

# INSTRUCTION MANUAL



## **EnviroSCAN™ Soil Water** **Content Profile Probes**

Revision: 9/16



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## General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

## Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

## Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

## Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

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# **EnviroSCAN™**

## ***Soil Water Content Profile Probes***

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### **1. General**

EnviroSCAN™ (previously known as EnviroSMART™) probes measure a profile of volumetric soil water content. EnviroSCAN probes measure at 10 cm increments from soil surface to 2 m. 2 meter probes are limited to 16 sensors. TriSCAN versions of these probes also measure soil salinity.

Irrigation scheduling, waste water treatment, and other applications requiring continuous monitoring of water or water and ion movement in a soil profile may benefit from EnviroSCAN technology. Water content measurements can be made in all soil types. Salinity measurements are restricted to sand, loamy sand and sandy loam soils.

### **2. Absolute Data**

EnviroSCAN probes calibrated for a particular site, including the textural layers of a soil profile, will produce absolute and accurate data. Absolute data, however, require that sensors be calibrated for each soil type and each soil horizon. Absolute calibration is a costly and time consuming process, but must be done if absolute data are required. A manual for absolute data calibration is published by Sentek.

### **3. Relative Data**

Relative data are produced by an instrument calibrated for a range of soil types, and this calibration is used as a default calibration on all soil types. Readings cannot be considered as absolute data, but instead reflect soil water and ion changes used as decision criteria in soil management.

Relative water content data have been used since at least 1992 for irrigation management, isolating factors such as depth of irrigation and rainfall, depth of effective root zone, onset of crop water stress, and avoidance of water logging. Economic gains achieved with soil profile management in commercial agriculture and waste water management are typically made using the concept of 'relative' change in soil dynamics.

### **4. Measurements**

Sensors are measured by the probe's SDI-12 interface. The interface transmits measurements to the datalogger. TriSCAN sensors provide two outputs, water content and salinity. Both outputs can be presented as dynamic trend changes over a chosen time scale. Acceptable time stamp data range from 00:00:00 as midnight to 23:59:59.

## 4.1 Water Content

Sensor output is a dimensionless frequency (raw count) that is converted via a normalization equation and then a default or user-defined calibration equation into volumetric soil water content. The measurement unit is volumetric water content (Vol %) or millimetres of water per 100 mm of soil. Acceptable data range for scaled frequencies is >0 to 1.0. Water content measurements using the default calibration range from 0 to 53%.

## 4.2 Salinity

Sensor output is a dimensionless frequency (raw count) that, in conjunction with the water content output signal, is proportional to changes in soil water content and salinity. A proprietary data model processes the changes of both output signals simultaneously to reflect the changes in soil salinity. The output of the data model is a nominal Volumetric Ion Content (VIC). Measurement units of VIC can be quantitatively related (benchmarked) to the soil EC through site-specific soil sampling and analysis.

Acceptable VIC data range from 1000 to 17,000. The effective salinity measurement range is between 0 and 17 dS m<sup>-1</sup> in sand, loamy sand and sandy loam textures (Australian Soil and Land Survey Field Handbook). Salinity levels and soil textures outside this range are currently not supported by TriSCAN.

# 5. Resolution and Accuracy

## 5.1 Volumetric Water Content

The sensor has a resolution of 0.1 mm of soil moisture. Consecutive readings in equilibrated soil have a coefficient of variation of 0.1%. Accuracy of the system is dependent upon the similarity of the soil site to that of the original default soil type used by Sentek. Calibration coefficients based on this default soil type are used in normal operation. If site-specific (quantitative) values are required, then a calibration procedure is required to be performed (refer to “Calibration of Sentek Probes” Manual). A high level of accuracy can be attained with careful calibration.

## 5.2 Salinity

To date, statements on the resolution and accuracy of the salinity output can only be made with regard to the particular type of sand that has been used to develop the TriSCAN data processing models. These specifications do not necessarily reflect the resolution and accuracy of the sensor on any other soil types. Accuracy and precision of the sensor in the tested sand are as follows:

In saturated soil conditions at low EC 55  $\mu\text{S cm}^{-1}$ :

Repeatable change of VIC to a resolution of 1  $\mu\text{S cm}^{-1}$  (Accuracy  $\pm 1.8\%$ )

In saturated soil conditions at medium EC up to 5600  $\mu\text{S cm}^{-1}$ :

Repeatable change of VIC to a resolution of 25  $\mu\text{S cm}^{-1}$  (Accuracy  $\pm 0.4\%$ )

VIC can be related directly to a site-specific soil EC through the use of Sentek's Benchmarking Procedure.

The accuracy of any such relationships are dependent upon the accuracy and competency with which this procedure is performed. In Sentek's own field testing, strong relationships ( $r^2=0.9$ ) have been achieved. Refer to the benchmarking section of the Sentek TriSCAN manual.

Precise temperature effects on salinity data output are currently unknown. It is, however, known that there is a minor positive relationship between VIC and soil temperature. The salinity model currently does not include temperature correction.

## 6. Specifications

| Feature  | EnviroSCAN™<br>SDI-12   |
|--|---|
| Maximum cable length to logger or third party device | 60 m (200 ft)*  |
| Maximum sensors per standard probe                   | 16  |
| Sensor Measuring Principle                           | High frequency capacitance  |
| Output Options                                       | SDI-12  |
| Protocol options                                     | SDI-12  |
| Interface Measuring Principle                        | 16 Bit pulse count  |
| Output Resolution                                    | 16 Bit  |
| Output Method  | Serial data   |
| Current Consumption                                  | 250 $\mu$ A @ Sleep<br>66 mA @ Standby<br>100 mA @ Sampling                           |
| Reading range  | Water Content/Salinity<br>0 to ~65%/0 to 17 dSm <sup>-1</sup>                         |
| Temperature effects                                  | $\pm 3\%$ 5°C to 35°C   |
| Operating temperature range                          | -20°C to +75°C  |
| Time to read one sensor                              | 1.1 seconds   |
| Sphere of influence                                  | 99% of the reading is taken within a 10 cm radius from the outside of the access tube |
| Sensor diameter                                      | 50.5 mm   |
| Access tube diameter                                 | 56.5 mm   |
| Probe length   | 50 cm (20 inches)   |
| * Based on SENSDI12CBL-L cable.                      |   |

## 7. Installation

Several configurations are possible when using the EnviroSCAN™ / EasyAG® Probes with Campbell Scientific dataloggers. Among those configuration are the following:

### Option 1 (Preferred)

| <u>Device</u> | <u>Function</u>   |
|---------------|---|
| Probe         | Output scaled frequency                                   |
| Datalogger    | Store scaled frequency, calculate and store water content |

### Option 2

| <u>Device</u> | <u>Function</u>      |
|---------------|----------------------|
| Probe         | Output water content |
| Datalogger    | Store water content  |

Option 1 allows for use of data in Sentek's Irrimax Software, which allows for application of new soil calibrations after data are collected. Option 1 is used for the purposes of this manual.

Refer to the installation manual published for each probe for information on access tube installation. Appendix A addresses probe normalization.

## 8. Probe Wiring

A very small flat-point screw driver is used to open the gates of the EnviroSCAN™ terminals before insertion of wires. Tighten the gate screws after inserting wires.

### 8.1 SDI-12 Interface Wiring

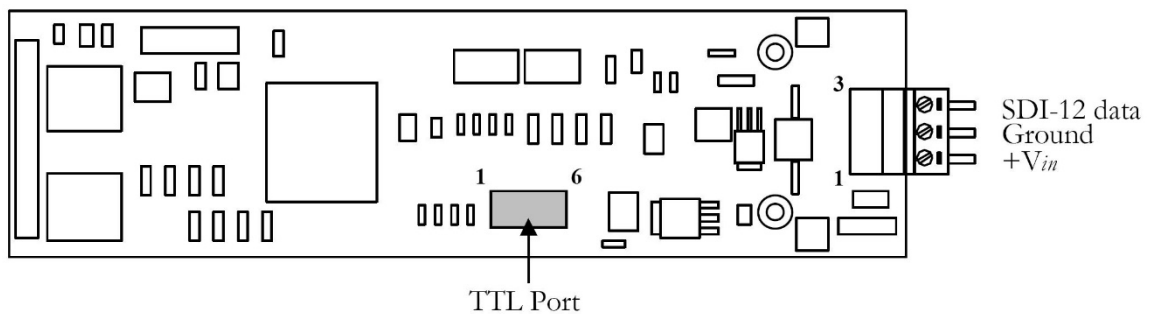


FIGURE 8-1. EnviroSCAN™ SDI-12 Interface

| <u>Probe</u>     | <u>Pin</u> | <u>CR10X / CR23X</u> | <u>CR200 Series</u> |
|------------------|------------|----------------------|---------------------|
| SDI-12           | 3          | C1                   | C1 / SDI-12         |
| Gnd              | 2          | G or $\perp$         | $\perp$             |
| +V <sub>in</sub> | 1          | 12 V                 | SW Battery          |

## 8.2 Cable Installation

Securely tighten the gland nut through which the cable passes into the probe cap. Inject a small amount of silicon sealant into the sensor end of the cable to ensure that water or water vapor will not pass into the probe.

## 9. Datalogger Programming

Example program corresponds to setup example in Appendices A and B.

### Sample CR1000 Program

Shaded portions of program can be omitted if TriSCAN sensor options are not used.

```
'CR1000 Datalogger
'Program Author: Campbell Scientific, Inc.
'Date: 04-12-06

'Description:   Program measures 1 EnviroSCAN / TriSCAN probe with 8 sensors or 1 EasyAG
'               TriSCAN probe with 4 sensors. -1000 is loaded as the "measurement" for
'               non-existent sensors. Program measures scaled frequencies, calculates
'               water contents, and stores scaled frequencies, water contents, and
'               volumetric ion contents separately. Scaled frequencies are stored with an
'               "array identifier" leading 8 data values per record followed by 8 VIC per
'               record, with the record ending with zero rain and irrigation values for
'               compatibility with DBLOAD & Irrimax software.

'Assumptions:  EnviroSCAN or EasyAG probe SDI-12 interface is configured to output
'               scaled frequencies

'Wiring:       EnviroSCAN / EasyAG 12 Volts (Pin 1)----- CR1000 12 V
'               EnviroSCAN / EasyAG Ground (Pin 2)----- CR1000 Ground
'               EnviroSCAN / EasyAG Signal (Pin 3)----- C7

'               Rain Gage Pulse Out ----- CR1000 P2
'               Rain Gage Ground ----- CR1000 Ground

'Program Declarations

'Public (Displayed) Variables
Public ES1_ID(1)
Public ES1_SF(8)
Public ES1_WC(8)
Public ES1_VIC(8)
Public Rain_mm
Public Irrig_mm

'EasyAG / EnviroSCAN Scale Frequency to Water Content Calibration Co-efficients
Const a = .1957
Const b = .404
Const c = .02852
```

```

'Program Control Variables
Dim X

'Definition of DataTables
DataTable (ES1_SF,1,-1)
    Sample (1,ES1_ID,FP2)
    Sample (8,ES1_SF(1),FP2)
    Sample (8,ES1_VIC(1),FP2)
    Totalize (1,Rain_mm,FP2,False)
    Sample (1,Irrig_mm,FP2)
EndTable
DataTable (ES1_WC,1,-1)
    Sample (8,ES1_WC(1),FP2)
EndTable

'Program
BeginProg

    'Set Probe ID
    ES1_ID = 101

    'Set Scan Interval
    Scan (30,Sec,3,0)

    'Preload Inactive Sensor Error (covers all missing sensors)
    For X = 1 to 8 step 1
        ES1_SF(X) = -1000
        ES1_VIC(X) = -1000
    Next X

    'Measure Water Content Scaled Frequencies (SF) with 5 retries
    'See Appendix E for other SDI-12 commands
    For X = 1 to 5 step 1
        SDI12Recorder (ES1_SF(),7,0,"M!",1.0,0)
        If ES1_SF(1) <> NAN then ExitFor
    Next X

    'Measure Electrical Conductivity VIC with 5 retries
    For X = 1 to 5 step 1
        SDI12Recorder(ES1_VIC(1),7,0,"M2!",1,0)
        If ES1_VIC(1) <> NAN then ExitFor
    Next X

    'Load Measurement Failure Errors
    If ES1_SF(1) = NAN Then ES1_SF(1) = -99999 'If probe fails (NAN at first sensor)
    For X = 1 to 8 step 1
        If ES1_SF(1) < -9999 Then
            ES1_SF(X) = -99999
            ES1_WC(X) = -99999
            ES1_VIC(X) = -99999
        End If
    Next X

```

|  |   |
|--|---|
| Else   | '...OR...   |
| If ES1_SF(X) < -999 Then   | 'If a WC sensor fails   |
| (indicated by  |   |
|  | '-1000)   |
| ES1_WC(X) = -99999   | 'Load NAN for water   |
| content  |   |
| Else   | '...OR...   |
| ES1_WC(X) = ((ES1_SF(X) - c)/a)^(1/b)  | 'apply calibration  |
| EndIf  |   |
| EndIf  |   |
| Next X   |   |
|  |   |
| 'Measure rain  |   |
| PulseCount (Rain_mm,1,2,2,0,.01,0)   |   |
|  |   |
| 'Input irrigation events manually in Irrimax, 0 must be written to data file |   |
| Irrig_mm = 0   |   |
|  |   |
| 'Output Data to Storage  |   |
| CallTable ES1_SF   | 'Store Scaled Frequency and VIC Data with Rain and Irrigation |
|  | 'for Irrimax Software   |
| CallTable ES1_WC   | 'Store Water Content Data                                     |
|  |   |
| 'Next Scan   |   |
| Next Scan  |   |
|  |   |
| 'End Program   |   |
| EndProg  |   |

### Sample CR10X Program

Shaded portions of program can be omitted if TriSCAN sensor options are not used.

```

;CR10X Datalogger
;Program Author: Campbell Scientific, Inc.
;Date: 04-12-06

;Description:   Program measures 1 EnviroSCAN / TriSCAN probe with 8 sensors or 1 EasyAG
;               TriSCAN probe with 4 sensors.  -1000 is loaded as the "measurement" for
;               non-existent sensors.  Program measures scaled frequencies, calculates
;               water contents, and stores scaled frequencies, water contents, and
;               volumetric ion contents separately.  Scaled frequencies are stored with an
;               "array identifier" leading 8 data values per record followed by 8 VIC per
;               record, with the record ending with zero rain and irrigation values for
;               compatibility with DBLOAD & Irrimax software.

;Assumptions:  EnviroSCAN or EasyAG probe SDI-12 interface is configured to output
;               scaled frequencies
    
```



```

;Wiring:      EnviroSCAN / EasyAG 12 Volts (Pin 1) -----CR10X 12 V
;              EnviroSCAN / EasyAG Ground (Pin 2) -----CR10X Ground
;              EnviroSCAN / EasyAG Signal (Pin 3)-----C7

;              Rain Gage Pulse Out-----CR10X P2
;              Rain Gage Ground -----CR10X Ground

;{CR10X}
;
*Table 1 Program
  01: 30          Execution Interval (seconds)

;Load Scaled Frequency to Water Content Co-efficients

a = .1957
b = .404
c = .02852

;Preload missing sensor error

1: Beginning of Loop (P87)
  1: 0            Delay
  2: 8            Loop Count

      2: Z=F x 10^n (P30)
        1: -1000    F
        2: 0        n, Exponent of 10
        3: 1        -- Z Loc [ ES1_SF_1 ]

      3: Z=F x 10^n (P30)
        1: -1000    F
        2: 0        n, Exponent of 10
        3: 17       -- Z Loc [ ES1_VIC_1 ]

4: End (P95)

;Measure water content scaled frequencies (SF)

5: Beginning of Loop (P87)
  1: 0            Delay
  2: 5            Loop Count

;See Appendix E for other SDI-12 commands

6: SDI-12 Recorder (P105)
  1: 0            SDI-12 Address
  2: 0            Start Measurement (aM0!)
  3: 7            Port
  4: 1            Loc [ ES1_SF_1 ]
  5: 1.0          Mult
  6: 0            Offset

```

```

7: If (X<=>F) (P89)
  1: 1      X Loc [ ES1_SF_1 ]
  2: 2      <>
  3: 0      F
  4: 31     Exit Loop if True

8: End (P95)

;Measure salinity volumetric ion content (VIC)

9: Beginning of Loop (P87)
  1: 0      Delay
  2: 5      Loop Count

  10: SDI-12 Recorder (P105)
    1: 0      SDI-12 Address
    2: 2      Start Measurement (aM2!)
    3: 7      Port
    4: 17     Loc [ ES1_VIC_1 ]
    5: 1.0    Mult
    6: 0      Offset

  11: If (X<=>F) (P89)
    1: 17     X Loc [ ES1_VIC_1 ]
    2: 2      <>
    3: 0      F
    4: 31     Exit Loop if True

  12: End (P95)

;Load measurement failure errors

13: If (X<=>F) (P89)                                ;Measurement of 0 at 1st sensor
  1: 1      X Loc [ ES1_SF_1 ]                      ;indicates an inactive probe.
  2: 1      =
  3: 0      F
  4: 30     Then Do
    14: Z=F x 10^n (P30)                            ;Set 1st sensor reading to -99999
      1: -99999   F
      2: 0        n, Exponent of 10
      3: 1        Z Loc [ ES1_SF_1 ]

15: End (P95)

16: Beginning of Loop (P87)                          ;Loop to set error codes
  1: 0      Delay
  2: 8      Loop Count

```

```

17: If (X<=>F) (P89)                                ;If 1st sensor reading is < -9999 i.e. = -99999
1: 1          X Loc [ ES1_SF_1 ]                    ;then set all sensor readings to -99999
2: 4          <
3: -9999      F
4: 30         Then Do

18: Z=F x 10^n (P30)
1: -99999     F
2: 0          n, Exponent of 10
3: 1          -- Z Loc [ ES1_SF_1 ]

19: Z=F x 10^n (P30)
1: -99999     F
2: 0          n, Exponent of 10
3: 9          -- Z Loc [ ES1_WC_1 ]

20: Z=F x 10^n (P30)
1: -99999     F
2: 0          n, Exponent of 10
3: 1          -- Z Loc [ ES1_VIC_1 ]

21: Else (P94)                                       ;Otherwise, if a sensor scaled frequency
                                                    ;< -999, i.e. = -1000

22: If (X<=>F) (P89)
1: 1          -- X Loc [ ES1_SF_1 ]
2: 4          <
3: -999       F
4: 30         Then Do

23: Z=F x 10^n (P30)                                ;Set water content data to -99999
1: -99999     F
2: 0          n, Exponent of 10
3: 9          -- Z Loc [ ES1_WC_1 ]

24: Else (P94)                                       ;Otherwise, calculate water content for
                                                    ;the sensor

25: Z=X-Y (P35)
1: 1          -- X Loc [ ES1_SF_1 ]
2: 29         Y Loc [ C ]
3: 9          -- Z Loc [ ES1_WC_1 ]

26: Z=X/Y (P38)
1: 9          -- X Loc [ ES1_WC_1 ]
2: 30         Y Loc [ A ]
3:           -- Z Loc [ ES1_WC_1 ]

27: Z=1/X (P42)
1: 32         X Loc [ B ]
2: 34         Z Loc [ RecipB ]

```

```

28: Z=X^Y (P47)
   1:  9      -- X Loc [ ES1_WC_1 ]
   2: 34      Y Loc [ RecipB  ]
   3:  9      -- Z Loc [ ES1_WC_1 ]

29: End (P95)                                ;End If

30: End (P95)                                ;End If

31: End (P95)                                ;Next Loop

;Measure Rain

32: Pulse (P3)
   1:  1      Reps
   2:  1      Pulse Channel 1
   3:  2      Switch Closure, All Counts
   4: 25      Loc [ Rain_mm  ]
   5: .1      Mult
   6:  0      Offset

;Input irrigation events manually in Irrimax, 0 must be written to data file

33: Z=F x 10^n (P30)
   1:  0      F
   2:  0      n, Exponent of 10
   3: 26      Z Loc [ Irrig_mm ]

;Output SF & VIC Data to Storage

34: Do (P86)
   1: 10      Set Output Flag High (Flag 0)

35: Set Active Storage Area (P80)
   1:  1      Final Storage Area 1
   2: 101     Array ID

36: Real Time (P77)                          ;Midnight = 0000 required by Irrimax
Software
   1: 1110    Year,Day,Hour/Minute (midnight = 0000)

37: Sample (P70)
   1:  8      Reps
   2:  1      Loc [ ES1_SF_1 ]

38: Sample (P70)
   1:  8      Reps
   2: 17      Loc [ ES1_VIC_1 ]

39: Totalize (P72)
   1:  1      Reps
   2: 25      Loc [ Rain_mm  ]

```

```

40: Sample (P70)
    1: 1          Reps
    2: 26         Loc [ Irrig_mm ]

;Output Water Content Data to Storage

41: Do (P86)
    1: 10         Set Output Flag High (Flag 0)

42: Set Active Storage Area (P80)
    1: 1          Final Storage Area 1
    2: 201        Array ID

43: Real Time (P77)
    1: 1220       Year,Day,Hour/Minute (midnight = 2400)

44: Sample (P70)
    1: 8          Reps
    2: 9          Loc [ ES1_WC_1 ]

*Table 2 Program
    02: 0.0000    Execution Interval (seconds)

*Table 3 Subroutines

End Program

-Input Locations-
1 ES1_SF_1 5 6 4
2 ES1_SF_2 1 1 0
3 ES1_SF_3 1 1 0
4 ES1_SF_4 1 1 0
5 ES1_SF_5 1 1 0
6 ES1_SF_6 1 1 0
7 ES1_SF_7 1 1 0
8 ES1_SF_8 1 1 0
9 ES1_WC_1 1 3 5
10 ES1_WC_2 1 1 0
11 ES1_WC_3 1 1 0
12 ES1_WC_4 1 1 0
13 ES1_WC_5 1 1 0
14 ES1_WC_6 1 1 0
15 ES1_WC_7 1 1 0
16 ES1_WC_8 1 1 0
17 ES1_VIC_1 5 2 3
18 ES1_VIC_2 1 1 0
19 ES1_VIC_3 1 1 0
20 ES1_VIC_4 1 1 0
21 ES1_VIC_5 1 1 0
22 ES1_VIC_6 1 1 0
23 ES1_VIC_7 1 1 0
24 ES1_VIC_8 1 1 0
25 Rain_mm 1 1 1
26 Irrig_mm 1 1 1
27 _____ 0 0 0
28 _____ 0 0 0

```

|           |       |
|-----------|-------|
| 29 C      | 1 1 0 |
| 30 A      | 1 1 0 |
| 31        | 0 0 0 |
| 32 B      | 1 1 0 |
| 33        | 0 0 0 |
| 34 RecipB | 1 1 1 |

## 10. Care and Maintenance

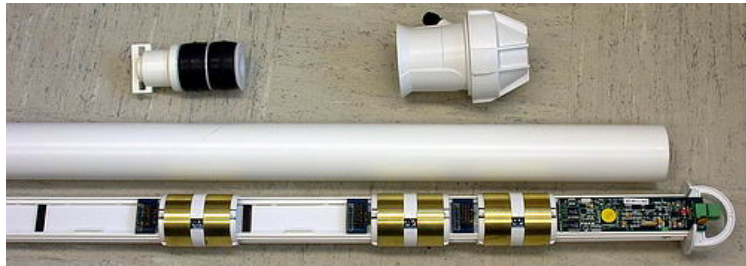
Probe electronics will be damaged if exposed to water or condensation. A proper installation must include active desiccant in the cap of each probe. Be certain the gland nut through which the cable passes is tight. Also, maintain the silicon plug material in the sensor end of the cable to ensure water vapor does not pass into the probe through the cable.

## 11. Acknowledgements

Campbell Scientific, Inc. gratefully acknowledges the contribution of Sentek Pty Ltd to concepts, text, and images used in this manual.

# ***Appendix A. Probe Assembly***

---



*FIGURE A-1. Finished EnviroSCAN™ Assembly*

FIGURE A-1 shows a finished three-sensor probe. Your probe may require more or less than three sensors at different spacing.



*FIGURE A-2. Probe Rod Top*

Remove the probe rod from the access tube by removing the plug on one end of the tube. The plug can be removed by shaking the tube vertically such that the rod internally hammers on the plug and eventually dislodges it. Identify the “top” as indicated in FIGURE A-2.

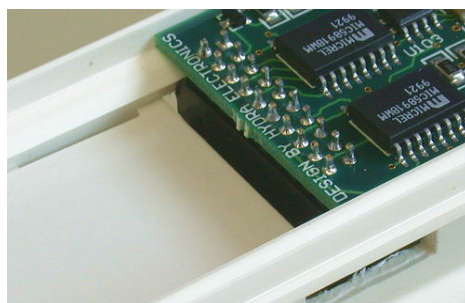


*FIGURE A-3. Location of Large Handle Screws*

“Loosely” attach the handle to the rod with two of the large screws that came with the assembly as shown in [FIGURE A-3](#).

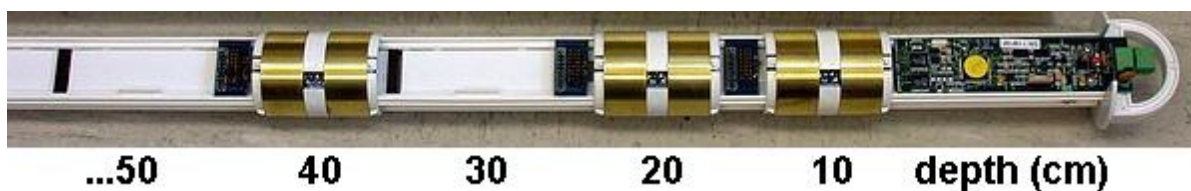


*FIGURE A-4. Location of Small Main Board Screws*



*FIGURE A-5. Securing Main Board Electrical Connection*

Install the main board assembly as shown in [FIGURE A-4](#) between the two sides of the mounting rail. The header is plugged into the first connector in the rail as shown in [FIGURE A-5](#). Secure the main board to the probe with two of the small screws that came with the assembly. Tighten the two large screws.



*FIGURE A-6. Possible Sensor Positions*



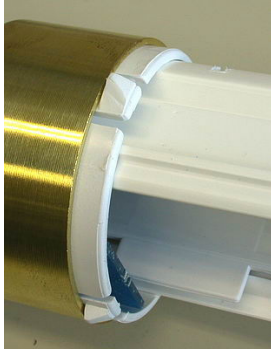


FIGURE A-7. Sensor Orientation

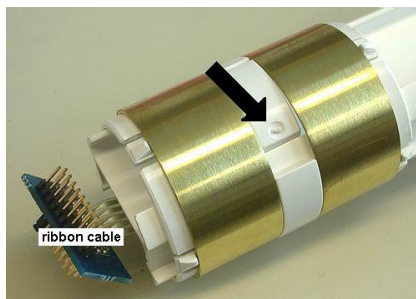


FIGURE A-8. Sensor Ribbon Cable

Determine the number and locations of sensors that are to be installed. They may or may not be as indicated in the example in [FIGURE A-6](#). Place the first sensor carefully over the rail, oriented as shown in [FIGURE A-7](#). To advance the sensor assembly to its location on the rail, press and hold the spot indicated by the arrow in [FIGURE A-8](#).

---

**CAUTION**

As you advance the sensor, carefully position the ribbon cable to prevent breaking it, as it will tend to catch, especially when first starting.

---

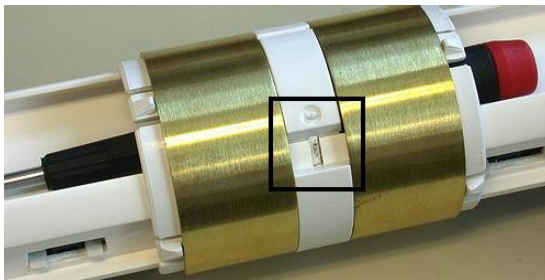


FIGURE A-9. Locking Sensor in Place

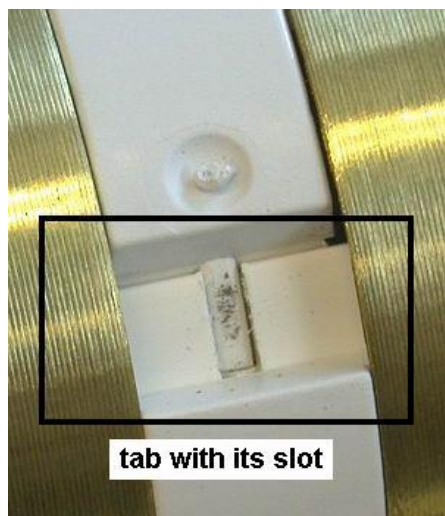


FIGURE A-10. Aligning Sensor Tab with Probe Slot

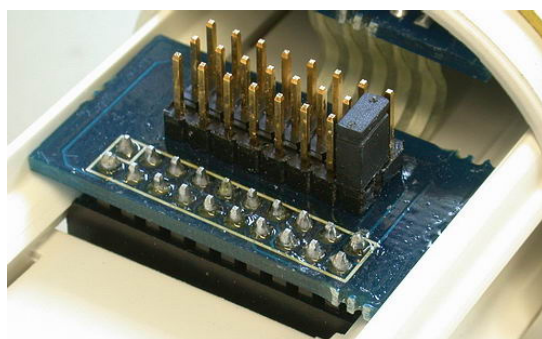


FIGURE A-11. Plugging in Ribbon Cable Header

Advance the sensor to its proper location. Align and snap the lock ring in place. Insert a screwdriver as shown in FIGURE A-9 and pull outward on the screwdriver after carefully aligning the tab with its slot in the rail, as shown in FIGURE A-10. After snapping in place, carefully plug the header on the ribbon cable into its proper connector in the rail as shown in FIGURE A-11.

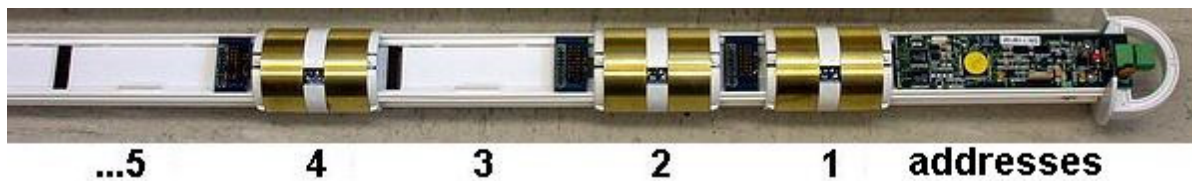


FIGURE A-12. Sensor Addresses

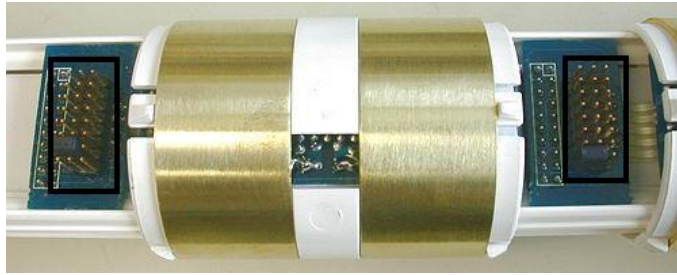


FIGURE A-13. Location of Addressing Jumpers

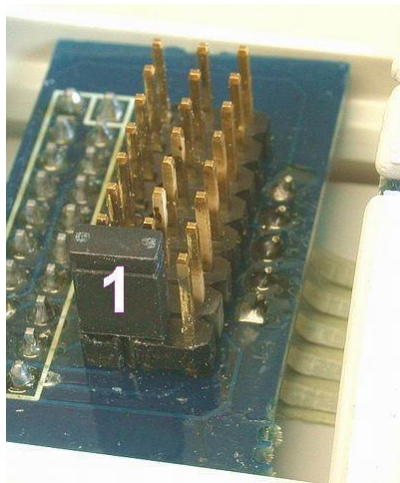


FIGURE A-14. Location of Jumper 1

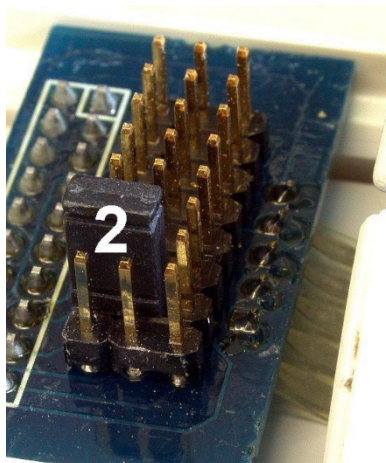
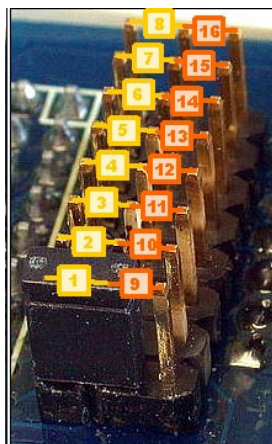


FIGURE A-15. Location of Jumper 2



*FIGURE A-16. Location of Jumpers 1..16*

After positioning and securing each sensor in its proper location, install the jumpers on the ribbon cable boards. Begin at the main board end and install the jumpers on each sensor board in numeric sequence as shown in [FIGURE A-12](#). Locate the sensor jumper pins as shown in [FIGURE A-13](#). Set sensor 1 jumper to the first position as shown in [FIGURE A-14](#). Set sensor 2 jumper to the second position as shown in [FIGURE A-15](#). Set subsequent jumpers as indicated in [FIGURE A-16](#). The position of the jumper on the header and the location of the sensor on the rail are NOT related and may or may not be the same.

# Appendix B. Normalization and Function Test

---

Normalization is the setting of the range over which the electronics is effective. This range is bounded by the two extremes of air and water.

## B.1 Normalization

Connect +12 Volts DC and ground to the green connector at the top of the probe as shown in FIGURE B-1.

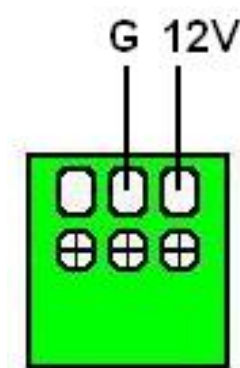


FIGURE B-1. SDI-12 Interface Power Connection

Connect the Intelligent Probe Utility Cable (P/N SEN06020) to the TTL port near the top of the probe at the location indicated in FIGURE B-2.

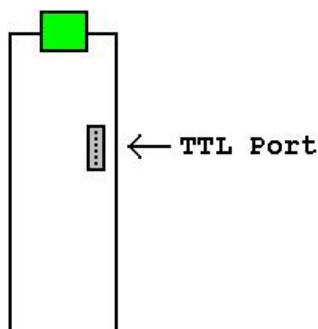


FIGURE B-2. SDI-12 Interface TTL Connection

Connect the other end of the utility cable to the serial port on a PC. This may require a 9 to 25 pin serial adaptor. CSI serial cable (P/N 7026) is available as an adaptor.

Start the IPConfig Utility (Intelligent Probe Utility Software, P/N SEN06025) on the PC by clicking on the IPConfig Utility icon (shown in FIGURE B-3).



FIGURE B-3. IPConfig Utility Icon

Click “Connect” in the upper right area of the IPConfig window. The software will connect to the probe and set up a configuration window.

### B.1.1 Water Content Only

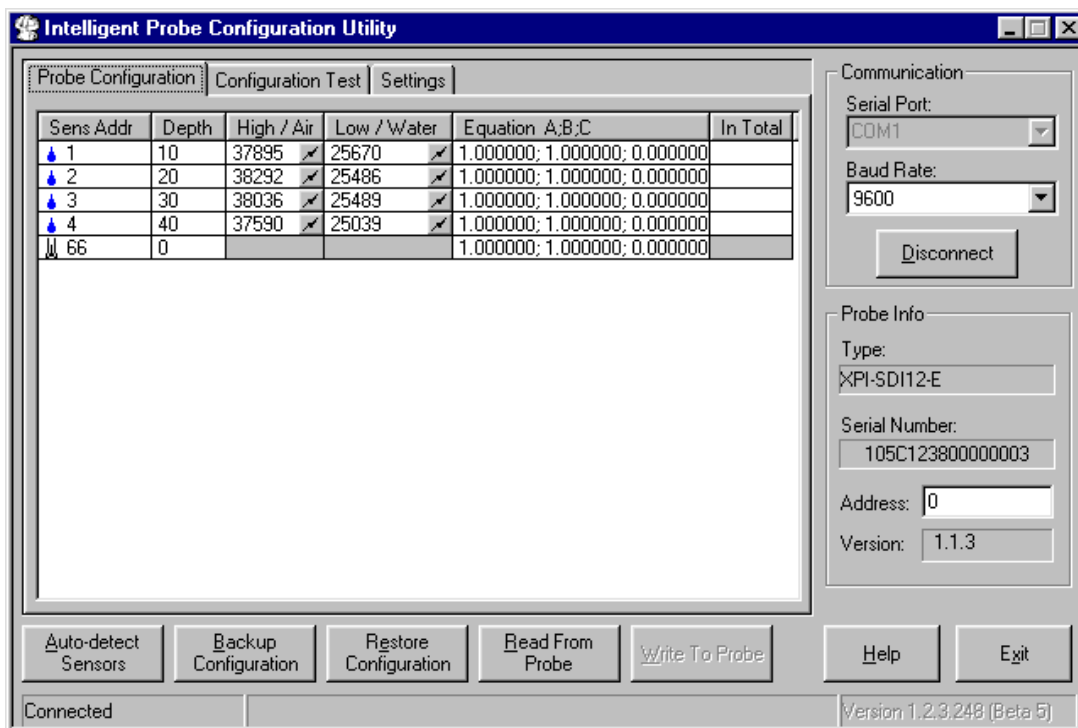




FIGURE B-4. IPConfig Probe Configuration Window

FIGURE B-4 shows an IPConfig Utility Probe Configuration window after normalization is complete on a three-sensor probe with sensors placed at 10, 20, and 30 cm. Complete the following operations for a new probe:

1. Click on “Auto-detect Sensors” in the lower left corner. Wait until all sensors are auto-detected. If the number of sensors detected does not correspond with the number of sensors on the probe, check to ensure that each sensor is addressed sequentially, beginning with address 1 on the top sensor.
2. Enter the depth of each sensor in the “Depth” column. Each depth will be a multiple of 10.
3. Enter “1.000000;1.000000;0.000000” on each line in the “Equation A;B;C” column.
4. With the probe in a matching access tube, hold the probe in the air, away from any other object, with your hands away from the sensors, i.e. set the end of the probe on the floor and hold it upright. For each sensor, press the “High / Air” toggle button . Allow about 10 seconds, then toggle the button off. Values will be within a few thousand of those shown in the example above.
5. Fill the normalization chamber (P/N SEN70056) or a deep bucket with water. If using the normalization chamber, take the probe out of the access tube. For each sensor, slide the probe into the normalization chamber tube such that the sensor is in the center of the tube. If using a bucket, submerge most of the white tube portion of the probe into the center of the bucket. Do not submerge the blue portion of the probe, or allow the electronics to get wet. Press the “Low / Water” toggle button . Allow about 10 seconds, then toggle the button off. Values will be within a few thousand of those shown in the example above.
6. Set the SDI-12 probe address in the lower right area of the IPConfig window. The SDI-12 address is used in the datalogger program. If only one probe is to be used on a datalogger SDI-12 input channel, you may leave the address at “0.”
7. Press “Write to Probe” in the lower right of center of the window.
8. Press “Backup Configuration” in the lower left of center of the window. Use the default file name.

## B.1.2 TriSCAN Normalization

When normalizing TriSCAN sensors for water content, follow the procedure in B.1.1 using distilled or deionized water in step 5. As illustrated in FIGURE B-5, the same procedure is followed when normalizing TriSCAN sensors for salinity.

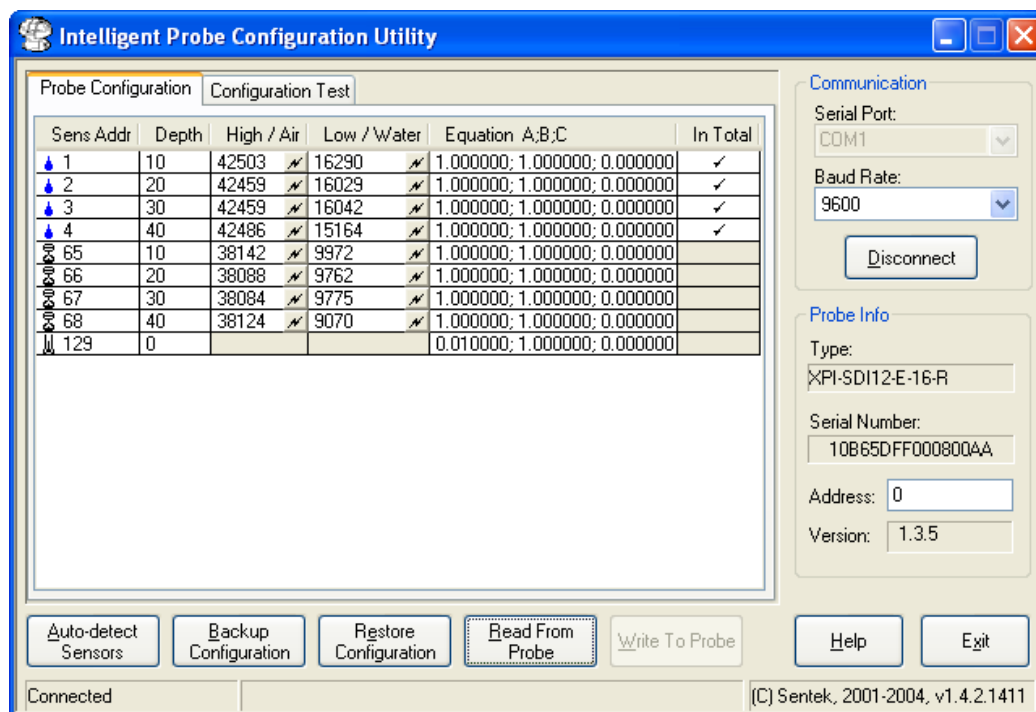


FIGURE B-5. IPConfig Probe Configuration Window for TriSCAN



## B.2 Configuration Testing

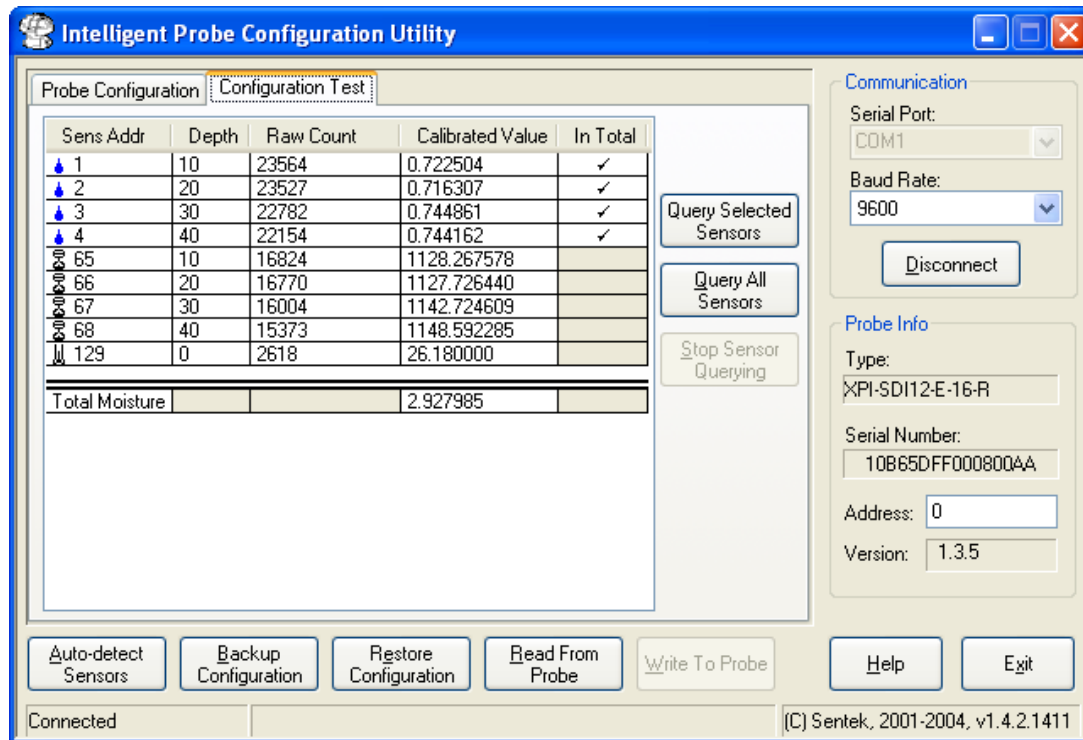


FIGURE B-6. IPConfig Configuration Test Window

Test the configuration by going to the “Configuration Test” tab as shown in FIGURE B-6. Again, with the probe in the access tube, hold the probe in the air, then press “Query All Sensors.” Press “Stop Sensor Querying” when values appear in the window. Raw counts should be close to the values shown in the example above.



# ***Appendix C. Access Tube Installation***

---

The information below is a summary. Further information is provided in the Sentek Diviner2000® Installation Guide Version 1.0, available as a .PDF file from Campbell Scientific, Inc.

Sensors must be installed correctly into the soil medium. The soil around the sensor needs to be representative of the rest of the field.

The aim of the installation is to cause minimum disturbance to the crop and soil profile. Disturbances to the soil may produce pockets of air or loosely packed soil material. These conditions will cause preferential flow of irrigation water or rain to a greater depth compared with the rest of the field. Access tubes must be installed to fit tightly in the soil along their entire length.

Permanent errors can be introduced into the measurements through poor or hasty installations. Air gaps existing between the sensors (or access tubes) and the soil will bias sensor readings, i.e. the sensor will read high when the air gaps are filled with water and low when they drain. Poor installation is a primary source of inconsistencies between sensors.

The additional time taken in careful installation ensures access to accurate and meaningful data. Sentek has developed precision installation tools to be used for the installation of Sentek access tubes. The precision of the access tubes and tools is designed to complement the high value of the readings taken by the Sentek sensors.

---

## **CAUTION**

Sentek access tube installation tool kits are not designed to withstand the stresses often required by installations in dry clays. While the tools should withstand the installation of a few tubes, expect tool failure, resulting replacement costs, and occasional distorted and unusable access tubes.

---

Access tubes are to be installed at monitoring sites chosen using a series of proven evaluation methods. Monitoring sites must be selected so that information gathered from them is representative of surrounding crop / ground cover water use and soil water capacity. Appendix [D](#) discusses site selection.

Always try the standard manual installation method first. Alternatively, a slurry method is available for installations in soils with high stone and gravel content. However, the slurry method may have an impact on soil moisture readings at those sites.

To identify the tools required to install access tubes, examine the soil profile with a shovel or backhoe at the proposed monitoring sites.

---

## **NOTE**

An access tube is required for obtaining air readings in the probe normalization procedure. Campbell Scientific recommends that you perform the normalization procedure as described in Appendix [B](#) prior to installing all available access tubes.

---

## C.1 Standard Access Tube Installation

### C.1.1 Installation Tools

#### Toolkit items

Installation Toolkit No. 1

#### Items ordinarily required

1 x Regular Auger 47.0 mm

1 x Auger Cleaning Tool (small)

2 x Auger Extension Rods 0.5 m

3 x Auger Extension Rods 1.0 m

1 x Regular T-handle

2 x Tommy Bars

1 x Access Tube Cleaning Tool No. 1 – spiral

1 x Access Tube Cleaning Tool No. 2 – foam

1 x Access Tube Cleaning Tool No. 3 – rag tool

1 x Access Tube Cleaning Tool No. 4 – nylon brush

1 x Access Tube Bailer

1 x Expandable Bung Tightening Tool

1 x Dolly No.1

1 x Access Tube Cutting Tool No. 1

1 x Access Tube Cutting Tool No. 2

1 x Toolbag No. 1

#### Safety items

1 x Pair of Gloves

1 x Pair of Safety Goggles

1 x Plastic Sheet

#### Additional items for difficult soils

1 x Regular Auger 53.0 mm

1 x Regular Auger 56.0 mm

1 x Regular Auger Cleaning Tool – large

#### Installation Toolkit No. 2

1 x Access Tube Installation Tripod

3 x Tripod Anchor Pins

1 x Base Plate

1 x Auger Centralization Poly Guide

1 x Dolly No. 2

1 x Dolly No. 3

1 x Toolbag No. 2

### C.1.2 Installing the Access Tube

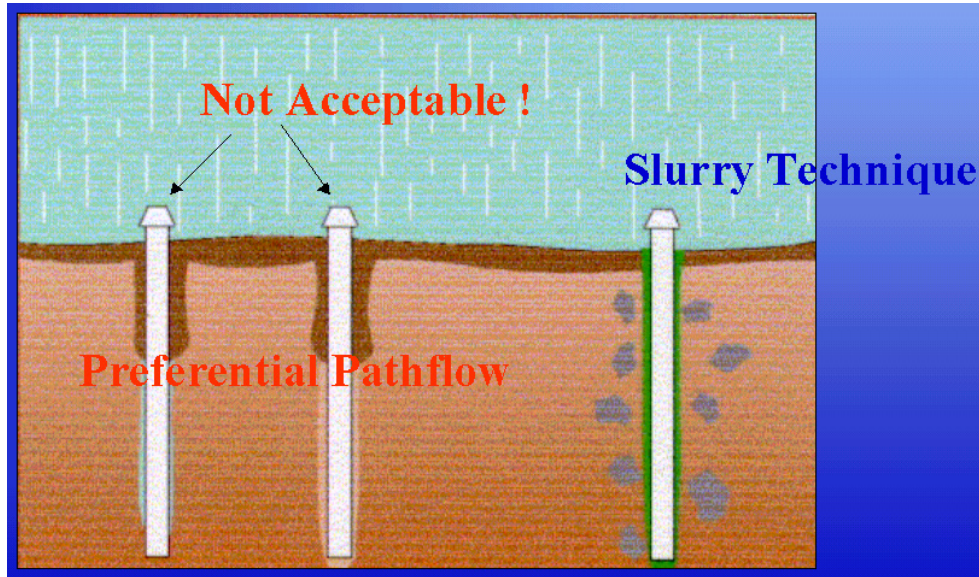


FIGURE C-1. Incorrect Installation

To install the access tube, follow these steps (requires tool kits #1 and #2):

1. Put on the gloves.
2. Put on the safety goggles.
3. Select the 47 mm regular auger head.
4. Select the required extension rods and screw the auger head and the t-handle to the extension rods. The length of assembled auger must exceed the length of the access tube by at least 20 cm.
5. Insert the auger into the access tube while the tube is lying on the ground until the auger head protrudes by 20 cm.
6. Use a marking pen to mark the auger extension rod at the point where it disappears into the top of the access tube.
7. Remove the auger from the tube.
8. Select the yellow cutting edge and push it into the end of the access tube ensuring it fits squarely. Note: If you experience difficulties fitting the cutting edge onto the tube (1) turn the cutting edge on its side and, with a twisting motion, shave a layer of PVC from the lip of the access tube; and (2) carefully bounce the access tube and the partially fitted cutting edge on the side of the sledgehammer head.
9. Insert the access tube with fitted cutting edge into the tripod guide tube.
10. Select dolly no. 1 or dolly no. 2 and insert it into the top of the access tube.

11. Use a sledgehammer to tap the dolly until the access tube is embedded approximately 5-10 cm into the soil.
12. Place the auger inside the access tube and turn the auger handle. Auger ahead of the access tube by approximately 20 cm (until the pen mark made in Step 6 is flush with the top of the access tube).
13. Take the auger out of the tube and empty the soil using the small auger cleaning tool no. 1.
14. Select dolly no. 1 or dolly no. 2 and re-insert it into the top of the access tube.
15. Use the sledgehammer to drive the access tube further into the pre-drilled hole.
16. When you reach the bottom, remove the dolly. Again, auger ahead of the access tube by approximately 10-20 cm. Alternate between auguring and hammering until the dolly resting on top of the access tube touches the top of the tripod.
17. Insert dolly no. 3 and continue hammering and auguring until the mark on the dolly is level with the top of the tripod.
18. Remove the tripod by inserting the tommy bars into the holes of the tripod pins and pulling them upward with a twisting motion.
19. When all pins are removed carefully lift the tripod straight upward and off the access tube.
20. Try twisting and moving the access tube. It should not move. There should be no air gaps.
21. If there is an air gap, retrieve the access tube and start the installation process again at a site that is at least one meter away from the failed installation.

### **C.1.3 Cleaning the Access Tube**

The access tube must be cleaned before the top cap is installed and readings are taken. The bottom stopper is installed after cleaning in all soils except very wet and saturated soils. The type of soil at the installation site will determine which of the three cleaning methods is to be used. For instance, if you have dry/moist sandy to loamy soil conditions:

1. Detach auger head and attach cleaning tool no. 2 – foam.
2. Plunge foam tool up and down length of access tube.
3. Remove loose soil, dry sand, etc. from the bottom of the access tube by using cleaning tool no. 1.
4. Turn tool few times at the bottom of the access tube until sand collects on top of the spiral. Pull tool up and retrieve the material.

5. Select Access Tube Cleaning Tool no. 3 — rag tool. Insert a clean cotton cloth into the eyelet and saturate with denatured alcohol. Move this tool up and down the access tube to clean off the final dirt residue from the access tube.
6. After cleaning the tube, use a flashlight to inspect the inside of the access tube. You should be able to see clean walls and the lip of the cutting edge at the bottom.

### **C.1.4 Installing the Bottom Stopper Bung**

The bottom stopper bung is installed after the access tube has been cleaned. To install the bung:

1. Ensure access tube is clean.
2. Partially insert bung into access tube and hold it at the upper end so 75% of the top rubber ring is within the access tube.
3. Tighten the wing nut to the point where there is enough friction on the wall of the access tube to prevent the bung from turning in the tube while the wing nut is tightened.
4. Attach the bung tightening tool and auger extension rod and use the tommy bars to tighten it firmly to the extension rods.
5. Place the bung tightening tool over the wing nut and slowly push the bung down the access tube. Allow air to escape until the bung rests on top of the internal cutting edge on the inside of the tube.
6. Slowly turn t-handle until you feel resistance to turning when the bung is sitting tight.
7. Twist tool clockwise quickly while pulling upwards. This will release the spring on the tool from the wing nut and enable you to pull the tool out of the access tube.

### **C.1.5 Installing the Top Cap**

The top cap assembly is installed after the access tube has been cleaned and the bottom stopper fitted. To install the top cap assembly follow these steps:

1. Ensure the 4 cm of the access tube protruding from the soil is clean on the inside and the outside.
2. With a silicon gun and new nozzle, apply three rings of silicon around outside of the access tube about 1 cm below the top rim of the tube.
3. Unscrew cap from top cap assembly base.
4. Take top cap base and push it onto the top of the access tube with a slight forward and backward rotating motion until the bottom foot of the top cap touches the undisturbed soil surface.

5. Wipe off excess silicon from the inside of the access tube.
6. Screw the cap back onto the top cap housing.

## C.2 Access Tube Removal

Requires tool kits #1 and #3.

1. Unscrew the top cap.
2. Attach t-handle and bung tightening tool to the required auger extension rods.
3. Use tommy bars to tighten t-handle and bung tightening tool firmly to the extension rods.
4. Insert this tool into the access tube until you feel the top of the bottom stopper bung.
5. Turn the tool slowly until the slot of the tool slides over the wing nut, which causes the tool to drop 1 cm downward. The spring on the side of the tool will make sure that enough pressure is applied on the wing nut to enable you to pull the stopper up once the wing nut has been loosened.
6. Turn the t-handle counter-clockwise until you can pull the bottom stopper upwards and remove it from the access tube. If the bung tightening tool starts to unscrew from the extension rod, remove the entire assembly and tighten the connection between the extension rod and the bung tightening tool with the tommy bars.
7. Assemble the tripod.
8. Place the tripod so that the cable is centered over the access tube.
9. Slide the diagonal parts of the tube extraction tool so that they form a cylinder, which will slide the tool into the access tube.
10. Insert the tube extraction tool into the access tube and tap the horizontal bar of the tool with a small hammer.
11. Tapping the horizontal bar of this tool will cause the halves of the cylinder to slide apart and the tool will sedge itself to the inside walls of the access tube.
12. Put on the safety goggles.
13. Place the hook of the cable from the tripod through the upper eye of the extraction tool.
14. Put on the gloves and start turning the handle of the winch.
15. Apply more pressure until you see the upward movement of the access tube.







# ***Appendix D. Site Selection***

---

Site selection is a critical process for all soil water sensors. A properly selected site will reflect changes in soil moisture and plant water use trends over a larger area. This area may be an entire field, sub-section of a field, a crop variety, a planting, a soil type, etc. Putting a sensor in a 'dry zone' or under the influence of a malfunctioning sprinkler will invalidate data.

Site selection is carried out by identifying macro-zones and micro-zones.

Macro-zone selection divides the property in zones according to soil type, soil depth, water holding capacity, and water tables and salinity. Irrigation applications can be specifically tailored to these zones to match soil and crop variability as a macro zone consists of areas with similar crop water use.

Micro-zone selection determines the position of access tubes in relation to the crop and irrigation system and considers the areas of the root zone, canopy spread, water distribution uniformity, and moisture pattern of drip irrigation. Measurements are taken from a small part of the root-zone. If the extent and depth of the root-zone is misjudged and/or when sensors are placed in dry or wet spots associated with a bad distribution uniformity of water, the soil water data will not indicate optimal irrigation scheduling.

## **Important factors to take into consideration for site selection are:**

1. Soil spatial variability
2. Topography
3. Aspect of sloping land
4. Crop type
5. Crop age
6. Crop planting density
7. Size and extent of the effective root system of the crop
8. Irrigation system layout and flexibility
9. Water Distribution uniformity
10. Moisture patterns under drip irrigation.



## ***Appendix E. SDI-12 Commands***

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The SDI-12 EnviroSCAN probe interface communicates with Campbell Scientific dataloggers by way of SDI-12 protocol. A complete treatment of SDI-12 communications for the EnviroSCAN is available from Sentek or Campbell Scientific in the EnviroSCAN & EasyAG SDI-12 Probe Interface Manual. Commonly used commands are listed below. Refer to Edlog and CRBasic help for information on how to use these commands while programming Campbell Scientific dataloggers.

The EnviroSCAN probe interface accepts SDI-12 addresses in the range of “0” to “9”, “A” to “Z”, and “a” to “z”.

| <b>SDI-12<br/>Command*</b> | <b>Function</b>                               |
|----------------------------|---|
| aAb!                       | Change address (for use in terminal emulator) |
| aM!                        | Read soil moisture values 1 to 9              |
| aM1!                       | Read soil moisture values 10 – 16             |
| aM2!                       | Read salinity values 1 to 9                   |
| aM3!                       | Read salinity values 10 to 16                 |

\*where “a” is the probe address





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