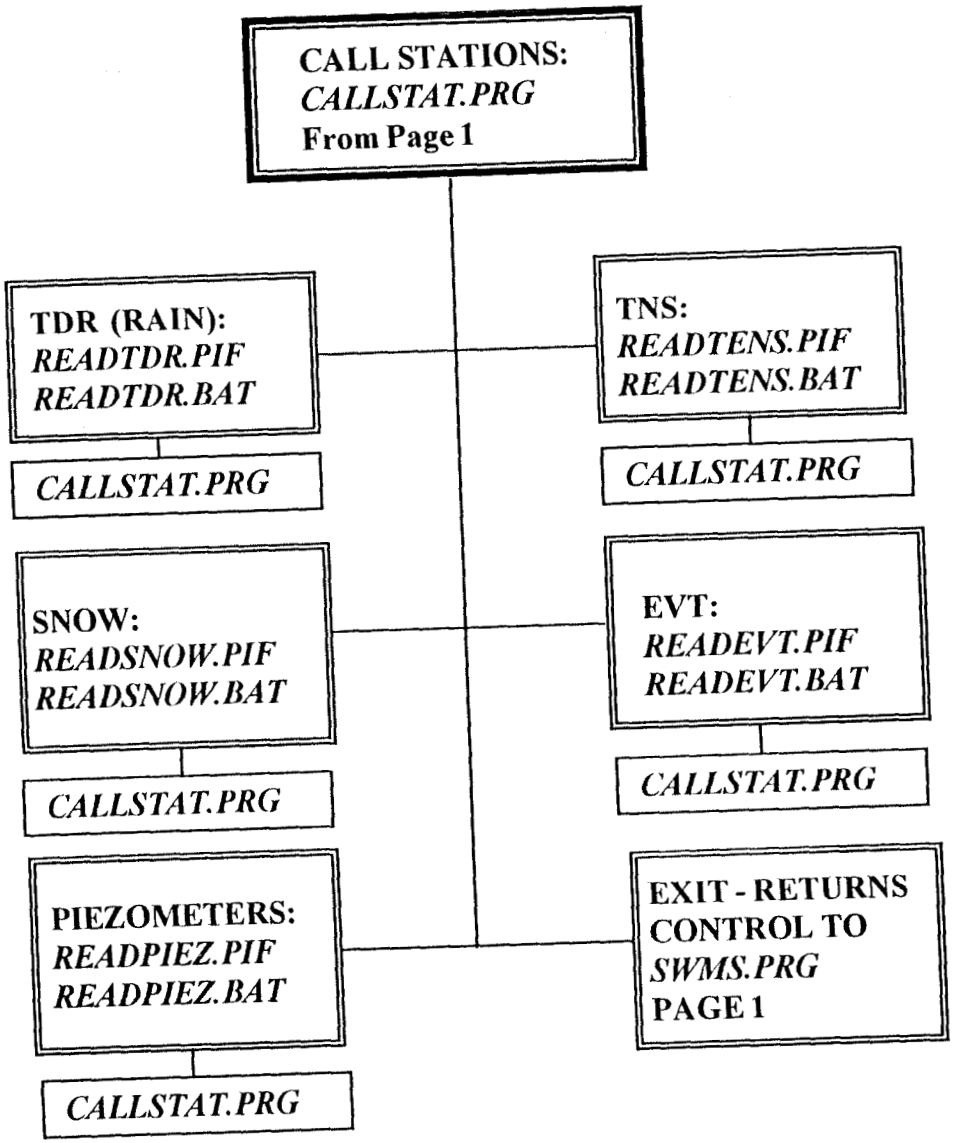
SWMS DATA FLOW



Windows icon activates *SWMS.APP*

CONTROL - *SWMS.PRG*
SCREEN - *SWMS.SPR*

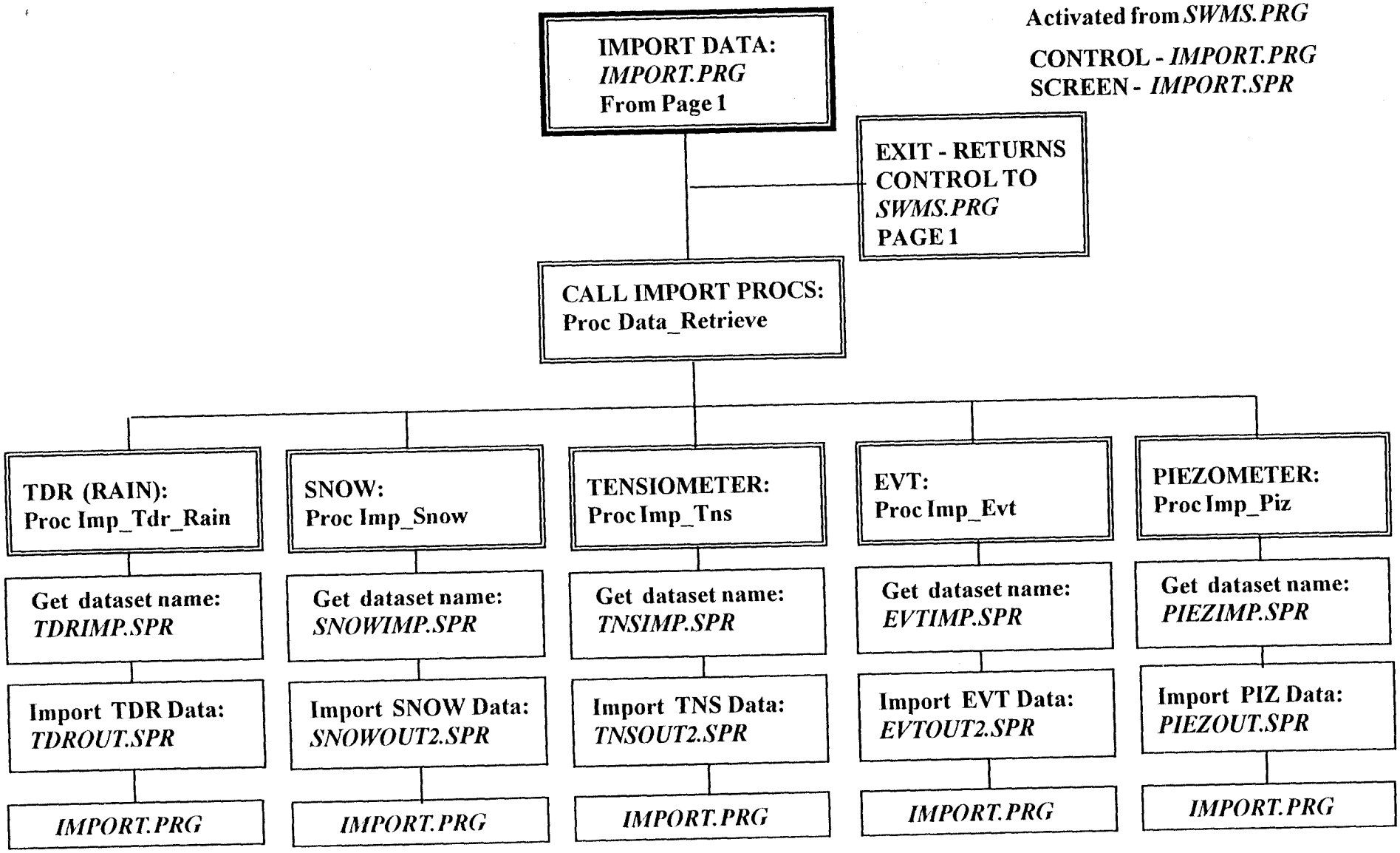
SWMS DATA FLOW



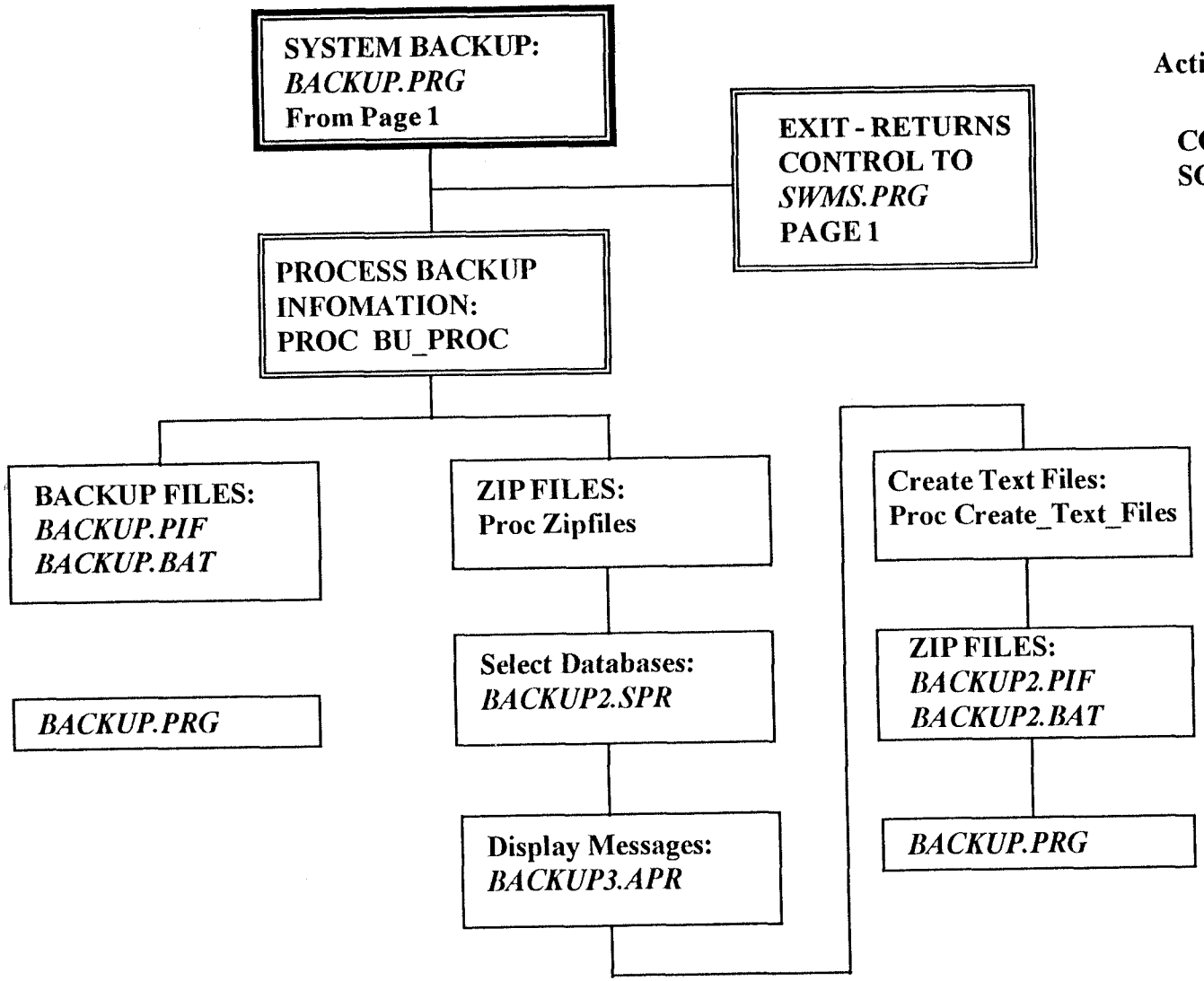
Activated from *SWMS.PRG*

CONTROL - *CALLSTAT.PRG*
SCREEN - *CALLSTAT.SPR*

SWMS DATA FLOW



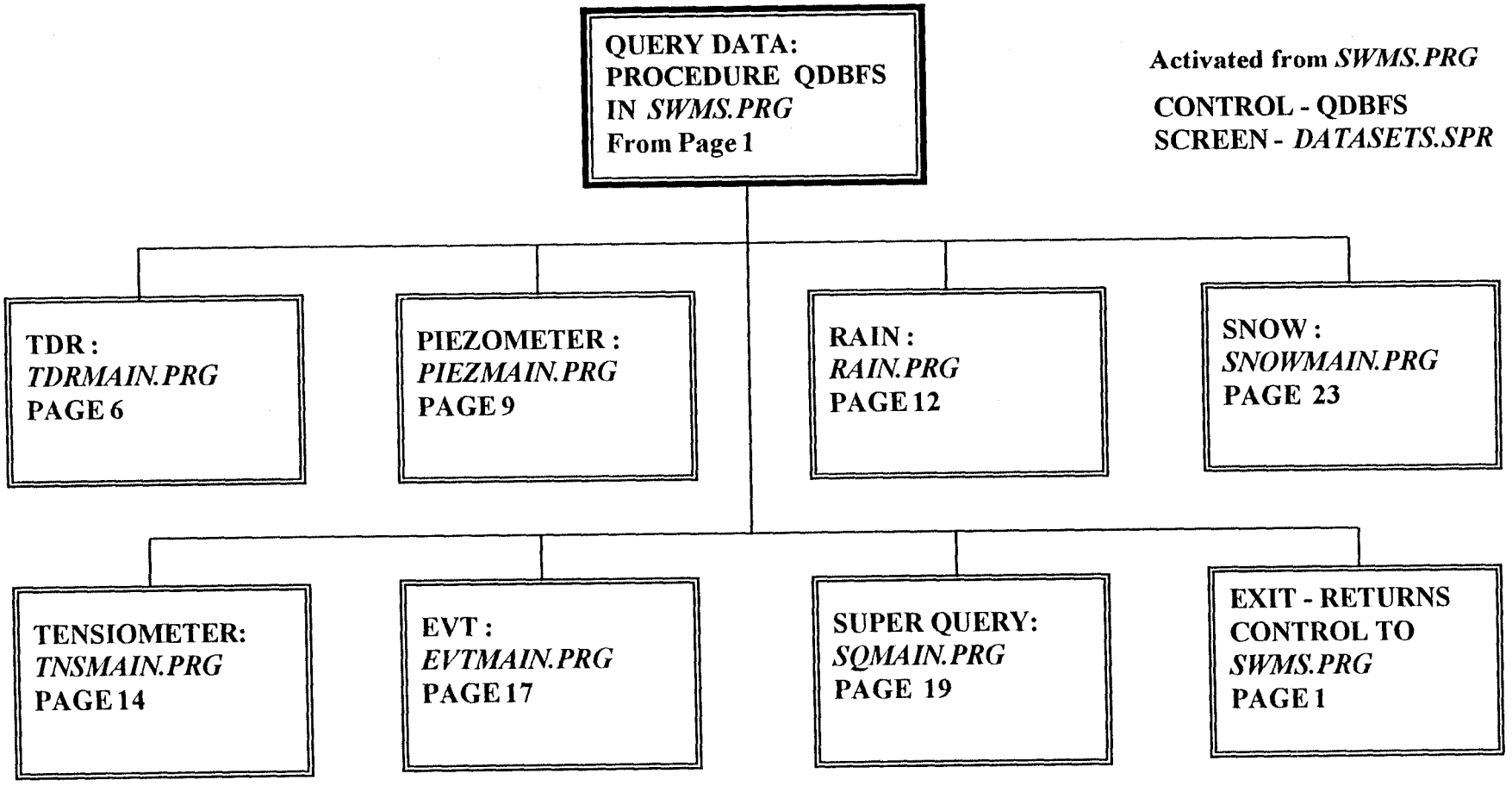
SWMS DATA FLOW



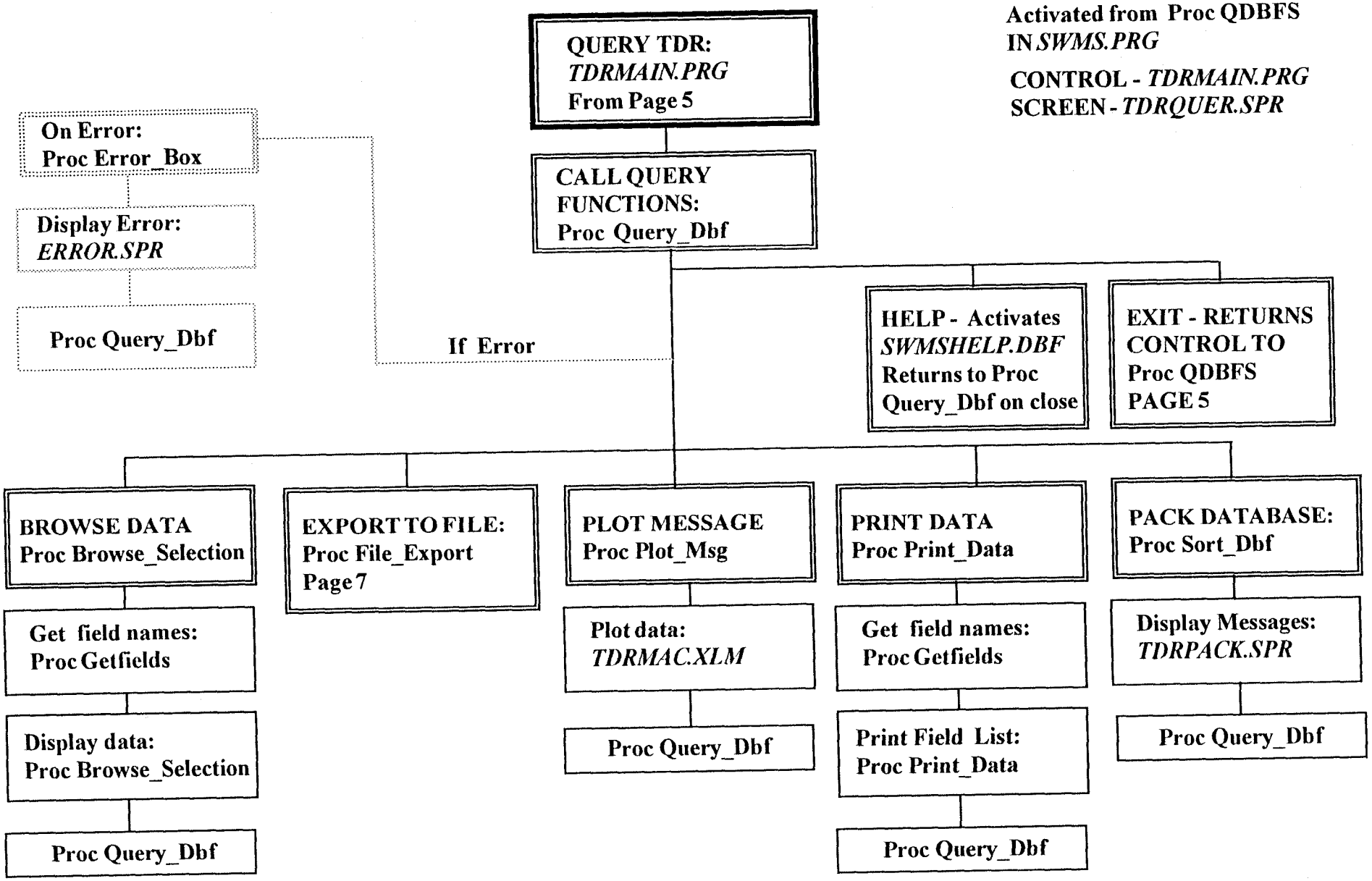
Activated from *SWMS.PRG*

CONTROL - *BACKUP.PRG*
SCREEN - *BACKUP.SPR*

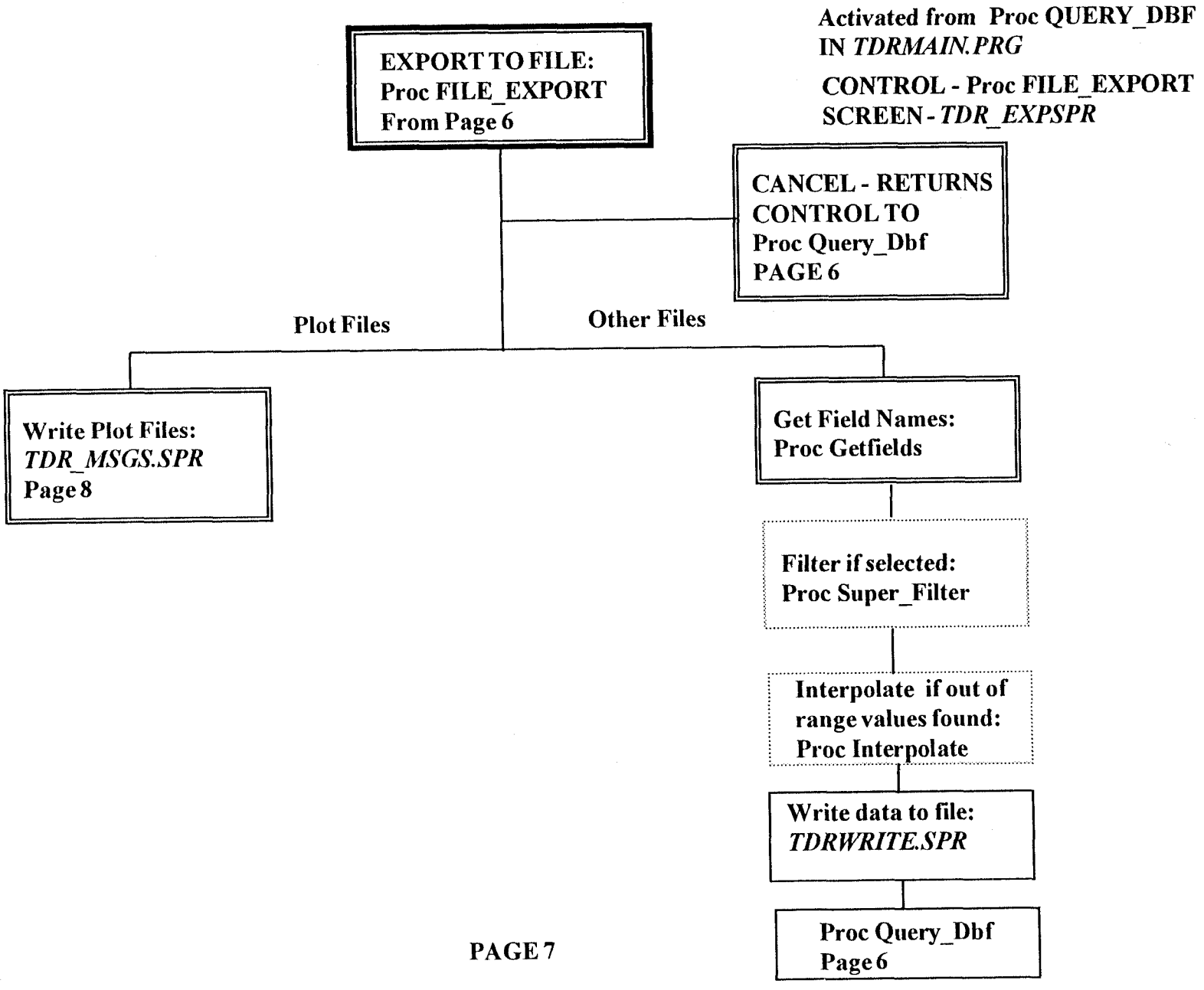
SWMS DATA FLOW



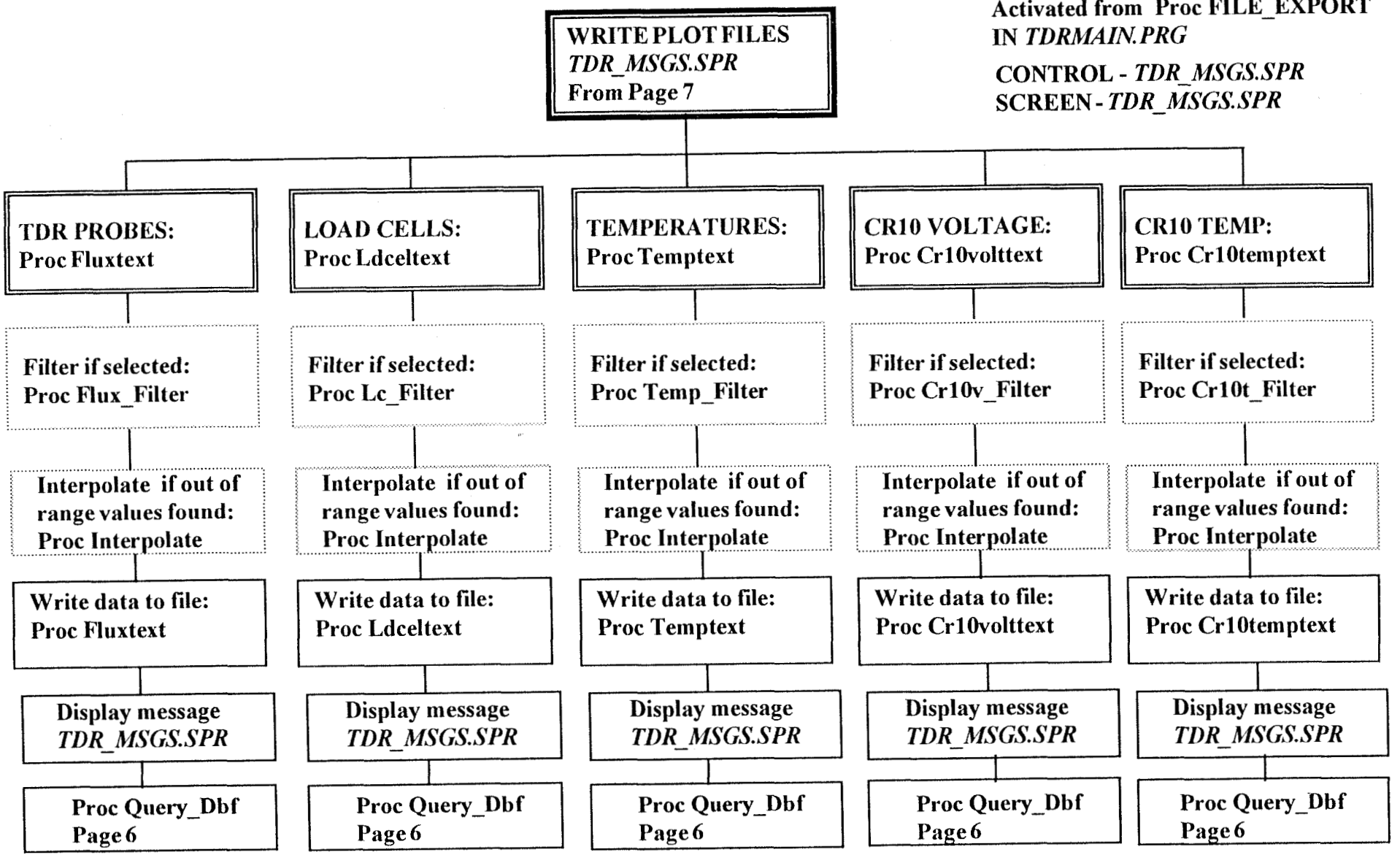
SWMS DATA FLOW



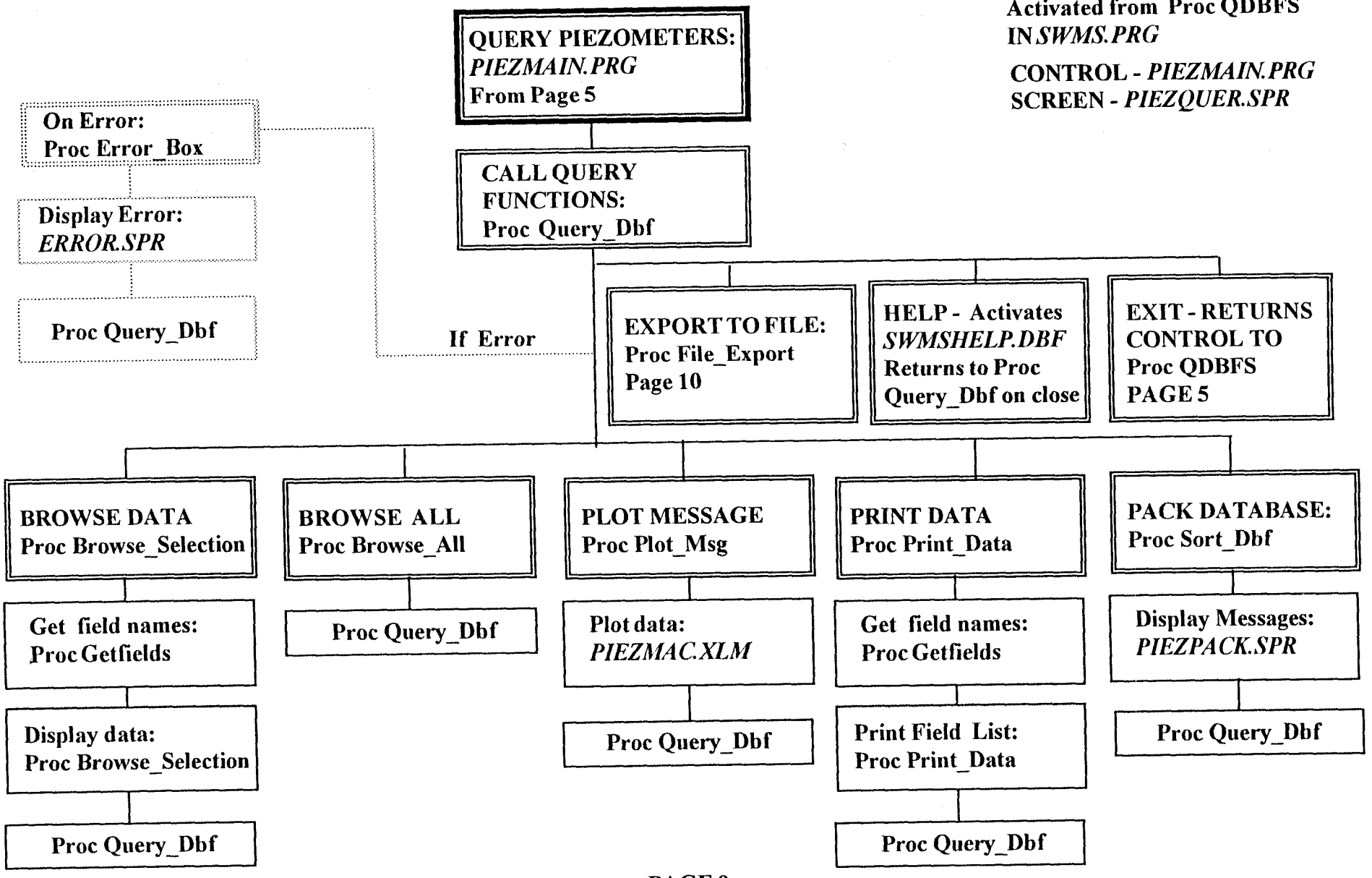
SWMS DATA FLOW



SWMS DATA FLOW



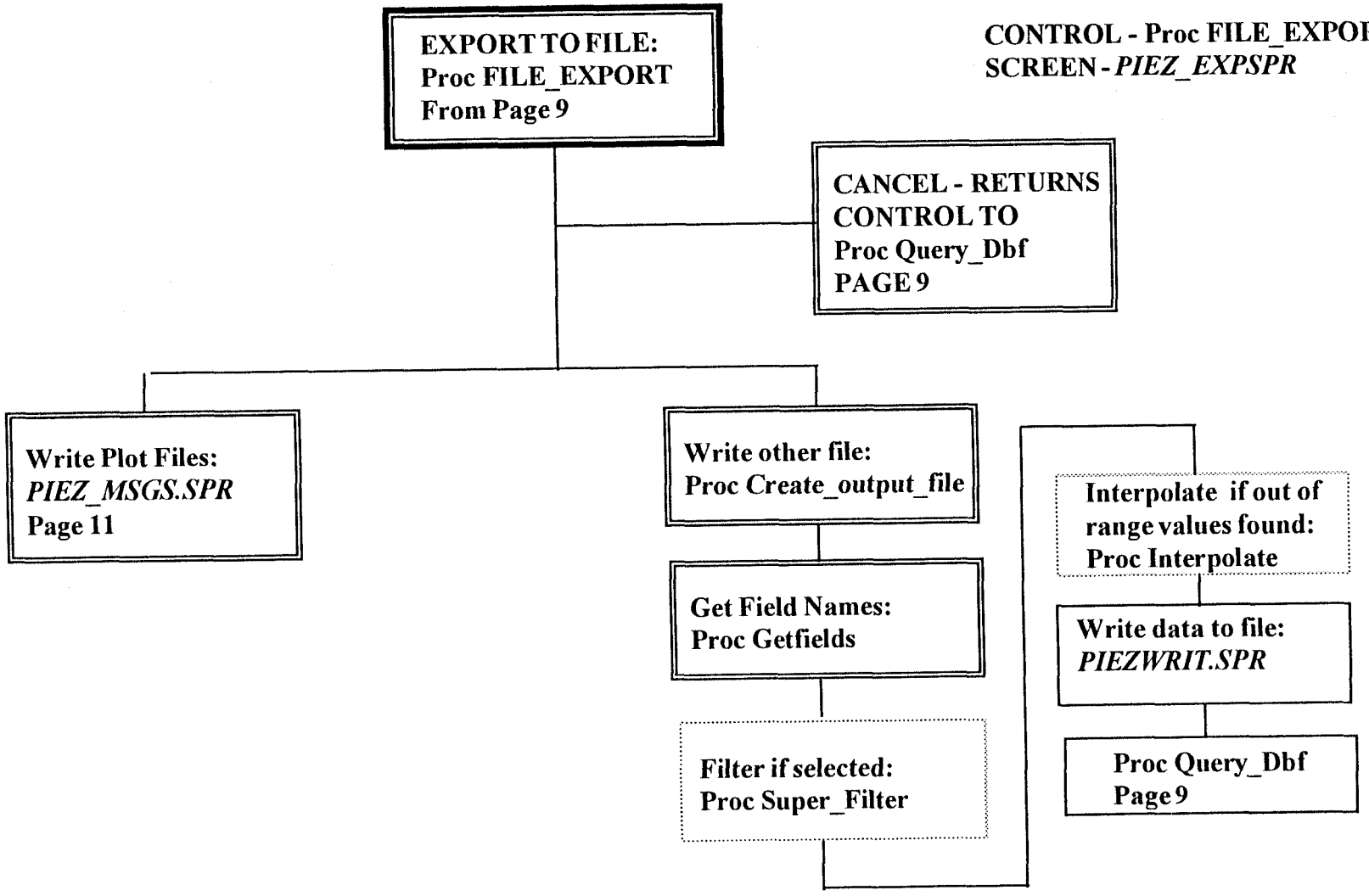
SWMS DATA FLOW



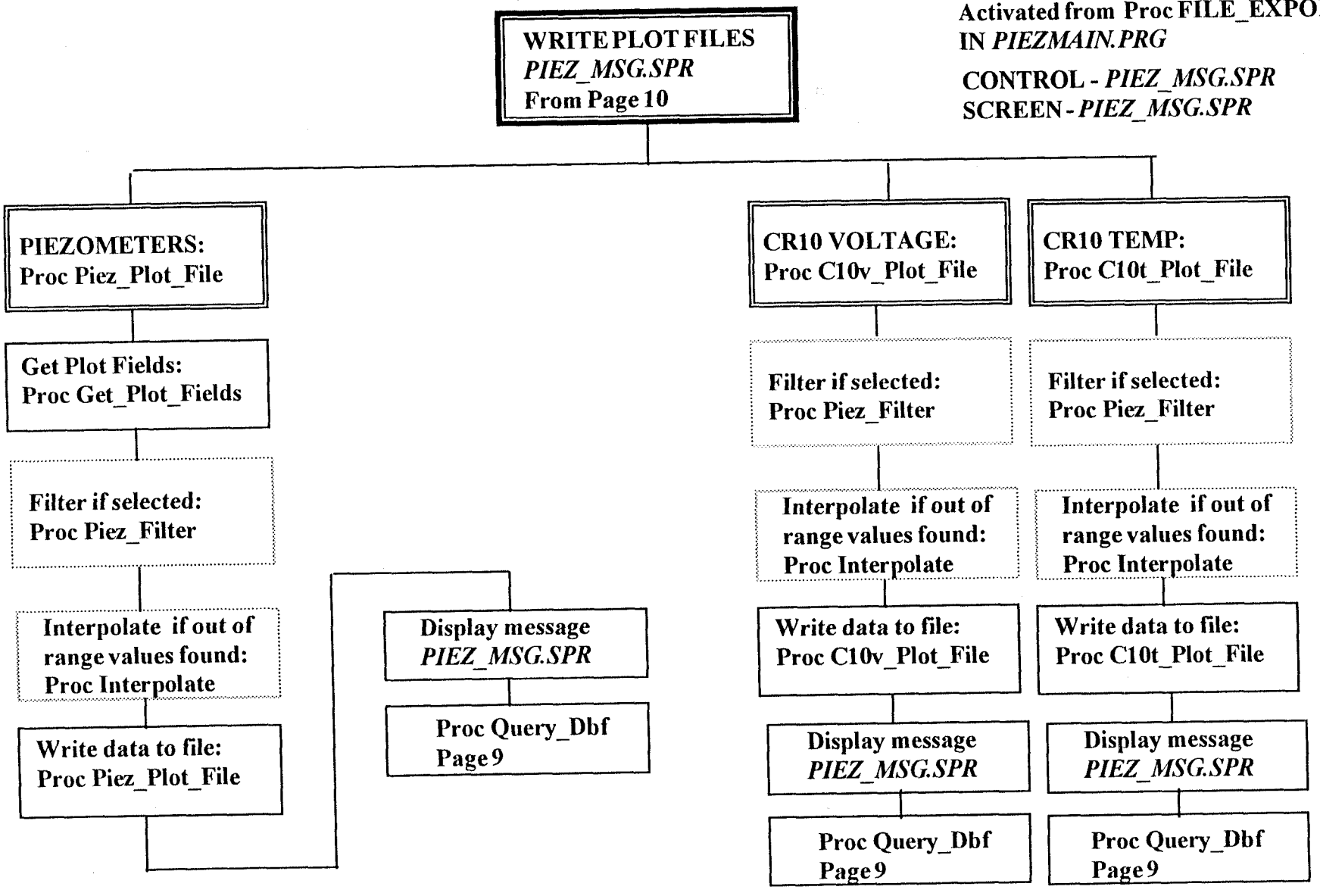
SWMS DATA FLOW

Activated from Proc QUERY_DBF
IN *PIEZMAIN.PRG*

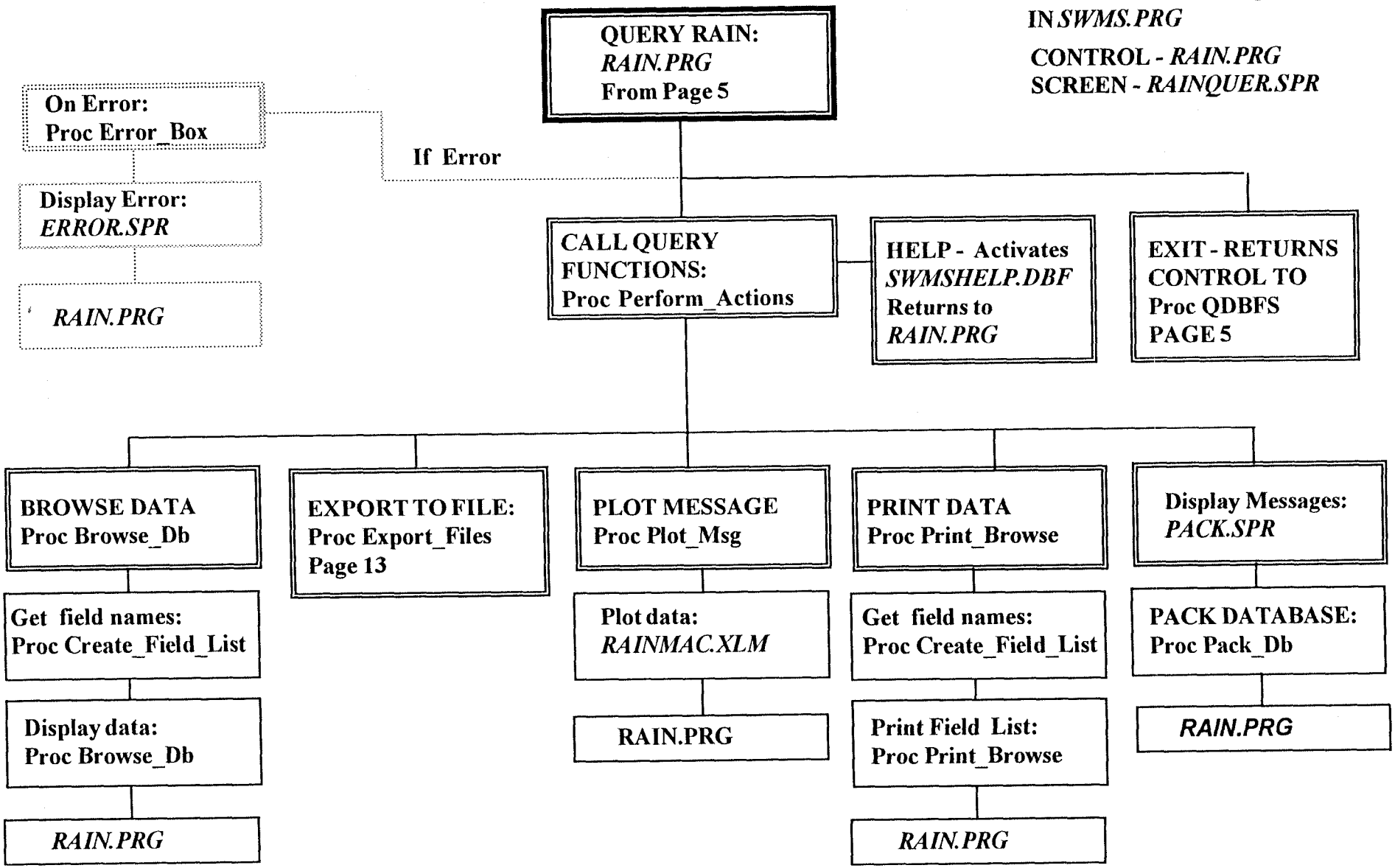
CONTROL - Proc FILE_EXPORT
SCREEN - *PIEZ_EXPSPR*



SWMS DATA FLOW



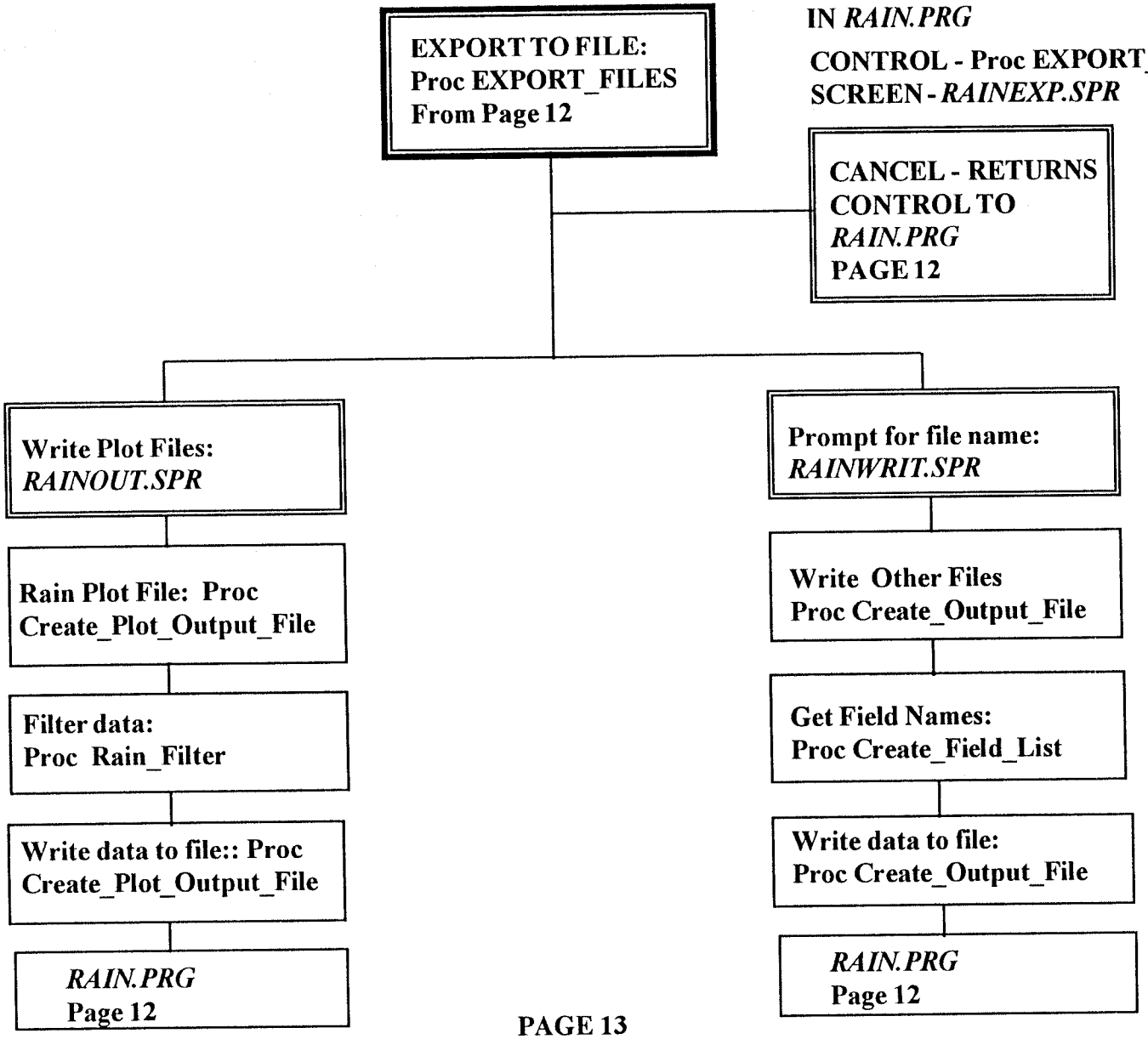
SWMS DATA FLOW



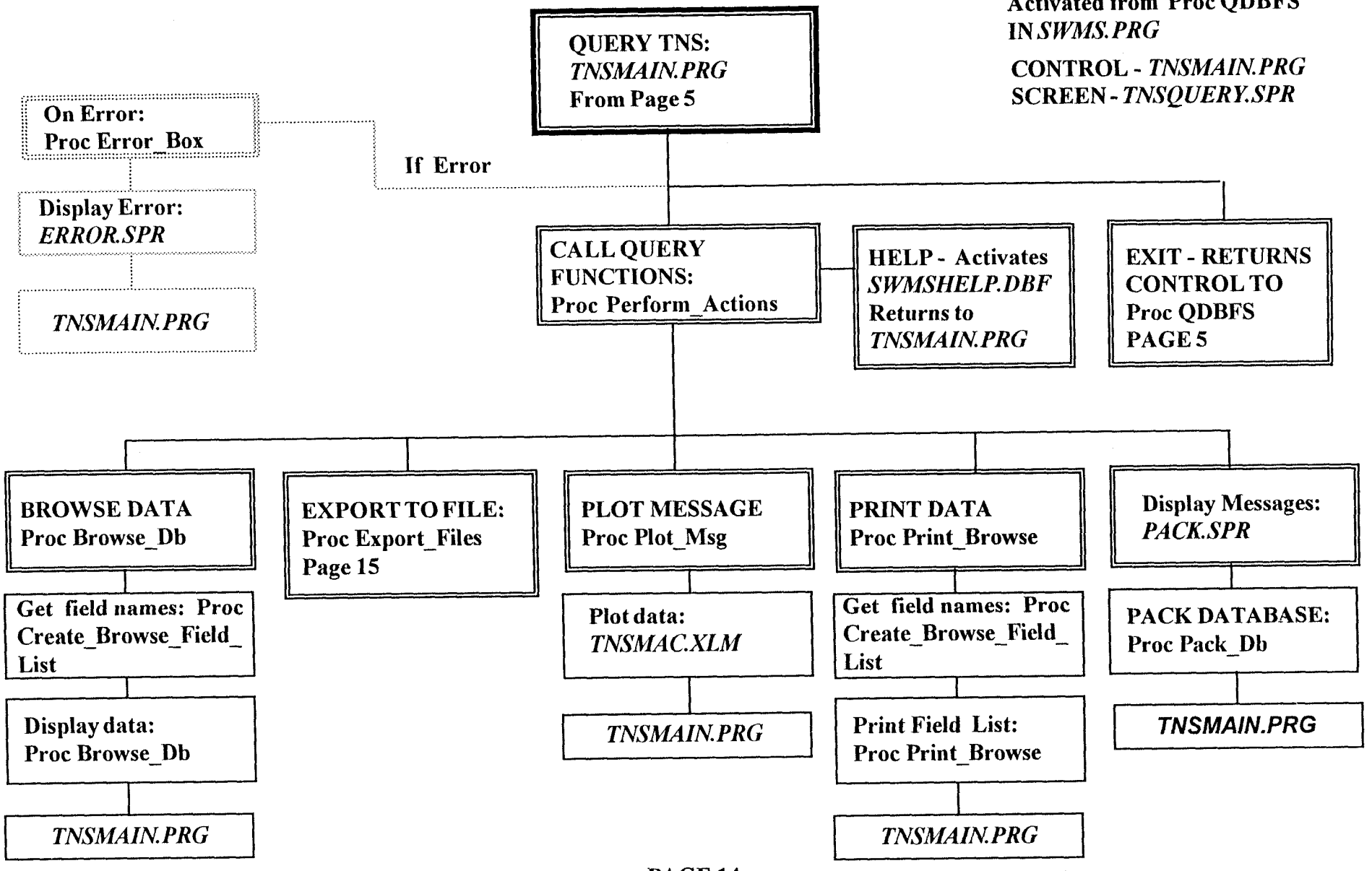
SWMS DATA FLOW

Activated from Proc PERFORM_ACTIONS IN *RAIN.PRG*

CONTROL - Proc EXPORT_FILES
SCREEN - *RAINEXP.SPR*



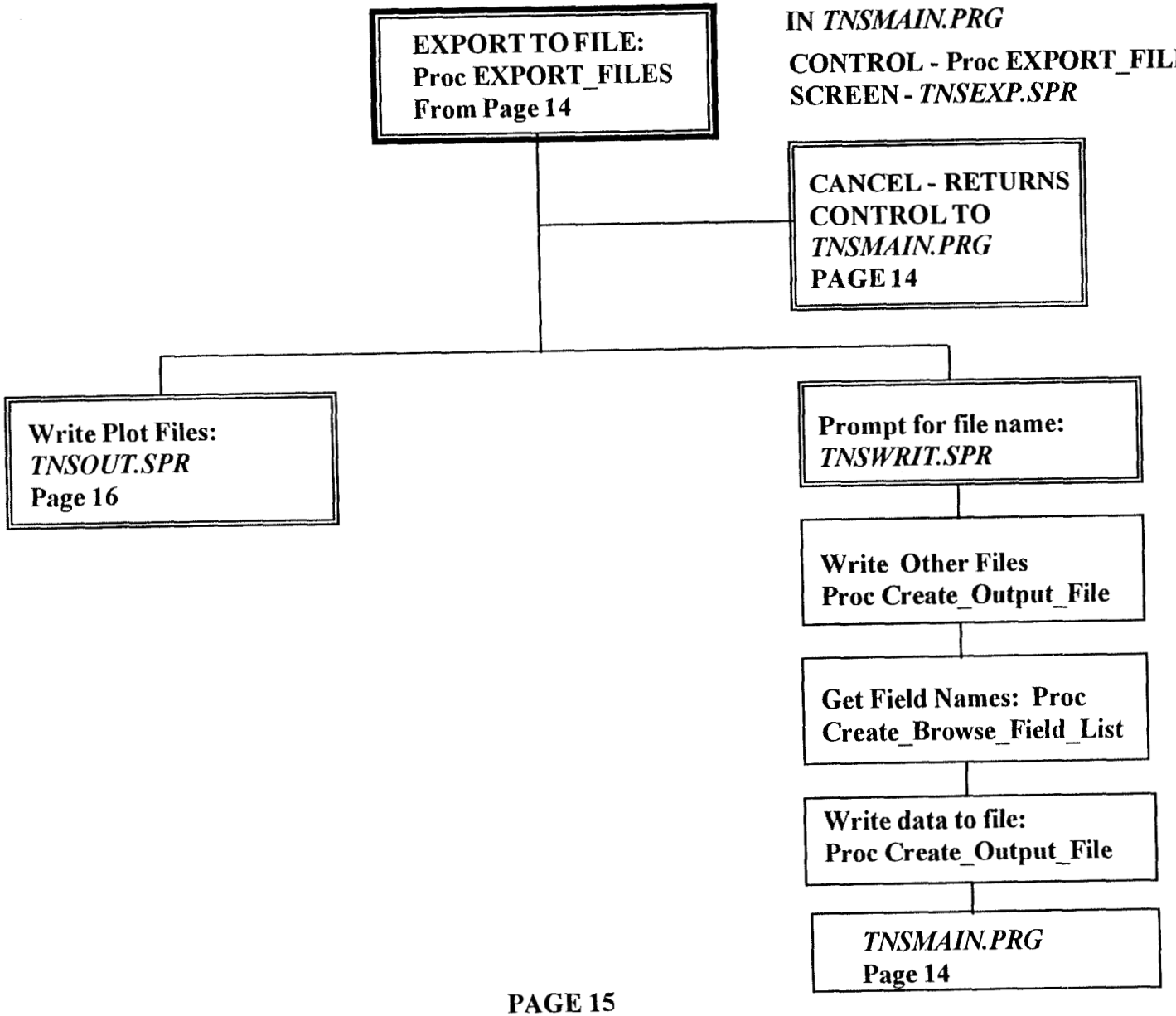
SWMS DATA FLOW



SWMS DATA FLOW

Activated from Proc PERFORM_ACTIONS IN *TNSMAIN.PRG*

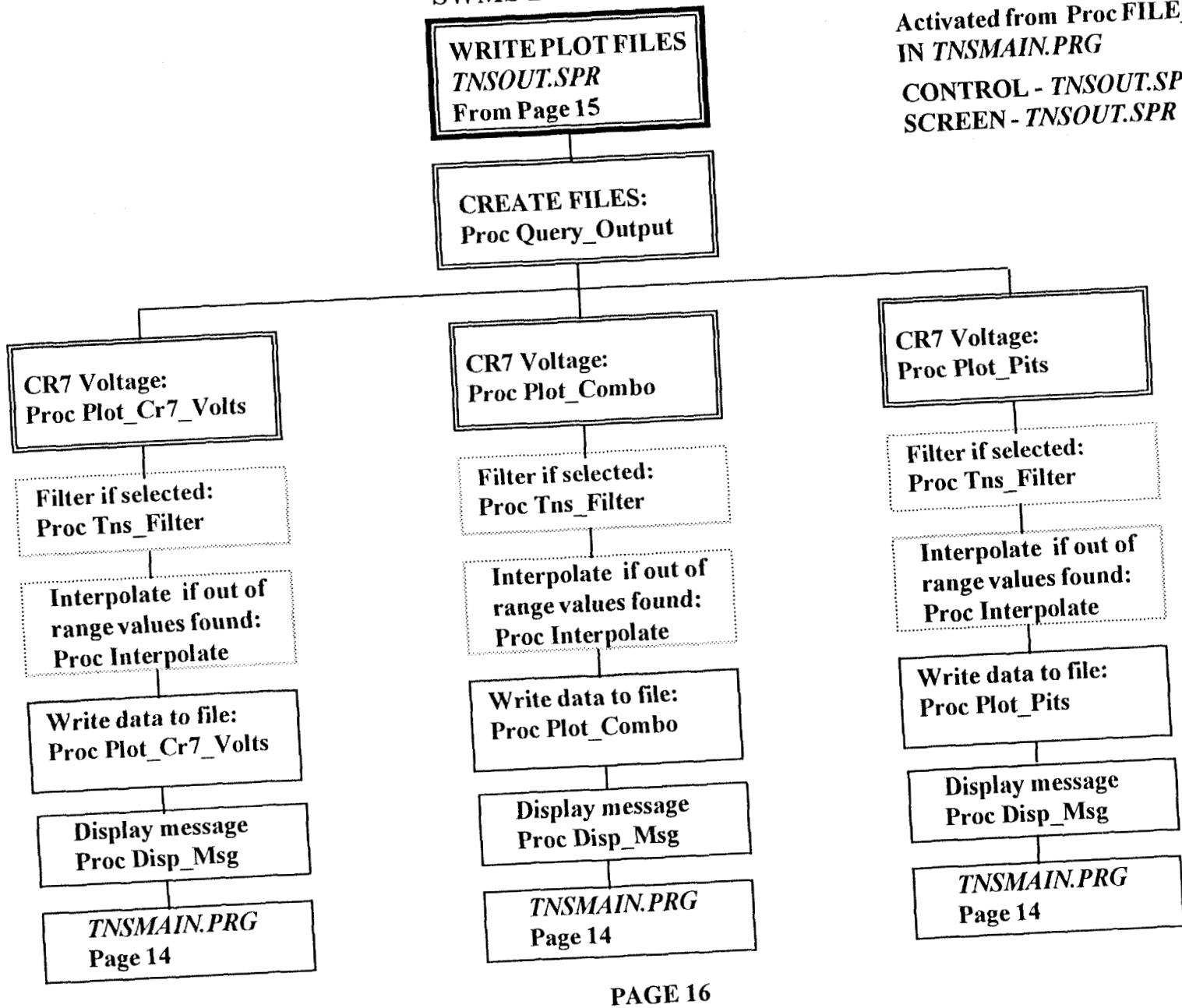
CONTROL - Proc EXPORT_FILES
SCREEN - *TNSEXP.SPR*



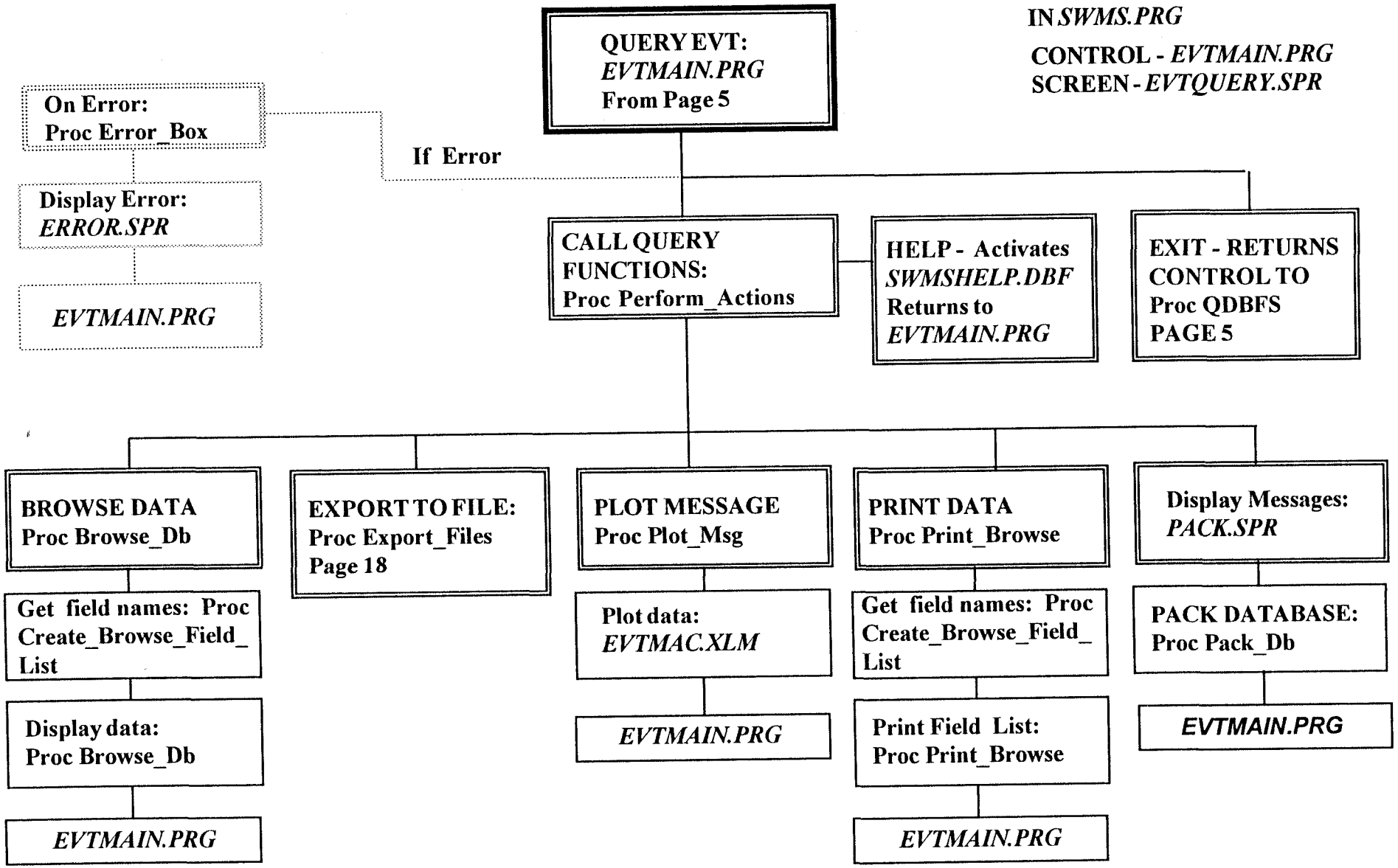
SWMS DATA FLOW

Activated from Proc FILE_EXPORT
IN *TNSMAIN.PRG*

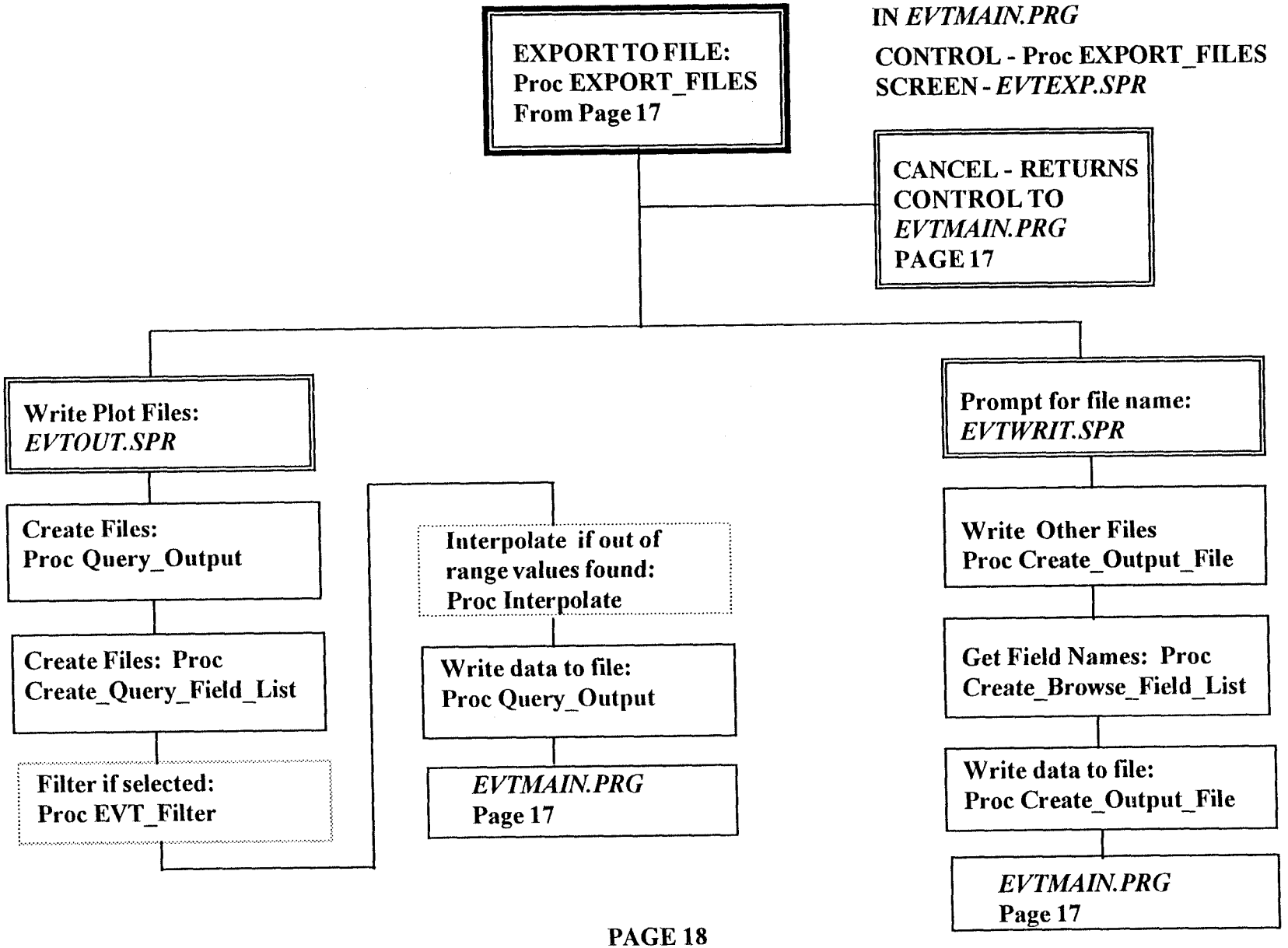
CONTROL - *TNSOUT.SPR*
SCREEN - *TNSOUT.SPR*



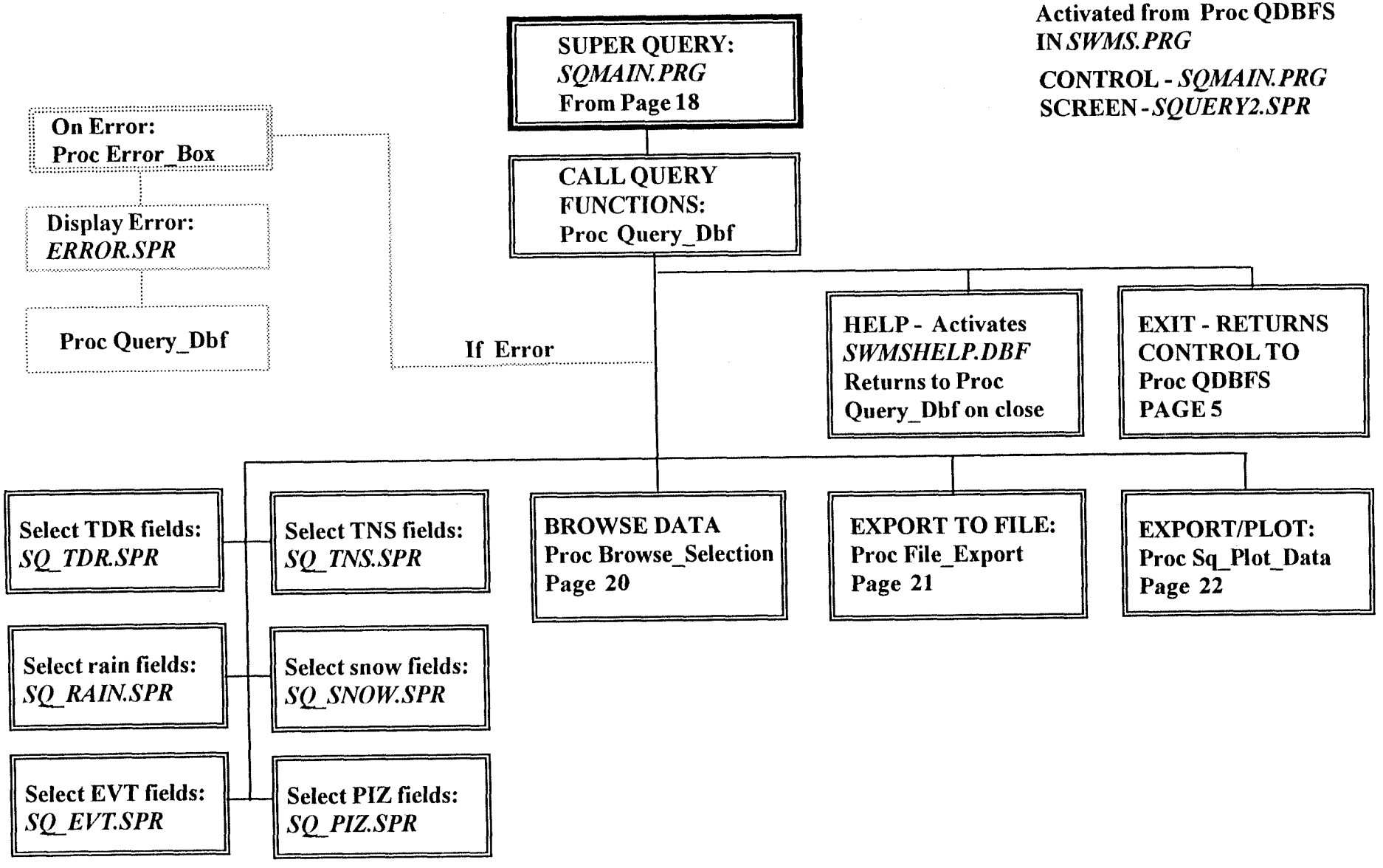
SWMS DATA FLOW



SWMS DATA FLOW



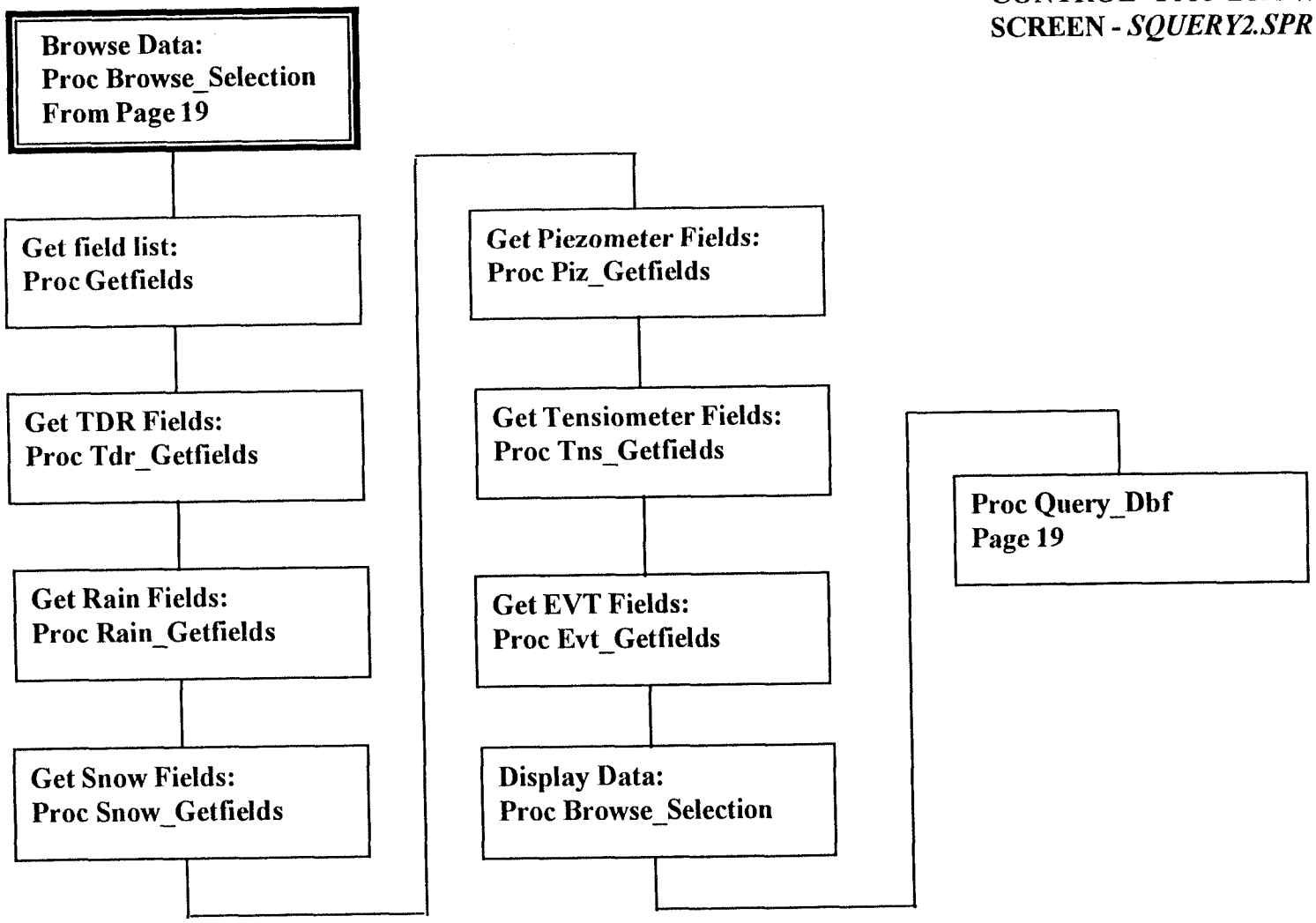
SWMS DATA FLOW



SWMS DATA FLOW

Activated from Proc QUERY_DBF
IN *SQMAIN.PRG*

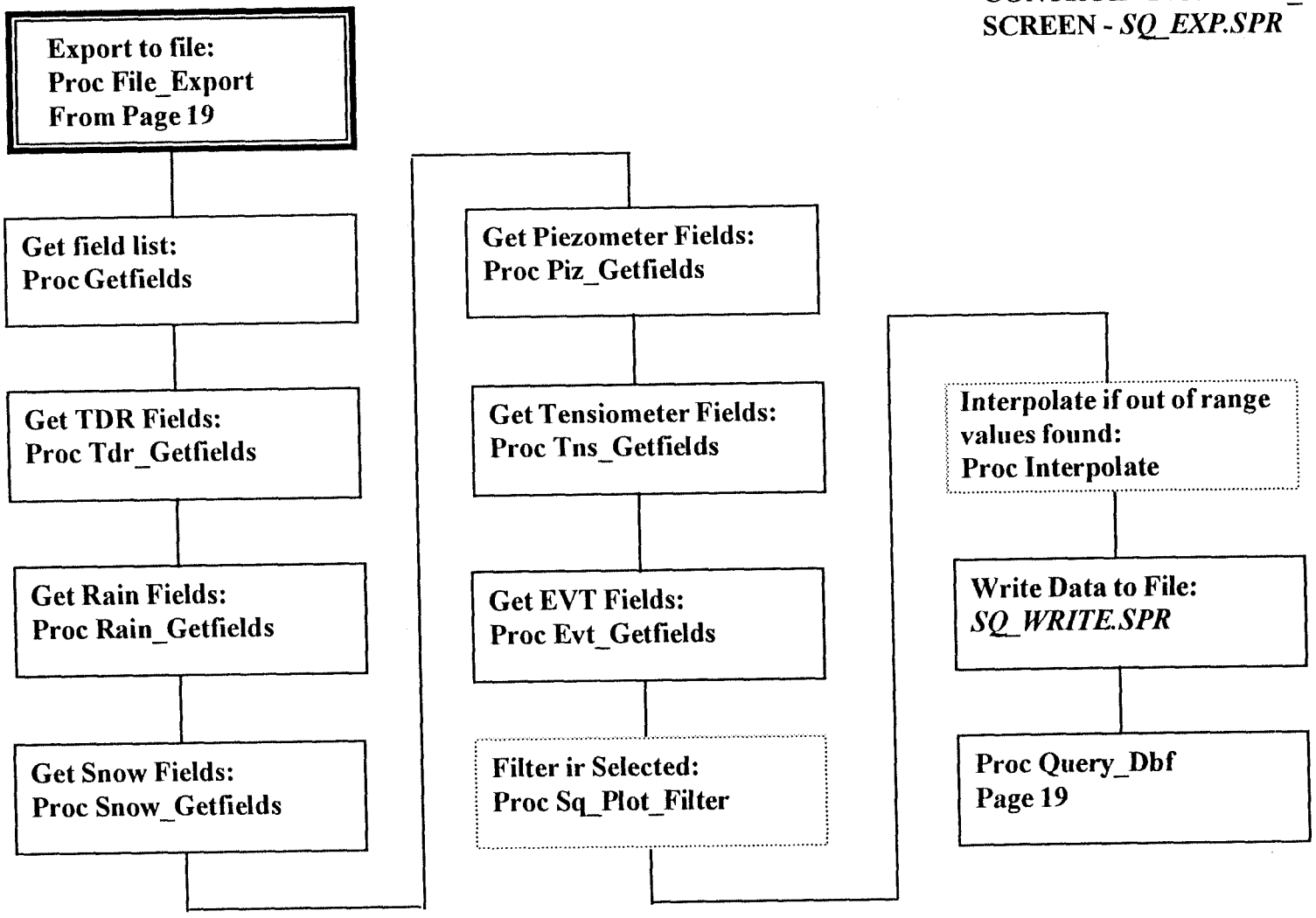
CONTROL - Proc BROWSE_SELECTION
SCREEN - *SQUERY2.SPR*



SWMS DATA FLOW

Activated from Proc QUERY_DBF
IN *SQMAIN.PRG*

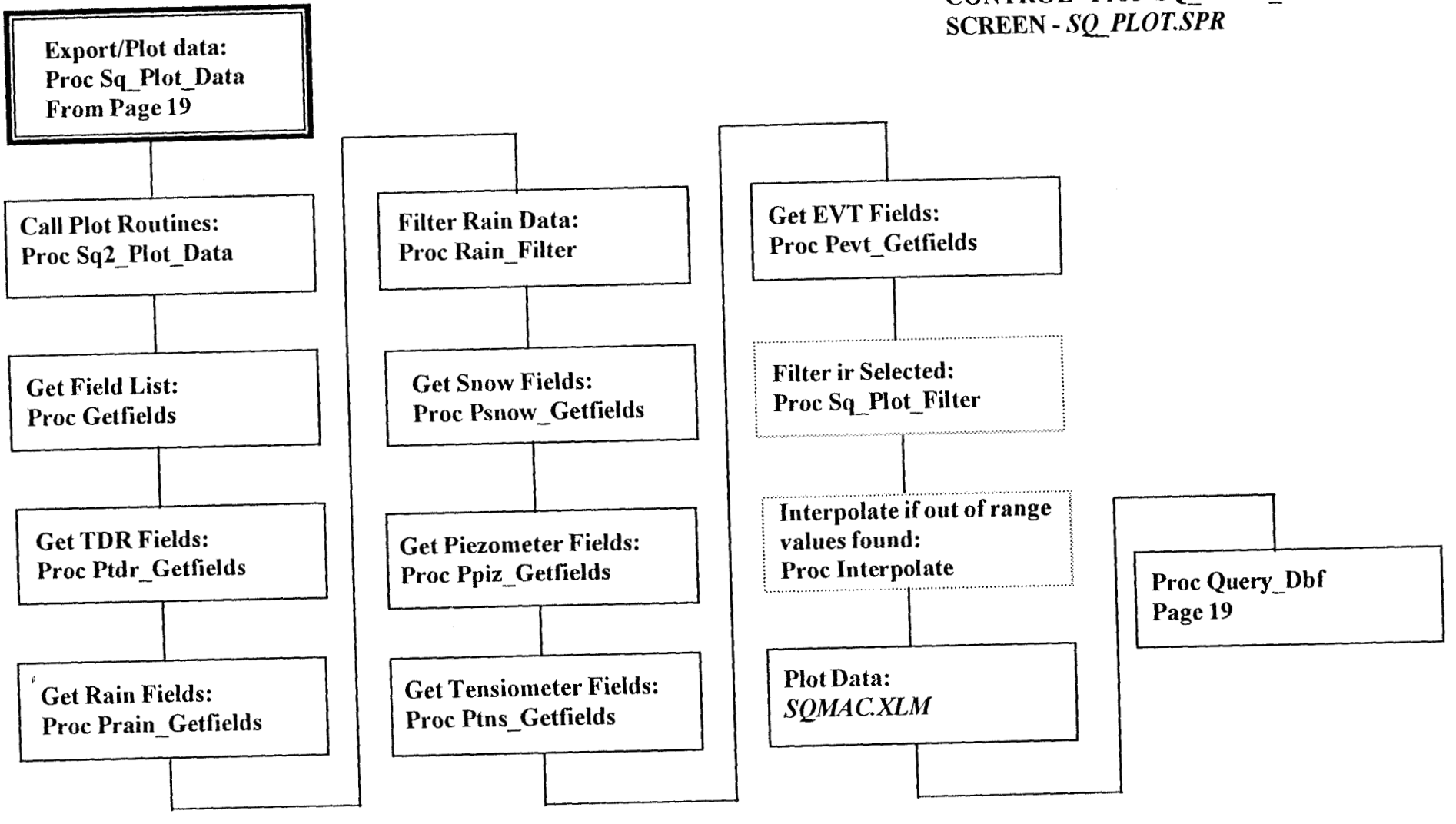
CONTROL - Proc FILE_EXPORT
SCREEN - *SQ_EXP.SPR*



SWMS DATA FLOW

Activated from Proc QUERY_DBF
IN *SQMAIN.PRG*

CONTROL - Proc SQ_PLOT_DATA
SCREEN - *SQ_PLOT.SPR*



Component: EVT

The Evapotranspiration query screen allows the user to select data from the lysimeters, the evaporation pan and the EVT TDRs.

Selecting fields: Either Julianday or Decimal Day/Time may be selected but not both. If the Temperature, TDR, or Load Cells are selected you will also need to select one or both Lysimeters. All other fields may be selected independently. The [CLEAR] button will clear all selections allowing the user to start with a clean selection area.

Setting time: Either use the spinners are select the field and manually edit the time parameters.

[BROWSE ALL] - Allows user to browse all fields in the two EVT databases over the selected time interval.

[BROWSE SELECTION] - Allows the user to browse selected fields over the selected time interval.

[EXPORT TO FILE] - The user may export to an Excel file for plotting, an Excel file with all selected fields, a text file, or a Lotus 123 file.

Plot files: An individual file will be written for each item selected with the exception of temperatures, TDRs, and Load Cells. Here the selected probes are written to the same file so they can be plotted on the same graph.

Other files: The user will be prompted for a file name. All selected fields will then be written to that file. If filtering of data is requested the Decimal Day/Time must also be selected to allow for interpolation of out of range values.

[PLOT DATA] - Excel will be evoked to plot data. The user will then select the graphs he would like to see. To print the graphs either select print on the first screen or select print on the top corner of the graphs. The second option allows you to view the graphs first and print only the graphs you want.

[PRINT SELECTION] - Allows the user to print selected fields over the selected time interval. User should limit the number of fields and records printed. User will be prompted for printer setup options so landscape may be chosen to allow more fields to fit across the page.

[DAILY EVAP REPORT] - Prints a daily evaporation report giving the Daily Evaporation, Average,Maximum, and Minimum Air and Water Temperatures, Average Velocity, and Average Humidity for each day in the selected range. The report also gives a summary of the values over the selected range. The report can be either previewed on the screen or sent to the printer.

[PACK DATABASE] - Checks for duplicate records and packs the database to get rid of the duplicates that may be caused by multiple appends of CR10 files.

[HELP] - On-line help for SWMS system. To view other help topics select the [TOPIC] button on the Help

screen.

[EXIT] - Exits to previous menu.

PIEZOMETER

Component: Piezometer

The Piezometer query screen allows the user to select data from the piezometer wells.

Selecting fields: Either Julianday or Decimal Day/Time may be selected but not both. Any/All other fields may then be selected. The [CLEAR] button will clear all selections allowing the user to start with a clean selection area.

Setting time: Either use the spinners are select the field and manually edit the time parameters.

[BROWSE SELECTION] - Allows the user to browse selected fields over the selected time interval.

[BROWSE ALL] - Allows user to browse all fields in the piezometer database over the selected time interval.

[EXPORT TO FILE] - The user may export to an Excel file for plotting, an Excel file with all selected fields, a text file, or a Lotus 123 file.

Plot files: Individual file will be written for CR10 Voltage and Temperature if they are selected. All selected piezometers are written to the same file so they can be plotted on the same graph.

Other files: The user will be prompted for a file name. All selected fields will then be written to that file. If filtering of data is requested the Decimal Day/Time must also be selected to allow for interpolation of out of range values.

[PLOT DATA] - Excel will be evoked to plot data. The user will then select the graphs he would like to see. To print the graphs either select print on the first screen or select print on the top corner of the graphs. The second option allows you to view the graphs first and print only the graphs you want.

[PRINT] - Allows the user to print selected fields over the selected time interval. User should limit the number of fields and records printed. User will be prompted for printer setup options so landscape may be chosen to allow more fields to fit across the page.

[PACK DATABASE] - Checks for duplicate records and packs the database to get rid of the duplicates that may be caused by multiple appends of CR10 files.

[HELP] - On-line help for SWMS system. To view other help topics select the [TOPIC] button on the Help screen.

[EXIT] - Exits to previous menu.

RAIN

Component: RAIN

The Rain query screen allows the user to select data from the rain database.

Selecting fields: Either Julianday or Decimal Day/Time may be selected but not both. Any/All other fields may then be selected.
Setting time: Either use the spinners are select the field and manually edit the time parameters.

[BROWSE SELECTION] - Allows the user to browse selected fields over the selected time interval.

[BROWSE ALL] - Not available because rain has only one significant field.

[EXPORT TO FILE] - The user may export to an Excel file for plotting, an Excel file with all selected fields, a text file, or a Lotus 123 file.

Plot files: One individual file is created. Filtering of rain data is different in that record with 0 in the raingauge field is added 10 minutes before and 10 minutes after each rain event.

Other files: The user will be prompted for a file name. All selected fields will then be written to that file. If filtering of data is requested the Decimal Day/Time must also be selected to allow for interpolation of out of range values.

[PLOT DATA] - Excel will be evoked to plot the rain data. To print the graph select print on the top corner of the graph.

[PRINT] - Allows the user to print selected fields over the selected time interval.

[PACK DATABASE] - Checks for duplicate records and packs the database to get rid of the duplicates that may be caused by multiple appends of CR10 files.

[HELP] - On-line help for SWMS system. To view other help topics select the [TOPIC] button on the Help screen.

[EXIT] - Exits to previous menu.

SNOW

Component: SNOW

To be written by Jim Moffett

SUPER QUERY

Component: Super Query

The Super Query option allows users to query any of the SWMS databases and create their own database, spreadsheet , or text file. Unlike in other components the Export to file and Plot options work independently. The Plot option creates the file for you based on screen selections.

This option does however have several limitations.

For the browse and export file function the number of items you select is limited based on the length of allowable Foxpro commands. Data is not filtered. Any missing data points are replaced by 3333 for export if no filtering is requested.

Selecting fields: Use the radio button to select either Julianday or Decimal Day/Time. Then check the component from which you want to select fields. A screen will come up with the fields for that component. You need to fully qualify field selections, i.e. if you select a TDR probe or temperature probe you may also need to select the Pit, cluster, etc. to tell the program which TDR probe or Temperature probe you're talking about. After all selections are made for a component use the [OK] button to return to the main menu. From there you can select other components or browse, export, or plot items with your current selection. To change selections for a component deselect the component and reselect it. This will return you to the selection screen for that component so you may make any changes. The [CLEAR] button will clear all selections allowing the you to start with a clean selection area.

Setting time: Either use the spinners are select the field and manually edit the time parameters.

[BROWSE SELECTION] - Allows the user to browse selected fields over the selected time interval.

[EXPORT TO FILE] - The user may export to DBF file, an Excel file, a text file, or a Lotus 123 file. The user will be prompted for a file name. All selected fields will then be written to that file. If filtering of data is requested the Decimal Day/Time must also be selected to allow for interpolation of out of range values.

[EXPORT/PLOT DATA] - To plot super query data only two items may be selected. For example:

Item 1 - TDRs from Pit 1, Cluster 1
Item 2 - Tensiometers from Pit 1, Clusterl.

If less than two are selected an error message will occur. If more than two are selected a warning will be

displayed and only the first two will be plotted. Data is written to an Excel file for plotting. Excel is then evoked to plot the data. To print the graph select print on the top corner of the graph.

[HELP] - On-line help for SWMS system. To view other help topics select the [TOPIC] button on the Help screen.

[EXIT] - Exits to previous menu.

SWMS Main SWMS Help Screen.

The sequence that should be followed to receive, store and plot data is:

1. Read the data from the field controller (CR10,CR7,etc.);
2. Import the data into the appropriate data base;
3. Identify and extract the data that needs to be plotted based on the Julian Day and Year;
4. Plot the data.

Step 1 is accomplished by clicking on the CALL STATIONS picture button. Select the required Station and click on the OK button. When prompted for a parameter enter the output file name in the form MMDDYYa,b,c,... using (a) on the first download, (b) on the second, etc. The CR10 is called via the RF modem and instructed to send any data acquired since the last data transfer.

Step 2 is accomplished by clicking on the IMPORT DATA picture button. Select the required data type and click on the OK button. You will be prompted for a filename. Use the same file you downloaded in step 1. The number of records added to the database will be listed after the file has been read.

Step 3 is accomplished by clicking on the QUERY DATABASES picture button. Then click on the button for the database you want to query. Select the pits and data you wish to export data for. Set the time interval you want to select data from. Then click on the IMPORT data button. Select Excel File for plotting and Click on the OK button. This will write the data to an Excel file which will be used by the plotting macro.

Plotting (step 4) is accomplished by selecting the PLOT DATA button on the query screen. An Excel macro is executed automatically that displays a PLOT MENU on the screen. Check the boxes of the data you want to see plotted. (Make sure you extracted the same data from the database in step 3 so you don't get a plot of old data).

The browse button on the query screen can be used to view selected data fields over selected time from the database records in the data base. The pack button should be used if an append was done more than once to eliminate any duplicate records.

See also: Super Query, Users Guide

TDR

Component: TDR

The TDR query screen allows the user to select data from the Soil measurement/TDR database.

Selecting fields: Either Julianday or Decimal Day/Time may be selected but not both. CR10 Voltage and Temperature may be selected individually. If Clusters, Load Cells, or Temperatures are selected you will also need to select one or more Pits. The All Fields check box will cause all fields to be selected. The [CLEAR] button will clear all selections allowing the user to start with a clean selection area.

Setting time: Either use the spinners are select the field and manually edit the time parameters.

[BROWSE ALL] - *Not available for TDRs. Select the* All Fields check box and use [BROWSE SELECTION].

[BROWSE SELECTION] - Allows the user to browse selected fields over the selected time interval.

[EXPORT TO FILE] - The user may export to an Excel file for plotting, an Excel file with all selected fields, a text file, or a Lotus 123 file.

Plot files: An individual file will be written for each item selected.

Other files: The user will be prompted for a file name. All selected fields will then be written to that file. If filtering of data is requested the Decimal Day/Time must also be selected to allow for interpolation of out of range values.

[PLOT DATA] - Excel will be evoked to plot data. The user will then select the graphs he would like to see. To print the graphs either select print on the first screen or select print on the top corner of the graphs. The second option allows you to view the graphs first and print only the graphs you want.

[PRINT] - Allows the user to print selected fields over the selected time interval. User should limit the number of fields and records printed. User will be prompted for printer setup options so landscape may be chosen to allow more fields to fit across the page.

[PACK DATABASE] - Checks for duplicate records and packs the database to get rid of the duplicates that may be caused by multiple appends of CR10 files.

[HELP] - On-line help for SWMS system. To view other help topics select the [TOPIC] button on the Help screen.

[EXIT] - Exits to previous menu.

TNS

Component: TNS

The tensiometer query screen allows the user to select and graph data from the tensiometers.

Selecting fields: Either Julianday or Decimal Day/Time may be selected but not both. CR7 Voltage may be selected by itself. All pits requires the Voltages and/or Refilling Tank Levels next to the all pit check box to be selected. This option will allow you to plot all Voltages and/or Refilling Tank Levels on the same plot. The other Voltage, Temperatures, the other Refilling Tank Levels, Matric Potential, and Water Level requires you to select one or more Pits. In addition you will need to select one or more clusters if Matric Potential and/or water Level is selected. The [CLEAR] button will clear all selections allowing the user to start with a clean selection area.

Setting time: Either use the spinners are select the field and manually edit the time parameters.

[BROWSE ALL] - Not available for Tensiometers because the number of fields exceeds the Foxpro limits.

[BROWSE SELECTION] - Allows the user to browse selected fields over the selected time interval. You may have limit selections because of the Foxpro limits.

[EXPORT TO FILE] - The user may export to an Excel file for plotting, an Excel file with all selected fields, a text file, or a Lotus 123 file.

Plot files: An individual file will be written for each item selected.

Other files: The user will be prompted for a file name. All selected fields will then be written to that file. If filtering of data is requested the Decimal Day/Time must also be selected to allow for interpolation of out of range values.

[PLOT DATA] - Excel will be evoked to plot data. The user will then select the graphs he would like to see. To print the graphs either select print on the first screen or select print on the top corner of the graphs. The second option allows you to view the graphs first and print only the graphs you want.

[PRINT] - Allows the user to print selected fields over the selected time interval. User should limit the number of fields and records printed. User will be prompted for printer setup options so landscape may be chosen to allow more fields to fit across the page.

[PACK DATABASE] - Checks for duplicate records and packs the database to get rid of the duplicates that may be caused by multiple appends of CR7 files.

[HELP] - On-line help for SWMS system. To view other help topics select the [TOPIC] button on the Help screen.

[EXIT] - Exits to previous menu.

USERS GUIDE

Soil Water Monitoring System Overview

The Soil Water Monitoring System(SWMS) graphic user interface system has been implemented so that it uses the standard software available at Rocky Flats. These standard software packages: Microsoft Foxpro, Ver. 2.6; Microsoft Excel, Ver 4.0 (later versions do not work); Campbell Scientific PC208, Item 7040, Ver. 6306-06; PKZIP, PKUNZIP Ver. 1.1 or later; and Windows Ver. 3.0 or later.

The SWMS system provides the mechanism to download data from the field, manage the data in a database and allow the user to access the data for browsing, graphing and printing. All these functions are provided by a series of simple screen dialogs consisting of check boxes and push buttons.

The Campbell Scientific PC208 software provides the communication between the PC and the field radio modem. Data files are downloaded by the PC208 TERM and TELCOM programs to the PC in a flat file format. The flat data files are appended to databases stored on the PC. Foxpro is used to manage the databases and provide the application dialogs to query and extract data from the databases. Data extracted for graphing is output in Microsoft Excel format. Excel macros are used to provide the application dialogs to perform automated graphing. The different software products are connected such that the user does not need to know the details of any of the software used, the dialogs control the commands.

System Components

The SWMS application is mainly controlled through Foxpro screen dialogs. After the user launches the SWMS application, a Foxpro screen is displayed which contains picture buttons for the various functions of the system:

Call Station - this function uses the PC208 software to download a data file from the field modem to the PC. The control of the PC208 program is done through the Foxpro dialog and a DOS batch file, so the user does not need to know the details or commands for PC208.

Import Data - This function uploads data files into the appropriate component database.

Backup System - This function stores a copy of the SWMS data to the external Bernoulli hard drive.

Query System - This function displays the query screen for any of the component databases, which allow access

to the data for browsing, graphing and printing. The query function dialog is controlled by Foxpro. However, the plotting function is performed by Excel. Excel macros are called from Foxpro to display the plotting dialogs.

Procedure Logic

Call Station Procedure - The call station procedure uses a series of DOS batch files to call the field modem using the TELCOM Campbell Scientific program and download the datafile. There is one set of batch files per component, each component calls its own radio modem station.

Import Data Procedure - The import data screen lists the five components. Selecting a component and selecting the OK button will import the CR10/7 data for that component into the appropriate database file. The individual procedure for each component will first append all records into a temporary database. It will then check to see if the previous download resulted in an incomplete record. (i.e. The download timed out during the middle of a record) If so, the incomplete record will be filled in with data from this download. All complete records are then appended into the final database. If the final record is incomplete it is kept in the temporary database until the next download and appended after the record has been completed.

Backup System Procedure - The system backup screen gives the user the option to backup all files (database, CR10/7, and program), only the database and CR10/7, or only the database files. For backup, the Bernoulli disk should have the same directory structure as the main computer for the SWMS system. The root directory is called SOIL. Its subdirectories are DATABASE, PROGRAMS, BMPS, SCREENS, RAW, TNS, EVT, PIZ, and SNO. The backup procedure calls a DOS batch file BACKUP.BAT to do the actual file with parameters for previous month number as two digits, previous month name, and level of backup requested. The batch file will then do a straight DOS copy of the requested files to the backup Bernoulli disks.

Query System Procedure - All of the functions of the query system procedure are controlled through the components' query screen. These query screens, created in Foxpro application language, allow the user to select various criteria for viewing the components' data. A sequence of data specified by the year, day and time and a specific group of instruments is selected by a number of check boxes on the query screen. The query screen allows the user to browse the numerical data, extract data from the database into output files or remove duplicates from the database. A help function is also available to provide information on the component.

The action functions are controlled by a code snippet, which in turn calls a procedure in the main program (.prg) file to perform an action based on the button pressed. The browse function is performed by issuing a select statement and requesting the database fields the user selected from the query screen. The select statement places the output of the query in a query window. Code has been added to display a 'Done' button at the bottom of the query screen.

The export files function is performed by issuing another select statement. This time fields are categorized

and a small list of fields is selected from the database and the output from the query placed in an output data file. This process is repeated until all the categories of output data the user selected have been output in individual data files. During the file creation an output dialog screen is displayed and information messages are displayed as the files are created.

The print function performs yet another query of the database and routes the output from the query directly to the printer. The plot data command simply calls the excel plotting macro which opens the extracted data files and charts the data. The pack database command removes duplicate records from the database if they exist.

The Super Query procedure is a special cross component query tool. The user may select from any of the components. Any number of fields up to the system limitation (about 100 fields) may be selected from any/all of the components and output to the screen or an Excel, Text, or Lotus file. Another option lets the user plot any two items from one or two components. (i.e. TDR probes, from one pit and cluster and TDR probes from a different pit and cluster or TDR probes from a pit and cluster and tensiometers from a pit and cluster)

Software Components

Component Naming Conventions - Each component has a abbreviation which is used as part of the file naming convention. The abbreviations are:

Evapotranspiration - EVT
Piezometers - PIZ
Rain - RAIN
Snow - SNO
TDRs - TDR
Tensiometers - TNS
Super Query - SQ

PC208 Files and Data Files - The c:\pc208 directory contains all the files required for the communication between the field modem and the PC to download the raw data files for the individual components. The various file types are described by their file extensions as follows:

read*.pif - the pif file is the top level program run from the Foxpro application. The pif file is a description of how to call a DOS batch file from the windows environment. A parameter dialog box is displayed and the name of the data file is entered by the user. The pif file calls the c:\pc208\read*.bat and displays its execution in a window.

read*.bat - This DOS batch file displays some messages to the user and calls c:\stdprogs\gocr10*.bat with the parameters the user entered. The gocr10*.bat file contains a letter describing the component:

```
<blank> - TDR
t       - TNS
s       - SNO
e       - EVT
p       - PIZ
```

gocr10*.bat - This DOS batch file uses the telcom program to connect to a field radio. The field radio to call is defined by the *.stn file.

*.stn - For each component there is a station file. This file contains the characteristics of the station to call. To edit the station file enter telcom. At the telcom 'enter script:' prompt enter: tens/e, to edit the tens.stn station file.

*.err - This file contains all the error and warning messages that were encountered in all the station calls. Messages are appended to this file and the date is logged.

*.cqr - the telcom communication quality report file. This file contains all the numeric values that are returned after the data transmission. These values are the values entered in the log book by hand.

*.dlc - this is the datalogger program code

*.dld - this is the compiled datalogger code

By convention, the data file downloaded has the date as its name. If there are multiple data files for a component for a given day, a letter (a,b,c,d...) follows the date in the name. The file extension for each of the components data is also unique. The extension are:

```
EVT  - .evt
PIZ  - .piz
RAIN - .raw
SNO  - .sno
TDR  - .raw
TNS  - .tns
```

When the data files are first downloaded from the field modem, they are placed in the c:\PC208 directory, in the *.dat file. This data file is copied to a file in the subdirectory of c:\soil named for the component. i.e. c:\soil\raw contains all the TDR flat files downloaded from the field. c:\soil\tns contains all the TNS flat files.

Data within data files are identified by unique array numbers. The following array numbers have been used:

	#	Start	End
TDR:	151	1992-304 -	1993- 26
	166	1993- 26 -	1993- 41

	251	1993- 41 - 1993-179	
	287	1993-179 - 1993-179	
	251	1993-179 - 1993-180	
	287	1993-180 - 1993-188	
	289	1993-188 - 1993-189	
	293	1993-189 - 1993-190	
	342	1993-190 - 1993-194	
	376	1993-194 - 1993-203	
	457	1993-203 - 1993-218	
	440	1993-218 - 1993-221	
	279	1993-221 - 1993-221	
	440	1993-221 - 1993-222	
	481	1993-222 - 1993-231	
	279	1993-231 - 1993-231	
	481	1993-231 - 1993-305	
	444	1993-305 - Present	
Rain	5	1993- 42 - 1994-194	
	104	1994-194 - 1994-244	
	5	1994-244 - Present	
Snow	114	1993-349 - 1994-121	
	111	1994-121 - 1994-145	
	111,116	1994-145 - Present	Every 12th record uses 111
TNS1	221	All records Pits 1-2	
TNS2	222	All records Pits 3-4	
EVT1	123	All records except TDR	
EVT2	TBD	All records TDR only	124
PIEZ	69	All records	

Foxpro Modules and Files

The Foxpro application is a single executable which is launched from the main windows desktop. The Foxpro application SWMS.APP consists of a multitude of Foxpro programs, screens and databases. This application file is provided for convenience, all of the SWMS components are built into this one application by Foxpro. After any changes in programs or screens are made, recreate the application by opening c:\soil\programs\swms.pjx as a project file and selecting the build button on the following dialog and rebuilding the application. If any of the program modules are not found during the build, use the locate button to hunt through the directory structure to find the requested file.

Naming Conventions for Foxpro Files

The Foxpro program files are located in the c:\soil\programs directory and have the file type *.prg. These files contain almost all of the database application code for a given component in one file *main.prg, where * is the component's abbreviation, i.e. tns, tnsmain.prg. Other small sections of application code can be found as part of the screen definition. These sections, called snippets, are contained within the screen definition and perform only screen functions to set or clear check boxes or call a procedure based on a button action. All procedures called from snippets reside in the *main.prg program code and are documented that they are called by a screen snippet. When changes are made to a program file a backup is created by Foxpro with the name *.bak.

The logic and flow of control within a component's database application program has been standardized. The programs: evtmain.prg, tnsmain.prg and snowmain.prg are very similar, as they were created from the same base code.

The Foxpro screen files are located in the c:\soil\screens directory. The *.scx files are the screen definition files, which are edited to change the screen. The *.spr files are Foxpro code files generated from the *.scx screen definition. The *.spr files should not be edited to modify a screen function, rather edit the *.scx definition by opening the screen file into the point and click screen editor, and regenerate the *.spr file. Other screen files have file extensions *.sct and *.spx. The *.sct file is a memo file associated with the *.scx definition. The *.spx file is the compiled version of the *.spr file. Both the *.spx and *.sct files are only readable by Foxpro and should not be edited.

The Foxpro databases reside as files in c:\soil\database with the file extension *.dbf. The database name for each component contains the 3/4 letter abbreviation followed by 'meas', as in soilmeas.dbf. The TNS and EVT components use two databases each, and are named *meas1.dbf and *meas2.dbf. The structure of the fields contained in each database can be viewed by opening the *.dbf file and using the setup function under the database pulldown. Another file associated with the database is the *.cdx file. This is the compound index file used for ordering the database by date and time. The index is created by using the setup function under the database pulldown. The resulting index file is managed by Foxpro and should not be edited.

Output Data Files

Data extracted from the database can be output in Excel (*.xls), Lotus 123 (*.wk1) or an ASCII flat file format (*.txt). Files extracted for plotting are in Excel format. The data files are placed in c:\soil when they are extracted. Each individual category of data i.e. Lysimeter 2 load cells or evaporation pan depth, is output in its own Excel file. Each component can output quite a number of different datafiles, each having unique names. Given file name length constraints, the component abbreviation DOES NOT always appear in the datafile names. A complete list of data file names and the data contained in them follows:

TDR Component:

TR#FLUX#.xls - contains the fluxmeter data for a given trench and fluxmeter. Trench(Pit) number can be 1-5, fluxmeter number can be 1-4.

TR#LDCEL.xls - contains the loadcell data per pit. Trench (Pit) number can be 1-5

TR#TEMPS.xls - contains temperature probe data per trench. Trenches 1,3: 4 probes; Trench 2: 6 probes; Trench 4: 8 probes; and Trench 5: 3 probes

Rain Component:

RAIN.xls - contains raingauge data

Piezometer Component:

PIEZ.xls - contains data columns for up to 20 different piezometers

PIEZVOLT - contains battery voltages from CR10

PIEZTEMP - contains temperature from CR10

EVT Component:

LYS##LDC.xls - contains all the selected load cell data for a given lysimeter: up to 3 load cells and 1 load cell total. ## will be either 01 or 02.

LYS##TMP.xls - contains all the selected temperature data for a given lysimeter: up to 7 soil temperature probes and 1 air temperature probe. ## will be either 01 or 02.

LYS##TDR.xls - contains all the selected TDR data for a given lysimeter: up to 8 TDR probes per lysimeter. ## will be either 01 or 02.

EPAN.xls - contains the evaporation pan depth in inches.

EPANTEMP.xls - contains the evaporation pan water and air temperature.

WINDVEL.xls - contains the wind velocity data.

RELHUM.xls - contains the relative humidity data.

EVTBATT.xls - contains the CR10 battery voltage.

EVTCR10.xls - contains the CR10 temperature.

TNS Component:

PIT#VOLT.xls - contains the voltage values per pit. CR7 voltage value may also be included. # can be 1-4.

ALLVOLTS.xls - contains the voltage data for all the pits. This special data file is used for a combination Excel plot showing data for all the pits plotted per pit arranged all on one page.

PIT#TEMP.xls - contains the temperature probe data per pit. Pit 1,2 and 4contain 5 probes, pit 3 contain 7 probes. # can be 1-4.

PIT#FILL.xls - contains the refilling tank water levels for the selected pit. # can be 1-4.

ALLFILLS.xls - contains the refilling tank data for all the pits. This special data file is used for a combination Excel plot showing data for all the pits plotted per pit arranged all on one page.

PIT#MAT#.xls - contains the matric potential data for a given pit and a given cluster. Pit numbers can be 1-4, cluster numbers can be 1-5.

PIT#TEN#.xls - contains the tensiometer water level data for a given pit and a given cluster. Pit numbers can be 1-4, cluster numbers can be 1-5.

SNO Component:

TVEL#.xls - contains tower wind velocity at a specific level. # can be 1,2 or 3.

WINDPRO.xls - contains wind velocities at all levels to create a wind profile.

TVEL.xls - RMY data at level 3.

P#VEL#.xls - contains wind velocities at the pits at a specific level. Pit numbers can be 1,3 or 5 and level values can be 1,2 or 3.

WINDCOM#.xls - contains wind velocity comparison data at a specific level. Levels are 5m or 2m.

TDIR.xls - contains wind direction at the tower.

P#DIR.xls - contains wind direction at a pit. Pit numbers can be 1,3 or 5.

DIRCOM.xls - contains wind direction comparison data.

SHORTIN.xls - contains incoming short wave radiation data.

SHOUTOUT.xls - contains outgoing short wave radiation data.

LONGIN.xls - contains incoming long wave radiation data.

NETRAD.xls - contains the net radiation data.

SHORTS.xls - contains both incoming and outgoing short wave radiation data.

SOLARALL.xls - contains all the solar data.

VOLTS.xls - contains voltage data.

TMELT.xls - contains snowmelt data at the tower.

P#MELT.xls - contains snowmelt data at a pit. Pit numbers can be 1,3,4 or 5.

MELTALL.xls - contains all the snowmelt data.

TSNOW.xls - contains snow depth data at the tower.

P#SNOW.xls - contains snow depth data at a pit. Pit numbers can be 1,3,4 or 5.

SNOWALL.xls - contains all the snow depth data.

TMLTSNO.xls - contains comparison data for snowmelt and snow depth at the tower.

P#MLTSNO.xls - contains comparison data for snowmelt and snow depth at a pit. Pit number can be 1, 3, 4 or 5.

DENSITY1.xls - contains snow density data.

TTEMP#.xls - contains air temperature at a given level at the tower. Level can be 1,2 or 3.

TEMPPRO.xls - contains all air temperature data at the tower for a temperature profile.

TRH#.xls - contains the relative humidity data at a given level at the tower. Level can be 1,2 or 3.

RHPRO.xls - contains all relative humidity data at the tower for an RH profile.

P#TEMP.xls - contains air temperature data at a pit. Pit value can be 1,3 or 5.

P#SOILTP.xls - contains soil temperature at a pit. Pit value can be 1,3 or 5.

P#RAINTP.xls - contains rain temperature at a pit. Pit value can be 1,3 or 5.

P#SNOWTP.xls - contains snow temperature at a pit. Pit value can be 1,3 or 5.

SQ Component:

SQPLOT.xls - contains data from the two items the user has selected to plot.

The user can request the data to be filtered prior to output. Different components have different filters for removing erroneous data points or smoothing noisy data. The year, Julian day and military time are used to create the date in mm/dd/yy format and the decimal day i.e. 185.5 (noon on day 185). Data files can be output containing the converted decimal day field or the original database fields julianday and military time. The users choice for data file type, filtering or to create a file containing all database fields is selected on an output screen prior to file creation.

Help Information

The SWMS system uses the native Foxpro help facility to display the help information in a dialog. The textual information for the SWMS system and the individual components is stored in the help database swmshelp.dbf and as memo fields. When the help button is pressed, the help information for the component is found in the help database and displayed in the help dialog. The help facility allows the user to view any of the other component help information by selecting from a list of component names displayed by the topics button. The user can also view the previous and next components in the list by selecting the previous and next buttons. The actual memo information is stored in swmshelp.fpt and should be kept with the *.dbf file.

Excel Macros

Excel macros are called from the Foxpro database applications to perform automated graphing of the component data. The Excel application consists of dialogs which allow the user to select the data to be graphed. Datafiles which have been previously extracted from the database are opened by the macros and used for plotting.

There is one excel macro file per component to perform the automated graphing. The format of the excel version 4.0 macros is just sequences of commands in the cells of a spreadsheet. Excel 4.0 allows the user to record macros. That is, the mouse is used to perform actions with the spreadsheet, i.e. cutting and pasting, selecting and copying cells; and the macro functions are placed in the spreadsheet cells in the order they were executed. This method was used to originally create the base code for the automated graphing. These recorded macros were expanded and formatted for easier reading. The basic structure of the macro code has been copied across components for consistency.

Many of the programming techniques used are unique to the excel macro language. Procedure calls are similar to goto statements; control just moves to another named cell. These defined names can only be seen when a named cell is selected. The name appears near the formula bar at the top left of the excel screen. Defined names are also used for the names of dialog box definitions in the sheet. Named cells are used to hold the values of the check boxes in the dialogs. Where possible, comments are used as labels to denote the named cells. To find a named cell, use the goto function under the formula menu item in excel.

Naming Conventions for Excel Files

The Excel macros are located in the c:\soil\macros directory and have the file type *.xlm. The names of the macro files closely resemble the component abbreviations followed by 'mac'. All the excel macro files are hidden, so they will not be displayed during execution and cause screen flickering. Before the macros can be edited, they must be unhidden (using the unhide function from the window pulldown in Excel).

Excel Dialogs

The dialog screen definitions for the macros are included in the *.xlm file. The definitions are labeled and consist of just a block of labels and numbers. The DIALOG.BOX() excel function interprets this block of data and displays the dialog screen.

See also: SWMS

```
Select area:  1, Table in Use: C:\SOIL\DATABASE\SOILMEAS.DBF    Alias: SOILMEAS
            Code page:   0
  Structural CDX file:   C:\SOIL\DATABASE\SOILMEAS.CDX
            Index tag:   DATETIME     Collate: Machine    Key: STR(YEAR,4)+STR(JULIANDAY,3)+STR(
MILTIME,4)
       Lock(s): Exclusive USE

Select area:  2, Table in Use: C:\SOIL\DATABASE\RAIN.DBF    Alias: RAIN
            Code page:   0
  Structural CDX file:   C:\SOIL\DATABASE\RAIN.CDX
            Index tag:   DATETIME     Collate: Machine    Key: STR(YEAR,4)+STR(JULIANDAY,3)+STR(
MILTIME,4)
       Lock(s): Exclusive USE

Select area:  3, Table in Use: C:\SOIL\DATABASE\TNSMEAS1.DBF    Alias: TNSMEAS1
            Code page:   0
  Structural CDX file:   C:\SOIL\DATABASE\TNSMEAS1.CDX
            Index tag:   DATETIME     Collate: Machine    Key: STR(YEAR,4)+STR(JULIANDAY,3)+STR(
MILTIME,4)
       Lock(s): Exclusive USE

Select area:  4, Table in Use: C:\SOIL\DATABASE\TNSMEAS2.DBF    Alias: TNSMEAS2
            Code page:   0
  Structural CDX file:   C:\SOIL\DATABASE\TNSMEAS2.CDX
            Index tag:   DATETIME     Collate: Machine    Key: STR(YEAR,4)+STR(JULIANDAY,3)+STR(
MILTIME,4)
       Lock(s): Exclusive USE

Select area:  5, Table in Use: C:\SOIL\DATABASE\EVTMEAS1.DBF    Alias: EVTMEAS1
            Code page:   0
  Structural CDX file:   C:\SOIL\DATABASE\EVTMEAS1.CDX
            Index tag:   DATETIME     Collate: Machine    Key: STR(YEAR,4)+STR(JULIANDAY,3)+STR(
MILTIME,4)
       Lock(s): Exclusive USE

`ect area:  6, Table in Use: C:\SOIL\DATABASE\EVTMEAS2.DBF    Alias: EVTMEAS2
            Code page:   0
  Structural CDX file:   C:\SOIL\DATABASE\EVTMEAS2.CDX
            Index tag:   DATETIME     Collate: Machine    Key: STR(YEAR,4)+STR(JULIANDAY,3)+STR(
MILTIME,4)
       Lock(s): Exclusive USE

Select area:  7, Table in Use: C:\SOIL\DATABASE\SNOW.DBF    Alias: SNOW
            Code page:   0
  Structural CDX file:   C:\SOIL\DATABASE\SNOW.CDX
            Index tag:   DATETIME     Collate: Machine    Key: STR(YEAR,4)+STR(JULIANDAY,3)+STR(
MILTIME,4)
       Lock(s): Exclusive USE

Currently Selected Table:
Select area:  8, Table in Use: C:\SOIL\DATABASE\PIEZMEAS.DBF    Alias: PIEZMEAS
            Code page:   0
  Structural CDX file:   C:\SOIL\DATABASE\PIEZMEAS.CDX
            Index tag:   DATETIME     Collate: Machine    Key: STR(YEAR,4)+STR(JULIANDAY,3)+STR(
MILTIME,4)
       Lock(s): Exclusive USE
```

NOTE: To recreate an index tag open the database and enter in command box.

```
INDEX ON STR(YEAR,4)+STR(JULIANDAY,3)+STR(MILTIME,4) TAG DATETIME
```

FIELD NAME	COMPONENT	DEFINITION
AIR_TEMP	EVT	Air temperature for EVT module.
ARRAYNUM	ALL	Data logger program array identification number
BATTVOLT	EVT	Battery voltage from EVT module
CR10TEMP	TDR	CR10 Temperature from TDR module
CR10VOLT	TDR	CR10 Voltage from TDR module
CR7_VLT	TNS	CR7 Voltage from TNS module
DENSITYx	SNOW	x=1,2 / Calculated density for snow from snow load cells.
EPAN	EVT	Evaporation Pan water depth
EVAPBLANK	EVT	Not yet defined.
E_CR10TEMP	EVT	CR10 Temperature from EVT module
HTPLATEx	SNOW	x=1,2 / Heat Transfer Plate
JULIANDAY	ALL	Julian day data was logged
LDCELLx	SNOW	x=1-6 / Load Cells for Snow module.
LONGIN	SNOW	Incoming longwave
LONGOUT	SNOW	Relected longwave
LYSxxATMP	EVT	xx=01-02 / Lysimeter xx, Atmospheric temperature.
LYSxxBLyy	EVT	xx = 01-02; yy=01-02 / Not used.
LYSxxLDTOT	EVT	xx=01-02 / Lysimeter xx, Load Cell Total
LYSxxLDyy	EVT	xx=01-02; yy=01-03 / Lysimeter xx, Load cell data.
LYSxxTDRyy	EVT	xx=01-02; yy=01-08 / Lysimeter xx,TDR probes
LYSxxTMPyy	EVT	xx=01-02; yy=01-07 / Lysimeter xx, temperatures.
MILTIME	ALL	Time on 24 hr clock that data was logged.
NETRAD	SNOW	Net radiometer
PIEZxx	PIEZ	xx=01-15 Water altitude at Piezometer wells 1-15
PxCLy_TMP	TNS	x=1-4; y=1-5 / Pit x, Tensiometer temperature at cluster y
PxDIR	SNOW	x=1,3,5 / Wind direction at pit x
PxFILLy	TNS	x=1-4; y=1-3 / Not used.
PxIT_LVL	TNS	x=1-4 / Tensiometer refilling tank levels at Pit x
PxMELT	SNOW	x=1,3,4,5 / Number of tips of raingauge for snow melting at Pit x
PxSNOW	SNOW	x=1,3,4,5 / Snow depth at Pit x
PxTEMPATM	SNOW	x=1,3,5 Atmospheric temperature at pit x
PxTEMPRAIN	SNOW	x=3,5 Pit x Temperature of snow melt
PxTEMPy	SNOW	x=1,3,5; y=0-6 / Temperature reading at Pit x
PxTEMP_10	SNOW	x=1,3 Pit x soil temperature at -10 centimeters
PxTEMP_20	SNOW	x=1,3 Pit x soil temperature at -20 centimeters
PxTNyz	TNS	x=1-4, y=1-5, for x=1,2, or 4 z=1-5 else z=1-7 Pit x matric potential at cluster y probe z
PxTNyz_LV	TNS	x=1-4, y=1-5, for x=1,2, or 4 z=1-5 else z=1-7 Pit x Tensiometer water presence/absence at cluster y probe z where absence = 0 and presence = 1
PxVEL	SNOW	x=1,3,5 Pit x wind velocity at 2 meters.
PxXT_LVL	TNS	x=1-4 Pit x refilling tank level
Px_EX	TNS	x=1-4 Pit 1 EX voltage
Px_VLT	TNS	x=1-4 Pit x voltage
P_CR10TEMP	PIEZ	CR10 Temperature for Piezometer module
P_CR10VOLT	PIEZ	CR10 Voltage for Piezometer module
RAINGAUGE1	RAIN	Water accumulation per raingauge tip
REL_HUM	EVT	Relative Humidity in EVT module
SHORTIN	SNOW	Incoming Shortwave
SHORTOUT	SNOW	Reflected Shortwave
TDIR	SNOW	Tower wind direction at 5 meters.
TMELT	SNOW	Tower snow melt
TRHx	SNOW	x=1-3 Tower Relative Humidity at .5, 2, and 3.7 meters.
TRxLCy	TDR	x=1-5, if x = 5 then y=1-2 else y=1-3 Pit x, TDR component Load cells
TRxTDRyy	TDR	x=1-5, y=1-24 Pit x, TDR probes use to measure soil moisture. Probes 1-4 is cluster 1, 5-8 - cluster 2, 9-12 -cluster 3, 13-16 - cluster 4, 17-20 - cluster 5 and 21-24 cluster 6.
TRxTEMPy	TDR	x=1-5; if x=2, y=1-6; if x=4, y=1-8; if x=5, y=1-3 else y=1-4 Pit x, TDR component temperature probes
TSNOW	SNOW	Tower snow depth
TTEMPx	SNOW	x=1-3 Tower temperature at .5, 2, and 3.7 meters

TVEL	SNOW	Tower RMY velocity at 5 meters
TVELx	SNOW	x=1-3 Tower Wind Velocity at .5, 2, and 5 meters
VOLTS	SNOW	CR10 Voltage for Snow module
WATERTEMP	EVT	Epan Water Temperature
WIND DIR	EVT	Wind direction in EVT module
WIND VEL	EVT	Wind velocity in EVT module
YEAR	ALL	Year data was logged

Structure for table: c:\soil\database\snow.dbf
Number of data records: 20668
Date of last update: 08/30/94
Code Page: 0

Field	Field Name	Type	Width	Dec	Index	Collate
1	ARRAYNUM	Numeric	4			
2	JULIANDAY	Numeric	3			
3	MILTIME	Numeric	4			
4	TMELT	Numeric	5			
5	P1MELT	Numeric	5			
6	P3MELT	Numeric	5			
7	P4MELT	Numeric	5			
8	P5MELT	Numeric	5			
9	TSNOW	Float	8	3		
10	P1SNOW	Float	8	3		
11	P3SNOW	Float	8	3		
12	P4SNOW	Float	8	3		
13	P5SNOW	Float	8	3		
14	TDIR	Float	7	3		
15	P1DIR	Float	7	3		
16	P3DIR	Float	7	3		
17	P5DIR	Float	7	3		
18	TVEL	Float	7	3		
19	P1VEL	Float	7	3		
20	P3VEL	Float	7	3		
21	P5VEL	Float	7	3		
22	TVEL1	Float	7	3		
23	TVEL2	Float	7	3		
24	TVEL3	Float	7	3		
25	SHORTIN	Float	8	3		
26	SHORTOUT	Float	8	3		
27	LONGIN	Float	8	3		
28	LONGOUT	Float	8	3		
29	NETRAD	Float	8	3		
30	TRH1	Float	7	3		
31	TRH2	Float	7	3		
32	TRH3	Float	7	3		
33	TTEMP1	Float	7	3		
34	TTEMP2	Numeric	7	3		
35	TTEMP3	Numeric	7	3		
36	P1TEMP0	Numeric	7	3		
37	P1TEMP1	Numeric	7	3		
38	P1TEMP2	Numeric	7	3		
39	P1TEMP3	Numeric	7	3		
40	P1TEMP4	Numeric	7	3		
41	P1TEMP5	Numeric	7	3		
42	P1TEMP6	Numeric	7	3		
43	P1TEMPATM	Numeric	7	3		
44	P1TEMP_10	Numeric	7	3		
45	P1TEMP_20	Numeric	7	3		
46	P3TEMP0	Numeric	7	3		
47	P3TEMP1	Numeric	7	3		
48	P3TEMP2	Numeric	7	3		
49	P3TEMP3	Numeric	7	3		
50	P3TEMP4	Numeric	7	3		
51	P3TEMP5	Numeric	7	3		
52	P3TEMP6	Numeric	7	3		
53	P3TEMPATM	Numeric	7	3		
54	P3TEMP_10	Numeric	7	3		
55	P3TEMP_20	Numeric	7	3		
56	P3TEMPRAIN	Numeric	7	3		
57	P5TEMP0	Numeric	7	3		
58	P5TEMP1	Numeric	7	3		
59	P5TEMP2	Numeric	7	3		
60	P5TEMP3	Numeric	7	3		
61	P5TEMP4	Numeric	7	3		
62	P5TEMP5	Numeric	7	3		
63	P5TEMP6	Numeric	7	3		
64	P5TEMPATM	Numeric	7	3		
65	P5TEMPRAIN	Numeric	7	3		
66	HTPLATE1	Numeric	7	3		
67	HTPLATE2	Numeric	7	3		
68	LDCELL1	Numeric	7	3		
69	LDCELL2	Numeric	7	3		

70	LDCELL3	Numeric	7	3
71	LDCELL4	Numeric	7	3
72	LDCELL5	Numeric	7	3
73	LDCELL6	Numeric	7	3
74	DENSITY1	Numeric	7	3
75	DENSITY2	Numeric	7	3
76	VOLTS	Numeric	7	3
77	YEAR	Numeric	4	
** Total **			527	

Structure for table: c:\soil\database\tnsmeas1.dbf
Number of data records: 1635
Date of last update: 09/19/94
Code Page: 0

Field	Field Name	Type	Width	Dec	Index	Collate
1	ARRAYNUM	Numeric	4			
2	JULIANDAY	Numeric	3			
3	MILTIME	Numeric	5			
4	CR7_VLT	Numeric	9	3		
5	P1_VLT	Numeric	9	3		
6	P1_EX	Numeric	9	3		
7	P1CL1_TMP	Numeric	9	3		
8	P1CL2_TMP	Numeric	9	3		
9	P1CL3_TMP	Numeric	9	3		
10	P1CL4_TMP	Numeric	9	3		
11	P1CL5_TMP	Numeric	9	3		
12	P1IT_LVL	Numeric	9	3		
13	P1XT_LVL	Numeric	9	3		
14	P1FILL1	Numeric	9	3		
15	P1FILL2	Numeric	9	3		
16	P1FILL3	Numeric	9	3		
17	P1TN11	Numeric	9	3		
18	P1TN12	Numeric	9	3		
19	P1TN13	Numeric	9	3		
20	P1TN14	Numeric	9	3		
21	P1TN15	Numeric	9	3		
22	P1TN21	Numeric	9	3		
23	P1TN22	Numeric	9	3		
24	P1TN23	Numeric	9	3		
25	P1TN24	Numeric	9	3		
26	P1TN25	Numeric	9	3		
27	P1TN31	Numeric	9	3		
28	P1TN32	Numeric	9	3		
29	P1TN33	Numeric	9	3		
30	P1TN34	Numeric	9	3		
31	P1TN35	Numeric	9	3		
32	P1TN41	Numeric	9	3		
33	P1TN42	Numeric	9	3		
34	P1TN43	Numeric	9	3		
35	P1TN44	Numeric	9	3		
36	P1TN45	Numeric	9	3		
37	P1TN51	Numeric	9	3		
38	P1TN52	Numeric	9	3		
39	P1TN53	Numeric	9	3		
40	P1TN54	Numeric	9	3		
41	P1TN55	Numeric	9	3		
42	P1TN11_LV	Numeric	1			
43	P1TN12_LV	Numeric	1			
44	P1TN13_LV	Numeric	1			
45	P1TN14_LV	Numeric	1			
46	P1TN15_LV	Numeric	1			
47	P1TN21_LV	Numeric	1			
48	P1TN22_LV	Numeric	1			
49	P1TN23_LV	Numeric	1			
50	P1TN24_LV	Numeric	1			
51	P1TN25_LV	Numeric	1			
52	P1TN31_LV	Numeric	1			
53	P1TN32_LV	Numeric	1			
54	P1TN33_LV	Numeric	1			
55	P1TN34_LV	Numeric	1			
56	P1TN35_LV	Numeric	1			
57	P1TN41_LV	Numeric	1			
58	P1TN42_LV	Numeric	1			
59	P1TN43_LV	Numeric	1			
60	P1TN44_LV	Numeric	1			
61	P1TN45_LV	Numeric	1			
62	P1TN51_LV	Numeric	1			
63	P1TN52_LV	Numeric	1			
64	P1TN53_LV	Numeric	1			
65	P1TN54_LV	Numeric	1			
66	P1TN55_LV	Numeric	1			
67	P2_VLT	Numeric	9	3		
68	P2_EX	Numeric	9	3		
69	P2CL1_TMP	Numeric	9	3		

70	P2CL2 TMP	Numeric	9	3
71	P2CL3 TMP	Numeric	9	3
72	P2CL4 TMP	Numeric	9	3
73	P2CL5 TMP	Numeric	9	3
74	P2IT LVL	Numeric	9	3
75	P2XT LVL	Numeric	9	3
76	P2FILL1	Numeric	9	3
77	P2FILL2	Numeric	9	3
78	P2FILL3	Numeric	9	3
79	P2TN11	Numeric	9	3
80	P2TN12	Numeric	9	3
81	P2TN13	Numeric	9	3
82	P2TN14	Numeric	9	3
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92	P2TN34	Numeric	9	3
93	P2TN35	Numeric	9	3
94	P2TN41	Numeric	9	3
95	P2TN42	Numeric	9	3
96	P2TN43	Numeric	9	3
97	P2TN44	Numeric	9	3
98	P2TN45	Numeric	9	3
99	P2TN51	Numeric	9	3
100	P2TN52	Numeric	9	3
101	P2TN53	Numeric	9	3
102	P2TN54	Numeric	9	3
103	P2TN55	Numeric	9	3
104	P2TN11 LV	Numeric	1	
105	P2TN12 LV	Numeric	1	
106	P2TN13 LV	Numeric	1	
107	P2TN14 LV	Numeric	1	
108	P2TN15 LV	Numeric	1	
109	P2TN21 LV	Numeric	1	
110	P2TN22 LV	Numeric	1	
111	P2TN23 LV	Numeric	1	
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113	P2TN25 LV	Numeric	1	
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115	P2TN32 LV	Numeric	1	
116	P2TN33 LV	Numeric	1	
117	P2TN34 LV	Numeric	1	
118	P2TN35 LV	Numeric	1	
119	P2TN41 LV	Numeric	1	
120	P2TN42 LV	Numeric	1	
121	P2TN43 LV	Numeric	1	
122	P2TN44 LV	Numeric	1	
123	P2TN45 LV	Numeric	1	
124	P2TN51 LV	Numeric	1	
125	P2TN52 LV	Numeric	1	
126	P2TN53 LV	Numeric	1	
127	P2TN54 LV	Numeric	1	
128	P2TN55_LV	Numeric	1	
129	YEAR	Numeric	4	
** Total **			742	

Structure for table: c:\soil\database\tnsmeas2.dbf
Number of data records: 258
Date of last update: 09/19/94
Code Page: 0

Field	Field Name	Type	Width	Dec	Index	Collate
1	ARRAYNUM	Numeric	4			
2	JULIANDAY	Numeric	3			
3	MILTIME	Numeric	5			
4	P3_VLT	Numeric	9	3		
5	P3_EX	Numeric	9	3		
6	P3CL1_TMP	Numeric	9	3		
7	P3CL2_TMP	Numeric	9	3		
8	P3CL3_TMP	Numeric	9	3		
9	P3CL4_TMP	Numeric	9	3		
10	P3CL5_TMP	Numeric	9	3		
11	P3IT_LVL	Numeric	9	3		
12	P3XT_LVL	Numeric	9	3		
13	P3FILL1	Numeric	9	3		
14	P3FILL2	Numeric	9	3		
15	P3FILL3	Numeric	9	3		
16	P3TN11	Numeric	9	3		
17	P3TN12	Numeric	9	3		
18	P3TN13	Numeric	9	3		
19	P3TN14	Numeric	9	3		
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21	P3TN16	Numeric	9	3		
22	P3TN17	Numeric	9	3		
23	P3TN21	Numeric	9	3		
24	P3TN22	Numeric	9	3		
25	P3TN23	Numeric	9	3		
26	P3TN24	Numeric	9	3		
27	P3TN25	Numeric	9	3		
28	P3TN26	Numeric	9	3		
29	P3TN27	Numeric	9	3		
30	P3TN31	Numeric	9	3		
31	P3TN32	Numeric	9	3		
32	P3TN33	Numeric	9	3		
33	P3TN34	Numeric	9	3		
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37	P3TN41	Numeric	9	3		
38	P3TN42	Numeric	9	3		
39	P3TN43	Numeric	9	3		
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41	P3TN45	Numeric	9	3		
42	P3TN46	Numeric	9	3		
43	P3TN47	Numeric	9	3		
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48	P3TN55	Numeric	9	3		
49	P3TN56	Numeric	9	3		
50	P3TN57	Numeric	9	3		
51	P3TN11_LV	Numeric	1			
52	P3TN12_LV	Numeric	1			
53	P3TN13_LV	Numeric	1			
54	P3TN14_LV	Numeric	1			
55	P3TN15_LV	Numeric	1			
56	P3TN16_LV	Numeric	1			
57	P3TN17_LV	Numeric	1			
58	P3TN21_LV	Numeric	1			
59	P3TN22_LV	Numeric	1			
60	P3TN23_LV	Numeric	1			
61	P3TN24_LV	Numeric	1			
62	P3TN25_LV	Numeric	1			
63	P3TN26_LV	Numeric	1			
64	P3TN27_LV	Numeric	1			
65	P3TN31_LV	Numeric	1			
66	P3TN32_LV	Numeric	1			
67	P3TN33_LV	Numeric	1			
68	P3TN34_LV	Numeric	1			
69	P3TN35_LV	Numeric	1			

70	P3TN36 LV	Numeric	1	
71	P3TN37 LV	Numeric	1	
72	P3TN41 LV	Numeric	1	
73	P3TN42 LV	Numeric	1	
74	P3TN43 LV	Numeric	1	
75	P3TN44 LV	Numeric	1	
76	P3TN45 LV	Numeric	1	
77	P3TN46 LV	Numeric	1	
78	P3TN47 LV	Numeric	1	
79	P3TN51 LV	Numeric	1	
80	P3TN52 LV	Numeric	1	
81	P3TN53 LV	Numeric	1	
82	P3TN54 LV	Numeric	1	
83	P3TN55 LV	Numeric	1	
84	P3TN56 LV	Numeric	1	
85	P3TN57_LV	Numeric	1	
86	P4 VLT	Numeric	9	3
87	P4 EX	Numeric	9	3
88	P4CL1 TMP	Numeric	9	3
89	P4CL2 TMP	Numeric	9	3
90	P4CL3 TMP	Numeric	9	3
91	P4CL4 TMP	Numeric	9	3
92	P4CL5 TMP	Numeric	9	3
93	P4IT LVL	Numeric	9	3
94	P4XT LVL	Numeric	9	3
95	P4FILL1	Numeric	9	3
96	P4FILL2	Numeric	9	3
97	P4FILL3	Numeric	9	3
98	P4TN11	Numeric	9	3
99	P4TN12	Numeric	9	3
100	P4TN13	Numeric	9	3
101	P4TN14	Numeric	9	3
102	P4TN15	Numeric	9	3
103	P4TN21	Numeric	9	3
104	P4TN22	Numeric	9	3
105	P4TN23	Numeric	9	3
106	P4TN24	Numeric	9	3
107	P4TN25	Numeric	9	3
108	P4TN31	Numeric	9	3
109	P4TN32	Numeric	9	3
110	P4TN33	Numeric	9	3
111	P4TN34	Numeric	9	3
112	P4TN35	Numeric	9	3
113	P4TN41	Numeric	9	3
114	P4TN42	Numeric	9	3
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116	P4TN44	Numeric	9	3
117	P4TN45	Numeric	9	3
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120	P4TN53	Numeric	9	3
121	P4TN54	Numeric	9	3
122	P4TN55	Numeric	9	3
123	P4TN11 LV	Numeric	1	
124	P4TN12 LV	Numeric	1	
125	P4TN13 LV	Numeric	1	
126	P4TN14 LV	Numeric	1	
127	P4TN15 LV	Numeric	1	
128	P4TN21 LV	Numeric	1	
129	P4TN22 LV	Numeric	1	
130	P4TN23 LV	Numeric	1	
131	P4TN24 LV	Numeric	1	
132	P4TN25 LV	Numeric	1	
133	P4TN31 LV	Numeric	1	
134	P4TN32 LV	Numeric	1	
135	P4TN33 LV	Numeric	1	
136	P4TN34 LV	Numeric	1	
137	P4TN35 LV	Numeric	1	
138	P4TN41 LV	Numeric	1	
139	P4TN42 LV	Numeric	1	
140	P4TN43 LV	Numeric	1	
141	P4TN44 LV	Numeric	1	
142	P4TN45 LV	Numeric	1	
143	P4TN51 LV	Numeric	1	
144	P4TN52_LV	Numeric	1	

145	P4TN53 LV	Numeric	1
146	P4TN54 LV	Numeric	1
147	P4TN55_LV	Numeric	1
148	YEAR	Numeric	4
** Total **			833

Structure for table: c:\soil\database\evtmeas1.dbf
Number of data records: 1647
Date of last update: 09/19/94
Code Page: 0

Field	Field Name	Type	Width	Dec	Index	Collate
1	ARRAYNUM	Numeric	4			
2	YEAR	Numeric	4			
3	JULIANDAY	Numeric	3			
4	MILTIME	Numeric	5			
5	E_CR10TEMP	Numeric	5	2		
6	BATTVOLT	Numeric	4	2		
7	EPAN	Numeric	6	4		
8	WATERTEMP	Numeric	9	3		
9	REL_HUM	Numeric	9	3		
10	WIND_DIR	Numeric	8	2		
11	WIND_VEL	Numeric	8	2		
12	AIR_TEMP	Numeric	9	3		
13	EVAPBLANK	Numeric	9	3		
14	LYS01LD01	Numeric	9	3		
15	LYS01LD02	Numeric	9	3		
16	LYS01LD03	Numeric	9	3		
17	LYS01LDTOT	Numeric	9	3		
18	LYS01TMP01	Numeric	9	3		
19	LYS01TMP02	Numeric	9	3		
20	LYS01TMP03	Numeric	9	3		
21	LYS01TMP04	Numeric	9	3		
22	LYS01TMP05	Numeric	9	3		
23	LYS01TMP06	Numeric	9	3		
24	LYS01TMP07	Numeric	9	3		
25	LYS01ATMP	Numeric	9	3		
26	LYS01BL01	Numeric	9	3		
27	LYS01BL02	Numeric	9	3		
28	LYS02LD01	Numeric	9	3		
29	LYS02LD02	Numeric	9	3		
30	LYS02LD03	Numeric	9	3		
31	LYS02LDTOT	Numeric	9	3		
32	LYS02TMP01	Numeric	9	3		
33	LYS02TMP02	Numeric	9	3		
34	LYS02TMP03	Numeric	9	3		
35	LYS02TMP04	Numeric	9	3		
36	LYS02TMP05	Numeric	9	3		
37	LYS02TMP06	Numeric	9	3		
38	LYS02TMP07	Numeric	9	3		
39	LYS02ATMP	Numeric	9	3		
40	LYS02BL01	Numeric	9	3		
41	LYS02BL02	Numeric	9	3		
** Total **			336			

Structure for table: c:\soil\database\evtmeas2.dbf
Number of data records: 1515
Date of last update: 08/18/94
Code Page: 0

Field	Field Name	Type	Width	Dec	Index	Collate
1	ARRAYNUM	Numeric	4			
2	JULIANDAY	Numeric	3			
3	MILTIME	Numeric	5			
4	LYS01TDR01	Numeric	9	3		
5	LYS01TDR02	Numeric	9	3		
6	LYS01TDR03	Numeric	9	3		
7	LYS01TDR04	Numeric	9	3		
8	LYS01TDR05	Numeric	9	3		
9	LYS01TDR06	Numeric	9	3		
10	LYS01TDR07	Numeric	9	3		
11	LYS01TDR08	Numeric	9	3		
12	LYS02TDR01	Numeric	9	3		
13	LYS02TDR02	Numeric	9	3		
14	LYS02TDR03	Numeric	9	3		
15	LYS02TDR04	Numeric	9	3		
16	LYS02TDR05	Numeric	9	3		
17	LYS02TDR06	Numeric	9	3		
18	LYS02TDR07	Numeric	9	3		
19	LYS02TDR08	Numeric	9	3		
20	YEAR	Numeric	4			
** Total **			161			

Structure for table: c:\soil\database\ettable.dbf
Number of data records: 15
Date of last update: 09/19/94
Code Page: 0

Field	Field Name	Type	Width	Dec	Index	Collate
1	YEAR	Numeric	4			
2	JULIANDAY	Numeric	3			
3	DAILYEVAP	Numeric	7	4		
4	AVGAIRTEMP	Numeric	6	3		
5	AVGWTRTEMP	Numeric	6	3		
6	MAXAIRTEMP	Numeric	6	3		
7	MINAIRTEMP	Numeric	6	3		
8	MAXWTRTEMP	Numeric	6	3		
9	MINWTRTEMP	Numeric	6	3		
10	AVGWIND	Numeric	6	3		
11	AVGHUM	Numeric	6	3		
** Total **			63			

Structure for table: c:\soil\rain.dbf
Number of data records: 1176
Date of last update: 06/09/94
Code Page: 0

Field	Field Name	Type	Width	Dec	Index	Collate
1	ARRAYNUM	Numeric	4			
2	JULIANDAY	Numeric	3			
3	MILTIME	Numeric	5			
4	RAINGAUGE1	Numeric	8	2		
5	YEAR	Numeric	4			
** Total **			25			

Structure for table: c:\soil\database\piezmeas.dbf
Number of data records: 3923
Date of last update: 09/21/94
Code Page: 0

Field	Field Name	Type	Width	Dec	Index	Collate
1	ARRAYNUM	Numeric	4			
2	JULIANDAY	Numeric	3			
3	MILTIME	Numeric	5			
4	PIEZ07	Numeric	9	3		
5	PIEZ08	Numeric	9	3		
6	PIEZ09	Numeric	9	3		
7	PIEZ10	Numeric	9	3		
8	PIEZ11	Numeric	9	3		
9	PIEZ04	Numeric	9	3		
10	PIEZ05	Numeric	9	3		
11	PIEZ06	Numeric	9	3		
12	PIEZ14	Numeric	9	3		
13	PIEZ15	Numeric	9	3		
14	PIEZ12	Numeric	9	3		
15	PIEZ13	Numeric	9	3		
16	PIEZ01	Numeric	9	3		
17	PIEZ02	Numeric	9	3		
18	PIEZ03	Numeric	9	3		
19	P_CR10VOLT	Numeric	9	3		
20	P_CR10TEMP	Numeric	9	3		
21	YEAR	Numeric	4			
** Total **			170			

Structure for table: c:\fox\soil\soilmeas.dbf
Number of data records: 1874
Date of last update: 05/24/94
Code Page: 0

Field	Field Name	Type	Width	Dec	Index	Collate
1	ARRAYNUM	Numeric	4			
2	JULIANDAY	Numeric	3			
3	MILTIME	Numeric	5			
4	TR1TDR01	Numeric	9	3		
5	TR1TDR02	Numeric	9	3		
6	TR1TDR03	Numeric	9	3		
7	TR1TDR04	Numeric	9	3		
8	TR1TDR05	Numeric	9	3		
9	TR1TDR06	Numeric	9	3		
10	TR1TDR07	Numeric	9	3		
11	TR1TDR08	Numeric	9	3		
12	TR1TDR09	Numeric	9	3		
13	TR1TDR10	Numeric	9	3		
14	TR1TDR11	Numeric	9	3		
15	TR1TDR12	Numeric	9	3		
16	TR1TDR13	Numeric	9	3		
17	TR1TDR14	Numeric	9	3		
18	TR1TDR15	Numeric	9	3		
19	TR1TDR16	Numeric	9	3		
20	TR1TDR17	Numeric	9	3		
21	TR1TDR18	Numeric	9	3		
22	TR1TDR19	Numeric	9	3		
23	TR1TDR20	Numeric	9	3		
24	TR1TDR21	Numeric	9	3		
25	TR1TDR22	Numeric	9	3		
26	TR1TDR23	Numeric	9	3		
27	TR1TDR24	Numeric	9	3		
28	TR2TDR01	Numeric	9	3		
29	TR2TDR02	Numeric	9	3		
30	TR2TDR03	Numeric	9	3		
31	TR2TDR04	Numeric	9	3		
32	TR2TDR05	Numeric	9	3		
33	TR2TDR06	Numeric	9	3		
34	TR2TDR07	Numeric	9	3		
35	TR2TDR08	Numeric	9	3		
36	TR2TDR09	Numeric	9	3		
37	TR2TDR10	Numeric	9	3		
38	TR2TDR11	Numeric	9	3		
39	TR2TDR12	Numeric	9	3		
40	TR2TDR13	Numeric	9	3		
41	TR2TDR14	Numeric	9	3		
42	TR2TDR15	Numeric	9	3		
43	TR2TDR16	Numeric	9	3		
44	TR2TDR17	Numeric	9	3		
45	TR2TDR18	Numeric	9	3		
46	TR2TDR19	Numeric	9	3		
47	TR2TDR20	Numeric	9	3		
48	TR2TDR21	Numeric	9	3		
49	TR2TDR22	Numeric	9	3		
50	TR2TDR23	Numeric	9	3		
51	TR2TDR24	Numeric	9	3		
52	TR3TDR01	Numeric	9	3		
53	TR3TDR02	Numeric	9	3		
54	TR3TDR03	Numeric	9	3		
55	TR3TDR04	Numeric	9	3		
56	TR3TDR05	Numeric	9	3		
57	TR3TDR06	Numeric	9	3		
58	TR3TDR07	Numeric	9	3		
59	TR3TDR08	Numeric	9	3		
60	TR3TDR09	Numeric	9	3		
61	TR3TDR10	Numeric	9	3		
62	TR3TDR11	Numeric	9	3		
63	TR3TDR12	Numeric	9	3		
64	TR3TDR13	Numeric	9	3		
65	TR3TDR14	Numeric	9	3		
66	TR3TDR15	Numeric	9	3		
67	TR3TDR16	Numeric	9	3		
68	TR3TDR17	Numeric	9	3		
69	TR3TDR18	Numeric	9	3		

70	TR3TDR19	Numeric	9	3
71	TR3TDR20	Numeric	9	3
72	TR3TDR21	Numeric	9	3
73	TR3TDR22	Numeric	9	3
74	TR3TDR23	Numeric	9	3
75	TR3TDR24	Numeric	9	3
76	TR4TDR01	Numeric	9	3
77	TR4TDR02	Numeric	9	3
78	TR4TDR03	Numeric	9	3
79	TR4TDR04	Numeric	9	3
80	TR4TDR05	Numeric	9	3
81	TR4TDR06	Numeric	9	3
82	TR4TDR07	Numeric	9	3
83	TR4TDR08	Numeric	9	3
84	TR4TDR09	Numeric	9	3
85	TR4TDR10	Numeric	9	3
86	TR4TDR11	Numeric	9	3
87	TR4TDR12	Numeric	9	3
88	TR4TDR13	Numeric	9	3
89	TR4TDR14	Numeric	9	3
90	TR4TDR15	Numeric	9	3
91	TR4TDR16	Numeric	9	3
92	TR4TDR17	Numeric	9	3
93	TR4TDR18	Numeric	9	3
94	TR4TDR19	Numeric	9	3
95	TR4TDR20	Numeric	9	3
96	TR4TDR21	Numeric	9	3
97	TR4TDR22	Numeric	9	3
98	TR4TDR23	Numeric	9	3
99	TR4TDR24	Numeric	9	3
100	TR5TDR01	Numeric	9	3
101	TR5TDR02	Numeric	9	3
102	TR5TDR03	Numeric	9	3
103	TR5TDR04	Numeric	9	3
104	TR5TDR05	Numeric	9	3
105	TR5TDR06	Numeric	9	3
106	TR5TDR07	Numeric	9	3
107	TR5TDR08	Numeric	9	3
108	TR5TDR09	Numeric	9	3
109	TR5TDR10	Numeric	9	3
110	TR5TDR11	Numeric	9	3
111	TR5TDR12	Numeric	9	3
112	TR5TDR13	Numeric	9	3
113	TR5TDR14	Numeric	9	3
114	TR5TDR15	Numeric	9	3
115	TR5TDR16	Numeric	9	3
116	TR5TDR17	Numeric	9	3
117	TR5TDR18	Numeric	9	3
118	TR5TDR19	Numeric	9	3
119	TR5TDR20	Numeric	9	3
120	TR5TDR21	Numeric	9	3
121	TR5TDR22	Numeric	9	3
122	TR5TDR23	Numeric	9	3
123	TR5TDR24	Numeric	9	3
124	TR1LC1	Numeric	9	3
125	TR1LC2	Numeric	9	3
126	TR1LC3	Numeric	9	3
127	TR2LC1	Numeric	9	3
128	TR2LC2	Numeric	9	3
129	TR2LC3	Numeric	9	3
130	TR3LC1	Numeric	9	3
131	TR3LC2	Numeric	9	3
132	TR3LC3	Numeric	9	3
133	TR4LC1	Numeric	9	3
134	TR4LC2	Numeric	9	3
135	TR4LC3	Numeric	9	3
136	TR5LC1	Numeric	9	3
137	TR5LC2	Numeric	9	3
138	TR1TEMP1	Numeric	9	3
139	TR1TEMP2	Numeric	9	3
140	TR1TEMP3	Numeric	9	3
141	TR1TEMP4	Numeric	9	3
142	TR2TEMP1	Numeric	9	3
143	TR2TEMP2	Numeric	9	3
144	TR2TEMP3	Numeric	9	3

tr?temps.txt

1 - 4
2 - 6
3 - 4
4 - 8
5 - 3

145	TR2TEMP4	Numeric	9	3
146	TR2TEMP5	Numeric	9	3
147	TR2TEMP6	Numeric	9	3
148	TR3TEMP1	Numeric	9	3
149	TR3TEMP2	Numeric	9	3
150	TR3TEMP3	Numeric	9	3
151	TR3TEMP4	Numeric	9	3
152	TR4TEMP1	Numeric	9	3
153	TR4TEMP2	Numeric	9	3
154	TR4TEMP3	Numeric	9	3
155	TR4TEMP4	Numeric	9	3
156	TR4TEMP5	Numeric	9	3
157	TR4TEMP6	Numeric	9	3
158	TR4TEMP7	Numeric	9	3
159	TR4TEMP8	Numeric	9	3
160	TR5TEMP1	Numeric	9	3
161	TR5TEMP2	Numeric	9	3
162	TR5TEMP3	Numeric	9	3
163	CR10VOLT	Numeric	9	3
164	CR10TEMP	Numeric	9	3
165	YEAR	Numeric	4	
** Total **			1466	

WINDOWS™ WORLD OPEN

1995 Official Entry Form

Please send your completed Entry Kit to: **Windows World Open**
c/o Janet Church & Associates, Inc.
101 Stewart Street, Suite 300
Seattle, WA 98101

All Entries must be received by January 23, 1995.

If you have questions, call Windows World Open Hotline **1-800-829-4143!**

A completed Entry Kit includes: Nine (9) copies of your completed 1995 Official Entry Form including your screen capture print outs, and five (5) 3.5" PC formatted diskettes with your screen captures saved in 480 x 640 resolution.

The top three entries from each category will be selected and announced as finalists on or before March 1, 1995. These twenty-four finalists will compete on the show floor at the Windows World Open booth during Windows World '95 in Atlanta, April 24-27. Set-up will be April 22, 1995. Final judging will be April 23 1995. Winners will be announced at the Windows World Open Awards Program, Tuesday, April 25, 1995.

PLEASE TYPE

Contact Name: Gilbert Barth Title: Environmental Engineer

Company Name: EG&G Rocky Flats

Street Address: Colorado State Highway 93 (Bldg 080, P.O.Box 464)

City: Golden State/Region: Colorado

Country: USA ZIP/Postal Code: 80402-0464

Phone: 303-966-8707 Fax: 303-966-8663 Email:

Category: Check one of the following. If you need assistance selecting a category, please see the attached page titled Official Categories and Descriptions.

	Accounting		**Healthcare**
	Banking/Securities		**Manufacturing**
XX	**Environmental/Natural Resources**		**Services**
	Franchise		**Wholesale/Retail/Distribution**
	Government/Public Sector		

Name of your custom application:

Environmental Monitoring System Graphical User Interface (EMS GUI) **Version:** 2.3

Description of your custom application: (100 words or less)

The Environmental Monitoring System (EMS) Graphical User Interface (GUI) is an automated data retrieval, archiving and processing interface created by the Soil Study Team at the Rocky Flats Environmental Technology Site (RFETS) in Golden, Colorado. The EMS consists of more than four hundred field sensors from five separate field networks and a system of 40 automated soil water samplers. The sensors measure physical parameters ranging from groundwater levels to long-wave electromagnetic radiation. All data collected is used for the analysis and modelling of contaminant transport at RFETS. The interface provides access to a hierarchy of automated functions including radio communications, system backup, help, data extraction, plotting and format conversion through a consistent point and click interface. The user selects options such as sensor and desired time frame from a series of screens consisting of messages, icons, dialog boxes, popups and radio and push buttons.

Has your application been entered in prior Windows World Open contests?

☐ Yes ■ No

If yes, what year:_____

What upgrades or further development has the application undergone?

• Windows based FoxPro replaced DOS based dBase IV as the database. All code was reevaluated during the transition and optimized wherever possible. Database indexing was incorporated. • The system originally handled data from only one of the five EMS field networks. The system was expanded to include all five networks, collecting all the EMS field data. The expansion increased the volume of data handled by about 500%. • The level of automation was increased to include all radio communications and file importation operations. • Data compression option was added to the archiving functions. • Automated multi-database queries ("Super-Query") added for graphing and extraction of data from multiple field networks.

Is the application in English: YES **If no, what language:**_____

Type of computer system used to run this application:

☐ Mobile PC ■ Stand Alone PC ☐ Network

☐ Host based ☐ Other:_____

Family of Windows: Which does your product require?

■ Microsoft Windows 3.1 or higher ☐ Microsoft Windows for Workgroups ☐ Microsoft Windows NT

How many users run this application? 15-20 **What network is used?** NONE

How long did it take to develop this release of your application from start to finish?

☐ 0-6 months ☐ 6-12 months ■ 1-2 years ☐ 2 years or more

How long has this custom application been in use?

☐ 0-6 months ☐ 6-12 months ■ 1-2 years ☐ 2 years or more

Does this custom application use? (Select all that apply)

■ DDE ☐ Multimedia ☐ Client Server ☐ Pen Computing

☐ OLE ■ Communications ■ Database Architecture

List all members of the Development Team and their titles:

Name	Phone	Title
Gil Barth	303-966-8707	Env. Engineer (GUI lead)
Jim Moffitt	303-966-8515	Environmental Engineer
M. (Iggy) Litaor	303-966-8583	Soil Scientist

List any third parties involved in the design/development of this custom application:

Company Name	S.M. Stoller Corporation
Address	5700 Flatirons Parkway
City, State, Zip	Boulder, Colorado
Phone	303-449-7220
Fax	303-443-1408
Contact Name	Rick Bell
Development Role	Programmer

List all the development tools, language products, and on-line help and documentation software used in developing this custom application:

Name of Product	Manufacturer	Version Number
FoxPro for Windows	Microsoft	2.6
Excel for Windows	Microsoft	4.0
dBase III for DOS	Borland	4.0
Telcom	Campbell Scientific Incorporated	1.7
Windows	Microsoft	3.1

What was the business problem solved with this custom application? (100 words or less)

Getting large amounts of real time environmental monitoring field data from five different sources into a single consistent format, easily accessible to any user. The EMS consists of five field networks which measure soil moisture and infiltration, precipitation, snowmelt, evaporation, and other meteorological data. Over 60 readings are taken on a 10-minute interval, 25 on a 15-minute interval, and over 300 on a hour and a half interval. The EMS collects over 3 megabytes of raw environmental data per month. Collecting, managing, processing and graphing this amount of data on a daily basis was extremely labor intensive prior to the installation of the EMS GUI. The EMS GUI provides a quick and efficient method of data display and serves as a real-time management decision tool.

Why was the business problem important to solve? (100 words or less)

A thorough evaluation of the potential for spreading of the contamination is critical due to the extreme potential health risk involved and the proximity of the Denver metropolitan area. The data handled by the EMS GUI is necessary for the characterization and modeling of the fate and transport of radioactive contaminants in the soil at RFETS. RFETS has been designated as a Superfund site, and is subject to Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) regulations. Characterization of the fate and transport of the contaminants is required in order to evaluate health risks and options for remediation.

What were the net results of this solution? (Return on investment, time to market, % of savings, user satisfaction, quality, etc.-- 100 words or less)

The EMS GUI has resulted in considerable time savings. Prior to the GUI a basic data plotting/viewing operation would require approximately 50 minutes for a user familiar with the data structure and communications and the database and spreadsheet software. Using the EMS GUI no specialized system knowledge is necessary. All operations are point-and-click and the time required is reduced to about 10 minutes, the majority of which is consumed by radio communication/data retrieval operations.

The interface has improved quality control of the data collected. Automation of data management has produced standardized processes including data retrieval, data archiving, database updates and queries, data format conversion, and data plotting. The standardization of all phases of the data management has resulted in better access and reliability.

The EMS GUI eliminates the need to dedicate an expert data manager to provide access to the data set. Without the interface a dedicated expert user would be necessary to maintain the data set, keep it current and provide access for the wide range of users.

What was the impact on the organization? (100 words or less)

Improved communication between investigators analyzing events. The single interface providing access to all of the EMS's field networks promotes communication.

Increased cross-comparisons of data sets from the five field networks. Multivariate analysis combining data from a range of sensors is crucial to determining the mechanisms involved in the fate and transport of contaminants.

Efficient trouble shooting of the EMS. Data can be quickly accessed and analyzed, and problems can be promptly identified. If needed, all instruments of any network can be monitored in a matter of minutes.

Describe the key functionality of the product? (100 words or less)

The EMS GUI provides the mechanism necessary to maintain or increase focus on understanding, evaluating and modelling the data, not struggling to supervise it. The interface has proven to be an important and essential tool. Its success can be measured by the reduction in effort directed towards data management and the frequency with which it is utilized. The EMS GUI is used to automate retrieval, graphing/viewing, access and archiving of a large data set which continues to grow rapidly. The EMS functions efficiently, is based on standard off-the-shelf software and could be applied to any automated environmental monitoring scenario.

How did you hear about the Windows World Open?

- ☐ Ad in *Computerworld* (please specify issue and date): _____
- ☐ Ad in other publication (please specify): _____
- ■ Article in publication (please specify): Microsoft Magazine (Fall, 1994)
- ☐ Direct Mail Letter (please specify company): _____
- ☐ From my sales rep (please specify company): _____
- ☐ Other (please specify): _____

The information supplied in the 1995 Official Entry Kit will be used by the judges to select three finalists from each category. The Windows World Open and its sponsors and co-sponsors retain the right to use any information or screen captures for promotional purposes, editorial coverage, demonstration purposes, or for the pre/post-event promotion, unless you inform us in writing by January 23, 1995.

Please sign this form to verify that the information supplied in this 1995 Official Entry Form is accurate and that you understand the requirements of the Windows World Open.

Signature (Entrant)	Signature (Supervisor)
Name (Please print)	Name (Please print)
Title	Title
Date	Date

Screen Description for the Environmental Monitoring System (EMS) Graphical User Interface (GUI)

The flowchart in Diagram 1 (next page) illustrates the hierarchy and structural design of the Environmental Monitoring System (EMS) Graphical User Interface (GUI). This software application is comprised of over 35 dialog boxes and menu windows. Seven of these screens have been included on diskette in the bit-map format, saved as *figure1.bmp* through *figure7.bmp*. The selected screens are highlighted in the flowchart with shaded boxes. The dashed-line represents the division of FoxPro and Excel programming.

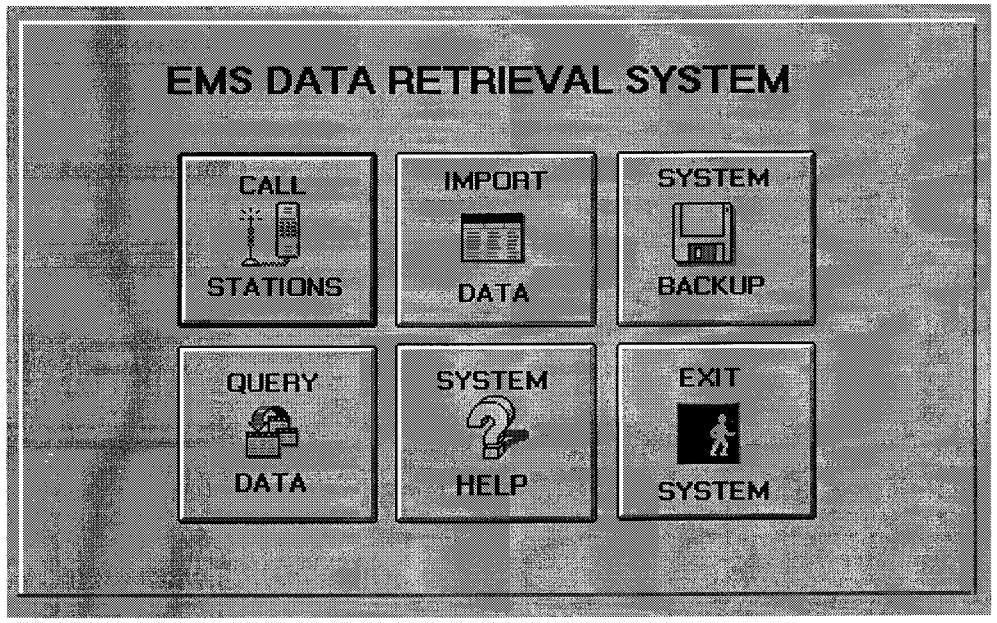


Figure 1 - EMS GUI Main Menu

Figure 1 shows the EMS GUI main menu. The 'Call Stations' icon is selected to retrieve data from the field. Selection of this option displays the 'Call Station' menu window (Figure 2). After selecting the desired network to communicate with, the user is prompted to supply a name for the retrieved data file. A default name based upon the current date and selected network is provided. When the file name is confirmed, Campbell Scientific Inc. communication software is executed. While file retrieval has been automated, this feature remains important for system testing and trouble-shooting.

Retrieved files are appended to the appropriate database by selecting the 'Import Data' icon. Selecting this option results in dialog boxes similar to the 'Call Station' option, whereby the user selects the desired data network and file name. This procedure has

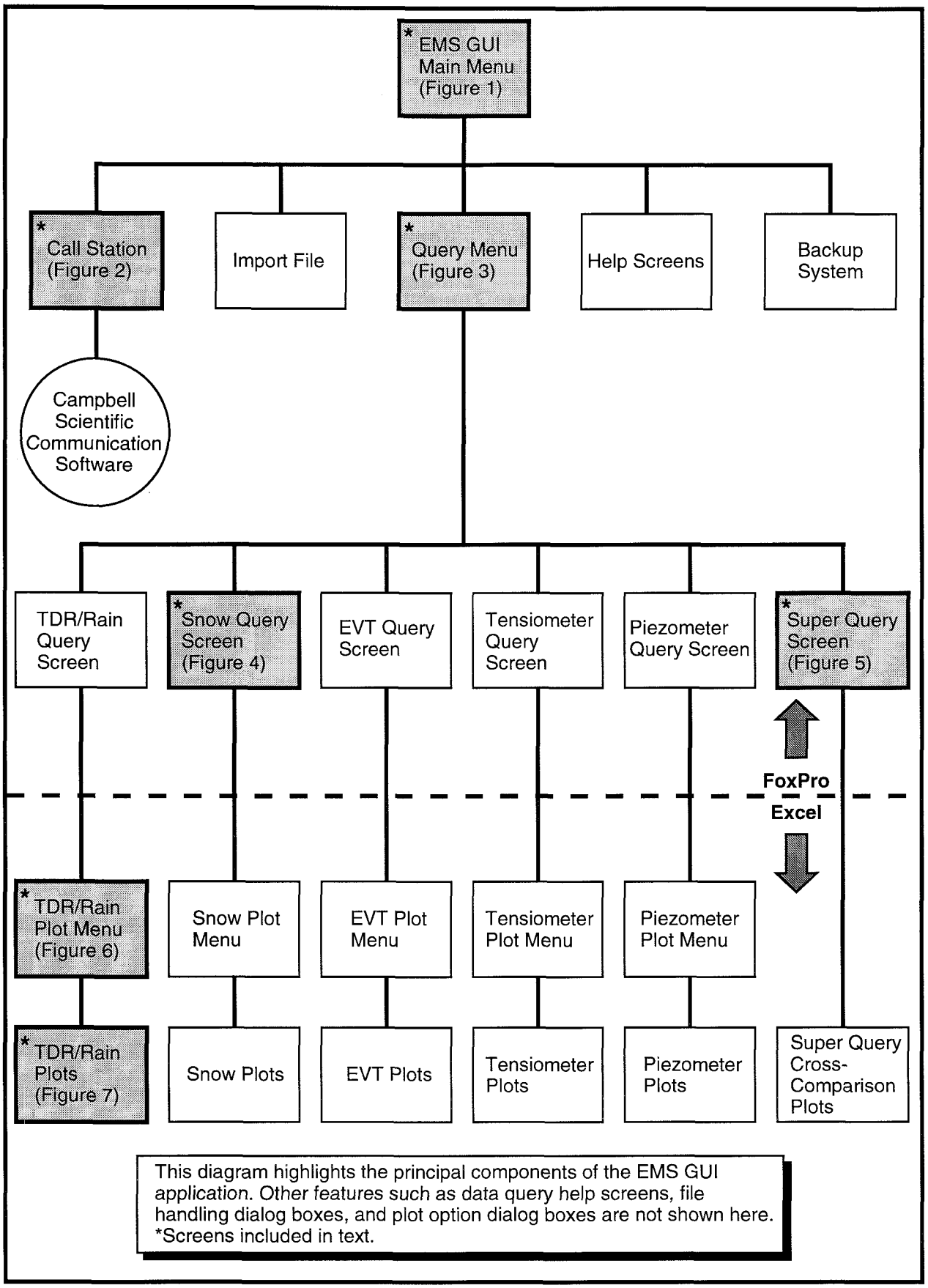


Diagram 1 Environmental Monitoring System Graphical User Interface Flowchart.

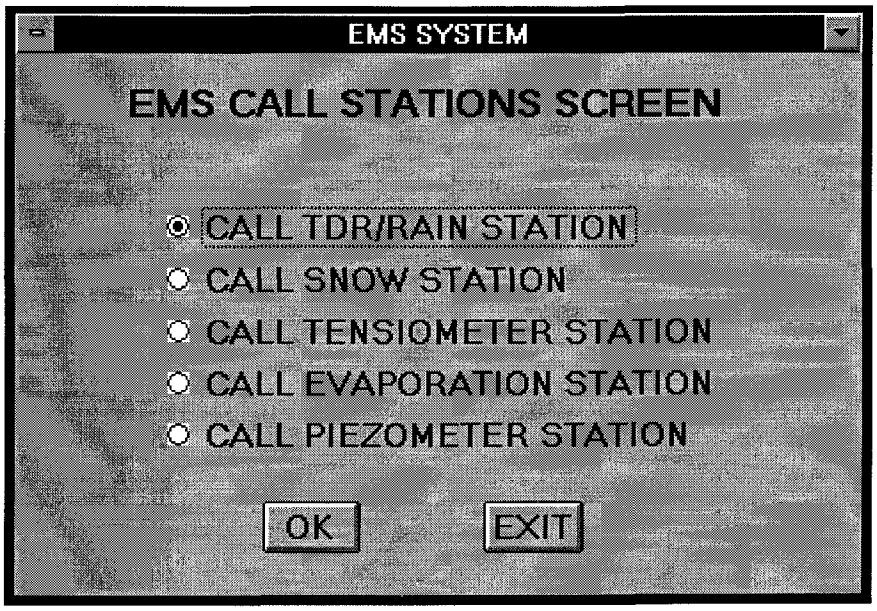


Figure 2 - Call Station Menu

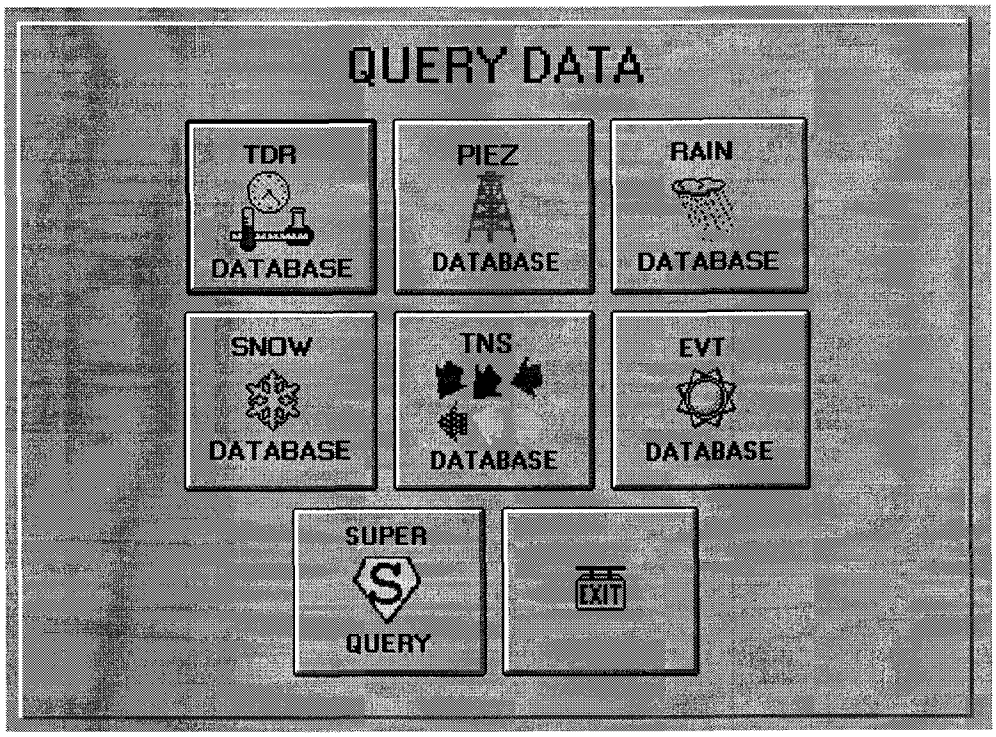


Figure 3 - Query Data Main Menu

also been automated and is performed by the user only in special circumstances.

The 'System Backup' icon allows the user to backup raw data files, databases, and EMS GUI system files. The 'System Help' icon provides the user instructions and tips on how to use the EMS GUI system. The help screens are windows-based, arranged by topic and can be accessed with a search.

Selection of the 'Query Data' icon results in the display of the 'Query Data Main Menu' (Figure 3). At this point, the desired database icon is selected for data evaluation, exportation, and plotting. Selection of one of the database icons displays the corresponding 'Query Data' selection menu. The snow data query screen for solar and wind data is shown in Figure 4. This screen displays the consistent features of all the 'Query Data' screens: the time period selection box, the corresponding instrument options, and the processing options available.

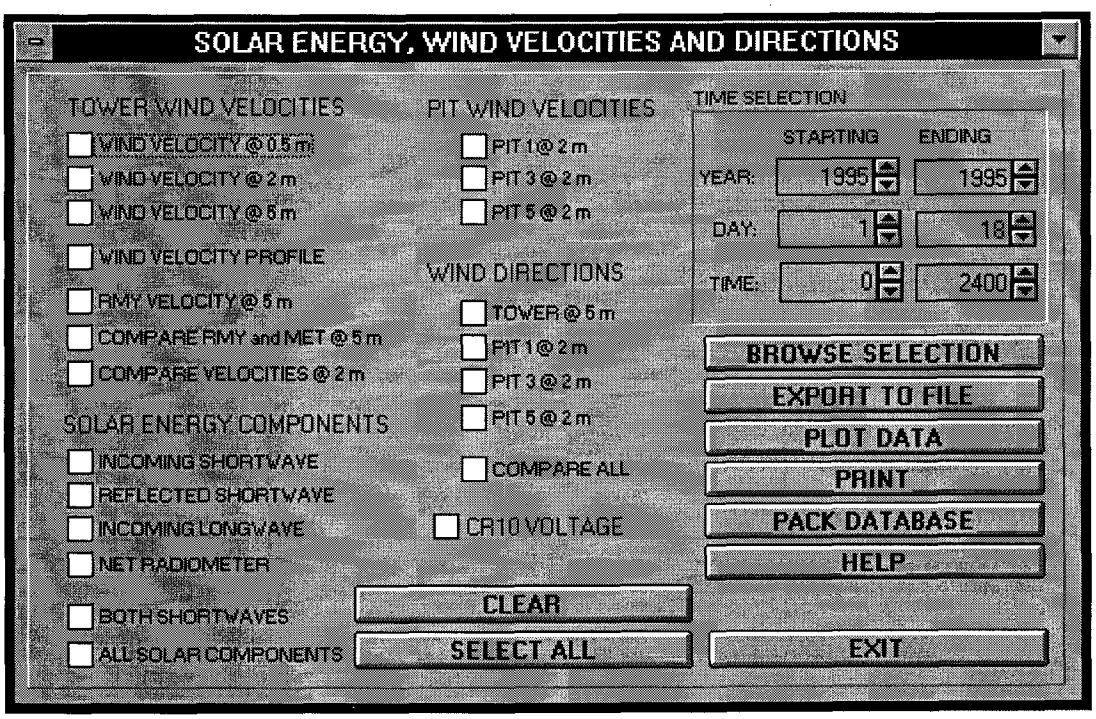


Figure 4 - Snow Query Screen for Solar and Wind Data

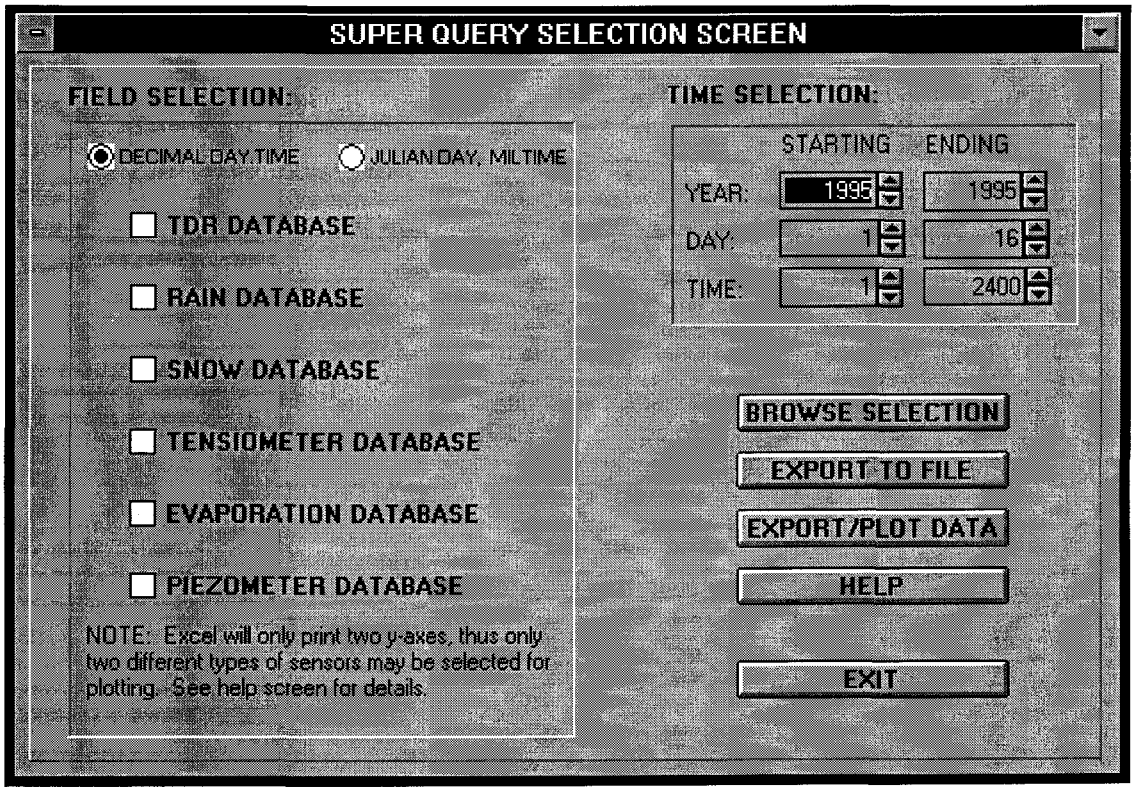


Figure 5 - Super Query Screen

Figure 5 shows the selection screen for the 'Super Query' feature. This option allows the user to select data from two databases for exportation and cross-comparison plots.

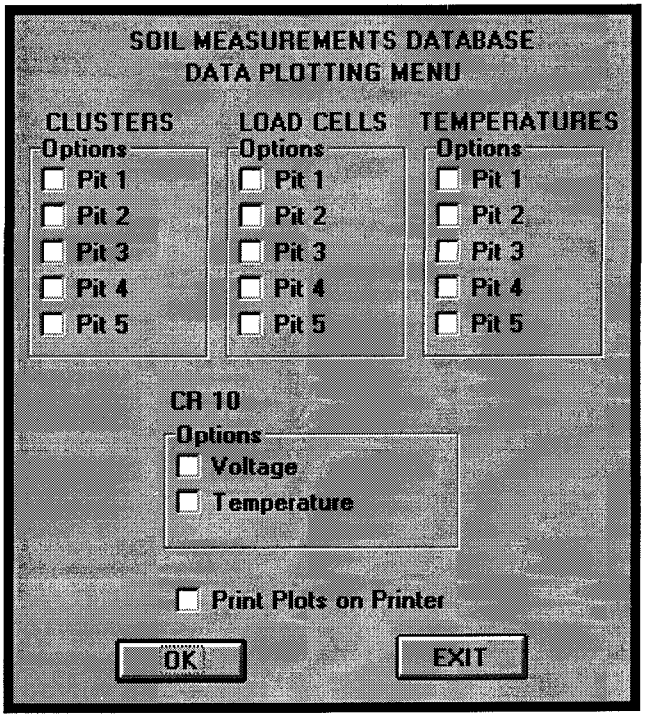


Figure 6 - Plot Main Menu for Soil Moisture Network

When the 'Plot Data' option is selected from any of the 'Query Data' selection screens, the corresponding Excel plot macro is executed. Figure 6 displays the plot selection menu for the soil moisture monitoring network.

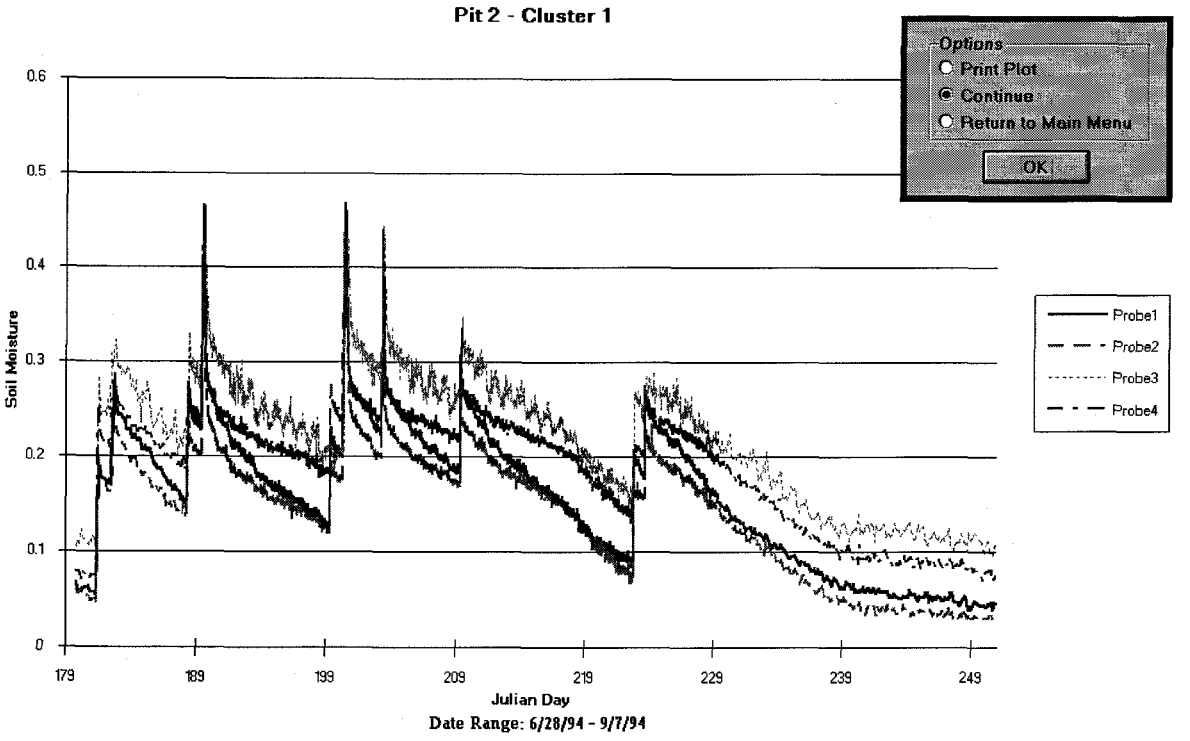


Figure 7 - Soil Moisture Plot with Plot Options Menu

Figure 7 is an example of a soil moisture plot displaying data collected during 1994. The graph clearly displays the infiltration and drainage cycles of several precipitation events. Beginning with downloading data from the field the image was created in a matter of minutes using the interface.

GUIDISK.SN

Appendix X - SWMS GUI and Database Files

The 1995 SST_SNBK Bernoulli data diskette contains the SWMS GUI files and updated databases. The directory structure of the 1995 SST_SNBK Bernoulli data diskette is shown below. This directory structure must be set up on the 'C' hard drive to operate the SWMS GUI system. The use of other directory structures and hard drives will require extensive program code changes. The root directory contains two files which contain descriptions of the SWMS GUI system. A Word 6.0 document, named *flow.gui*, containing an overview of the software using screen graphics as examples. The ASCII file *swmsdoc.txt* describes the system structure and file naming conventions. The following sections contain details on the contents of the specified directories.

```
SOIL
  ├──AUTOCOM
  ├──AUTOPLOT
  ├──BATCH
  ├──BMPS
  ├──DATABASE
  ├──MACROS
  ├──PROGRAMS
  ├──REPORTS
  └──SCREENS
```

AUTOCOM Directory

This directory contains the FoxPro and batch files used for automatic data retrieval calls to the field dataloggers. Automatic data retrieval is initiated with Norton's Scheduler. The Scheduler is used to schedule the execution of a datalogger specific FoxPro program. These programs first assemble a file name based upon the current date, then executes a communication batch file. These batch files execute the Campbell Scientific Inc. Telcom communication software.

The file name conventions are based upon the SWMS component abreviation names (*tdr, snow, tens, evt* and *piez*). The FoxPro program files are named *auto*.prg* (e.g. *autotdr.prg*). The compiled versions have a *.fxp extension. The batch files are named *auto*.bat*. There are also communication batch files for DOS manual retrieval calls. These are named *manu*.bat*.

After these automatic calls are made, an automatic database importation FoxPro program is executed with Norton's Scheduler. This program imports the raw data files into the appropiate database. This program's files are named *autoimp.**.

AUTOPLOT Directory

This directory is used to temporarily store files to be plotted by the AutoPlot Excel macros (currently set up for the snow system only). When the 'Auto Plot' option is selected, the current data query selection files are archived in the c:\soil directory and also copied into the c:\soil\autoplot directory. The Excel 4.0 *snowauto.xlm* macro is then executed. This macro checks the c:\soil\autoplot directory and plots what files it finds. After plotting, the files in this directory are deleted.

BATCH Directory

The batch files used to back up the SWMS GUI files are stored in this directory. The Windows based PIF and batch files used to call the field dataloggers from within the SWMS GUI are also stored here. These files have the *read*.pif* and *read*.bat* naming conventions (e.g. *readtdr.pif* and *readtdr.bat*).

BMPS Directory

This directory contains the fourteen bit-map icon files used by the SWMS GUI system. These icon are used with the SWMS Main Menu screen and the Data Query screen, and are called by the FoxPro program, *swms.prg*.

DATABASE Directory

All of the current SWMS databases are found in this directory. These files contain all data collected by the SWMS during 1994 and 1995 up until March 20, 1995. These database files can be viewed with FoxPro or dBase.

Database field names closely follow the naming conventions of the raw field data files documented in Appendix 10 of the *1994 OU2 Closure Soil Studies Scientific Notebook* for the RFETS, RFP/ERM-94-00021.

MACROS Directory

This directory contains Excel 4.0 macros used for graphing. All of these macros are executed from FoxPro programs. These macros can be viewed with the Excel software (the window must be unhidden to view the code). These macros display a menu system with which the user selects what data to plot. The macro then plots the specified data *.xls file produced with the SWMS GUI.

The naming convention is *mac.xlm (e.g. *tdrmac.xlm*). These macros are executed by the component specific FoxPro program, such as *tdrmain.prg*. The snow

component has a macro which automatically plots current selections (no menu selection system is used). This macro is named *autosnow.xlm*.

PROGRAMS Directory

The FoxPro program files are found in this directory. The source code files are named with a **.prg* extension. The compiled versions have a **.fxp* extension. Hard copies of all FoxPro SWMS GUI programs are on file in the Soil Study Team laboratory (T891M, computer room).

The main program files have the *swms.** name. This program calls the SWMS GUI main menu and data query interface screens. Based upon user selections, the other FoxPro programs are executed. There is a program for each of the SWMS components. These programs are tailored to each of the component's set of intruments. These programs call the data query screens, produce export and plot files, and execute the Excel plotting macros. These programs have the **main.prg* name convention (e.g., *tdrmain.prg*). The *sqmain.prg* file contains the 'Super Query' option programming.

REPORTS Directory

This directory contains the SWMS help and evapotranspiration component FoxPro report templates.

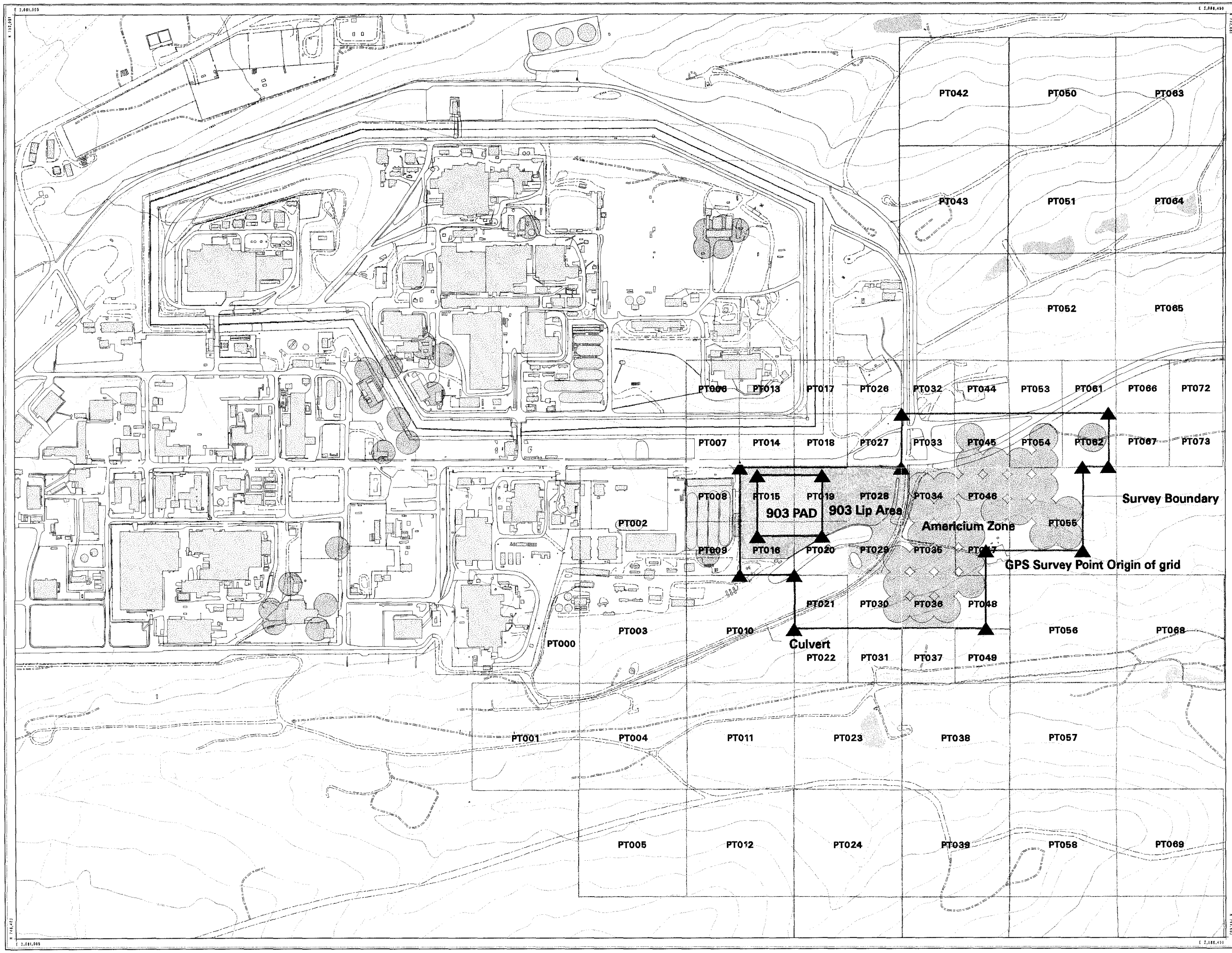
SCREENS Directory

The SWMS GUI screen files are stored in this directory. There are four FoxPro files associated with each SWMS GUI screen. The *.scx files contain the graphic information which is editted within FoxPro. The *.sct files contain screen information on screen size, position, and associated programming code (called 'code snippets'). The FoxPro screen generator produces the *.spr files. The *.spx files are the compiled versions of the *.spr files. The only files that should be editted are the *.scx files. FoxPro generates the other three file types.

Running the SWMS GUI System

Running the SWMS GUI System requires that the FoxPro application files be built on the target computer. This procedure is required when any SWMS GUI updates are made. The SWMS GUI application is built by opening the project file *swms.pjx*. This is done by starting FoxPro, and selecting 'Open' from the 'File' menu. After setting the directory to '\soil\programs' and setting 'List Files of Type:' to 'Projects', press the 'Open' button. The user will then see the *swms.pjx* dialog box, and should press the 'Build' button. The 'Build Option' dialog box is display, from which the user should

select the 'Build Application' and press 'OK.' FoxPro then builds and compiles the SWMS GUI application and produces a *swms.app* file, which is executable from within FoxPro (or can be specified in the 'run FoxPro' command line). If additional information is required, please refer to the FoxPro manuals.



Special Task
Health and Safety Plan for the Site Characterization at the 903 Drum Storage Area, 903 Lip Area and Americium Zone

Investigation Area Location Map

Figure 1.1

Explanation

- HPGe 150 foot FOV Circles (above 10pCi/g Am-241)
- Plots above Tier I Action Levels
- Investigation Area
- Route to Emergency Medical Services, Bldg. 122
- Proposed GPS Survey Point
- 1976 Soil Removal Area (approx)
- 1978 Soil Removal Area (approx)
- 1970 Soil Fill Area

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
HPGe data from Ron Reiman, Gamma Survey Group, Safeguard Measurements, EG&G Rocky Flats, Inc. June 1994

Scale = 1 : 6610
1 inch represents approximately 551 feet

100 0 200 400 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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/gis2/projects/hy97/97-0147/safety.aml