Sentek sensor technologies

ACCESS TUBE INSTALLATION GUIDE

Version 1.0

for

EnviroSCAN

EnviroSMART

Diviner 2000

Access Tube Installation Guide

EnviroSCAN

EnviroSMART

Diviner 2000

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About this manual

This guide describes the principles of site selection and the materials and methods that are used to install **Sentek** access tubes.

Document Conventions

Before you start it is important that you understand the conventions used in this manual.

Conventions	Type of Information
Bold text	Bold text is used to highlight names of products and companies, for example **Sentek** or an emphasized word, for example, '**Note**:' or '**Warning'**
This font face	This font face is used for the names of tools, methods and miscellaneous items, for example *Regular T-Handle*.
Text presented under the heading:	
'Note:'	Important information that should be considered before completing an action
'Hint:'	Information that makes a process easier or saves time
Text presented under the heading:	
'Warning:'	Information which, if not strictly observed, could lead to misleading moisture trends and wrong irrigation management decisions. Critical information that must be considered before completing an action.
'Disclaimer:'	Critical information regarding the liability of Sentek and the responsibility of the client to use the equipment responsibly and as described in the manual.
'Caution:'	Information which, if not strictly observed, could result in damage to, or destruction of, equipment.

Disclaimer:

The access tubes, probes and sensors supplied by **Sentek** are specifically designed to be used together. Other brands of probe and access tubes are not compatible with the **Sentek** products and should not be used as they may damage **Sentek** equipment. Damage to **Sentek** equipment through incorrect use will invalidate warranty agreements.

Sentek has developed precision installation tools are to be used for the installation of **Sentek** access tubes. The precision of the access tubes and tools is designed to complement the value of the readings taken by **Sentek** sensors. The value of readings is compromised when poor and hasty installation methods are used.

Sentek does not accept any responsibility for damage caused by incorrect site selection, poor installation or inappropriate use of Sentek products.

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Introduction

The Access Tube Installation Guide provides important information about how to select monitoring sites and install access tubes. Please read this information prior to installing access tubes.

Site selection and access tube installation have a significant impact on the value of the soil moisture data that can be gathered on your property.

Warning: Good Site Selection is Critical

To obtain representative soil moisture readings, the site where the access tube is installed must reflect changes in soil moisture and crop water use trends which can then be used to representatively schedule irrigations over a defined area.

This area may be an entire field or a subsection of a field where irrigation water is applied during a watering shift.

The quality of access tube installation is critical. The access tube must fit tightly against the soil and cause the least possible disturbance to the surrounding soil profile.

To take soil moisture readings, access tubes are installed at monitoring sites, which should be chosen using a series of proven evaluation methods described in the section on **Site Selection**.

It is important to select monitoring sites so that the information that is gathered from them is representative of the surrounding crop water use and soil water holding capacity. At each site, one or several PVC access tubes may be driven into the soil. The access tube prevents the direct contact of the **Sentek** probe with the soil. The bottom stopper and top cap prevent moisture and dirt from entering the tube.

The access tube installation process is described in the section on **Access Tube Installation for Diviner 2000, EnviroSCAN and EnviroSMART**.

Warning: If you do not understand any of the information presented here on Site Selection, consult a trained Sentek reseller or agronomist. Incorrect site selection can result in misleading data and/or crop damage.

Access tubes are installed using **Sentek** precision installation tools designed to install access tubes in a range of soil types. It is recommended that you always try the *Standard manual installation method* first. A *slurry method* is available for installations in soils with high stone and gravel content.

Note: To identify the tools you require to install the access tube, examine the soil profile with a shovel or backhoe close to the nominated monitoring sites. Read the section on Access Tube Installation for Diviner 2000, EnviroSCAN and EnviroSMART to work out which toolkits and additional tools will be required for your installations.

When the monitoring of a soil profile is no longer required, the access tubes can be removed, cleaned and stored. This process is described in the section on **Removing Access Tubes**.

If you have any questions, **Sentek** recommends consultation with a trained reseller or agronomist prior to installation. Trained resellers and agronomists understand the complexity of site selection for irrigation scheduling and the need for proper installation of the access tubes.

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Site Selection

The key to effective soil moisture monitoring is to select monitoring sites which truly represent irrigation management areas. The same basic site selection principles apply to the full range of **Sentek** soil moisture monitoring devices. Many variables influence the spatial distribution of water across an area of land. These variables and their impact on site selection are discussed in more detail below.

What is site selection?

A site is defined here as:

"The location of the access tube within a field or irrigation shift, where soil water readings are taken at different depth levels within the soil profile."

> **Note**:
> If readings are to be used as a basis for scheduling irrigations over larger defined areas, it is imperative that monitoring sites are representative of these areas.

Soil moisture data can provide information about the:

- Quality and depth of irrigations
- Levels of soil moisture retention
- Depth of the crop root zone
- Impact of weather and rainfall events on an area

> **Warning**:
> Do not select irrigation scheduling sites at random on your property. Poor site selection will result in soil moisture data that is unrepresentative of soil water changes and crop water use in that field.

Site selection is carried out in two stages:

- Macro zone selection
- Micro zone selection

Relationship between macro and micro zones in the field

Traditional practice within the field and across the whole farm has been for irrigation to be applied on a hypothetical "farm average" – in a similar way to traditional broad acre management practices.

Uniform application of irrigation across areas with highly variable soils and different levels of crop water use causes significant differences in yield and quality, creating commercial losses and environmental harm through increasing problems with rising water tables and increasing salinity.

If different soil types are ignored in terms of their different irrigation scheduling requirements, crop setbacks or failures may occur.

Macro zone selection defines the number of zones on a property where the amount of timing of irrigation applications can be specifically tailored to match soil and crop variability – a macro zone comprises areas with similar crop water use.

Crop water use is governed by many factors such as soil properties, water quality, weather patterns and type of irrigation system. These factors need to be considered when defining the macro zones on your property and are described in the following pages.

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Micro zone selection determines the position of access tubes in relation to the crop and irrigation system.

Micro zone selection considers the:

- Area of root zone and canopy spread
- Water distribution uniformity (sprinkler pattern)
- Moisture pattern of drip irrigation
- Surface, topographic and soil anomalies

The consideration of these factors will assist in finding the best representative position or site for access tube placement within the macro and micro zones.

Macro and micro zone selection is described in greater detail in the following pages. If you require further information, consult your Sentek reseller and/or a trained agronomist.

Important factors you should know that affect crop water use

All the factors listed below can have an impact on the way the water is stored in the soil and on the way that plants use that water. They affect transpiration and evaporation rates and have a direct impact on irrigation scheduling. In macro zone selection, it is important to consider the way these factors influence water use in a particular area or zone:

- Climate
- Soils
- Crop
- Cultural management
- Irrigation system

Climate

The most commonly recognized factor influencing the amount of crop transpiration is the weather.

Temperature

Crops need to draw up water to compensate for water use through transpiration (water loss through the leaves) and evaporation (water loss from the surface of soil and leaves). The demand increases with increasing temperature up to a maximum threshold for each crop (when the stomata close and photosynthesis stops).

Humidity

Atmospheric demand for transpiration and evaporation is relative to the humidity (amount of water vapour in the air). The higher the humidity level, the lower the demand.

Wind speed

Crop transpiration and evaporation increase with increasing wind speed, creating an increased water demand. At higher wind speeds, transpiration eventually decreases due to stomata closure, but evaporation increases.

Solar radiation

On sunny days, crops can synthesize more basic sugars and more complex plant food compounds, through the combination of atmospheric carbon dioxide and soil-derived water, than on cloudy days. Although crops vary in their sensitivity of photosynthetic response, they all require access to greater amounts of soil water.

Rainfall

Rain is generally associated with higher humidity levels and lower solar radiation and temperatures. It follows that days on which rainfall occurs are associated with lower water demand and use than dry sunny days.

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Notwithstanding the care taken to delineate macro zones, some variability in soil moisture levels is inevitable. For example: on large properties, rain events may cover only a portion of the land area, replenishing some soil reservoirs and leaving others dry.

The aspect or orientation of sloping fields can subject the crop to more or less solar radiation, wind exposure or water run-off – all affecting crop water use.

Soils

An understanding of how soil type influences plant-soil-water-dynamics, and hence irrigation scheduling is important. Intrinsic soil properties are texture, structure, depth, chemistry, organic matter content, rocks and stones and clay mineralogy. Influencing factors include compaction, salinity, water-table development, drainage rate dynamics and topography.

Soil texture

Water storage in the soil profile and the rate it dries out, depends on the soil texture. At one end of the spectrum, sandier soils fill up and drain quickly. Hence these soils, in general, require smaller and more frequent irrigations. In contrast, heavier clay soils replenish and drain slowly and to a higher total water content than lighter (sandier) soils. An infinite range of textures exist between the two extremes. Textures often change within a profile, with the layering of different textural bands playing a large part in determining the water holding capacity of a soil.

Soil structure

Water infiltration rates and air and water permeability within the soil profile are closely related to the size and distribution of soil pores. Porosity in turn, is dependent upon the arrangement and aggregation (binding) of sand, silt and clay particles (soil structure). Soil structure is as important as soil texture in governing how much water and air move in the soil and their availability to crops. Roots penetrate more easily and rapidly in soils that have stable aggregates than in similar soil types that have no or highly developed structures. The effectiveness of soil moisture, air and nutrient utilization is related to the efficiency of root colonization of the entire soil profile.

Soil depth

The effective depth of soil affects the extent of root penetration. The deeper the soil, the greater the volume of soil that is available for gaseous exchange and water uptake. Drainage is also influenced by effective depth.

Soil compaction

Soil compaction from farm machinery can change pore size and distribution resulting from the natural arrangement of the sand, silt and clay particles. This can cause reductions in water infiltration rates, and air and water permeability within the soil profile. The resultant impact upon the effectiveness of root penetration, air exchange and water uptake affects plant growth efficiency and hence water demand.

Salinity

Salinity lowers the osmotic potential, reducing the efficiency with which water and nutrients are taken up by the plant. The dominance of the contributing ions can result in a nutrient imbalance causing deficiencies of essential macro and micro nutrients. The reduced plant health and vigor affect crop water use.

Water tables and drainage rate

Poor drainage can lead to the development of water tables and/or cause a temporarily saturated soil profile. The presence of impermeable soil layers can cause the formation of perched water tables, which saturate parts of the root zone. Efficient gaseous exchange becomes restricted and plant health and water use is reduced.

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Organic Matter

The presence of organic matter and humus increases the cation exchange capacity (CEC), water holding capacity and structural stability of soils.

Soil chemistry

Acid, alkaline, sodic (soils characterized by a dominance of sodium ions) or nutrient deficient conditions impact on expected soil chemical properties. For example:

- pH conditions change CEC and the availability of nutrients (by changing their form). Nutrient deficient plants have a lower water uptake rate
- high levels of sodium can lead to structural collapse, infiltration problems and reduced water availability

Rocks and stones

Stones and rocks and other coarse fragments within a soil profile occupy part of the soil volume and hence reduce the soil water storage capacity. Very stony soils have a substantially lower water holding capacity than soils of the same texture that are free of stones.

Topography

Topography relates to the configuration of the land surface and is described in terms of differences in aspect, elevation and slope. This has an impact on plant-soil-water dynamics via influencing climatic conditions including:

- rain shadows and sunshine hours
- rainfall and temperature patterns up slopes
- elluviation (washing-out) of clays from higher elevations and illuviation (washing-in and accumulation) of clays at lower elevations
- relatively poorer drainage in low lying areas

Crop

Crop differences have an impact on crop water use and irrigation scheduling requirements. While all require management between field capacity and wilting point at most times, the depth of root extraction varies, as do specialized requirements, e.g. the deliberate stressing of wine grapes.

Most plant tissues contain about 90% water and the rate of uptake of water from the soil solution by plant roots is largely controlled by the rate of water loss through transpiration. Plant characteristics such as crop type, size, age, vigour, variety, rootstock, development stage, leaf area, nutritional status, crop load and harvest all affect crop water use. Specialized advice should be sought in this regard. A rough guide to water use can be obtained from crop coefficients, which are widely available in the literature for different growth stages of most crops. These express evapotranspiration as a ratio of reference evaporation.

Cultural Management

The impacts of cultural management (agronomic/horticultural practices) also need to be understood for proper irrigation scheduling.

Soil preparation

Cultivation increases evaporation from the topsoil, reducing the amount of soil water available to the plant. It may also reduce water run-off and improve the infiltration of rain and irrigation water, improving plant water availability.

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Cover crop and mulch

Cover crops provide more competition for water, but reduce evaporation and facilitate infiltration of rain and irrigation water, reducing run-off.

Mulch can improve the infiltration rate of the soil, reduce water run-off, encourage root growth near the soil surface and increase the soil water holding capacity over time, through the accumulation of soil organic matter, and reduce soil temperature.

Oil spraying

Oily substances on leaves reduce water use by temporarily closing stomata. An example of this is mite control in citrus.

Fertilizer management

In order to ensure that no nutrients are deficient, fertilizer applications are normally based on soil and/or leaf sample analyses. The degree of precision varies from a rough averaging approach to precision farming where sample points are matched to requirements using satellite tracking technology. Healthy crops require more water and have different nutrient dynamics to crops that have been stunted or diseased through inefficient fertilizer management.

Pest/disease management

Good pest/disease management keeps the crop protected and in good health, sustaining its potential growth and transpiration rates. Infestations can result in lower than normal water uptake.

Irrigation System

The effectiveness of an irrigation system to deliver water affects crop water use. Variations in irrigation system pressure, flow and water distribution uniformity cause variations in irrigation application. This affects root zone wetting patterns and therefore crop water use.

The preceding crop water use factors should be taken into account when matching your irrigations to areas of similar crop water use. These areas are then represented by soil water monitoring sites and the data collected at these sites is used for irrigation scheduling purposes.

Water Quality

The source and constituents of irrigation water impact on osmotic potential and hence plant water uptake. Water quality can vary both within and between seasons and between water sources. Highly sodic waters can also affect soil structural properties, reducing water infiltration rates.

A general view of macro scale zone selection

Macro zone selection is used to identify the total number of required zones and their locations on your property. A macro zone comprises areas of similar crop water use. The aim of good site selection is to select a monitoring site that reflects changes in soil water content and crop water use trends.

The representative data gained from monitoring sites is used to schedule irrigations over a larger defined area. This area (or macro zone) may be an entire field, or a sub-section of a field, where irrigation is applied during a watering shift.

As an irrigator, you want to replenish the soil water used by plants for growth and transpiration. So, it is important to understand the many factors that affect crop water use or transpiration, and how these factors may vary on your farm.

A primary goal of good irrigation management is to match irrigations to areas with similar crop water use, within the limits of your irrigation system flexibility. This consideration will ultimately determine how many monitoring sites you will need and where you should locate them.

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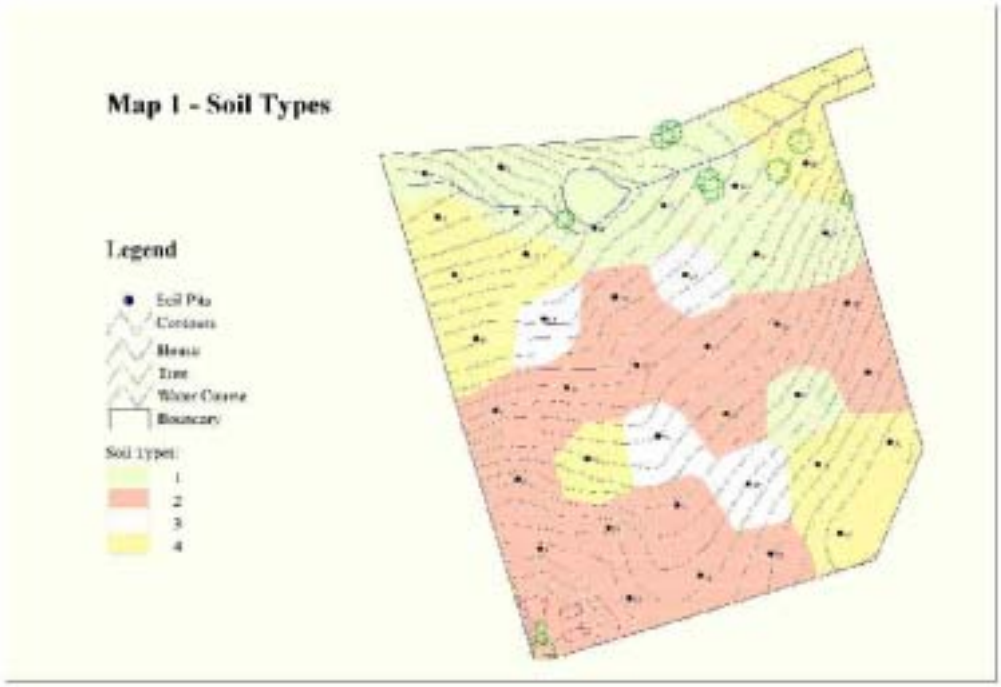
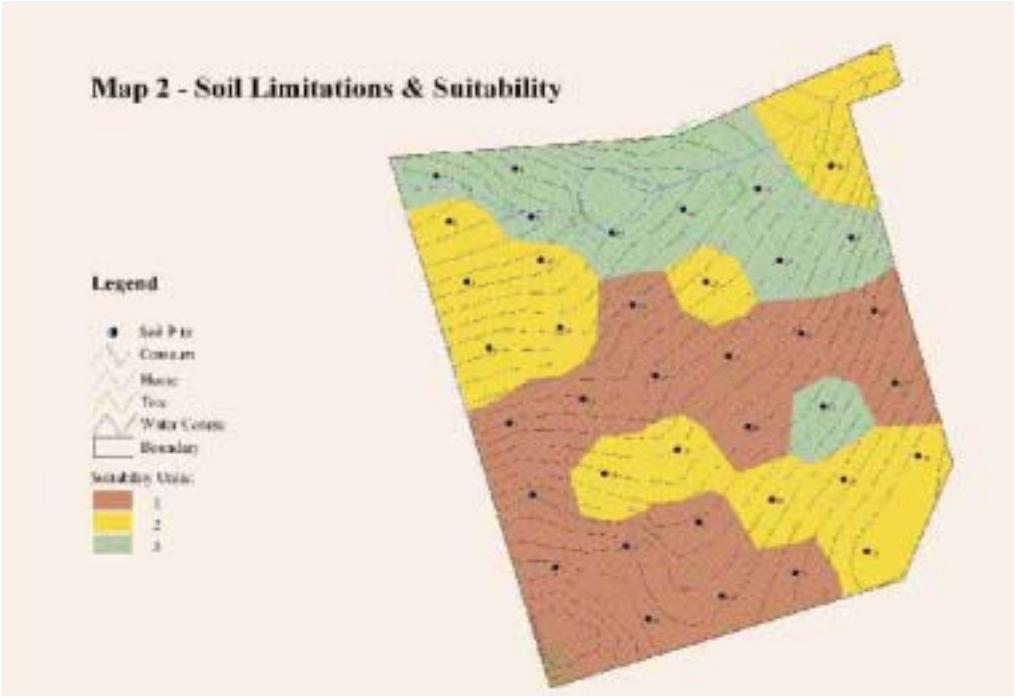
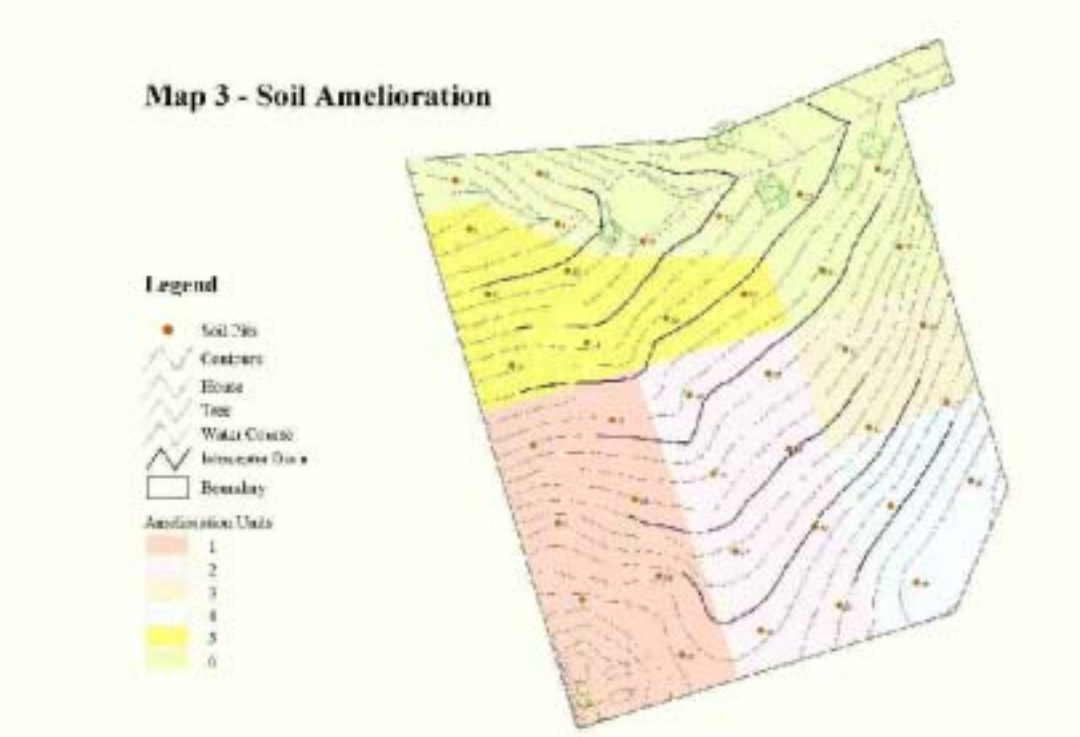
The diagrams on the following pages show an example of how 'factors that affect crop water use' can be used to determine macro zones. Consult your local soil specialist for further information on the soils at your site. Firstly the soil properties and types are considered, to differentiate between areas of varying soil-water properties:



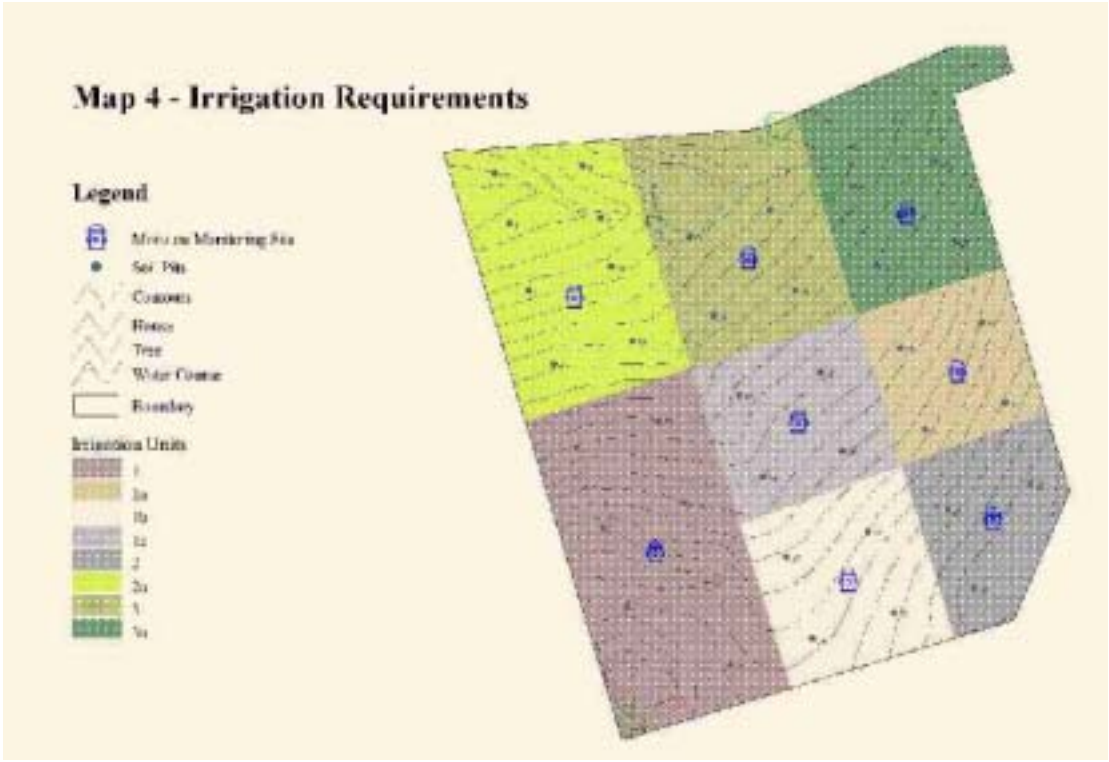
Then the soil limitations and suitability for the proposed use are identified in order to determine the need for soil improvements and amelioration:



From this the requirements for soil improvements and amelioration are outlined:



Once the soil has been ameliorated and improved, then the altered soil properties are considered in conjunction with the topography, irrigation system and crop types to delineate irrigation management units.



Overlaying all this information makes it possible to identify, within a property, areas (zones) that have significantly different requirements.

In the example used, the property has been divided into eight macro zones. Each macro zone requires a monitoring site. Potential sites are shown by the dots, but final positioning can be determined by the information in the micro scale zone selection.

Micro scale zone selection

With macro zone selection you have identified the irrigation management units on your property. Micro scale zone selection is used to target the actual site of the access tube in relation to crop, micro-scale soil variability and irrigation delivery point.

> **Note**: Micro zone selection is equally as important as macro zone selection and has a direct effect on the representative value of the data.

In soil-based monitoring the measurements are taken from a small part of the root zone. Sentek sensors record the dynamics of moisture in the part of the soil profile where the access tube has been installed. If you miss the root system or install the access tube in dry or wet irrigation spots, the data will not make sense and cannot be used for irrigation scheduling, as it will not be representative of an entire irrigation management unit.

Soil moisture monitoring instruments are often blamed if there is no increase in moisture content after an irrigation, but testing will almost always show that the siting of the equipment is wrong. For example it is common to find that the access tube is placed in a dry spot, cause by a sprinkler system having a poor distribution uniformity. Also, on sloping ground, the lateral movement of water needs to be taken into consideration when siting the access tube.

Where there are variations in the micro relief or soil properties and depth over very small distances that affect the root distribution and growth of the plant (e.g. in gilgai soils), it may be necessary to install more than one soil moisture probe in the same area to represent these variations.

Micro zone selection guidelines

Following is a set of guidelines for selecting access tube installation sites within irrigation management units. Three major factors need to be taken into account; irrigation, plant health and soil type.

Irrigation system

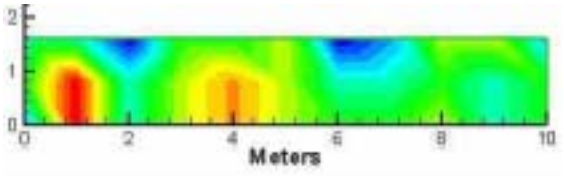
It is important to check that your irrigation system is performing as per the design specifications prior to installation. Variations in sprinkler pressure and flow, pump performance, distribution uniformity and wind can result in uneven patterns of watering and irrigation depths. This can lead to salinity problems, development of water tables, water logging, root death and an overall decline in crop health, yield and quality.

Before you commence irrigation scheduling make sure your irrigation system performance is at an acceptable level. Read the recommended literature (Merriam & Keller, 1978) to perform detailed checks on irrigation systems or contact your irrigation consultant or Department of Agriculture for further advice. It is important to check your irrigation system at least once a year.

Conducting a distribution uniformity (DU) test

Prior to installing the site, it is also necessary to check the distribution uniformity of the system. The uniformity of water distribution from sprinklers can be checked with a simple can test. The method involves arranging cans in a grid pattern within the wetted area and measuring the volume of water in each can.

In the example illustrated below, cans in the blue shaded area received above average water; those in the red shading below average; while those in the green shaded area received an average amount.

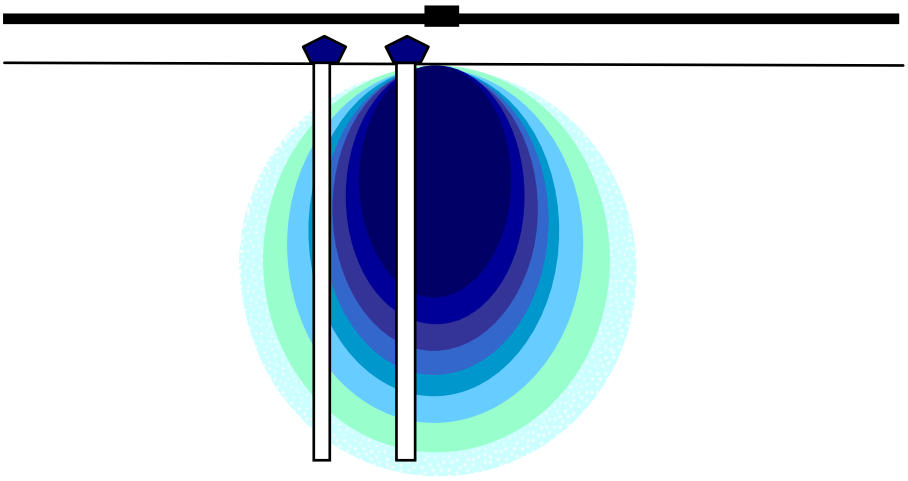


Due to the specific nature of each site in terms of irrigation system, it is inappropriate to give prescriptive advice on tube placement. For soil moisture monitoring, tube placement should however, be representative and consistent of the area being watered. General guidelines for commonly used systems and principles of sample site selection follow.

For sprinkler systems, it is preferable to use two access tubes per site, placing one into an area receiving average precipitation and the other one into a wet or dry spot, depending on a soil salinity or water table problem.

In centre pivots, if the distribution uniformity tests show significant variation between booms, two or more access tubes should be installed, with at least one tube in each different area. For high pressure rain guns, measure the water application pattern under different wind conditions to ensure that you don't pick on area of extremely low or high water application.

Installation of probes in drip irrigated crops needs consideration of the extent of the 'wetting onion.' Use at least two probes to monitor soil moisture of drip irrigated crops to measure both the vertical and the lateral spread of water. The schematic below shows an example of the variation in the wetting pattern below a dripper. The darker blue colour signifies wetter soil conditions, while the lighter blue colour signifies drier soil conditions. The plant roots will utilize the water from different locations under the dripper at different intervals; therefore it is very important to measure these differences using more than one probe.



In addition, in drip irrigation, the slope needs to be taken into consideration, to account for movement of water down slope.

In furrow irrigated fields, access tubes should be installed 50 to 100 metres away from the head ditch. Access tubes should not be installed solely at the opposite side to the head ditch, as tail water from the irrigation may back up the furrows and give unrepresentative readings. Placement of tubes here may be considered when measurement of deep percolation below an irrigation field is required. Consideration should also be given to placing another tube in the middle of the field to measure the depth of irrigation there.

Plant health

Select a site next to an average-sized, healthy plant representing the *Irrigation management unit*. Avoid:

- Stunted or sick plants
- Unusually large plants or trees
- Spots where plants are missing

General guidelines for key crops include:

- In field crop and vegetable production, choose a uniform crop stand, and ensure that the probes are inserted within the actively growing root zone.
- In orchards, use two access tubes to monitor the site. Place one access tube under the canopy of the trees and another outside the canopy – there will be some interception of rainfall by the canopy so less rain water will penetrate the ground directly under the canopy. Select a site that represents dynamic data trends (more root activity) and again consider irrigation distribution uniformity.

Soil properties

Soil properties influence probe placement in drip irrigation, as the wetting pattern is highly dependent upon the soil. In uniform sands, most of the water applied under the dripper will tend to move vertically through the profile, with minimal lateral spread. Conversely, in uniform clay soils, the water will tend to spread laterally as well as vertically. In soils of contrasting textures, there will be varying wetting patterns that need to be taken into consideration.

In many soils there are substantial variations in the thickness of horizons and in the potential rooting depth. This can lead to significant variations in soil water storage capacity and plant growth over relatively short distances. Under these conditions, it is recommended to install to two access tubes to ensure that this variability is taken into account.

Other micro zone selection considerations

There are several other factors when considering micro zone selection that also need to be taken into consideration. These are:

- Do not install access tubes in outside rows. These locations are usually exposed to wind and dust, particularly in the vicinity of roads or adjoining broad-acre properties.
- Avoid the 'drip ring' in, for example, citrus orchards, where sprinkler irrigation water is channeled by the canopy to the outside bottom edge of the foliage creating wetter soil conditions at the edge of the canopy.
- Avoid wheel tracks (and wheel track rows) as the soil is more compacted in these areas and stores less readily available water than the rest of the field (non wheel track rows).

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Installing access tubes for Diviner 2000, EnviroSCAN and EnviroSMART probes

Introduction

It is necessary to install **Sentek** access tubes before **Sentek** sensors can be used to measure volumetric soil water content. Access tubes are installed at selected sites using **Sentek** installation tools. The tools are specific to the installation method so it is important to understand the installation method before purchasing your installation tools. A slurry installation method may be used for soil with a high gravel and stone content.

> **Note**:
>
> Inspect the soil types on your property **prior** to undertaking an installation to ensure that you have the correct tools. The standard installation kit is designed for installation in most soil types, but in some situations such as very heavy clay or rocky soils, additional tools may be required.
>
> Once you have identified your soil properties, read the relevant section of this manual to determine what tools you require.
>
> If you are unsure about any aspect of the installation method, contact your Sentek reseller and discuss the sites you have selected and your installation needs.

The aim of the installation process is to cause minimum disturbance to the surrounding crops and soil profile. Disturbances to the soil may introduce pockets of air and loosely packed soil material. The disturbances affect the contact of the outer surface of the access tube with the surrounding soil profile and may lead to preferential flow of irrigation water or rain to a greater depth compared with the rest of the field. If readings are taken under disturbed soil conditions they may by incorrect or misleading.

> **Warning**:
> Access tubes must be installed so that they fit tightly in the soil along their entire length. Permanent errors can be introduced into the readings through poor or hasty installations. Any air gaps between the length of the access tube and the soil will cause data deviations.
>
> For example, the penetration depth of an irrigation appears to be much deeper if there is an air gap next to the access tube. This misrepresents the depth of the irrigation in the field at that site.
>
> The addition time taken in careful installation ensures access to accurate and meaningful data.

Disclaimer:
The access tubes, probes and sensors supplied by **Sentek** are specifically designed to be used together. Other brands of probe and access tube are not compatible with the Sentek products and should not be used as they may damage **Sentek** equipment through incorrect use and will invalidate warranty agreements.

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 readings taken by the **Sentek** sensors. This value of both relative and absolute readings is compromised when poor and hasty installation methods are used.

Safety

Sentek encourages the use of safe practices that minimize the risk to users, their machinery and their property. The following safety information is provided to help you prevent accidents on your property.

Carrying equipment into the field

An access tube installation requires access tube kits, toolkits, miscellaneous tools and duck boards. Often you cannot drive a vehicle alongside the installation site so it is important to consider how you will get the required equipment to the site.

The toolkits come in cases that protect them from the elements and from general damage. These kits have handles to help you carry them into the field. It is important to carry the longer kits in a way that does not place undue stress on your body nor damage crops.

When carrying equipment into the field remember to:

- Bend your knees and keep your back straight when lifting
- Make several small trips rather than trying to carry too much at one time

Working with installation equipment

It is important that you wear gloves and safety goggles to protect your hands from burns and to prevent your eyes from penetration injuries caused by splinters of metal or soil.

When using motors to drive augers, ensure you wear ear protectors to minimize the affects of the motor on your hearing.

Protecting and caring for equipment

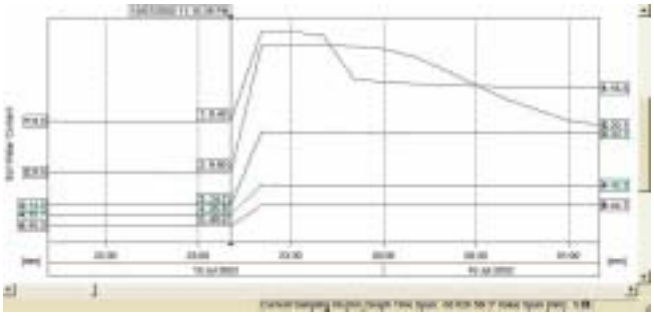
There are numerous items in the various toolkits. It is important to keep all of the items clean and to put them away in their protective cases when not in use.

Good versus poor installation

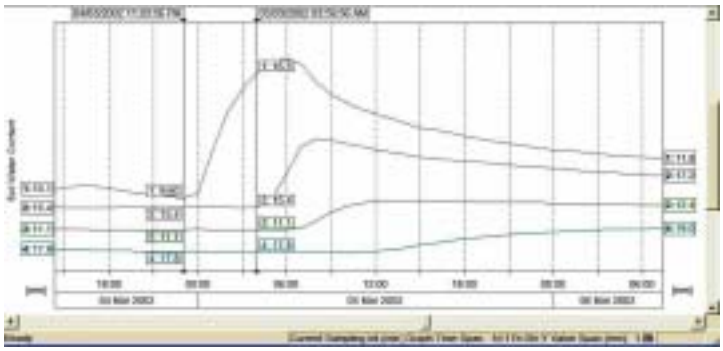
The aim of any installation is to cause as little disruption to the normal soil structure as possible, and provide an environment where the soil moisture may be detected repeatedly and accurately over an extended period of time.

If the surrounding soil is disturbed during the installation process, then air gaps may form down the side of the tube, which can lead to preferential flow of water between the soil and the access tube. Water will travel deeper than in the surrounding soil, leading to a misleading representation of water movement in the soil.

The figure below shows preferential flow of water down the side of the access tube, where the wetting front moves to the bottom sensor almost instantaneously.



The movement of wetting front should match the hydraulic properties of the soil, such as shown in the example below.



Standard manual installation method

Introduction

The *Standard manual installation method* is recommended for most soil types. In this method the access tube hole is hand augered into the soil, through and slightly ahead of the access tube. This is done using the *47.0 mm Regular Auger*. The augered hole is slightly smaller than the access tube. The access tube is fitted with a cutting edge that cuts the last of the soil away, providing a tight fit down the length of the access tube.

This method prevents the formation of air pockets along the length of the access tube and causes minimum disturbance to the surrounding soil profile. This installation method is proven to be the most reliable and provides the best soil moisture data.

Items required for standard manual installations

Sentek has developed a set of installation tools specifically for the installation of their access tubes. An installation requires:

- **Sentek** access tube items
- **Sentek** toolkits
- Miscellaneous items

Each toolkit comes in a protective carry case. Items that look similar are marked with their measurements for easy identification. Protective tubes are included to encase augers and other sharp tools. This protects them in transit and prevents damage to the tool bag.

All tools required for the Standard manual installation method are contained in the Standard Access Tube Installation Kit Complete. The tools are supplied in two carry bags.

Read through the installation method to identify the tools, cutting edges and bottom stoppers you will need and ensure you have those tools before proceeding to the installation site.

Sentek access tube items

Item		Part Number
Diviner 2000		
Access Tube Kits at ordered lengths (includes Access Tubes, Cutting Edges, Top Cap Assemblies and Expandable Bungs)		11720, 11700, 11710
EnviroSCAN & EnviroSMART		
Access tubes at ordered lengths		20510, 21010, 21510, 22010
Cutting edges		80035, 80040
Top cap assembly complete		22400
Expandable bungs		22455

Toolkit items

Item		Part Number
Standard Access Tube Installation Toolkit Complete		07000
Part A – Auger Kit, includes:		07050
1 x Regular Auger 47.0 mm		70135
1 x Regular (clay) Auger 53.0 mm		70140
2 x Auger Extension Rods (0.5 m)		70125
1 x Auger Extension Rod (1.0 m)		70130
1 x Regular T-handle		70150
2 x Tommy bars		70190
1 x Access tube rag cleaning tool		70110
1 x Access tube brush cleaning tool		70112
1 x Access tube bailer		70195
1 x Expandable bung tightening tool		70160
1 x Extraction tool		70305
1 x Toolbag No. 1		70100

Part B – Tripod Kit, includes:		07150
1 x Access tube installation tripod		70230
3 x Tripod anchor pins		70215
1 x Base plate		70220
1 x Auger centralisation poly guide		70225

1 x Nylon dolly		70205
1 x Heavy duty dolly		70210
1 x Toolbag No. 3		70300

Miscellaneous items (installer to supply)

- A ***length of rope*** – to tie branches or vines temporarily out of the way so that they do not get damaged or interfere with the augering process
- A set of ***duck boards*** – to prevent soil compaction around the access tube during the installation process
- 1 x ***sledge hammer*** – to drive the access tubes into the soil. A 3-4 kg (8-10 lb) hammer is recommended.
- 1 x ***measuring tape*** – to measure the required depth
- 1 x ***marking pen***
- 1 x ***10 litre (2 gallon) bucket*** – to collect the augered soil and remove it from the site
- 1 x ***flashlight (torch)*** – to inspect the inside walls of the access tubes after the cleaning process
- 1 x ***notepad and pencil*** – to record the depth and texture variation throughout the soil profile and any other site information
- ***Methylated spirits*** – to moisten the cloth used with the access tube rag cleaning tool to remove possible water and mud from the walls of the access tube, if required.
- ***Cotton cleaning cloths*** – to clean the inside of the access tubes and other tools after installation.
- ***Silicon glue*** – to seal the base of the top cap to the top of the access tube.

Installation procedure

Step 1 – Preparing the site

In all installations, disturbance to the surrounding crops and soil profiles must be minimized because soil compaction alters the capacity of the soil to absorb water.

1. Use duckboards at the site
2. Use ropes to tie crops out of the way if necessary

Step 2 – Assembling the tripod

The tripod keeps the auger in a stationary central position and prevents disturbance to the surrounding soil through 'wear out' or hole enlargement. It also stabilises the access tube during the installation process by stopping the access tube from flexing at the point where the access tube enters the soil each time it absorbs a hammer blow. This prevents air gaps from forming along the side of the access tube.

Warning:
This tripod **must** be used to ensure a sound installation using the standard 'through the access tube drilling method.' Any air gaps between the access tube and the soil will give false readings.

To assemble the tripod at the site:

1. Attach the base plate to the base of the tripod.

2. Centre the access tube installation tripod over the site where the access tube is to be installed.
3. Loosen the wing nuts and spread the legs of the tripod until the base plate touches the ground and the lower legs are protruding approximately 5 cm (2 inches) out of the upper leg sections. **Note**: The legs of the tripod can be adjusted for a straight access tube installation on sloping ground or on top of mounds.

4. Secure the tripod in position by driving the tripod pins through the holes in the foot of each leg into the soil using a sledge hammer. **Note**: Ensure the pin head touches the foot plate to ensure the feet of the tripod legs don't move during installation.

5. Check that all the wing nuts are loose. Insert the sledge hammer handle into the tripod cylinder and straighten the tripod by moving the tripod cylinder into a vertical position.

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Watch the bubble in the spirit level on the side of the tripod. Move the handle around until the bubble is located in the centre of the level window.

6. When the tripod cylinder is in a vertical position, firmly tighten the wing nuts of the legs.

Step 3 – Installing the access tube

Access tubes are supplied with 50 cm (20 inches) of extra length to accommodate at least one bottom stopper. In sites severely affected by a water table, two bottom stoppers may be used.

To install the access tube

1. Put on gloves to protect your hands and increase your ability to grip the equipment.
2. Put on safety goggles to protect your eyes from metal splinters, which may dislodge from the installation dolly on hammer impact.
3. Select the *yellow metal cutting edge*. Turn the cutting edge on its side and, with a twisting motion, shave a layer of PVC from the lip of the access tube. Carefully bounce the access tube and the partially fitted cutting edge on the side of the sledgehammer head until the cutting edge fits squarely onto the end of the access tube.

4. Select the *47.0 mm regular auger* head. **Note**: This auger is designed for all soils and should be used **where possible**, even in heavy textured soils, as it provides the best possible access tube installation method. The other augers are used to take over when you run into problems. See the Troubleshooting Section for further information.
5. Select the required extension rods and screw the *auger head* and *T-handle* to the extension rods.

Note: To add extra extension tubes to an existing auger assembly, place the auger on the ground. Insert the *Tommy bar* into the hole of the extension tube below the *T-Handle*. Loosen the extension rod from the *T-handle* using one quick jerk of the Tommy bar. When loose, remove the *Tommy bar* and unscrew these two parts until separated. Screw the additional extension(s) onto the existing auger extension and refit the *T-Handle*.

6. The total length of the auger should be a minimum of 20 cm longer than the access tube. Push the auger through the access tube until the auger head protrudes by 20 cm. Use the *marking pen* to mark the *auger extension rod* at the point where it disappears into the top of the *access tube*. This mark is later used to show the depth to which to auger.

7. Disengage the *metal "tooth"* on the *tripod* by turning the *lever* located on the *tripod cylinder*. The metal "tooth" is designed to prevent the access tube from spinning during augering, and should not be engaged while hammering in the access tube.

8. Insert the *access tube* with fitted cutting edge into the *tripod guide tube*, with *cutting edge* facing downwards.

9. Select the *Heavy duty dolly* and insert it into the top of the *access tube*.
10. Use the sledge hammer to tap the dolly until the access tube is embedded approximately 5-10 cm (2-4 inches) into the soil.

11. Place the *auger* inside the *access tube* and turn the auger handle clockwise to remove the soil from inside the access tube. Continue to auger ahead of the access tube by approximately 20 cm (8 inches). Use the pen mark on the rod to indicate when the desired

depth has been reached. **Note**: If the *access tube* spins while augering, engage the *metal "tooth"* on the tripod by turning the lever located on the tripod cylinder.

12. Use the auger cleaning tool to remove the soil from the auger head. Do not empty the augered soil near the access tube as it may change the infiltration rate of irrigation and rainfall. Dispose of the soil away from the monitoring site.

13. Select the *Heavy duty dolly* and re-insert it in the top of the access tube.
14. Turn the lever to make sure that the *metal tooth* on the tripod cylinder is "disengaged". Take the *sledge hammer* and hit the dolly to drive the access tube further into the pre-drilled hole.

15. When you reach the bottom of the pre-drilled hole, hammering becomes noticeably more difficult. Remove the dolly.

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16. Auger ahead of the access tube by approximately 10 – 20 cm (4 – 8 inches). Alternate between augering and hammering until the dolly resting on top of the access tube nearly touches the top of the tripod.

17. Insert the yellow *Nylon dolly* (which has the same diameter as the access tube) into the access tube and continue hammering and augering until the mark on the dolly is level with the top of the tripod.

Note: Installing the access tube to this depth will enable the base of the top cap to sit flush with the ground. This will position the middle of the first sensor at 10 cm below the ground surface. Sometimes it may be desirable to position the first sensor 5 cm below the ground surface. If this is the case, only hammer in the yellow *nylon dolly* until the mark on the dolly is 5 cm above the top of the tripod.

18. Auger out the remaining soil from inside the access tube.
19. Remove the *tripod pins* by inserting the *Tommy bars* into the holes of the *tripod pins* and pulling them upwards with a twisting motion.

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20. When all pins are removed, carefully lift the *tripod* straight upward and off the *access tube*.

21. Try twisting and moving the tube backwards and forwards while examining the surface soil surrounding the access tube. The tube should not move and there should be no visible air gaps.

22. If there is an air gap, retrieve the access tube and start the installation process again at a site that is at least one metre away from the failed installation.

Note: Clean the tools and return them to the case after use to ensure they are not lost or damaged.

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Step 4 – 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 for very wet and saturated soils. In these soils it is installed first to prevent the rise of water into the tube during cleaning.

To clean the tube

1. Installing an *access tube* in most soil types leaves a thin layer of soil coating on the inside wall.
2. Detach the *auger head* and attach the *Access Tube Nylon Brush Cleaning Tool* to the *auger extension*. Plunge it up and down the access tube using a rotating action. The brush tool will dislodge any soil coatings.

3. Select the *Access Tube Rag Cleaning Tool*. Fold the cleaning tool to its full length and secure it by sliding the locking bracket into place.
4. Insert a clean cotton cloth into the eyelet and saturate it with methylated spirits.

5. Insert the cotton cloth and move the tool up and down the access tube to clean any remaining soil particles from the wall of the access tube. The methylated spirits will also accelerate the drying process on the inside of the tube if the removed soil is wet.

6. Change cotton cloths as required and continue with the cleaning action until inspection with a flashlight (torch) shows that the access tube is clean and dry.
7. **Note**: In sandy soils, it may not be necessary to use the *nylon brush tool* as the access tube can be easily cleaned with the *rag tool*. An alternative is to use a *foam cleaning tool*, which is available as an Optional Extra (refer to section on **Toolkit Items**).

Step 5 – Installing the bottom stopper bung

The *bottom stopper bung* is installed after the access tube has been cleaned in all soil conditions, except for in very wet and saturated soils. In these conditions, the *bottom stopper bung* is installed prior to cleaning.

To install the bottom stopper bung

1. Ensure the *access tube* is clean before proceeding.
2. Partially insert the *expandable bung* into the access tube and hold it at the upper end so that about 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. **Note**: Do not tighten the bung too much as air will be unable to move past the bung and will make it hard or impossible to push to the bottom of the *access tube*.

4. Attach the *Expandable Bung Tightening Tool* to the *auger extension rod* and use the *tommy bars* to tighten it firmly to the *extension rods*.

Caution:
Failure to tighten this tool securely may result in the tool loosening, coming off the extension rod and landing in the bottom of the access tube.

5. Place the Expandable 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 the *T-Handle* until you feel you firm resistance to further turning. **Note**: The bottom stopper bung is designed to run out of thread while tightening. This prevents over-tightening which could cause damage to the walls of the access tube.
7. When the bung is sitting tight, twist the 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.

Warning:
A watertight installation of the bottom stopper bung is essential to prevent moisture and free water entering the access tube. Water inside the access tube will distort soil moisture readings and damage electronic circuitry.

In soils with water tables, it may be necessary to use two bottom stoppers to ensure a totally water tight installation.

Step 6 – 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

1. Make sure the 4 cm (1.6 inches) of access tube protruding from the soil is clean inside and out.

2. Take a silicon gun with a new nozzle and apply three rings of silicon around the outside of the access tube, approximately 1 cm (0.4 inch) below the top rim of the tube.

3. Unscrew the cap from the top cap assembly base.
4. For *EnviroSCAN* and *EnviroSMART* applications, feed the cable through the *FairRite bead* and then through the *cable gland*.
5. Take the top cap base and slowly 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. This will distribute the silicone evenly.

> **Note**: Ensure that no soil, grass or other material is present between the top cap and access tube, as this can provide pathways for water movement through the silicon and into the top cap.

6. For *EnviroSCAN* and *EnviroSMART* installations, ensure that the *cable gland* is pointing in the direction that the cable is to be laid.
7. Wipe off any excess silicon from inside the *access tube*.

8. For *EnviroSCAN* and *EnviroSMART* probes, strip back the outer sheath of the cable until the end of the outer sheath sits just inside the cable gland. Fill around the wires inside the end of the cable sheath with silicone to prevent moisture from travelling along the cable into the top cap. Insert the electronics and connect the cable to the probe interface. For further details on wiring of probes refer to the *EnviroSCAN* and *EnviroSMART hardware manuals*. Position a dry *silica gel bag* on top of the electronics.
9. Screw the top cap back onto the top cap housing. For *EnviroSCAN* and *EnviroSMART* probes, tighten the *FairRite Bead* on the cable next to the top cap.

Troubleshooting the standard manual installation method

The following alternative access tube installation techniques may be used when the Standard manual installation method proves unsuccessful.

Read the description of the problem and its solution. Select the solution that best fits your situation before trying the method. Alternative tools are available to assist in difficult installations and can be purchased separately as optional items (refer to section on **Toolkit Items**).

Moist and sticky heavy clay soils

Under moist and sticky, heavy clay conditions, the standard method of augering through the access tube and hammering in the access tube may be too strenuous using the *47.0 mm regular auger*. If this is the case, use the following installation method.

To install access tubes in moist and sticky heavy clay soils

1. Ensure the tripod is set up correctly and centred over the installation site.
2. Select the *53 mm Clay auger* and the required *extension rods*.
3. Fit the *Auger Stabilisation Poly Guide* over the extension rods and attach the *T-Handle*.

4. Put on gloves and safety goggles to protect your hands and eyes from damage.

5. Insert the assembled auger into the tripod ensuring the *centralization poly guide* is fitted to the top of the tripod cylinder.

6. Turn the auger 4-5 turns and lift it gently approximately five centimetres, then turn the auger another 3-4 turns. The lifting action moves the soil upward, partially filling the space around the auger head and providing a greater uptake for additional soil. **Note**: Do not try to auger too much soil at one time, as the auger may over-fill with soil, making it difficult to remove from the hole.
7. Clean the auger head and repeat the process to the required depth of installation.
8. When augering is complete, check the final depth with a measuring tape to ensure that you have enough depth for your tube length. To position the middle of the first sensor at 10 cm below the ground surface, ensure that 4 cm of access tube is protruding above the ground.
9. Ensure the *yellow metal cutting edge* is fitted squarely onto the *access tube*.
10. Place the access tube fitted with cutting edge in the tripod guide and insert the *heavy duty dolly* into the top of the access tube.
11. To prevent the access tube from flexing, attach *extension rods* to the *Heavy Duty Dolly*, ensuring they are firmly tightened.
12. Drive the access tube into the ground using the sledge hammer. If the driving of the access tube becomes too strenuous, use the *47 mm regular auger* to clean out the soil shavings repeatedly from the inside of the access tube. Continue hammering until you have reached the final depth.

Dry and heavy clay soil

For dry and heavy clay soils the *Dry Clay 56.0 mm auger* (available from Sentek as an accessory item) is used as it cuts only 0.5 mm smaller than the outside diameter of the access tube. This reduces the friction when driving into the access tube. The red cutting edge with a longer neck is used for better stabilization.

To install access tubes into dry and heavy clay soils

1. Ensure the tripod is set up correctly and centred over the access tube installation site.
2. Select the *Dry Clay 56.0 mm auger* and the required *extension rods*. Attach the auger head to the extension rods.

3. Fit the *Auger Centralization Poly Guide* over the extension and attach the *T-Handle*.

4. Put gloves and safety goggles on to protect your hands and eyes from damage.
5. Insert the assembled auger into the tripod ensuring the centralization poly guide is fitted to the top of the tripod cylinder.

6. Turn the auger 4-5 turns and lift it gently approximately five centimetres, then turn the auger another 3-4 turns. The lifting action moves the soil upward, partially filling the space around the auger head and providing a greater uptake for additional soil. **Note**: Do not try to auger too much soil at one time, as the auger may over-fill with soil, making it difficult to remove from the hole.
7. Clean the auger head then repeat the process to the required depth of installation.

> **Hint**:
> If the augering becomes too difficult, attach the Heavy Duty T-Handle and reinforced extension rods, and gently tap the top of the T-Handle with the sledge hammer between auger turns to assist the auger in "biting" into the soil.

8. When augering is complete, check the final depth with a measuring tape to ensure you have enough depth for your tube length. To position the middle of the first sensor at 10 cm below the ground surface, ensure that 4 cm of access tube is protruding above the ground.
9. Fit the **red** *metal cutting edge* squarely onto the access tube.
10. Place the access tube fitted with cutting edge in the tripod guide and insert the *Heavy Duty Dolly* into the top of the access tube.
11. To prevent the access tube from flexing, attach extension rods to the *Heavy Duty Dolly*, ensuring they are firmly tightened.
12. Ensure you have safety goggles on and drive the access tube into the ground using the sledge hammer. If the driving of the access tube becomes too strenuous, use the *47 mm regular auger* to clean out the soil shavings repeatedly from the inside of the access tube. Continue hammering until you have reached the final depth.

Gravelly soils

If you encounter a layer of small stones or gravel and the *47.0 mm regular auger* is unable to proceed, attach the *47.0 mm Open Centre Tungsten Tip Auger*. This auger is capable of breaking up and retrieving gravel of up to thumbnail size under most conditions.

If you encounter larger stones, attach the *47.0 mm rockbreaker* to the r*einforced auger extension rod* and fit the *Heavy Duty T-Handle*. This will allow occasional large stones to be broken.

Under very dry or wet conditions, you may need to attach the *Access Tube Spiral Cleaning Tool* to remove very dry and loose sand or gravel in liquid mud. When you have passed this obstacle you can continue augering using the *Standard Manual Installation Method*.

Extremely dry and loose sand

If you are installing access tubes into very dry and loose sand there could be problems with the augered material falling out of the auger when you pull it out of the access tube. If this occurs use the *Access Tube Spiral Cleaning Tool* as the augering device. The one-turn metal spiral tool does an excellent job retrieving the material in these conditions.

Water tables

On sites with a perched or shallow water table, water will enter the bottom of the access tube hole. Use the *access tube bailer* to remove water and liquid mud between each augering. Lower the bailer into the bottom of the access tube, wait a few seconds for it to fill, then pull the bailer up and empty it into a bucket. You will only be able to dig a certain distance into completely saturated soil, until conditions become too sloppy to continue work. The bottom stopper will need to be ready for immediate installation after retrieving the last auger load.

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Stony Soils

The standard manual installation method is not suitable for stony soils. If you know your soils are very gravely and stony, the Slurry Installation Method must be used (see following pages).

Slurry Installation Method

What are the different slurry methods?

The slurry installation methods are techniques used in soils with a high stone and gravel content. Stony soils are hard to auger and do not break up evenly. Large air pockets form easily when installing access tubes in these soils, causing unreliable readings.

Note:

The slurry methods are suggested for:

- Where the site soil has been tested and found to be high in stone and gravel content
- In access tube installations deeper than 2.5 – 3 m.

> **Warning**:
> Slurry installations are **not** recommended in sandy soils.

A slightly oversized hole is drilled and party filled with slurry. The slurry is a special mud mixture of kaolinite and cement that is poured into the augered hole and fills the spaces where air would normally gather. The access tube is pushed through the slurry and air bubbles move up through the slurry and are released. As the slurry dries, its moisture content balances with the moisture content of the surrounding soils.

> **Note**: The equilibrium with the surrounding soil may not be 100%, however the sphere of influence of the sensor penetrates the 5-10 mm slurry and measures the soil water content of the surrounding soil.

Although you are not measuring the pure undisturbed soil with this installation method, **Sentek** experience has shown that you can achieve good scientific study outcomes and commercial benefits using this method.

> **Warning**:
> If you require absolute data, **Sentek sensors** need to be calibrated with the dried slurry in place, as described in the Sentek Calibration Manual.

Two drilling methods are used for slurry installations:

- Manual slurry installation method – where a slightly oversized hole is drilled into very stony and gravelly soils using a hand auger
- Machine slurry installation method – where a slightly oversized hole is drilled into very stony and gravelly soils using a motorized auger.

The access tube installation is the same for both methods, which are described in detail below.

Sentek has developed a set of installation tools specifically for manual slurry installations (*Slurry Access Tube Installation Kit*).

An installation requires:

- **Sentek** access tube items
- Slurry Access Tube Installation Toolkit

Read through the installation method to identify the tools you will need and understand their use. Ensure that you have the tools you require before proceeding to the installation site.

Note: Slurry installations take some preparation time, and also sufficient time needs to be allowed for the slurry to dry and equilibrate with the surrounding soil before the data can be used. Slurry installations should only be attempted in soils where the standard installation method is not possible.

Items required for slurry installations

Sentek access tube items

Item		Part Number
Diviner 2000		
Access Tube Kits, Slurry (includes Access Tubes, Top Cap Assemblies and Slurry Bottom Stoppers)		11725, 11705, 11715
EnviroSCAN & EnviroSMART		
Access tubes at ordered lengths		20510
Top cap assemblies – complete		22405
Slurry bottom stoppers		22206

Toolkit items

Item		Part Number
Slurry Access Tube Installation Kit, includes:		07250
1 x Auger extension 0.5 m		70125
1 x Auger extension 1.0 m		70130
1 x Slurry auger 61.0 mm		70148
1 x Heavy duty T-handle		70030
2 x Tommy bars		70190
5 kg bag of kaolin clay		80090
1 x toolbag		70400

Additional items for difficult stony soils

Item		Part Number
Open Centre Tungsten Tip Auger 61.0 mm		70045
Rock Breaker 54.0 mm		70025
Auger extension rods re-enforced 1.0 m		70015

Miscellaneous Items (Installer to supply)

Length of rope – to tie branches or vines temporarily out of the way so that they do not get damaged or interfere with the augering process.

Duck boards – to prevent soil campaction around the access tube during the installation process.

Measuring tape – to measure to the required depth

Marking pen

2 x 10 litre (2 gallon) ***buckets*** – to collect the augered soil and remove it from the site, and to mix the slurry in.

Notepad and pencil - to record the depth and texture variation throughout the soil profile and any other site information.

Paint stirrer with electric drill attachment – for mixing the slurry.

Cordless electric drill – to attach to the paint stirrer for mixing the slurry.

Spatula or broad knife – to chip away excess slurry

Slurry Components

Grey cement

Kaolinite (potters clay as fine powder)

Water

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Installation procedure

Step 1 – Glue in bottom stopper

The slurry bottom stopper should be glued into the access tube prior to installation. Allow sufficient time for the PVC glue to dry.

To prepare the access tube

1. Use PVC cleaning fluid to clean the bottom rim of the slurry bottom stopper and the inside of the access tube.

2. Use PVC glue and apply evenly to both surfaces.

3. Insert the slurry bottom stopper into the access tube and hold in place until the glue sets.

Step 2 – Auger the hole

To manually auger the access tube hole

1. Select the required *extension rods* and screw the *regular 61.0 mm (slurry) auger head* and *T-handle* to the extension rods.

Note: To add extra extension tubes to an existing auger assembly, place the auger on the ground. Place one foot on either side of the *T-Handle* and insert the *Tommy bar* into the hole of the *extension tube* below the *T-handle*. Loosen the extension rod from the *T-Handle* using one quick jerk of the Tommy bar. When loose, remove the *Tommy bar* and unscrew these two parts until separated. Screw the additional extensions onto the existing auger extension and then refit the *T-Handle*.

2. Put on gloves to increase your grip on the equipment and to protect your hands from heated metal when installing on hot days.
3. Auger the hole to the required depth.

4. Insert the access tube with slurry bottom stopper fitted into the hole to check the depth level, and then remove the access tube. The top of the access tube should protrude out of the hole by 4 cm (1.6 inches) for the top cap to sit flush with the ground. This will place the centre of the first sensor 10 cm below the ground surface.

Hint:
If you encounter difficulties augering through rocky or stony soils with the *regular 61.0 mm (slurry auger)*, use the *Open Centre Tungsten Tip Auger 61.0 mm* or *Rock Breaker 54 mm Auger*. The *Open Centre Tungsten Tip Auger* is capable of breaking up and retrieving gravel of up to thumbnail size. The *54 mm rock breaker* will allow occasional larger stones to be broken. The 54 mm rock breaker must be used with the *re-inforced T-Handle* and *auger extension rods*.

If you still cannot auger a hole to the required depth, reposition the auger in an alternative site, or use a motorized or mechanical auger to drill the hole.

To drill the access tube hole using a motorized or mechanical auger

1. Select *flight auger rods* and attach a *61.0 mm tungsten tipped drill bit*.
2. Attached the flight auger to a motor or drill rig assembly.
3. Use gloves, ear protectors and safety goggles to auger the hole to the required depth.

Notes on using a handheld motor auger:
Getting the correct hole size in various soils using a flighted auger requires an understanding of what is happening while digging. In moist clay soils (or any soil which tends to adhere to the auger flight) the procedure used will either produce too tight a hole or a correctly sized hole.

No hole should be dug by going straight down, without lifting at intervals to clear the soil from the hole, or an undersized hole may result. The tendency for the soil to re-adhere to the wall of the hole as it moves up the flight will cause the hole to be undersized from the cutter size, making digging forces greater and the effort required to lift the auger out much harder.

To prevent this from happening, add a little water to the hole to “ease” the soil onto the flight each time the auger motor starts to strain and the rotational force becomes hard to hold. Lifting the auger 150-200 mm each time water is added will greatly assist the clearance of the soil up the flight. Stop the rotation for a few seconds each time water is added to the hole to allow time for it to run down the flight to the digging point.

If the job is done correctly, the auger flight should be almost soil free when lifted from the hole. If not then you may assume that too much soil has been retained on the flights and will tend to be forced back onto the wall of the access hole. The walls of the hole should be moist and smooth, not rough.

Digging should be done by starting with a 0.5 or 1.0 metre auger flight. Add 0.5 metre extensions as required.

Note: Sentek does not supply flight auger rods or mechanical augers, but can refer customers to a suitable supplier if required.

Step 3 – Make the slurry

Slurry Recipe

- 1 part grey cement.
- 4 parts kaolinite (potters clay as fine powder).
- 5 parts water

To mix the slurry on site, either take sufficient quantities of each slurry ingredient and suitable measuring utensils to the site or pre-mix the dry slurry ingredients and store them in a plastic container.

1. Measure out 4 parts kaolinite and 1 part cement and mix in a plastic container.

2. Slowly add water and stir with the paint stirrer until all the solids are completely suspended in the mixture. Ensure that no free water is separated from the solids and no dry lumps are left. The consistency of the slurry should be similar to that of a milkshake. The slurry has a working life of approximately two hours.

The quantity of slurry required will depend on the size of the access tube hole and the type of soil. The diameter of the access tube hole will vary depending on the quantity of stone present.

Step 4 – Insert the access tube

To install the access tube in the slurry mixture

1. Insert the sealed access tube into the augered hole. **Note**: At least 4 cm of extra access tube must protrude from the hole for top cap fitting.
2. If more than 4 cm of tube is protruding and you cannot auger any deeper, mark the point 4 cm above the soil surface on the access tube with a marking pen.
3. Remove the access tube from the hole and cut off the excess access tube if necessary.

4. Pour the slurry into the hole until it fills approximately a third to half of the hole.

5. Insert the sealed end of the access tube into the slurry.
6. Push the tube slowly through the slurry allowing air bubbles to escape and the slurry to flow out of the hole. **Note**: When installing access tubes longer than one metre, stop pushing the tube into the hole when approximately 30 cm (1 ft) of tube is left above the hole. Wait a few minutes to let air escape before slowly pushing in the remainder of the tube.

7. If the access tube starts to float back up out of the slurry, take two tent pegs and push them into the soil approximately 50 cm (20 inches) away from either side of the access tube. Stretch thin wire between the pegs and over the centre of the access tube to hold the tube in place while the slurry dries.
8. Allow overflow slurry to dry for a few hours.

Step 5 – Chip off excess slurry

To tidy up around the access tube you may need to do one of the following:

- Take a spatula or broad knife and remove the excess dried slurry from the soil surface. A fine white ring around the access tube, bridging the gap between the access tube and soil should be visible.
- If the slurry has settled and formed a depression in the soil, make up a small quantity of slurry and fill any depressions back up to the level of the natural soil surface and leave it to dry, then chip away any excess.

Step 6 – Installing the top cap

1. Make sure the 4 cm (1.6 inches) of access tube protruding out of the soil is clean on both sides.

2. Take a silicone gun with a new nozzle and apply three rings of silicone around the outside of the access tube about 1 cm (0.4 inch) below the top rim of the tube.

3. Unscrew the top cap from the base of the top cap assembly. For EnviroSCAN and *EnviroSMART* installations, feed the cable through the *FairRite bead* and then through the *cable gland* into the top cap.
4. Take the access tube 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 access tube touches the soil surface. This will distribute the silicone evenly. **Note**: For *EnviroSCAN* and *EnviroSMART* applications, ensure that the cable gland is facing the direction that the cable is to be laid.

5. Wipe off any excess silicone from the inside of the access tube.

6. Screw the cap back onto the top cap housing.

Removing Access Tubes

Access tubes can be removed from a site when the site no longer requires monitoring. The access tubes, top caps and bottom stoppers can be cleaned, stored and reused as required.

The access tube extraction tool can be used in conjunction with either the *Sentek Extraction Tripod*, or with machinery with lifting capacity (e.g. jacks, winches or tractor hydraulics) to remove access tubes.

Items required for access tube removal for EnviroSCAN, EnviroSMART and Diviner 2000

Item		Part Number
Extraction Tools		
Tube Extraction Tool		70305
Sentek extraction tripod*		70310
Additional Tools		
Expandable bung tightening tool		70160
Auger extensions		70125 & 70310
Regular T-handle		70150
2 x Tommy bars		70190

*__Note__: machinery with lifting capacity such as jacks, winches or tractor hydraulics may be used instead of the extraction tripod.

Additional items

1 x ***small hammer*** – to tap the extraction tool into place in the *access tube*.

1 x ***hot air paint stripper*** - to remove silicon from the *top cap*.

Gloves and safety goggles

Removing EnviroSCAN, EnviroSMART and Diviner 2000 Access Tubes

Step 1 – Removing the Bottom Stopper

1. Unscrew the *top cap* from the *access tube*
2. Remove the *EnviroSCAN* or *EnviroSMART* probe from the *access tube*, and carefully place on a clean dry surface.
3. Attach the *Regular T-Handle* and *Expandable bung tightening tool* to the required *auger extension rods*.

4. Use the *Tommy Bars* to tighten the *T-Handle* and *Expandable bung tightening tool* to the extension rods.

5. Insert this tool into the access tube until you feel the top of the *bottom stopper bung*.
6. Turn the tool slowly until the slot of the tool slides over the wing nut, which causes the tool to drop 1 cm (0.4 inch) 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 loosened.
7. Now turn the *Regular T-Handle* **anti-clockwise** until you can pull the bottom stopper upwards and remove it from the access tube. If the *Expandable bung tightening tool* starts to unscrew from the extension rod, remove the entire assembly and tighten the connection between the extension rod and the *Expandable bung tightening tool* with the *tommy bars*.

Step 2– Removing the Access Tube

1. Slide the diagonal parts of the *Tube extraction tool* so that they form a cylinder which will slide the tool into the access tube.

2. Insert the *Tube extraction tool* into the access tube and tap the horizontal bar of the tool with a small hammer. Tapping the horizontal bar of this tool will cause the halves of the cylinder to slide apart and the tool will wedge itself to the inside walls of the access tube.
3. Assemble the *Extraction tripod* so that the steel cable is centred over the *access tube*, or position another lifting device above the *access tube*.
4. Put on gloves and safety goggles.

5. Place the hook of the steel cable from the tripod through the upper eye of the extraction tool. Alternatively use a steel cable or strong chain attached to the other lifting device.

6. Winch the access tube carefully upward and out of the ground.
7. Remove the *Tube extraction tool* from the steel cable or chain, and then remove the *tube extraction tool* from the *access tube*. It may be necessary to gently tap on the top of the extraction tool to loosen it.
8. To separate the *top cap assembly base* from the *access tube*, loosen the silicon with a hot air gun and clean the components with acetone.

Toolkit Items

Sentek access tube items

Part No. 20510 Part No. 21010 Part No. 21510 Part No. 22010	1.0 metre access tube 1.5 metre access tube 2.0 metre access tube 2.5 metre access tube		Sentek precision manufactured access tubes enable measurement of soil moisture without direct contact with the soil. Tubes are manufactured to meet exact specifications of size of wall thickness and diameter to ensure consistency and precision of sensor readings.
Part No. 80035 Part No. 80040	Red Cutting edge Yellow Cutting edge	 	The cutting edge is a knife-sharp, metal cuff and edge that is attached to the bottom of the access tube. The cutting edge is used to cut through the soil as the access tube is driven into the soil profile. The edge of the cutter is designed to cut inward, minimizing soil compaction on the outside of the cutting edge. In this way the bulk-density and soil water storage capacity of the soil to be measured is left undamaged. Yellow cutting edges are for normal soils, red for hard soils.
Part No. 22410 Part No. 22400	Diviner Top Cap Assembly EnviroSCAN and EnviroSMART Top Cap Assembly	 	Each Top Cap Assembly consists of a base and a top. The base is siliconed onto the access tube protruding from the soil. The top is screwed onto the base until the rubber seal is tight enough to prevent the entry of moisture or water into the access tube. The base acts as a datum plate for depth setting and prevents the change of the rotational aspect of the sensor within the access tube. EnviroSCAN and EnviroSMART Top Cap Assemblies are fitted with a cable gland through which the cable is fed and connected to the probe.
Part No. 22455	Expandable plastic bung		The Expandable bungs are pushed to the bottom of the access tube and tightened so that the access tube is sealed against the entry of moisture or water.

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Standard Access Tube Installation Kit Complete (Part No. 07000)

Part A – Auger Kit (Part Number 07050)

Part No. 70100	1 x Tool Bag No 1		The tool bag is a specially designed tool bag that holds and protects all the tools that comprise the auger kit.
Part No. 70110	1 x Access Tube Cleaning, Rag Tool		The access tube cleaning rag tool holds a cotton cloth threaded through the eyelet. The tool is extended down the access tube. This is used to wipe mud and water from the inside wall of an access tube.
Part No. 70112	1 x Access Tube Cleaning, Brush Tool		The access tube cleaning brush tool is a nylon brush tool used to remove stubborn clay shavings from the inside of the access tube wall.
Part No. 70120	1 x Auger Cleaning Tool (small)		The auger cleaning tool is used to quickly clean compacted soil from the auger heads.
Part No. 70125 Part No. 70130	2 x Auger Extension 0.5 m 1 x Auger Extension 1.0 m		The auger extension rods can be screwed into any auger, each other and into the T-handle to provide enough length to auger to a depth of 2.2 metres. Additional auger extensions can be purchased if required.
Part No. 70135	1 x Regular Auger 47.0 mm diameter		The 47.0 mm regular auger is the recommended auger and should be used wherever possible. The diameter measurement is marked on the end of the auger. This auger is used in the Standard Installation Method. It drills through and ahead of the access tube during the installation process. This auger is designed for light and medium textured soils.
Part No. 70140	1 x Clay Auger 53.0 mm diameter		The Clay auger 53.0 mm is only used in moist, heavy clay soil where augering with the 47.0 mm auger becomes laborious and too difficult.

Part No. 70150	1 x Regular T-handle		The T-handle is attached to the auger extension rods, which are attached to the augers to complete the auger assembly. This auger assembly is used to manually drill holes for access tubes.
Part No. 70160	1 x Expandable bung tightening tool		The expandable bung tightening tool is used to tighten or release the expandable bung, which is inserted in the bottom of the access tube to make the bottom of the access tube watertight.
Part No. 70190	Pair of tommy bars		The tommy bars are used to tighten and loosen installation tools to and from extension rods. They are also used to combine or detach multiple extension rods.
Part No. 70195	1 x Access tube bailer		The access tube bailer is attached to a long rope. The bailer is used to empty water and liquid mud from the access tube.
Part No. 70305	1 x Tube extraction tool		The extraction tool is used to grip to access tube for removal from the ground
Part No. 81035	1 x Access Tube Installation Manual		The manual describes the recommended installation procedure in all soil types.

Part B – Tripod Kit (Part Number 07150)			
Part No. 70300	1 x Tool Bag No. 3		The Tool Bag is specially designed to hold and protect all the tools in the Tripod Kit.
Part No. 70205	1 x Nylon dolly		The nylon dolly is used to hammer the last part of the access tube into the ground through the cylinder of the tripod to the final recommended depth marker.
Part No. 70210	1 x Heavy duty dolly		The heavy duty dolly is used to hammer in the access tube during installation. This dolly can also be attached to the auger extension rods. The dolly, fitted to the extension rods, is inserted into long access tubes, where the rods minimize the flexing of the access tube above the tripod during the hammering process.

Part No. 70215	3 x Tripod anchor pins		The 600 mm tripod anchor pins are used to fix the tripod in place during the installation.
Part No. 70220	1 x Tripod base plate		The base plate is attached to the base of the tripod and prevents the tripod from compacting the soil around the top of the access tube.
Part No. 70225	1 x Auger centralization poly guide		The auger centralization poly guide is used to centre the auger extension rod within the tripod during pre-drilling. **Note**: The auger centralization poly guide is only used for installations that do not used the "through access tube installation" method.
Part No. 70230	1 x Access tube installation tripod		The access tube installation tripod is used to stabilize the access tube during the installation process. The tripod prevents the access tube from flexing. Flexing allows air to enter the soil, move along the tube and form air gaps around the installed access tube. **Note**: Do not attempt an installation without the Access Tube Installation Tripod. This item is essential for a sound installation using the preferred "through access tube drilling" method.

Part C – Normalization Container			
Part No. 70060	Normalization container		The normalization container is used to obtain water counts for EnviroSCAN, EnviroSMART, Diviner 2000 and EasyAG probes.

Slurry Access Tube Installation Kit (Part No. 07250)

Part No. 70400	Tool Bag No. 4		Bag specially designed to hold and protect the slurry installation tools.
Part No. 70125 Part No. 70130	Auger Extension 0.5 m Auger Extension 1.0 m		The auger extension rods can be screwed into any auger, each other and into the T-handle. Additional auger extensions can be purchased if required.
Part No. 70148	Regular Auger 61.0 mm (slurry auger)		The regular auger 61.0 mm (slurry) is used in slurry installations where an oversized hole is pre-drilled.

Part No. 70030	Heavy Duty T-Handle		The Heavy Duty T-Handle is a reinforced T-Handle that attaches to the auger extensions, that is designed to withstand light blows from a sledge hammer.
Part No. 70190	Tommy bars		The tommy bars are used to tighten and loosen installation tools to and from extension rods. They are also used to combine or detach multiple extension rods.
Part No. 80090	Slurry Powder (5 kg bag of kaolin clay)		The kaolin clay is mixed together with grey cement and water to form the slurry mixture used in slurry installations.
Part No. 81035	Access Tube Installation Manual		

Optional Tools for Access Tube Installation

Part No. 70015	Auger Extension 1.0 m reinforced		The reinforced extension rods are used with the Heavy Duty T-Handle and the Rock Breaker Tool.
Part No. 70025	Rock breaker 54.0 mm		The 54.0 mm Rock Breaker is attached to the special reinforced extension rods and the Heavy Duty T-Handle and it is used to hammer and break rocky obstacles when drilling an oversized hole for the slurry method.
Part No. 70027	Rock breaker 47.0 mm		The 47.0 mm Rock Breaker is attached to the special reinforced extension rods and the Heavy Duty T-Handle and it is used to hammer and break occasional rocky obstacles when installing using the “through the tube installation” method.
Part No. 70030	Heavy Duty T-Handle		The Heavy Duty T-handle is the hammer base for the Rock Breaker tools. It can also be used in heavy clay soils where augering becomes difficult.
Part No. 70035	Open centre tungsten tip auger 47.0 mm		The 47.0 mm Open Centre Tungsten Tip Auger is designed to be used in gravel and stone soils (where the 47.0 mm regular auger fails), using the Standard manual installation method.
Part No. 70045	Open centre tungsten tip auger 61.0 mm		The 61.0 mm open centre tungsten tip auger is designed to be used in severe gravel and stone soils where the regular 61.0 mm slurry auger fails.

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Part No. 70180	Access tube cutting tool		The access tube cutting tool is a precision PVC pipe cutting tool and is used to cut off any access tube length protruding out of the soil that is not required after the installation process.
Part No. 70310	Access Tube Extraction Tripod		The access tube extraction tripod has a two-stage winch which is used to remove the access tube from the ground.
Part No. 70105	Access Tube Spiral Cleaning Tool		The access tube spiral cleaning tool is a 'one turn metal spiral' tool. This tool is used to auger and retrieve very dry loose sand, mud and gravel from the bottom of the access tube that cannot be removed using the regular auger heads.
Part No. 70107	Access Tube Foam Cleaning Tool		The access tube foam cleaning tool is a foam tool used to remove dust, sand and loose dry soil form the inside wall of the access tube. **Note**: the foam tool should not be used in wet conditions as the foam body will clog and may tear as soil is smeared on the inside wall of the access tube.
Part No. 70122	Auger Cleaning Tool, Slurry		The auger cleaning tool, slurry, is used to quickly clean compacted soil from the 61.0 mm auger head.
Part No. 70145	Dry Clay Auger 56.0 mm		The dry clay auger 56.0 mm is used in very dry, hard and heavy clay soils where installation with the 53.0 mm auger becomes too difficult.
Part No. 70148	Regular Auger 61.0 mm (slurry)		The regular auger 61.0 mm (slurry) is used in slurry installations where an oversized hole is pre-drilled.
Part No. 70155	Light Duty Dolly		The Light Duty Dolly acts as a short hammer base, protecting the top of the access tube during installation. This tool is suitable for use in lighter textured soils and shallower installations up to 70 cm (27.6 inches). The dolly is inserted into the top of the access tube and takes the blows from the sledge hammer which drives the access tube into the ground.

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Recommended Reading

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Hillel, D., 1998, *Environmental Soil Physics*, Academic Press, San Diego, California, USA.

Merriam, J.L., Keller, J., 1978, *Farm Irrigation System Evaluation: A Guide for Management*, Agricultural and Irrigation Engineering Department Utah State University, Logan, Utah, USA.

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