



Stevens® Water Monitoring Systems, Inc.  
*Monitoring Earth's Water Resources Since 1911*



## Installation Quick Start

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Firmware version 2.9

## Comprehensive Stevens HydraProbe User's Manual

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## **1 Installation**

### **1.1 Precautions**

The HydraProbe is relatively easy to install depending on conditions in the field.

Avoid Damage to the HydraProbe:

- Do not subject the probe to extreme heat over 70 degrees Celsius (160 degrees Fahrenheit).
- Do not subject the probe to fluids with a pH less than 4.
- Do not subject the probe to strong oxidizers like bleach, or strong reducing agents.
- Do not subject the probe to polar solvents such as acetone.
- Do not subject the probe to chlorinated solvents such as dichloromethane.
- Do not subject the probe to strong magnetic fields.
- Do not use excessive force to drive the probe into the soil because the tines could bend. If the probe has difficulty going into the soil due to rocks, simply relocate the probe to an area slightly adjacent.
- Do not remove the HydraProbe from the soil by pulling on the cable.

While the direct burial cable is very durable, it is susceptible to abrasion and cuts by shovels. The user should use extra caution not to damage the cable or probe if the probe needs to be excavated for relocation.

Do not place the probes in a place where they could get run over by tractors or other farm equipment. The HydraProbe may be sturdy enough to survive getting run over by a tractor if it is buried; however, the compaction of the soil column from the weight of the vehicle will affect the hydrology and thus the soil moisture data.

DO NOT place more than one probe in a bucket of wet sand while logging data. More than one HydraProbe in the same bucket while powered may create an electrolysis affect that may damage the probe.

### **1.2 Topographical Station Placement Considerations**

The land topography often dictates the soil hydrology. Depending on the users' interest, the placement of the HydraProbe should represent what would be most useful. For example, a watershed researcher may want to use the HydraProbe to study a microclimate or small hydrological anomaly. On the other hand, a farmer will want to take measurements in an area the best represents the condition of the crops as a whole.

Other factors to consider would be tree canopy, slope, surface water bodies, and geology. Tree canopy may affect the influx of precipitation/irrigation. Upper slopes may be better drained than depressions. There may be a shallow water table near a creek or lake. Hill sides may have seeps or springs.



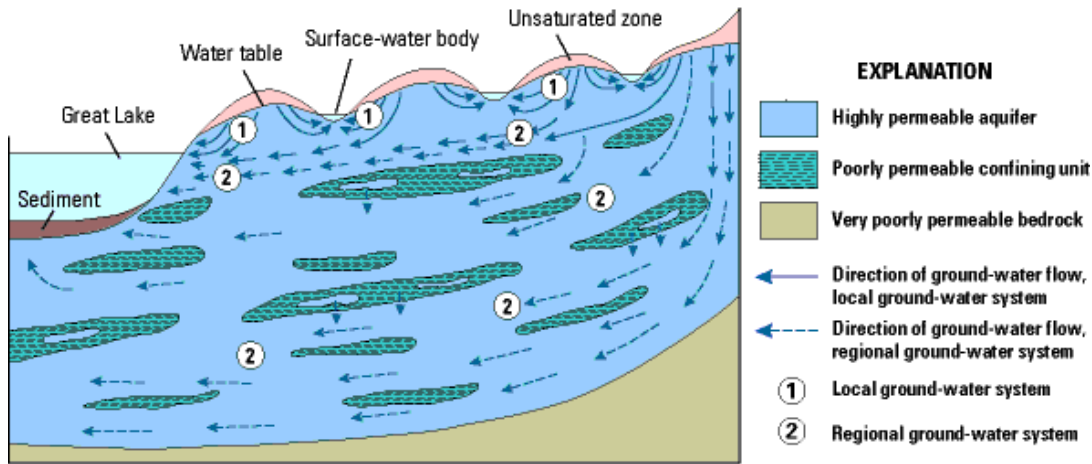


Figure 2.1 Groundwater pathways and Surface water. Taken from USGS Report 00-4008

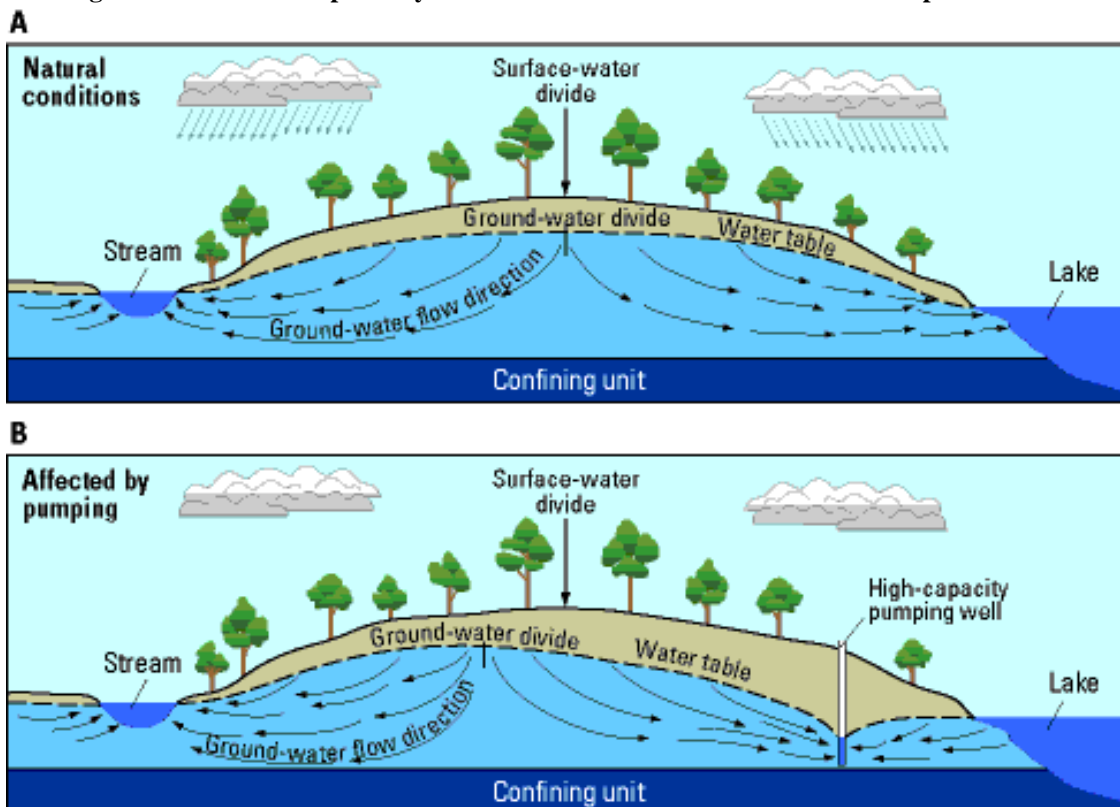


Figure 2.2 Groundwater flow direction and surface water body. Taken from USGS report 00-4008.

Figures 2.1 and 2.2 illustrate subsurface water movement in the water table. The HydraProbe data is most meaningful in the unsaturated zone where soil moisture values will fluctuate. If the water table rises to the depth of the HydraProbe, the HydraProbe soil moisture measurements will be at saturation and will be indicative of the porosity. If the user is interested in groundwater level measurements in wells, a water depth sensor might provide the necessary information.

### **1.3 Soil Sensor Depth Selection**

Like selecting a topographical location, selecting the sensor depth depends on the interest of the user. Farmers will be interested in the root zone depth while soil scientists may be interested in the soil horizons.

Depending on the crop and the root zone depth, in agriculture two or three HydraProbes may be installed in the root zone and one HydraProbe may be installed beneath the root zone. The amount of water that should be maintained in the root zone can be calculated by the method described in section 6. The probe beneath the root zone is important for measuring excessive irrigation and downward water movement.



**Figure 2.3 Six HydraProbes installed into 6 distinct soil horizons.**

The soil horizons often dictate the depths of the HydraProbes' placement. Soil scientist and groundwater hydrologist are often interested in studying soil horizons. The Stevens HydraProbe is an excellent instrument for this application because of the accuracy and precision of the volumetric water fraction calibrations. Soil horizons are distinct layers of soil that form naturally in undisturbed soil over time. The formation of soil horizons is called soil geomorphology and the types of horizons are indicative of the soil order (see table 2.1) Like other natural processes, the age of the horizon increases with depth. The reason why it is so useful to have a HydraProbe in each horizon is because different horizons have different hydrological properties. Some horizons will have high hydraulic conductivities and thus have greater and more rapid fluctuations in soil moisture. Some horizons will have greater bulk densities with lower effective porosities and thus have lower saturation values. Some horizons will have clay films that will retain water at field capacity longer than other soil horizons. Knowledge of the soil horizons in combination with the HydraProbes accuracy will allow the user to construct a more complete picture of the movement of water in the soil. The horizons that exist near the surface can be 6 to 40 cm in thickness. In general, with increasing depth, the clay content increases, the organic matter decreases and the base saturation increases. Soil horizons can be identified by color, texture, structure, pH and the visible appearance of clay films.





More information about soil horizons is provided by the USDA National Resource Conservation Service at [https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2\\_054308](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054308)

More information about the soil horizons in your area can be found by in a soil survey. A soil survey for your area can be found at <http://soildatamart.nrcs.usda.gov/>

<u>Soil Horizon</u>	<u>Property</u>
O	Decaying plants on or near surface
A	Top Soil, Organic Rich
B	Subsoil, Most Diverse Horizon and the Horizon with the most sub classifications
E	Leached Horizon (light in color)
C	Weathered/aged parent material

Table 2.1 Basic description of soil horizons.

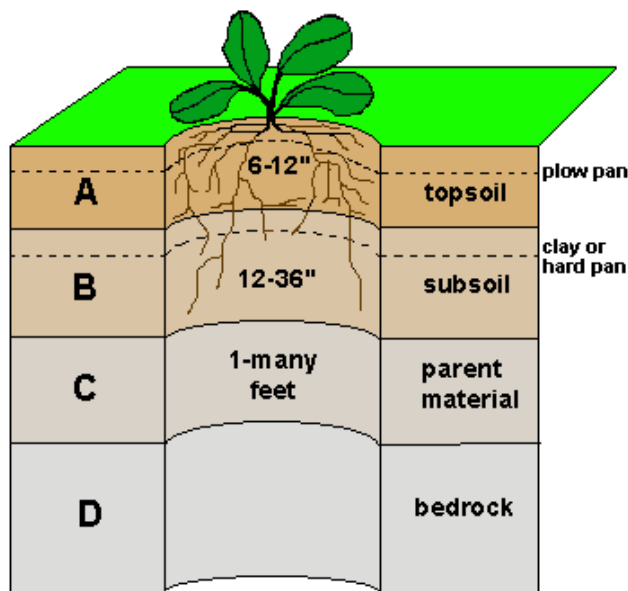


Figure 2.4 Soil Horizons.

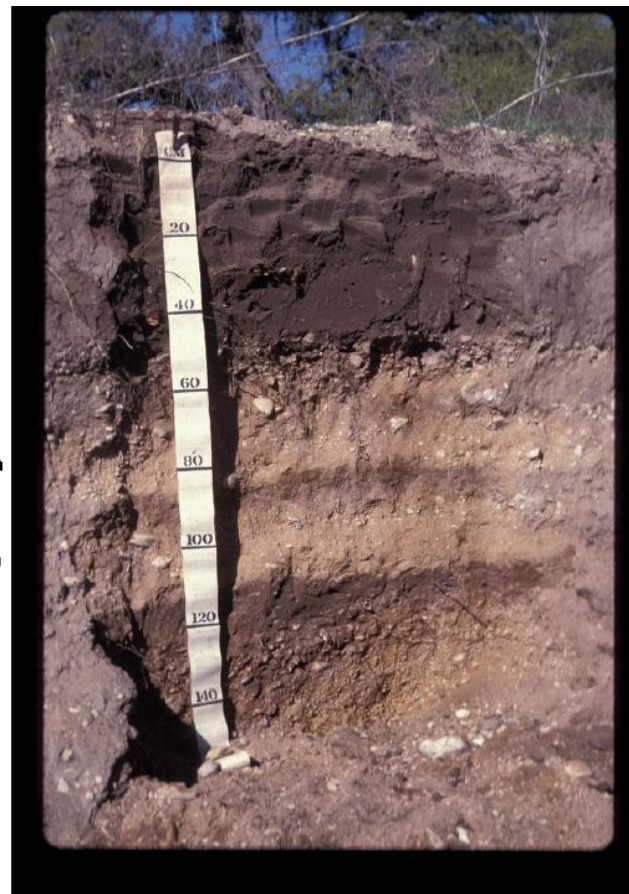


Figure 2.5 Illustration of soil horizons. In this frame, the soil horizons are very distinct and show the geological history of the soil.

## **1.4 Installation of the HydraProbe into the Soil**

### **1.4.1 Checklist before you go into the field**

Below are a list of helpful and recommended items to take into the field.

Note pad and pen	Gloves	SDI-12 Xplorer
Shovel	Water/food	Water bottle
Knife	Muncell Color book	Rags and towels
Trowel	Wrench	Hand held volt meter
Tape measure	Toe tags	Marker flags
Zip ties	Wire cutter and wire strippers	
Screw drivers	Needle nose plyers	

### **1.4.2 Test the Probes and logger in the Office before going into the Field**

It is recommend to setup the logger with the sensors in the office and running the system before installing in the field. This will allow the users to become familiar with the system and identify any problems. The HydraProbes can be placed in water to test functionality. See section 3.1.4

### **1.4.3 Labeling**

It is helpful to label the sensor at the head so they can be quickly identified before going in the hole. The cable at the logger end should also be labeled. The serial number and address should be documented. The serial number is printed on the label or use the SDI-12 “a!” command to get the serial number.

### **1.4.4 Installing the HydraProbe in the Soil**

The most critical considerations for the installation of the HydraProbe are that the soil should be undisturbed and the base plate of the probe needs to be flush with the soil. To install the probe into the soil, first select the depth (see section 2.3 for depth selection). A post-hole digger or spade works well to dig the hole. If a pit has been prepared for a soil survey, the HydraProbes can be conveniently installed into the wall of the survey pit before it is filled in. Use a paint scraper to smooth the surface of the soil where it is to be installed. It is important to have the soil flush with the base plate because if there is a gap, the HydraProbe signal will average the gap into the soil measurement and create errors.





**Figure 2.6** HydraProbe Installed in undisturbed soil.

Push the tines of the HydraProbe into the soil until the base plate is flush with the soil. The tines should be parallel with the surface of the ground, i.e. horizontal. Avoid rocking the probe back and forth because this will disturb the soil and create a void space around the tines. Again, it is imperative that the bulk density of the soil in the probe's measurement volume remain unchanged from the surrounding soil. If the bulk density changes, the volumetric soil moisture measurement and the soil electrical conductivity will change.

#### **1.4.5 Soil Sensor Orientation**



**Figure 2.7** Horizontal placement sensor and dipping the cable is recommended

It is recommended to keep the tine assembly horizontal with the ground particularly near the surface. A drain loop can be put in the cable to prevent water from running down the cable to the probe's sensing area.

### **1.5 Wiring to a Logger Station**

Connect the red wire to a +12 volt DC power supply, connect the black wire to a ground for all HydraProbe models. The measurement duty cycle is 2 seconds.





<b><u>Wiring and power for HydraProbes</u></b>	
<b><u>Power Requirements</u></b>	<b><u>9 to 20 VDC (12VDC Ideal)</u></b>
Red Wire	+Volts Power Input
Black Wire	Ground
Green Wire	Data Signal A -inverting signal (-)
White Wire	Data Signal B non-inverting signal (+)
Blue Wire	SDI-12
Power Consumption RS485	<10 mA Idle 30 mA Active for 2s
Power Consumption SDI-12	<1 mA Idle 10 mA Active for 2s

**Table 2.2, Wiring connections and power considerations.**

The user may also want to run the HydraProbe cable through a metal conduit like the one shown in figure 2.3 to add extra protection to the cable.

Once the probes are wired to the logger, test the communication between the logger and all of the probes. This can be achieved by current reading features in the logger or in SDI-12 transparent mode. See Appendix A for SDI-12 command or Appendix B for RS485 Commands.

### **1.5.1 Sensor Setup**

It is recommended for most applications to use the default factory settings and the factory soil moisture calibration which will accommodate most all soil types. The default soil moisture calibration is called GENERAL and most users will not need to change it. If you have unique soil that requires a one of the other factory calibrations or a site specific calibration, see appendix C.

## **1.6 Backfilling the Hole**

### **1.6.1 Test Before you Backfill**

Before you begin backfilling the hole, when the probes are securely installed in the undisturbed soil, test the communication between the logger and all of the probes. This can be achieved by current reading features in the logger or in SDI-12 transparent mode. See Appendix A for SDI-12 command or Appendix B for RS485 Commands. The Xplorer SDI-12 to USB adapter PN# 51139 can be used to independently test the SDI-12 bus or individual SDI-12 Sensors in the field.





Figure 2.8. Xplorer SDI-12 to USB Adapter Stevens part number 51139 for testing SDI-12 bus or individual SDI-12 Sensors.

### 1.6.2 Backfilling Precautions

After soil is removed from the ground and piled up next to the hole, the horizons and soil become physically homogenized. The bulk density decreases considerably because the soil structure has been disturbed. After the probes are securely installed into the wall of the pit, the pit needs to be backfilled with the soil that came out of it. It is impossible to put the horizons back the way they have formed naturally, but the original bulk density can be approximated by compacting the soil. For every 24 cm (1 foot) of soil put back into the pit, the soil should be compacted. Compaction can be done by trampling the soil with feet and body weight. Mechanical compactors can also be used, though typically they are not required. Extra care must be taken not to disturb the probes that have exposed heads, cables and conduits when compacting the soil. If the probes were installed in a post hole, a piece of wood, such as a post, can be used to pack the soil.

If the soil is not trampled down while it is being back filled, the compaction and bulk density of the backfill will be considerably less than the native undisturbed soil around it. After a few months, the backfilled soil will begin to compact on its own and return to a steady state bulk density. The HydraProbe will effectively be residing in two soil columns. The tines will be in the undisturbed soil column, and the head, cable and conduit will be in the backfill column that is undergoing movement. The compaction of the backfilled soil may dislodge the probe and thus affect the measurement volume of the probe. After the probes are installed, avoid foot traffic and vehicular traffic in the vicinity of the probes.

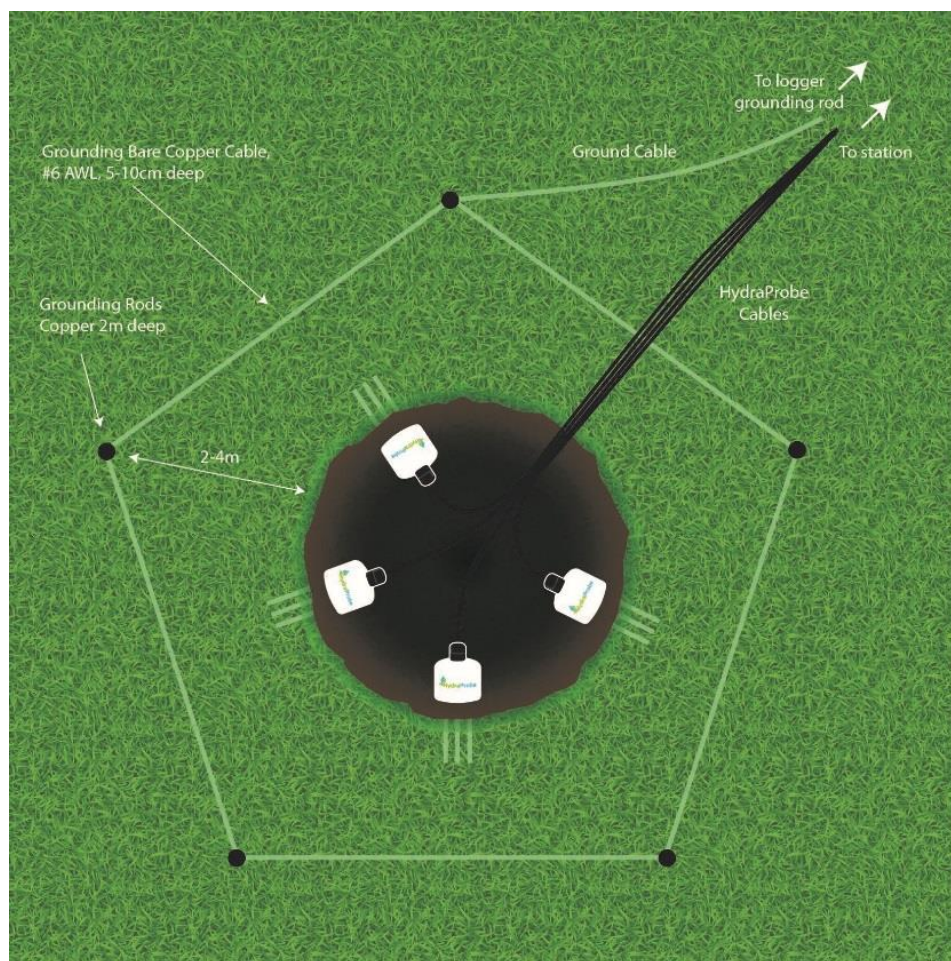


## 1.7 Lightning

Lightning strikes will cause damage or failure to the HydraProbe or any other electrical device, even though it is buried. In areas prone to lightning, surge protection and /or base station grounding is recommended.

While lightning can hit the logger station, the voltage surge propagating underground can cause serious damage to soil sensors. Underground voltage surges are called earth surge transients and the station needs to be protected both above and below ground.

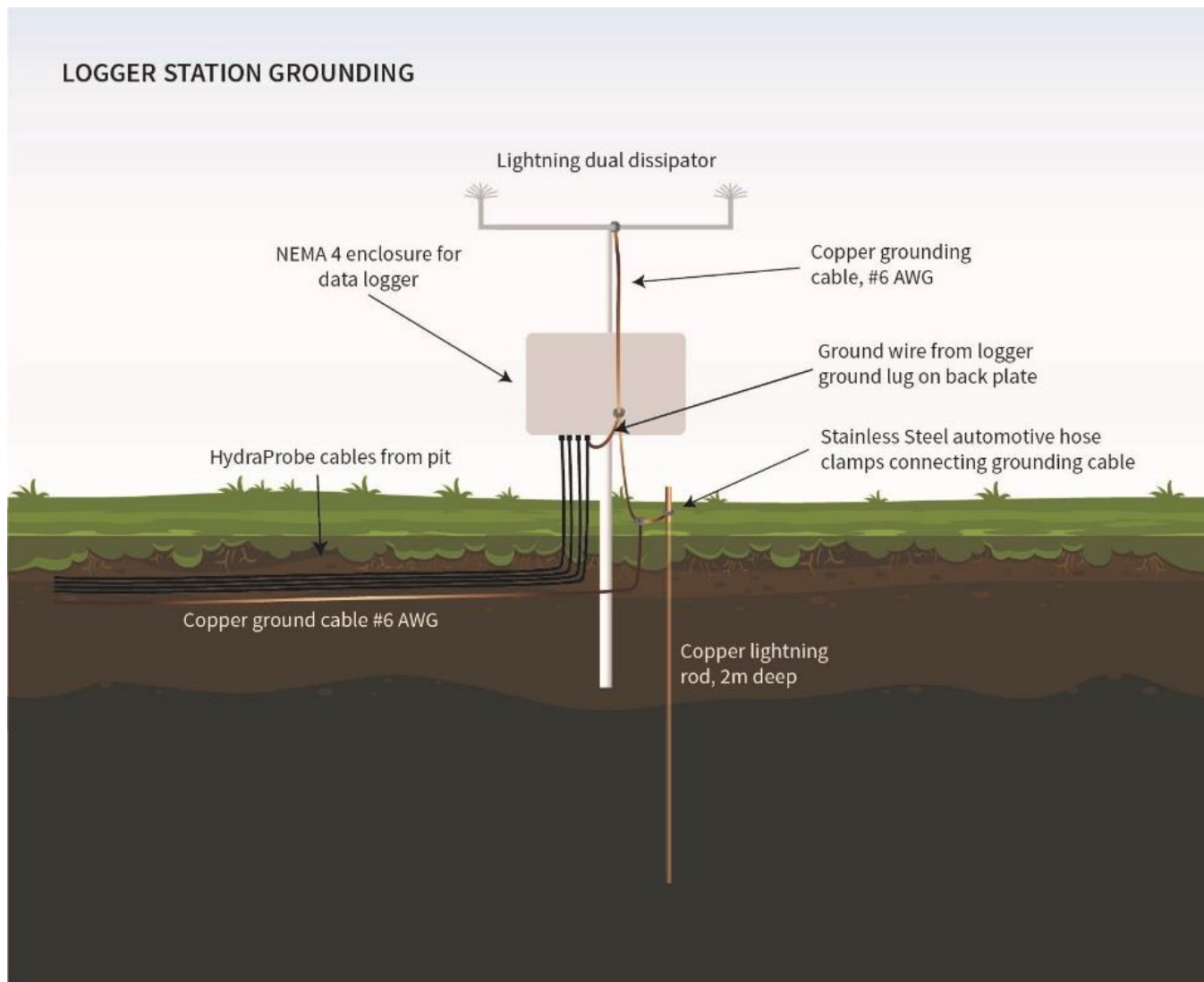
For maximum protection from lightning, attach a dual lightning dissipators to the top of the lightning rod 3 to 6 meters above the ground surface. Using at least a 1 cm thick copper cable, connect the dissipator to a series of buried copper rod 2 cm in diameter. The buried copper rods should be at least 2 meters long buried horizontally 1.5 to 2 meters deep. Figures 2.9 and 2.10 show grounding of the soil monitoring location and the logger station. More information can be found in the Soil Sensor Lightning Protection Guide located at <http://www.stevenswater.com/products/sensors/soil/hydraprobe/>



**Figure 2.9. Place grounding rods around the perimeter of the soil monitoring area**



Place a series of grounding rods 2 to 4 meters away from the soil probes two meters deep and clamp and connect them with a copper cable. Circle the soil sensors with the grounding rods in a way so that electrical surges propagating through the ground will go around the soil sensors.



**Figure 2.10. Ground the logger station with dual dissipators and ground rod.**





## 2 Trouble Shooting and Soil Considerations

This section discusses trouble shooting and how the nature of soil can affect data. If a probe appears to be malfunctioning, there are generally three main reasons that may explain why a probe may appear to be malfunctioning. The three most common reasons why a probe may seem to be malfunctioning are:

- 1) Improper logger setup, or improper wiring,
- 2) Soil hydrology may produce some unexpected results, and
- 3) Power failure.

HydraProbes have a longevity in soil and a long warranty period, therefore; it is recommend to record the serial numbers on the probes for support purposes.

### 2.1 Trouble shooting at the Logger end and Out of the ground

Section 3.1 summarizes the steps the user should take if the HydraProbe is unresponsive or outputs data that is suspect. If the probes are in the ground, it is best to try to trouble shoot at the logger end before digging the probes up. Keep in mind that digging the probes out of the ground can be labor intensive and may disturb the other probes in the soil column. If the probe have to be dug out of the ground, they can be tested in water to determine if they are functioning properly.

#### 2.1.1 Check Wiring and Power

If the user is unable to get a response from the HydraProbe it is recommended to first physically check wire connections from the probe to the logger. Check the cable for cuts and abrasions. A handheld voltmeter can be used to check the voltage on the battery and the SDI-12 bus. The voltmeter can also be connected in series with the ground wire to measure the current draw from the sensors. Idle, each HydraProbe draws 1 mA.

#### 2.1.2 Communicate with the Sensor at the Logger End

If the logger has a current reading feature, run this feature from a laptop, app, or display that interfaces with the logger. Try to reproduce what was observed in the logged data.

If the logger has an SDI-12 Transparent mode, issues SDI-12 commands to the sensors on the bus. The “aI!” command can give the serial number. Use the “aM!; aD0!, aD1! aD2!” command to take a reading. Tables 3.1 and 3.2 are a summary of the commands. Isolating the suspect sensor and testing it when it is by itself may also be helpful. An SDI-12 to USB adapter such as the Stevens Xplorer (Figure 2.8) can be used to trouble shoot SDI-12 sensors.

<u>Command Feature</u>	<u>SDI-12 Command</u>
Change Address	aAb!
Get Probe’s serial number and ID	aI!
Take a Reading	aM! Follow by aD0!, aD1!,aD2!

Table 3.1 Common SDI-12 Command





<b>Common Measurement Command sets for aM! And aC!</b>			
<b><u>Parameter ordering</u></b>	<b><u>Parameter</u></b>	<b><u>Unit</u></b>	<b><u>Letter designation</u> <u>(See table)</u></b>
Parameter 1	Soil Moisture	Water fraction by volume	H
Parameter 2	Bulk Electrical Conductivity with Temperature Correction	S/m	J
Parameter 3	Temperature	C	F
Parameter 4	Temperature	F	G
Parameter 5	Bulk Electrical Conductivity	S/m	O
Parameter 6	Real Dielectric Permittivity	Unitless	K
Parameter 7	Imaginary Dielectric Permittivity	Unitless	M

**Table 3.2 Common M and C command for SDI-12. For RS485 commands, please see appendix B.**

### 2.1.3 Check the Logger Configuration

If the connections are sound, the user will need to check the logger's setup. Programming a data logger is not always a trivial task. The data logger needs to extract the data from data ports on the logger with the desired timing interval. The logger is often times the power source for the probes. The user may also want to cycle the power to the probe and the logger by disconnecting and reconnecting power. Refer to the manufacturer of the logger for tech support with the logger.

### 2.1.4 Remove the Suspect Probe from the Soil

If the problem cannot be resolved by checking the logger and the wiring, the probes should be dug out of the ground, and cleaned off.

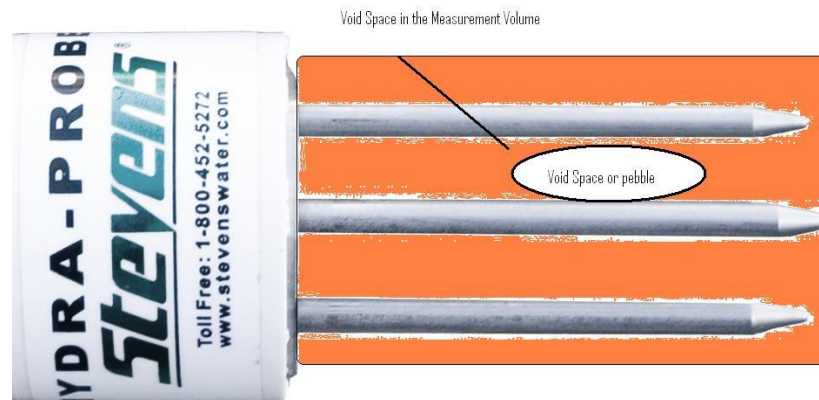
To verify that the HydraProbe is functioning properly perform the following commands: Place the HydraProbe in distilled water in a plastic container. Make sure the entire probe is submerged. In transparent mode and with the third parameter set (aM3!), type "**1M3!**" followed by "**1D0!**" (with a probe address of 1 for this example). The typical response of a HydraProbe that is functioning properly should be **1+77.895+78.826+2.462**. From this example, the real dielectric permittivity is 77.895, and the imaginary dielectric permittivity is 2.462. According to factory specifications, the dielectric constant should be from 75 to 85 and the imaginary dielectric permittivity should be less than 5. If distilled water is not available, the user may use tap water for this procedure. It is important to note, however, that tap water may contain trace levels of material that may affect the dielectric permittivities readings. Isopropyl alcohol with a dielectric constant of 18.6 @20 degree C can also be used.



## 2.2 Soil Hydrology

Sometimes the soil moisture data may look incorrect when in fact the HydraProbes are accurately measuring the actual soil moisture gradient. Soil Hydrology is complex and can be modeled by Darcy's Law and Richard's Equation. These involved theories are beyond the scope of this manual; however, knowledge of basic soil hydrology is worth discussing.

It's important to note that the soil that resides between the tine assembly is where the measurements are taken. If there is a void space in the soil between the tines, this will affect the hydrology where the HydraProbe is taking measurements. If the void space is saturated with water, it will increase the soil moisture measurement. If the void space is not fully saturated, the soil will appear dryer. Figure 3.1 shows the measurement volume where the HydraProbe takes measurements and a void space between the tine assembly. These void spaces can occur from a poor installation, such as rocking the probe side to side or not fully inserting the probe into the soil.



**Figure 3.1 Measurement volume with a void space between the tine assembly.**

Void spaces between the tine assembly can also occur from changing soil conditions. Factors such as shrink/swell clays, tree roots or pebbles may introduce a void space. The following sections describe some of these and other factors.

### 2.2.1 Evapotranspiration

Water in the soil will be pulled downward by gravity, however during dry periods or in arid regions, the net movement of water is up toward the surface. Water will move upward in the soil column by a phenomenon called Evapotranspiration (ET). ET is the direct evaporation out of the soil plus the amount of water being pulled out of the soil by plants. Factors such as wind, temperature, humidity, solar radiation and soil type play a role in the rate of ET. If ET exceeds precipitation, there will likely be a net upward movement of water in the soil. With the net upward movement of soil water, ET forces dissolved salts out of solution and thus creating saline soil conditions.



### 2.2.2 Hydrology and Soil Texture

Sandy soils drain better than soils that are clay rich. In general, the smaller the soil particle size distribution, the slower it will drain. Sometimes silt may have the same particle size distribution, as clay but clay will retain more water for longer periods of time than silt. This can be explained by the shape of the soil particles. Clay particles are planar whereas silt particles are spherical. Water basically gets stuck between the planar plate shaped clay particles and thus slows the flow of water.

### 2.2.3 Soil Bulk Density

In general, the greater the soil density, the less water it will hold and the slower water will move through it. There will often times be soil horizons that will be denser than others giving the soil different hydrological properties with depth. Occasionally, water will stop or slow down and rest on a dense, less permeable layer of soil. This phenomenon is called perched water. If two HydraProbes 20 cm apart have very different soil moisture readings, chances are that one of the probes is residing in perched water.

There is also a relationship between soil bulk density and the complex dielectric permittivity. The soil dry bulk density ( $\rho_b$ ) can be described by equation [3.1]

$$\rho_b = m/V \quad [3.1]$$

Where  $m$  is the mass of the dry soil in grams and  $V$  is the volume in cubic centimeters.

The bulk density is associated with the density of a soil ped or a soil core sample. The particle density ( $\rho_p$ ) is the density of an individual soil particle such as a grain of sand. The two densities should not be confused with one another. Because  $E_r$  and  $E_i$  of dry soil is a function of both the bulk and particle densities ( $\rho_b$ ,  $\rho_p$ ), the soil density often creates the need for soil specific calibrations. The relationship between porosity, bulk and particle density can be described by equation [3.2]

$$\varphi = 1 - \frac{\rho_b}{\rho_p} \quad [3.2]$$

### 2.2.4 Shrink/Swell Clays

Shrink/swell clays belong to the soil taxonomic order vertisol and are composed of smectite clays. These clays have a large ion exchange capacity and will shrink and swell seasonally with water content. The seasonal expansion and contraction homogenizes the top soil and the subsoil. As the clay shrinks during a drying period, the soil will crack open and form large crevasses or fissures. If a fissure forms in the measurement volume of the HydraProbe, the probe will signal average the air gap caused by the fissure into the reading and potentially generate biased results. If the fissure fills with water, the soil moisture measurement will be high, if the fissure is dry, the soil moisture measurement will be lower than expected. If the HydraProbe measurements are being affected by shrink/swell clays, it is recommend to relocate the probe to an adjacent location.



### 2.2.5 Rock and Pebbles

Often times, it will be obvious if a rock is encountered during an installation. Never use excessive force to insert the probe into the soil. Some soils will have a distribution of pebbles. If a pebble finds its way between the probe's tines, it will create an area in the measurement volume that will not contain water. The probe will signal average the pebble and thus lower the soil moisture measurement. If the pebble is an anomaly, relocating of the probe would provide more representative soil measurements. However, if it is revealed from the soil survey that there exists a random distribution of pebbles, a pebble between the tines may provide realistic measurements because of the way pebbles influence soil hydrology.

### 2.2.6 Bioturbation

Organisms such as plants and burrowing animals can homogenize soil and dislodge soil probes. A tree root can grow between the tines affecting the measurements and in some cases, tree roots can bring a buried soil probe to the soil surface. Burrowing mammals and invertebrates may decide that the HydraProbes' tine assembly makes an excellent home. If the HydraProbe's tine assembly becomes home to some organism, the soil moisture measurements will be affected. After the animal vacates, the soil will equilibrate and the soil measurements will return to representative values.

The cable leading to the probe may also become a tasty treat for some animals. If communication between the logger and the probe fails, check the cable for damage. A metal conduit like the one shown in figure 2.3 is recommended.

### 2.2.7 Salt Affected Soil and the Loss Tangent

The HydraProbe is less affected by salts and temperature than TDR or other FDR soil sensors because of the delineation of the dielectric permittivity and operational frequency at 50 Mhz. While the HydraProbe performs relatively well in salt affected soils, salts that are dissolved in the soil water will influence both dielectric permittivities and thus the measurements. The salt content will increase the imaginary dielectric constant and thus the soil electrical conductivity. See Chapter 4. The HydraProbe will not measure electrical conductivity or soil moisture beyond 1.5 S/m

In general, if the electrical conductivity reaches 1 S/m, the soil moisture measurements will be significantly affected. The imaginary dielectric constant will have an influence on the real dielectric constant because dissolved cations will inhibit the orientation polarization of water. When addressing the HydraProbes' performance in salt affected soil, it is useful to use the loss tangent equation [3.3].

$$\tan \delta = \frac{\epsilon_i}{\epsilon_r} \quad [3.3]$$

The loss tangent ( $\tan \delta$ ) is simply the imaginary dielectric constant divided by the real dielectric constant. If  $\tan \delta$  becomes greater than 1.5 then the HydraProbes calibration becomes unreliable. It is interesting to note that the HydraProbe will still provide accurate dielectric constant measurements up to 1.5 S/m. If the salt content reaches



a point where it is affecting the calibrations, the user can use a custom calibration that will still provide realistic soil moisture measurements in the most salt affected soils. See Appendix C for custom calibrations.

### 2.2.8 Ped Wetting

A soil ped is single unit of soil structure. Ped shapes include granular, platy, blocky and prismatic and ped sizes can range from 1mm granules to 10 cm prisms. The preferential pathway water travels through soil is between the peds. This is evident by clay film coatings that develops around a ped. The clay film precursors become dissolved in the pore water, as the pore water subsides, the clay film precursors fall out of solution and adhere to and surface of the peds creating the clay film. The clay film will often times delay the infiltration of water into the ped thus as the wetting front move down into the soil, the regions between the peds will be the preferential water pathway. As the wetting font moves through the soil column the soil moisture measurements may be temporarily biased by the peds. For example, if the soil probe's measurement volume is residing entirely in a single ped, the probe would not detect the wetting front until the water infiltrates the ped. Likewise, if the sensing volume is residing between several peds, the soil moisture measurements will reflect the movement of water between the peds. During installation, if a horizon has thick clay films around the peds, the user may want to use daily averages of soil moisture reading to accommodate soil moisture variations in the peds.

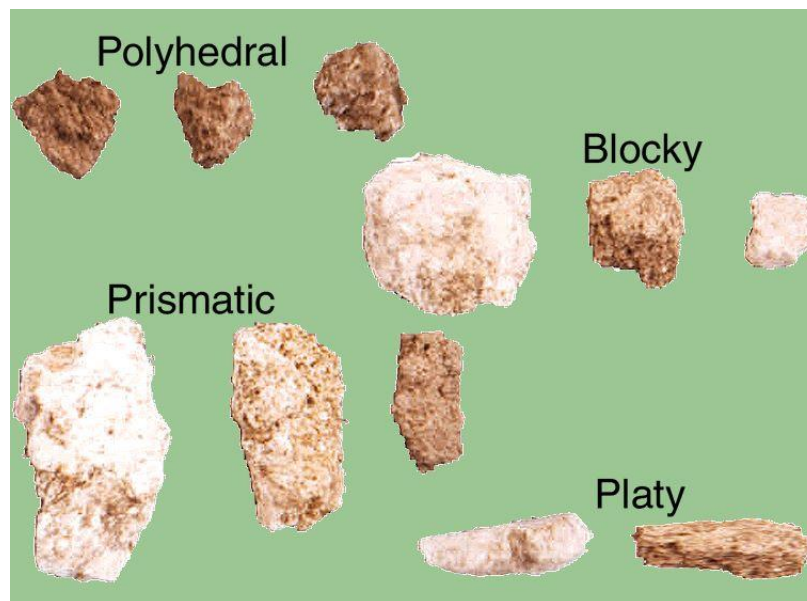


Figure 3.2. Soil Ped Types.

### 2.2.9 Frozen Soil

The HydraProbe can also be used to determine if soil is frozen. Once ice reaches 0° Celsius, it will begin to thaw and the real dielectric permittivity will increase from 5. The temperature alone may not indicate whether or not the soil is frozen. As the soil begins to thaw, the soil moisture and the real dielectric permittivity should return to values similar to what they were before the soil froze.





### 3 HydraProbe Basic SDI-12 Communication (2.9 Firmware)<sup>1</sup>

**Note:** It is recommended to keep the HydraProbe on its defaults and use only the “aM!” or “aC!” to retrieve data.

SDI-12 (serial data interface at 1200 baud) communications protocol allows compatible devices to communicate with each other. More information about SDI-12 can be found at <http://www.sdi-12.org/>.

#### SDI-12 Wiring Information

The SDI-12 HydraProbe has three wires. The default address is “0”.

<b>Wiring and Power for SDI-12</b>	
Power Requirements	9 to 20 VDC (12VDC Ideal)
Red Wire	+Volts Power Input
Black Wire	Ground
Blue Wire	SDI-12 Data Signal
Power Consumption	<1 mA Idle, 10 mA for 2s Active

**Table A1. Digital SDI-12 HydraProbe Information.**

#### Addressing an SDI-12 Sensor

It is important to note that each SDI-12 sensor must have its own unique address. The default address for the HydraProbe is “0”. Use SDI-12 “Transparent Mode” to issues commands.

<b>Command Feature</b>	<b>SDI-12 Command</b>
Change Address	aAb!
Get Probe’s serial number and ID	aI!
Take a Reading	aM! Follow by aD0!, aD1!,aD2!

**Table A2. Common SDI-12 Commands**

<b>Common Measurement Command sets for aM! And aC!</b>			
Parameter ordering	Parameter	Unit	Letter designation (See table)
Parameter 1	Soil Moisture	Water fraction by volume	H
Parameter 2	Bulk Electrical Conductivity with Temperature Correction	S/m	J
Parameter 3	Temperature	C	F
Parameter 4	Temperature	F	G
Parameter 5	Bulk Electrical Conductivity	S/m	O
Parameter 6	Real Dielectric Permittivity	Unitless	K
Parameter 7	Imaginary Dielectric Permittivity	Unitless	M

**Table A3. Common Commands.**

<sup>1</sup>2.8 and 2.7 firmware versions have a different array of C commands. Contact Stevens for more information.



## 4 RS-485 Communication

**Note:** It is recommended to keep the HydraProbe on its defaults and use only the “addrTR” <CR><LF> followed by “addrT0”<CR><LF> to take a reading and retrieve data.

The RS-485 HydraProbe has 4 wires: a ground wire, a +12 volt power wire and 2 data wires. The RS-485 HydraProbe communicates through two data wires and can be wired into a RS-485 port on a logger. They can be connected to a terminal assembly like the SDI-12 version, but with four wires instead of three. The advantage RS-485 has over the SDI-12 version is that the RS-485 version’s cable can run over 3000 feet. The disadvantage is that it draws more power.

The COM port setting are as follows

- COM Port should be set to correspond with actual port on the PC where the communications cable is plugged in. For instance COM1, COM2, etc.
- Baud rate should be set to 9600
- Data bits should be set to 8
- Parity should be set to none.
- Stop bits should be set to 1 (one).
- Flow control should be set to none.

In addition, these setting will make the program easier to use. In a terminal emulator these settings are found in the setup options:

- Select “**Send line ends with line feeds**”. All commands sent to an RS-485 version of the HydraProbe must end with a “Carriage Return” “Line Feed” pair.
- Select “**Echo typed characters locally**”. The HydraProbe does not echo any commands. Checking this enables you to see what you have typed.

<b>Wiring and power for RS484</b>	
<b>Power Requirements</b>	<b>9 to 20 VDC (12VDC Ideal)</b>
Red Wire	+Volts Power Input
Black Wire	Ground
Green Wire	Data Signal A -inverting signal (-)
White Wire	Data Signal B non-inverting signal (+)
Baud Rate	9600 8N1
Power Consumption	<10 mA Idle 30 mA Active

**Table B1. Digital RS-485 HydraProbe Information.**





## Stevens HydraProbe RS-485 Command Specification

For Use with Firmware Version 2.7 and Later

### Command Format

AAACC<CR><LF>	Execute
AAACC=?<CR><LF>	Query current setting
AAACC=XXX...<CR><LF>	Assign new value

**AAA:** 3 byte address  
ASCII characters, 0-9 A-Z a-z  
Wildcard character: "/"  
Broadcast address: "///"

**CC:** 2 byte command

**XXX...:** Command data. See command info for specific requirements.

**<CR>:** Carriage return character (ASCII 13)

**<LF>:** Linefeed character (ASCII 10)

### Other Grammar

**<d>:** Digit, ASCII '0' through ASCII '9'

**<a>:** ASCII 'A' through ASCII 'D', used for custom water constant

**<serial>:** Serial number, 8 digits. <d><d><d><d><d><d><d><d>

**<firmware>:** Firmware, 3 or 4 bytes, formatted like "2.7" or "R2.7" or "2s7"

**<text>:** Printable ASCII text

**<float>:** Decimal number, optionally using a form of scientific notation.  
Ex: "+23.54, 0.001, -123.0E5, 45.E-3"

**<readings>:** Comma-delimited string of floats. Ex: "+23.54,-42.532,+2342.12"

## HydraProbe Specific RS-485 Commands

### Information Commands

#### Serial Number

Description:	Returns the factory serial number.
Access Level:	Read only
Read Addresses:	Broadcast, Exact
Read Command:	<addr>SN=?<CR><LF>
Read Response:	<addr><serial><CR><LF>



## Firmware Version

Description: Returns the firmware version number.  
 Access Level: Read only  
 Read Addresses: Broadcast, Exact  
 Read Command: <addr>FV=?<CR><LF>  
 Read Response: <addr><firmware><CR><LF>

## Standard Configuration Commands

### Address

Description: Gets/sets the probe address.  
 Access Level: Read/Write  
 Read Addresses: Broadcast, Exact  
 Read Command: <addr>AD=?<CR><LF>  
 Read Response: <addr><CR><LF>  
 Write Addresses: Exact  
 Write Command: <addr>AD=<serial><new\_addr><CR><LF>  
 Write Response: <new\_addr><CR><LF>

## Advanced Configuration Commands

### Location

Description: Gets/sets the probe location.  
 Access Level: Read/Write  
 Read Addresses: Broadcast, Exact  
 Read Command: <addr>LO=?<CR><LF>  
 Read Response: <addr><text><CR><LF>  
 Write Addresses: Exact  
 Write Command: <addr>LO=<text><CR><LF>  
 Write Response: <addr><text><CR><LF>

### Description

Description: Gets/sets the probe description.  
 Access Level: Read/Write  
 Read Addresses: Broadcast, Exact  
 Read Command: <addr>DS=?<CR><LF>  
 Read Response: <addr><text><CR><LF>  
 Write Addresses: Exact  
 Write Command: <addr>DS=<text><CR><LF>  
 Write Response: <addr><text><CR><LF>



## Debug Commands

### Probe Enable

Description: Gets/sets whether the probe circuitry is enabled.  
 Access Level: Read/Write  
 Read Addresses: Broadcast, Exact  
 Read Command: <addr>PE=?<CR><LF>  
 Read Response: <addr><bool><CR><LF>  
 Write Addresses: Exact  
 Write Command: <addr>PE=<bool><CR><LF>  
 Write Response: <addr><bool><CR><LF>

## Measurement Commands

### Take Reading

Description: Instructs a probe or group of probes to take a reading sample.  
 Access Level: Execute  
 Execute Addresses: Broadcast, Exact, Wildcard  
 Execute Command: <addr>TR<CR><LF>  
 Execute Response: (none)

### Transmit Reading Set

Description: Instructs a probe to transmit a specific reading set.  
 Access Level: Execute  
 Execute Addresses: Broadcast, Exact  
 Execute Command: <addr>T<set><CR><LF>  
 Execute Response: <addr><readings><CR><LF>

## RS-485 TRANSMIT SETS

(tc) indicates values that have been temperature corrected

T0 - Transmit Set 0:

- H) Moisture
- J) Soil Electrical Conductivity (tc)
- F) Temp C
- G) Temp F
- O) Soil Electrical Conductivity
- K) Real Dielectric Permittivity
- M) Imag Dielectric Permittivity
- L) Real Dielectric Permittivity (tc)
- N) Imag Dielectric Permittivity (tc)





T1 - Transmit Set 1:

- F) Temp C
- G) Temp F
- I) Loss Tangent

T2 - Transmit Set 2:

- F) Temp C
- G) Temp F
- H) Moisture
- O) Electrical Conductivity
- J) Electrical Conductivity (tc)
- I) Loss Tangent

T3 - Transmit Set 3:

- F) Temp C
- G) Temp F
- H) Moisture
- I) Loss Tangent
- J) Soil Electrical Conductivity (tc)
- K) Real Dielectric Permittivity
- L) Real Dielectric Permittivity (tc)
- M) Imag Dielectric Permittivity
- N) Imag Dielectric Permittivity (tc)
- O) Soil Electrical Conductivity
- P) Diode Temperature
- Q) Blank

T4 - Transmit Set 4:

- A) V1 (volts)
- B) V2 (volts)
- C) V3 (volts)
- D) V4 (volts)
- E) V5 (volts)

T5 - Transmit Set 5:

- R) V1 raw adc
- S) V2 raw adc
- T) V3 raw adc
- U) V4 raw adc
- V) V5 raw adc

