Product Manual

Sensor

HS2 and HS2P

(HydroSense II)

Revision: 02/2020

RELIABLE SINCE 1974 MONITORING

CAMPBELL SCIENTIFIC

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CAMPBELL SCIENTIFIC, INC.
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

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Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC**. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

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General

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

Utility and Electrical

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

Elevated Work and Weather

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

Maintenance

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

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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HS2 and HS2P

1. Introduction

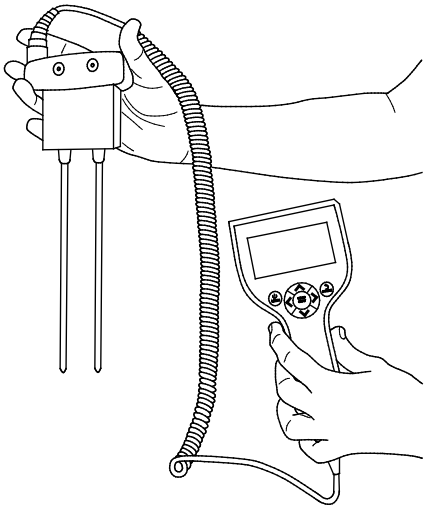


FIGURE 1-1. HS2 HydroSense II System

FIGURE 1-2. HS2P HydroSense II Pole System

The HydroSense II is an easy-to-use, portable device for measuring volumetric water content of soil. The major components of the system are the display, the sensor, and the software. A sensor with 12 cm rods (model CS659 or CS659P) and a sensor with 20 cm rods (model CS658 or CS658P) are available.

Campbell Scientific offers the HS2, the standard HydroSense II system, and the HS2P, a HydroSense II system with a strong handle and pole. FIGURE 1-1, *HS2 HydroSense II System (p. 1)*, shows the HS2 and FIGURE 1-2, *HS2P HydroSense II Pole System (p. 1)*, shows the HS2P.

NOTE Throughout the manual, HydroSense II refers to both the HS2 and HS2P, unless specified otherwise.

2. Precautions

- READ AND UNDERSTAND the *Safety* section at the front of this manual.
- The connectors that connect the HydroSense II display to the sensor are a push-pull type with locators to align the connectors. **DO NOT TWIST**. The connectors can be damaged if the user twists them or attempts to screw or unscrew them.
- Remove the AA batteries before putting the HydroSense II display into storage.
- An unobstructed view of the sky may be required to achieve the most accurate global position data possible from the HydroSense II GPS.
- Sensor rods must be completely inserted into the soil before making a measurement.

3. QuickStart

1. Remove the HS2 display or HS2P from the carry case.
2. Remove the blue protective strip from the display window.

NOTE Steps 3 and 4 are for the HS2 only because the HS2P comes fully assembled. If using an HS2P, go directly to step 5.

3. Remove the HS2 sensor from the carry case.
4. Connect the HS2 sensor to the display by mating the connector on the cable to the connector at the bottom of the display. **DO NOT TWIST** the connectors.

CAUTION

The connector is a push-pull type with locators to align the connectors. The connectors can be damaged if the user attempts to screw or unscrew them. To mate the connectors, simply bring them together and turn until they are aligned, then applying firm pressure, slide them together until they click. To disconnect, pull back on the connector collar with the thumb and forefinger and pull the two connectors apart.

5. Turn on the HydroSense II by holding the MENU button for 3 seconds.

6. Establishing a GPS sync may take up to one minute or more. When the GPS icon is displayed (), synchronization has been successful. Measurements with GPS data can now be taken. See Appendix A.14, *GPS Settings* *(p. A-6)*, for information on toggling the GPS.

NOTE

The HydroSense II stores positional information (when available), time, and date with measurements. To reliably take advantage of the GPS, use the HydroSense II outdoors with a clear view of the sky. Measurements can be made and data stored without a *GPS* *(p. 19)* signal; however, the HydroSense II Support Software (HydroSoft) will be unable to later group and display data geographically.

7. Insert the sensor rods fully into the soil. The HS2P uses a plastic bumper that covers the rod mounting nuts. Insert the rods into the soil up to the plastic bumper.

NOTE

Only remove the plastic bumper when replacing soil rods and put it back on when done.

8. To take a measurement, press READ OK. When the hourglass icon () in the lower right of the screen is extinguished, the measured VWC and period are shown on the screen.

9. Press STORE to store the measurement. Assuming the GPS is in sync, follow the prompts to create a zone, then data will be stored in the memory.

10. To retrieve the stored data, first establish a Bluetooth link with your computer, then collect data using the HydroSense II support software. See Section 8.4, *Connecting via Bluetooth* *(p. 19)*, and Section 8.5, *Collecting Data* *(p. 19)*.

4. Overview

The HydroSense II is a portable system for measuring volumetric water content of soil. It is an improved successor to the HydroSense. TABLE 4-1, *Comparison of HydroSense II and HydroSense(I)*, compares features of the HydroSense II and HydroSense (I).

TABLE 4-1. Comparison of HydroSense II and HydroSense(I)

Feature	HydroSense II	HydroSense (I)
Volumetric water content and period	Yes, period as µs	Yes, period as ms
Relative water content and water deficit with wet and dry references	Yes (10 profiles)	Yes (5 sites)
Sensor rod length	20 cm and 12 cm (replaceable but not interchangeable)	20 cm and 12 cm (both replaceable and interchangeable)
Accuracy	20 cm rods: ±3% (EC ≤ 4 dS/m) 12 cm rods: ±3% (EC≤ 6.5 dS/m)	±3% VWC (EC < 2 dS/m)
GPS and geotagging	Yes	No
GPS zones	Yes	No
Data storage	Yes (1000+ readings)	No
Bluetooth	Yes	No
Date and time	Yes (with GPS accuracy when available)	No
Display	128 x 64 pixel graphic LCD	2 line x 16 character alphanumeric LCD
LCD backlight	Yes	No
Firmware updates	User updateable	Factory only
Field carry case	Yes	No
Portable	Yes	Yes
Battery life	1000+ readings	2000+ readings

NOTE

Unlike the HydroSense (I), the 12 cm and 20 cm rods of the HydroSense II are not interchangeable.

The HydroSense II can display relative water content (RWC) based on wet and dry references set by the user. The unit also displays water deficit, which indicates how much water is required (in mm of applied water) to return the soil to the previously saved wet reference.

Measurements are made by fully inserting the sensor rods into the soil and pressing READ OK. The process takes 2 to 3 seconds. The measurement can be stored and later downloaded to a computer for display and analysis. Communications between the computer and HydroSense II are via *Bluetooth* *(p. 19)*. The HydroSense II includes a *GPS* (Global Positioning System) *(p. 19)* receiver that enables data to be stored with position information (*geotagged* *(p. 20)*).

The HydroSense II has these default power saving features:

- turns off when idle for a configurable period
- adjustable backlight brightness and on-time
- backlight automatically disabled in bright conditions
- GPS and Bluetooth can each be forced off.

The HydroSense II system consists of the items listed in TABLE 4-2, *HydroSense II Parts.* These parts are shown in FIGURE 4-1, *HS2 Parts in Hard Carrying Case*, FIGURE 4-2, *HS2P Carrying Tote*, and FIGURE 4-3, *HS2P Parts*.

TABLE 4-2. HydroSense II Parts

Qty	HS2 Part	HS2P Part
1	HydroSense II measurement and display unit	
1		HS2P Insertion Pole Assembly
1	CS658 (20 cm) or CS659 (12 cm) water content sensor	CS658P (20 cm) or CS659P (12 cm) water content sensor
4	AA batteries (factory installed inside the display)	
1	Spare battery holder; spare batteries not included	
1	Open-ended 7/16 wrench for installing / replacing rods	
1	Loctite thread locking compound for rod replacement	
1	#1 Phillips screwdriver	
1	Hard carrying case	Carrying tote or hard carrying case
1	HydroSense II Support Software (HydroSoft) on CD	
1		Quick Deployment Guide

FIGURE 4-1. HS2 Parts in Hard Carrying Case

FIGURE 4-2. HS2P Carrying Tote

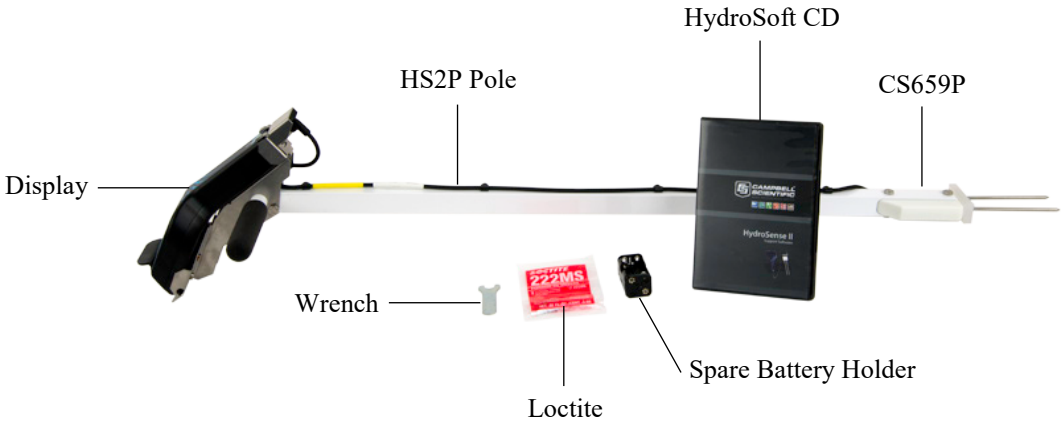


FIGURE 4-3. HS2P Parts

The following are spare and supporting parts available from Campbell Scientific:

- Spare 20 cm rods for the CS658 or CS658P sensor
- Spare 12 cm rods for the CS659 or CS659P sensor
- USB Bluetooth adapter for supporting computers

5. Specifications

Compliance documents: view at *www.campbellsci.com/hs2* or *www.campbellsci.com/hs2p*

5.1 Display Specifications

GPS Accuracy: ±5 m (16.4 ft) typical;
±1 ms time with GPS sync

Data storage: >1000 records (ring memory)

Zone storage: >100 records (fill and stop)

Display: 128 x 64 pixel graphic LCD

Backlight: blue / white LED; brightness adjustable

Compatibility: Bluetooth (range: ~10 m (~30 ft));
Google Earth (via software)

Weight: 0.34 kg (0.75 lb)

Dimensions: 200 x 100 x 58 mm (7.9 x 3.9 x 2.3 in)

Source: 4 x AA alkaline batteries

Battery life: 6 to 12 months (depends on usage and battery quality)

5.1.1 Current Drain

Asleep: 20 µA

Backlight off: 2 mA

Backlight 60%: 18 mA

Backlight 100%: 30 mA

GPS active: 35 mA

Bluetooth active: 30 mA

5.2 Sensors Specifications

5.2.1 Volumetric Water Content Measurement

Measurement principle:	time domain reflectometry
Measurement range:	0% – 50%
Precision:	<0.05%
Accuracy:	±3% VWC in mineral soils with solution EC ≤4.0 dS/m (20 cm rods) with solution EC ≤6.5 dS/m (12 cm rods)

5.2.2 Physical

Weight:	0.45 kg (0.99 lb)
Sensor body dimensions (L x W x H):	100 x 92 x 40 mm (3.9 x 3.6 x 1.6 in)
Rod length:	20 cm and 12 cm; rods are replaceable but not interchangeable
Rod diameter:	4.7 mm (nominal)

5.3 HS2P Pole Assembly

Handle width:	29.2 cm (11.5 in)
Pole width:	2.5 cm (1 in)
Pole depth:	2.5 cm (1 in)

5.3.1 Height

Handle to bottom of sensor:	82.3 cm (32.4 in)
Top of display to bottom of sensor:	96.5 cm (38 in)

5.3.2 Weight

With display and sensor:	1.4 kg (3 lb)
Without display:	1.1 kg (2.4 lb)

6. Operation

6.1 Assembly and First Use

This information is provided in Section 3, QuickStart *(p. 2)*.

6.2 Measurements

The HydroSense II presents two distinct data sets. One data set includes volumetric water content expressed as percent (%) and period (µs). The second data set includes an estimate of relative water content relative to pre-measured wet and dry references, and water deficit. Water deficit provides an estimate of applied water required (in mm) to return the soil to the **wet** water content. The default displays only water content. Using the *configuration menu (p. A-1)*, water deficit data can be enabled to display side-by-side with water content data.

6.3 Water Content Data

The sensor retrieves volumetric water content (VWC) and period (PER) data. A proprietary technique determines water content over widely varying soils while correcting for a range of bulk electrical conductivities. The sensor requests volumetric water content (**VWC**) and period (**PER**) data using SDI-12 serial protocol.

Soil consists of three main constituents – mineral particles (sand, loam, or clay), water and air. Air and water occupy the spaces or pores formed between the mineral particles. In agricultural soils, these pore spaces typically make up approximately 50% of the soil by volume, with water and air together making up the remaining 50%. As a result, water content normally ranges from 0% to 50%. In some conditions, the sensor is unable to determine the soil water content. In these cases, an out-of-range symbol (---) is displayed.

NOTE Even when the sensor cannot determine the VWC, the signal period measurement will always be displayed. In special media this value can often be used with a soil specific calibration to estimate water content.

6.4 Water Deficit Data

Water deficit data help irrigators with water management decisions. By default, the HydroSense II does not show water deficit data on the display screen. To enable the water deficit data display, turn on Deficit Mode in the *configuration menus (p. A-1)*.

In water deficit mode, wet and dry references can be stored for up to ten soils. The current measurement is compared to those reference values and relative water content (RWC) is calculated on a scale from 0% (dry) to 100% (wet). While any two volumetric water content measurements can be stored as **wet** and **dry** references, the normal procedure is to store the wilting point as the **dry** value and field capacity as **wet**. The relative water content is calculated as

$$RWC = \frac{VWC - VWC_{dry}}{VWC_{wet} - VWC_{dry}} \times 100$$

where

VWC = the current measurement

VWC_{dry} = the dry reference

VWC_{wet} = the wet reference.

For example, a particular clay-loam soil may reach wilting point at 18% and field capacity at 35%. With these references, a VWC measurement of 24.5% will display as a relative water content of 38.2%. A VWC of 30% is calculated as an RWC of 70.6%.

An RWC value greater than 100% indicates that the soil has a water content value greater than the **wet** reference; a negative value indicates that the water content is below the **dry** reference.

Water required (in mm of applied water) to return the soil to the **wet** reference is also calculated and reported as water deficit. A negative deficit indicates that that the water content is greater than the **wet** reference for that soil type.

Since the sensors average water content along the length of the rods, the sample volume difference between the 20 cm and 12 cm sensors is significant. This difference affects the water deficit value. Therefore, the current measurement and reference values must be made with the same rod length.

6.4.1 Soil Types

The HydroSense II needs three parameters to calculate relative water content and deficit:

- **wet** water content set point
- **dry** water content set point
- sensor length

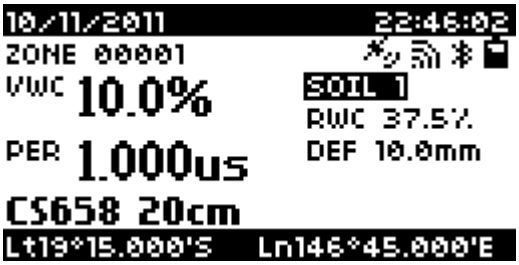
These parameters are soil specific and grouped as soil profiles. The HydroSense II holds up to 10 soil profiles labeled **SOIL 1** through **SOIL 10**.

Some soil profiles are preset to default values. These values may be used or overwritten as desired, but take care to record what soil type is used for each profile. The default soil profiles are described in TABLE 6-1, *Default Soil Profiles*.

TABLE 6-1. Default Soil Profiles

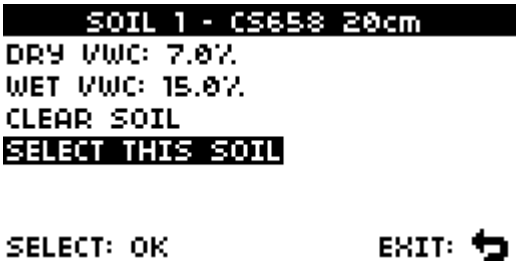
Soil No	Dry	Wet	Rod Length	Soil Description
1	7%	15%	20 cm	Sand
2	10%	20%	20 cm	Sandy Loam
3	18%	35%	12 cm	Sandy Clay
4	15%	30%	12 cm	Loam
5	20%	40%	12 cm	Silty Clay
6	17%	35%	12 cm	Clay Loam

6.4.2 Configuring Soil Profiles



When Deficit Mode is enabled (Section 7.3.4, *Deficit Display* (p. 17)), soil profiles are accessed from the *main screen* (p. 15) of the HydroSense II. To select the current soil profile (**SOIL 1** in the preceding figure), press the › button. The soil profile number will be highlighted. To open the soil profile list, press READ OK.

The soil profile list should be displayed. Use ^ v to move through the list to the desired soil profile and press READ OK.



A soil profile page will be displayed. This page shows the reference values stored for this soil profile and the rod length used.

To select this soil profile to apply to the current measurement, press v to highlight SELECT THIS SOIL and press READ OK.

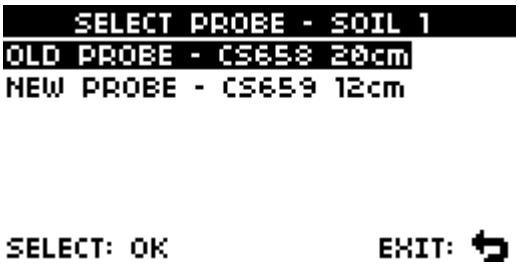
New reference values can be set from the soil profile screen. To do so, correctly insert the sensor in the reference soil and select **WET VWC** or **DRY VWC** and press READ OK.

The screen will show MEASURING… while the measurement is taken. After 3 to 4 seconds, the soil profile page will be shown with the reference value changed. Repeat this process for the remaining wet or dry set point.

If desired, the soil profile can be cleared by selecting CLEAR SOIL then READ OK.

NOTE The CLEAR SOIL operation cannot be undone.

The sensor length stored in a soil profile is automatically updated to match the sensor used whenever the wet and dry reference values are changed. If the sensor length used to change one of the references is different to that previously used for the soil profile, the following screen will be shown.



Selecting NEW PROBE will overwrite the soil profile, clearing the other reference value, whereas selecting OLD PROBE will discard the measurement and leave the soil profile unchanged. This feature forces both reference values to use the same rod length. This step cannot be reversed. Using ^ v, select the desired option and press READ OK to accept or STORE to discard the new measurement and return to the soil profile screen.

Once the soil profile changes are complete, use ^ v to choose SELECT THIS SOIL and press READ OK. This will return to the *main screen* *(p. 15)* and use the new soil profile.

6.4.3 Storage

The HydroSense II does not store relative water content or deficit measurements to flash. Only water content measurements are stored.

6.4.4 Proper Measurement Technique and Limitations

6.4.4.1 Measurement Principle

The HydroSense II uses soil dielectric permittivity to estimate volumetric water content. Dielectric permittivity of water is much greater than that of other soil

constituents making possible the correlation of water content to measured dielectric permittivity. Additionally, water and air are the only soil constituents that change appreciably over biological time scales.

The electronics contained in the water content sensor generate the high frequency electromagnetic energy necessary to polarize water molecules such that their permittivity can be determined. The energy passes along a waveguide formed by the two rods and reflects from the end of the rods and back into the sensor head where the reflected signal is detected and time of travel is measured. The time of travel along the waveguide is predominantly dependent on the dielectric permittivity. Since the measured time is the net result of passing down the length of the rods and back again, it reflects an average of the water content over the volume of the waveguide. The sensor electronics also detect electrical conductivity (EC) between the rods and use this to correct the permittivity measurement. This allows the sensor to operate in a wider range of soil EC. The calibration coefficients to convert measured time of travel to dielectric constant and water content are contained within the sensor head and are the intellectual property of Campbell Scientific.

6.4.4.2 Rod Insertion

For accurate, repeatable measurements, the rods of the sensor must be fully inserted into the soil. Since the water content is averaged over the length of the rods, the reading from a 20 cm sensor inserted vertically will be the average of the soil moisture over the top 20 cm; however, the same rods inserted at 45° will yield an average of the top 14 cm. This is often used for shallow rooted crops, such as turf, to measure the average water content in the root zone of the plant. Inserting the rods completely at an angle often requires more attention during the insertion action.

The measurement volume of a sensor varies somewhat with soil type. As a guide, volume extends along the full length of the rods and outward radially from each rod a distance of approximately 3 cm.

Soil is not homogeneous. Cracks, rocks, pore size, plant roots, and texture layers are not usually distributed uniformly throughout a measured profile. If the water content over a large area such as a cropped field is to be determined, several measurements may be required to establish a representative measurement.

6.4.4.3 Soil Factors Affecting Measurement

The HydroSense II is predominantly sensitive to dielectric permittivity, and therefore soil water content (see Section 6.4.4.1, *Measurement Principle (p. 12)*). Other physical properties of the soil can affect the measurement. If the soil contains a large clay fraction or has high electrical conductivity (EC), the applied signal can be attenuated sufficiently to affect detection of the reflected signal in the sensor electronics. A very high organic matter fraction has a similar effect. The HydroSense II will still respond to changes in water content in these atypical soils, but its response will deviate from that of soils wherein the attenuation factors are present in small non-interfering amounts. The calibration coefficients fixed in the HydroSense II sensor were determined in laboratory studies on typical soils. When measuring atypical soils, user determined coefficients can often be applied to the measured period value.

Rocky soils can make rod insertion difficult and introduce variability in water content measurements taken in the same general area. Rocks occupy space

otherwise occupied by the fine soil fraction, but they do not hold water in the same manner as soil. If two proximal measurements are made in rocky soil, the measured water content can differ significantly if large quantities of rock occupy part of the sensitive volume of one measurement but not the other.

6.4.4.4 Measurements in Special Materials

The HydroSense II was designed for use in agricultural soils, but the measurement technique underlying the instrument supports other potential applications. Other porous media can be monitored using the period value shown on the display. The period is strongly related to dielectric permittivity of the material surrounding the sensor rods and can be used as a relative value to measure changes in the material of interest. Period generally increases proportionally with water content. For actual water content values, a soil specific calibration can be performed using an independent measure of water content such as gravimetric analysis. A calibration equation can then be derived to relate period to water content.

7. User Interface

The following section contains a detailed description of the HydroSense II user interface.

Screenshots included in this section were captured using factory default settings (except where noted); however, they may not reflect the exact image seen on your screen because of configuration settings chosen or operating system updates

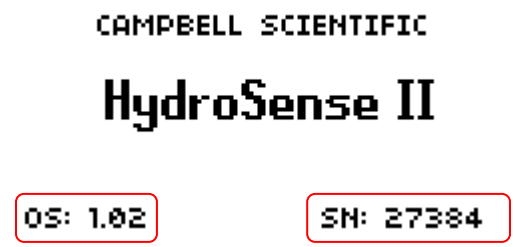
Red highlights on the images mark areas of interest. The highlights are added for illustrative purposes and are not present on the screen of an actual display.

7.1 Buttons

User Interface Buttons	
Button	Function
	Power/MENU — To turn the HydroSense II on or off, press and hold this button for 3 seconds. When pressed for less than 3 seconds in the *main screen* ***(p. 15)***, the *main menu* ***(p. A-1)*** will be displayed.
	READ/OK — Triggers a new measurement in the *main screen* ***(p. 15)***. Also used to select an item in a list or to answer OK to prompts.
	Back/STORE — From the *main screen* ***(p. 15)***, used to store the current reading to flash memory. In the menu system, used to move to the previous menu.
	Up — Moves the cursor up.
	Down — Moves the cursor down.
	Left — Moves the cursor to the left.
	Right — Moves the cursor to the right.

7.2 Splash Screen

To turn the HydroSense II on, press and hold MENU for 3 seconds. The following splash screen is displayed.

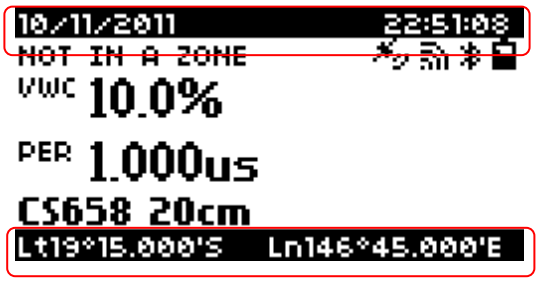


The operating system version number and device serial number are displayed. The splash screen is shown for 2.5 seconds.

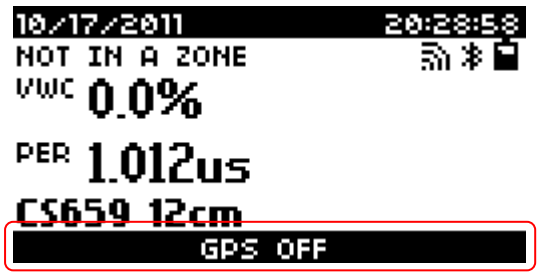
7.3 Main Screen

After the splash screen, the main screen is shown. The main screen contains a number of different elements which are explained in the following subsections.

7.3.1 GPS Information



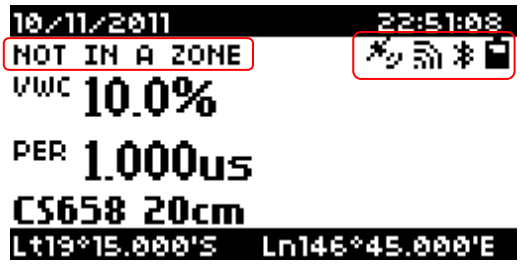
The top bar of the screen displays the current date and time information. This time is synchronized with the GPS when available. The bottom bar shows the current GPS coordinates. Both values are updated automatically.



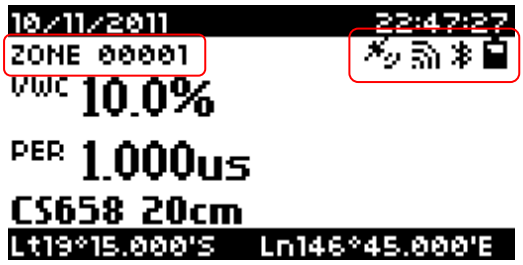
If the GPS is turned off using the *configuration menu* *(p. A-1)*, GPS OFF is displayed at the bottom.

7.3.2 Status Information

The zone name is shown in the upper left of the screen:



When the current position is not within an existing zone, **NOT IN A ZONE** is displayed. When the HydroSense II is moved within the boundaries of an existing zone (such as ZONE 00001 in the following figure), the zone name will be displayed.



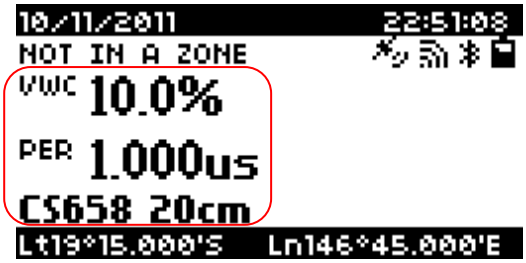
This change occurs automatically when the HydroSense II detects that it is within the boundaries of a zone. For more information on zones, please see Section 9.2, *Geotagging and Zones* *(p. 20)*.

The upper left of the *main screen* *(p. 15)* shows a group of status icons. They are detailed in TABLE 7-1, *Status Icons*.

TABLE 7-1. Status Icons

	GPS--This icon is shown when the GPS has acquired synchronization with the GPS satellite constellation. This icon disappears when the GPS is turned off or the GPS sync is lost.
	Bluetooth connection--This icon is displayed when a Bluetooth connection has been successfully established. When the Bluetooth connection is closed, this icon disappears.
	Bluetooth active--This icon is shown whenever the Bluetooth radio is turned on and discoverable. If the Bluetooth is turned off, this icon disappears.
	Battery--This icon indicates the state of charge of the battery pack. The icon changes from , which indicates the battery is fully charged, to when it is empty.

7.3.3 Measurement Display



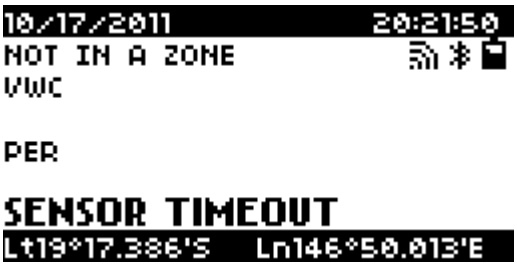
The center left of the screen contains the measurement results.

- VWC — This section shows volumetric water content in percent. This value is automatically compensated for varying soil conditions. If the measurement is out of range, the display will show **---** in this position.

- PER — The average period measured -- expressed in microseconds.

Under the sensor readings are displayed model number and rod length of the sensor used (in this case **CS658 20cm**). This is updated with each measurement.

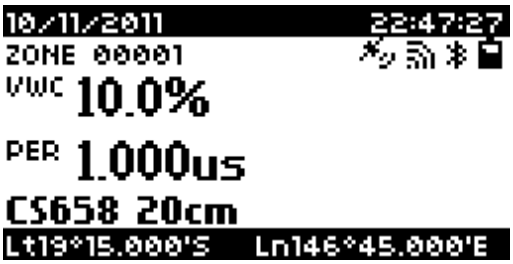
If the water content sensor is not properly connected or is malfunctioning, the display will show **SENSOR TIMEOUT**.



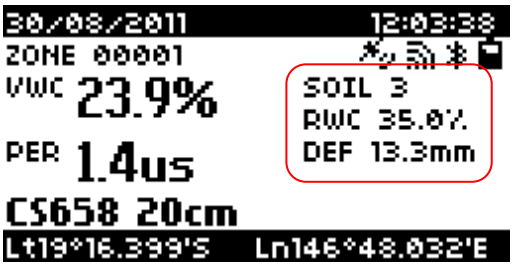
7.3.4 Deficit Display

When deficit mode is enabled, the water deficit section is displayed at center right of the *main screen* *(p. 15)*.

The following image shows the main screen without deficit mode enabled.



The following image shows the main screen with deficit mode enabled.



The water deficit section of the display contains the following information.

- SOIL # (soil profile number) — Range: 1 to 10.
- RWC — relative water content. Range: 0% to 100% where 0% represents dry (wilting point) and 100% is wet (field capacity).
- DEF— water deficit expressed in millimeters (mm).

8. Data Storage and Retrieval

The HydroSense II includes non-volatile flash memory for storage of data and configuration settings. Flash memory is preserved when the batteries are exhausted or changed.

8.1 Storing Data

To store data with the HydroSense II, press the STORE button from the *main screen (p. 15)*. If the current location is not within an existing zone, a prompt to create a new zone will be presented. If a zone already exists, the HydroSense II stores the data to that zone.

NOTE The STORE function stores volumetric water content values. Make a measurement before pressing the STORE button.

8.2 What is stored?

The flash file system holds the water content data file, the zone table, and the table of configuration settings. The most important among these is the water content data file. When the user stores a measurement by pressing STORE, the most recent measurement of volumetric water content (VWC) is stored with the measured period, sensor type, current date and time, and latitude and longitude (if GPS synchronization has been achieved). If the GPS is switched off or does not have a valid synchronization, system time and date are used without GPS confirmation of their accuracy. When the GPS is disabled, check and adjust the system clock before storing data.

The water content data file is configured as ring memory that holds over 1000 values. When the file becomes full, the oldest data is overwritten.

The zone data file is configured as fill-and-stop memory. It holds a list of zones that have been created. Zones are created whenever a datum is stored in a new location. Each zone record contains the center position (latitude and longitude),

radius in meters, and the zone name. The zone file is large enough to hold over 100 zones. When the zone data file is full, a new zone cannot be created until an old zone is removed.

The configuration settings file is managed automatically. These settings are synchronized to the computer where they can be viewed, modified, backed up, and restored. For more information, please refer to the HydroSense II Support Software user guide.

8.3 Software

The HydroSense II ships with the latest version of the HydroSense II Support Software on CD. For the latest version, please contact Campbell Scientific. For a complete guide to the use of this software, please refer to the HydroSense II Support Software user guide.

8.4 Connecting via Bluetooth

Steps to achieve a Bluetooth connection:

- Start HydroSense II Support Software.
- Turn on the HydroSense II display by holding the MENU button for 3 seconds.
- In HydroSense II Support Software, click the Discover button to find Bluetooth devices within range.
- When the HydroSense II unit is discovered, click **Connect**.

The first time the HydroSense II unit is used with a new computer, the computer and HydroSense II must be paired before a connection can be made. The pairing code is 1234. For more information, please refer to the HydroSense II Support Software user guide.

While a Bluetooth connection is open, the HydroSense II will not shut down. Turn off the HydroSense or disable the Bluetooth once data have been collected or settings have been updated to avoid early depletion of the batteries.

8.5 Collecting Data

Before collecting data, establish a Bluetooth connection (Section 8.4, *Connecting via Bluetooth (p. 19)*). Access the HydroSense II Support Software and click **Synchronise** to download new water content data and update the zone table and configuration settings.

For more information, please refer to the HydroSense II Support Software user guide.

9. GPS

The HydroSense II incorporates a receiver for the Global Positioning System (GPS). To calculate position, the GPS module must receive radio time signals from at least four satellites simultaneously. If the receiver detects signals from

more than four satellites, it will use the additional data to determine a more accurate position.

9.1 GPS Synchronization

The GPS receiver needs a clear view of the sky to reliably calculate position. When the receiver resolves the current position, it has achieved synchronization.

The GPS antenna is located inside the display above the LCD. The antenna faces toward the sky when the display is held upright in a comfortable reading position.

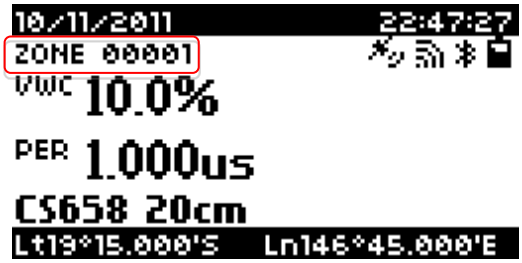
To synchronize the GPS, take the HydroSense II outside, away from tall buildings or large obstructions and turn it on. GPS synchronization will normally be achieved in approximately 30 seconds, but may take up to a minute or more. The HydroSense II indicates that synchronization has been achieved by displaying the GPS sync icon () on the *main screen* *(p. 15)*. When the GPS is synchronized, the internal clock of the HydroSense II is adjusted to match GPS time to within one millisecond. GPS can be disabled using the *configuration menus* *(p. A-1)*.

9.2 Geotagging and Zones

When the GPS module is enabled, the HydroSense II is able to store water content data tagged with position information (latitude and longitude).

Using this position information, data can be grouped by geographical location. These geographical areas are referred to as zones and are characterized by a center coordinate and radius. Volumetric water content values are grouped, filtered and charted by the computer software based on the zone in which the data was collected.

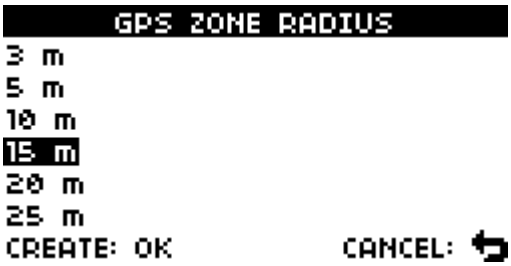
The HydroSense II keeps a table of up to 100 GPS zones in memory and searches through this table every few seconds to determine if it is within the boundary of a zone. When it has determined that the user is within a zone, it displays the zone name on the *main screen* *(p. 15)*.



Zones can be created while storing data. When the *Store* *(p. 14)* button is pressed, if the HydroSense II determines that the current location is not in an existing zone, **CREATE A NEW ZONE?** is displayed.

To create a new zone, select YES and press READ OK. To exit without storing, press STORE.

When a new zone is created, the following screen is displayed.



Use the ^ v buttons to select the radius to use for this zone and press READ OK to save the new zone details. Press STORE to return to the *main screen* *(p. 15)* without creating a new zone and without storing data.

Once a zone is created, the water content data will be stored. By default the zone name will be in the form of Zone xxxxx where xxxxx is a number that automatically increases each time a new zone is created. Zones can be renamed and updated using HydroSense II Support Software.

If the STORE button is pressed when the GPS does not have a valid GPS sync, a warning message is display.

This message warns that the current measurement may not be stored with an accurate date or time. To continue and store data without GPS information, press READ OK. To return to the *main screen* *(p. 15)* without storing, press STORE.

10. Troubleshooting

Problem	Explanation / Recommendation
Display shows **SENSOR TIMEOUT** continuously.	This message indicates that the HydroSense II display has not received a response from the sensor. Check that the connectors are mated correctly, the pins are clean, and the connector has not been damaged. If this problem persists, please contact Campbell Scientific.
Display shows **NO GPS LOCK. STORE ANYWAY?** when attempting to store data.	This warning indicates that the GPS has not achieved synchronization with the GPS satellite network. This may occur because the GPS has been turned off, does not have a clear view of the sky or simply has not been turned on long enough to achieve synchronization. If selecting OK in response to this query, data will be stored without positional information and the date and time information may be inaccurate.
The volumetric water content is reported as ---.	--- indicates that the water content sensor was unable to determine the volumetric water content for these soil conditions. Try taking the measurement a few more times or try another location close by. For extreme or special soils, period can sometimes be used in conjunction with a soil specific calibration to yield usable results.
The main screen shows **GPS off** in the bottom bar.	This indicates that the GPS is turned off. Please refer to Appendix A.14, *GPS Settings* *(p. A-6)*, to find the GPS power control.
On the display of my HydroSense II, the battery icon, the Bluetooth icon, and the GPS icon are visible, but a fourth icon appears to be missing.	The fourth icon is the Bluetooth connection icon. It appears only when the HydroSense II is paired to a computer and there is an active data connection between them. This happens when collecting data or changing configuration settings. Generally, when using the computer to collect data from the HydroSense II, focus is on the computer screen and not the HydroSense II display, so this icon may not be noticed.

11. Maintenance

11.1 Batteries

The HydroSense II is powered by four AA alkaline batteries. Use a high quality battery for best operation. Battery brands considered adequate for the power requirements of the HydroSense II include (inclusively) Energizer®, Duracell®, and Panasonic®. Under normal use, the life of high quality batteries should be close to a year. Replace the batteries when the voltage is less than 4 V. The battery indicator icon on the *main screen* *(p. 15)* gives a warning of the battery status. When the indicator shows the batteries are near empty ( ),

have replacement batteries available. The HydroSense II carry case has a spare battery pack (holder only – batteries not included).

Configuration settings, stored data, and zones are stored in flash memory such that they will be preserved during battery replacement.

11.1.1 Replacing the Battery Pack

The process to replace the battery pack is:

1. If using the HS2P, follow the procedure provided in Section 11.2, Removing *Display from HS2P Pole* *(p. 24)*.
2. Place the display face down on a clean dry surface.
3. Remove the four (4) Phillips screws on the back of the displays case with the Phillips screwdriver provided in the carry case.
4. Carefully separate the back cover from the front cover, taking care to keep the display face down (if the unit is turned face up, the battery holder inside may fall out and damage the battery wires).
5. Unclip the battery connector from the battery holder.

CAUTION Although this connector looks similar to the terminals of a 9 V PP3 battery, it is not compatible with the 9 V battery. Do not connect a 9 VDC battery to the terminals, because it can permanently damage the HydroSense II. This damage is not covered under the warranty.

6. Connect the spare battery holder to the battery connector.
7. Carefully replace the back cover of the display and replace the four screws.
8. Turn over the display and hold the MENU button for 3 seconds to activate.
9. If using the HS2P, reinstall the display onto the pole.

11.2 Removing Display from HS2P Pole

1. Disconnect the sensor cable at the bottom of the display.

2. Squeeze the clip to release the display from its holder.

3. Lift the display from its holder.

11.3 Rod Replacement

Threaded inserts in the epoxy body of the sensors allow user replacement of the stainless steel rods. Initially, these rods are fitted at the factory and with normal use should provide years of trouble-free service.

Insertion into rocky soils can bend the rods. Bent rods should be straightened or replaced as soon as possible since non-parallel rods can introduce error and cause more serious bending or breaking. Small bends can often be straightened by hand, but more serious bends may require rod replacement. Spare rods can be purchased from Campbell Scientific.

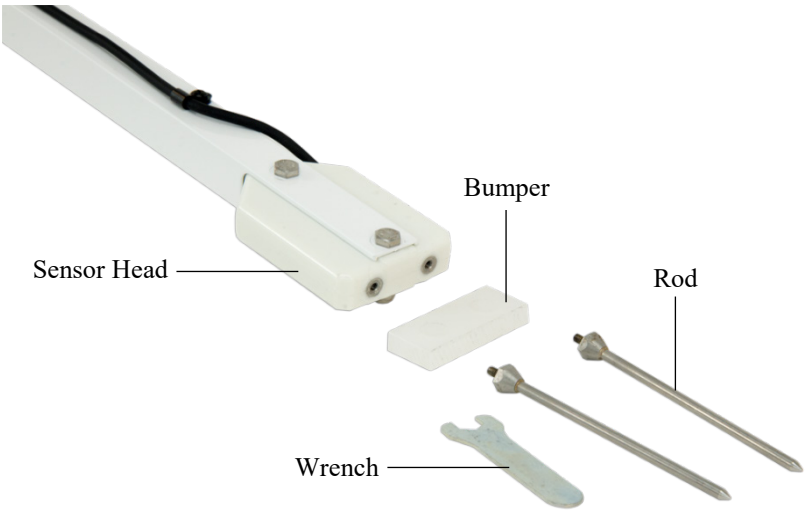
- Spare 20 cm rods for the CS658 or CS658P sensor
- Spare 12 cm rods for the CS659 or CS659P sensor

NOTE Unlike the original HydroSense, the HydroSense II sensors do not support interchangeable rods. The CS658 and CS658P will only measure accurately with 20 cm rods and the CS659 and CS659P will only measure accurately with 12 cm rods. Threads have been mismatched intentionally to ensure that rods are not inadvertently mixed up. Please do not attempt to change rod sizes.

The rods have a hexagonal nut collar. When threaded into the sensor body, this collar distributes lateral forces over a relatively large area to reduce rod deformation.

The procedure for replacing the rods is as follows:

1. If using the HS2P, slip off the plastic bumper.



2. Use the wrench to unscrew the rods.

3. Ensure that the threads of the replacement rods and the sensor body are clean and free from damage.

4. Apply thread locking compound on the threads of the replacement rods.

CAUTION Use the thread locking compound sparingly. A thick coating may affect measurements. The small tube of Loctite® 222MS Threadlocker that is shipped with the HydroSense II is enough to treat several sets of rods.

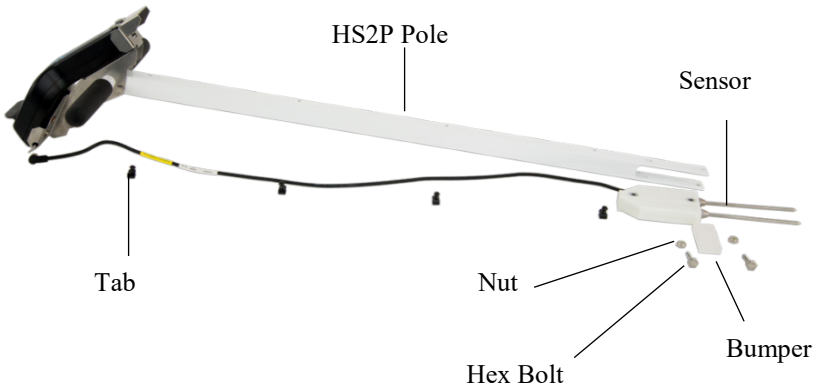
5. Use the wrench to screw in the rods. Full contact between the rod nut and sensor body is required for proper operation.

CAUTION Do not over tighten the rods. This can damage the threaded inserts of the sensor head, permanently damaging the sensor.

6. If using the HS2P, put on the plastic bumper.

7. Wait 3 to 12 hours before using the HydroSense II to allow the thread locking compound to cure. The required curing time depends on temperature. Allowing the threading compound to cure prevents loosening of the rods.

11.4 Replacing an HS2P Sensor



1. Unplug the cable that attaches the sensor to the display.
2. Remove the plastic bumper.
3. Use the wrench to remove the hex bolts and nuts that secure the sensor to the pole.
4. Use Phillips screwdriver to remove the screws and tabs that fasten the cable to the pole.
5. Remove the old sensor.
6. Place the new sensor in the slots at the bottom of the pole.
7. Secure the sensor to the pole using the hex bolts and nuts.

CAUTION Do not over tighten the hex bolts.

8. Put on the plastic bumper.
9. Secure the sensor cable to the pole using the Phillips screws and tabs.
10. Connect the cable to the display.

11.5 Operating System Updates

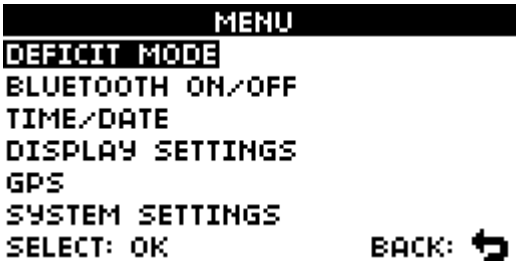
Updates to the HydroSense II operating system (firmware) are made available at or *www.campbellsci.com*. These updates may provide fixes for known problems, add new features, change default settings, or make improvements to the user interface. Normal practice is to keep the HydroSense II operating system up to date.

For details of the operating system update procedure, please refer to the HydroSense II Support Software user guide. Updating the operating system erases data, zones, and configuration settings. Therefore, collect and back up data on the computer before performing an update.

Begin an operating system upgrade with a fresh set of batteries. If the batteries in the HydroSense II fail during the update process, corruption of the operating system can result. Normally, the batteries can be replaced and the update restarted. In rare cases, however, this corruption will require factory repair.

Appendix A. Configuration Menus

A.1 Main Menu



To enter the main menu, press MENU from the *main screen (p. 15)*. Using the ^ v buttons, select the desired menu item and press READ OK. To exit the menu, press STORE.

A.2 Deficit Mode

This menu selects whether or not soil deficit is displayed. Select ON to show deficit results and OFF to hide them. To quit this menu without saving the changes, press STORE.

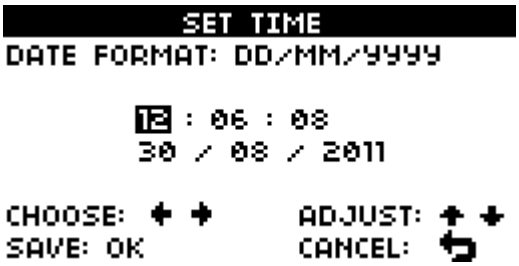
A.3 Bluetooth Power

This menu controls power to the Bluetooth module. Switching off Bluetooth will save power while the unit is awake and increase battery life. Bluetooth will need to be re-enabled to collect data with a computer. Using the ^ v buttons, select the power state to use and press READ OK. To exit the menu without saving, press STORE.

A.4 Time/Date Menu

This submenu contains a list of settings to configure the clock system of the HydroSense II. Using the ^ v buttons, highlight one of the options and press READ OK. Alternatively, press STORE to quit this menu.

A.5 Time Set

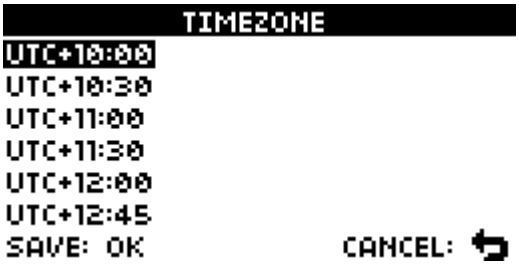


The HydroSense II clock is normally set automatically at GPS sync. This menu is used to set the HydroSense II clock if GPS is not used. The < > buttons can be used to move between the different parts of time and date, while the ^ v buttons adjust each individual part of the time and date. At the top of the screen, the date format is displayed for reference. To save the adjusted time to the clock, press READ OK. To exit without saving, press STORE.

A.6 Date Format

This menu sets the format in which dates are displayed throughout the system. Use the ^ v buttons to choose the desired format, and press READ OK. To quit the menu without saving, press STORE.

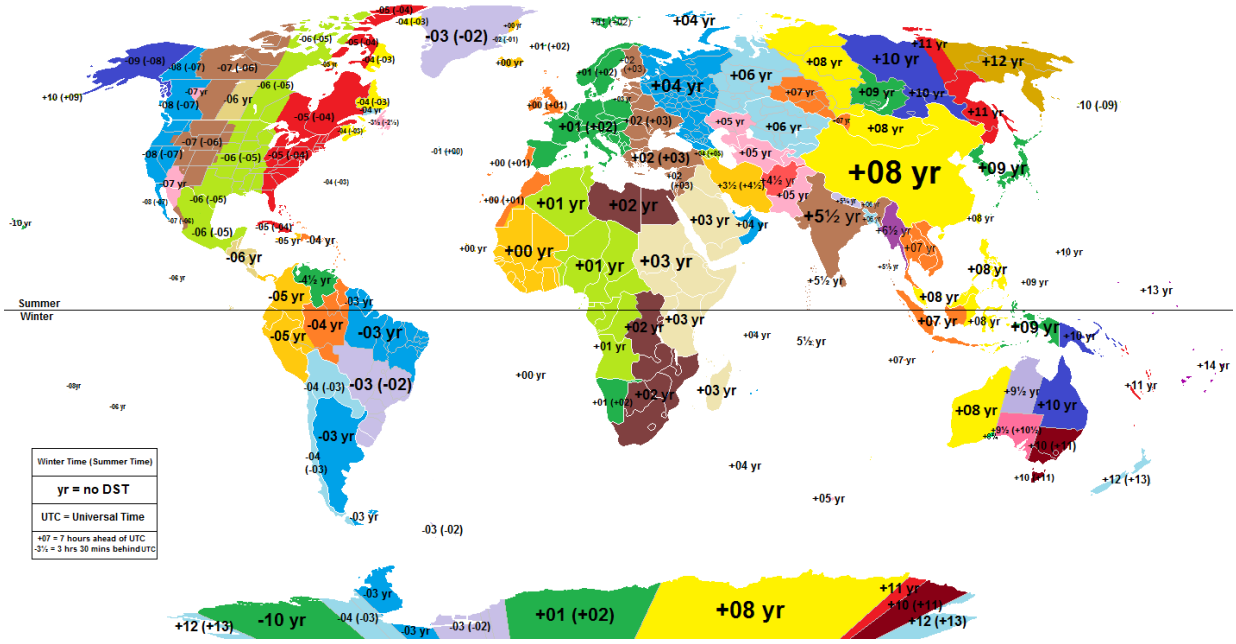
A.7 Time Zone



The HydroSense II is able to use its GPS to provide a very accurate clock. Whenever a valid GPS signal is detected, the clock is adjusted using the received time (in UTC) and the time zone selected in this menu.

Time zones from UTC-12 to UTC+14 are available. Use the following diagram for information on global time zones. Use ^ v to select a time zone and press READ OK. To exit without making changes, press STORE.

The HydroSense II supports only standard time; it does not automatically adjust for daylight saving time. However, by incrementing or decrementing to an adjacent time zone, daylight saving time can effectively be used if desired.



Source and copyright for this image - Wikipedia (http://en.wikipedia.org/wiki/Time_zone).

A.8 Time Synchronization

The HydroSense II uses its GPS to provide a very accurate clock. Whenever a valid GPS signal is detected, the clock is adjusted using the received time (in UTC) and the configured time zone. To use GPS synchronization, select ON from the list, or OFF to ignore the GPS time. This menu item does not disable GPS position. After highlighting a selection from the list, press READ OK. To quit the menu, press STORE.

A.9 Display Settings

This submenu contains a list of settings related to the screen of the HydroSense II. Using the ^ v buttons, highlight one of the options shown and press READ OK. Alternatively, press STORE to exit the menu.

A.10 Contrast

The contrast of the LCD can be affected by extremes of temperature or lighting. This menu controls screen contrast. Press the < button to lower the contrast (make the image lighter) or the > button to increase contrast (darker). Please note that the highest and lowest contrast settings should only be required in the most extreme conditions. Press READ OK to save the new setting and STORE to exit.

A.11 Brightness

This menu allows the brightness of the LCD backlight to be adjusted. Since the backlight uses a significant amount of power, reducing the brightness will extend battery life. In bright, sunny conditions, the backlight has very little effect and generally doesn't help readability, so the HydroSense II detects the ambient light conditions and automatically turns off the backlight when exposed to bright daylight. Using the < > buttons, set the brightness to an acceptable level. Press READ OK to save or STORE to quit.

A.12 Backlight on Time

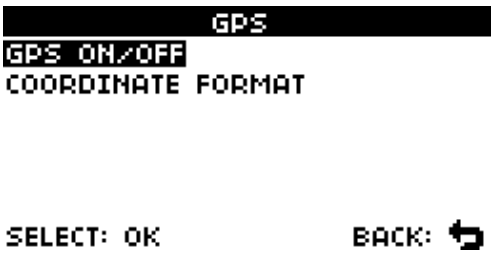
The LCD backlight turns on whenever a button is pressed. This menu configures how long it remains lit after each press. The < > buttons change the period and READ OK will save it. Press STORE to exit without saving.

Setting the backlight on time to **Always On** will increase average power consumption significantly, and drastically reduce battery life.

A.13 Light Sensing

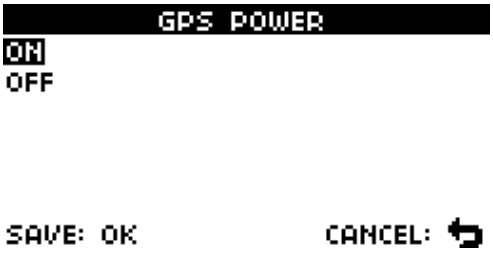
In bright, sunny conditions, the LCD backlight has very little effect on readability, so the HydroSense II detects the ambient light level and switches the backlight off in bright conditions. This feature can be disabled using this menu. Using the ^ v buttons, select ON or OFF from the list and press READ OK to save the setting. Press STORE to quit.

A.14 GPS Settings



This submenu contains a list of settings related to the GPS. Using the ^ v buttons, highlight one of the options shown and press READ OK to select that item. Alternatively, press STORE to exit the menu.

A.15 GPS Power



This menu controls power to the GPS module. Switching off GPS will save power while the unit is awake and increase battery life; however, the time and date used by the HydroSense II may be less accurate and any stored data will not be geotagged for future display and charting. Using the ^ v buttons, select a power state to use, and press READ OK. To exit the menu without saving, press STORE.

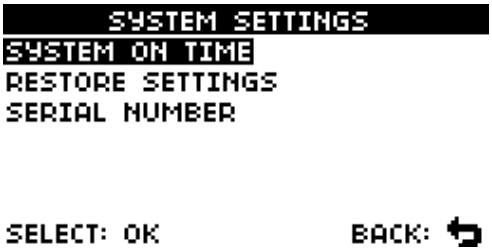
A.16 Coordinate Format

Latitude and longitude information can be displayed on the *main screen* *(p. 15)* in one of three formats:

DDD.DDDD°	decimal degrees
DDD°MM.MMMM’	degrees with decimal minutes
DDD°MM’SS”	degrees, minutes and seconds.

Using the ^ v buttons, select a format, and press READ OK. To exit the menu without saving, press STORE.

A.17 System Settings



This submenu contains a list of system-wide settings. Using the ^ v buttons, highlight one of the options shown and press READ OK. Alternatively, press STORE to exit the menu.

A.18 System on Time

To save power, the HydroSense II will automatically power off after a period of inactivity. This menu allows configuration of this time period. Press the < > buttons to choose a timeout period and press READ OK. Pressing STORE will exit without saving.

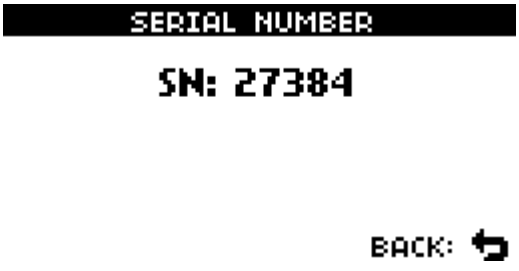
If the system on time is set to **Always on** the HydroSense II will only turn off when the MENU button is used. This will increase the average power consumption significantly. If the device is left running by accident, the batteries are likely to be exhausted in just a few days.

A.19 Restore Settings

This menu restores the HydroSense II to its factory defaults. Press READ OK to overwrite all configuration settings with default values or STORE to exit without changing settings.

This step cannot be undone. If the unit is inadvertently set to factory defaults, all settings will need to be restored manually through the previous menus.

A.20 Serial Number



This screen displays the serial number of the HydroSense II. This should match the serial number labeled on the front panel of the unit. Press STORE to exit this screen.

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