

# INSTRUMENTATION FOR APPLIED ENVIRONMENTAL RESEARCH

CATALOG VOLUME 12 NUMBER 1

Rocky Mountain iris  
*Iris missouriensis*

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## New Products



### RS3

Why stainless steel? Two of Decagon's new soil moisture sensors have stainless steel sensing needles instead of the traditional circuit board material. The stainless steel needles provide a stronger structure, easier insertion, and a much larger surface area for electrical conductivity.

See page 14 for more details.



### Em50G

The new Em50G lets you access data from anywhere with an internet connection. Self-contained logger runs on 5 AA batteries and sets up in about 27 minutes.

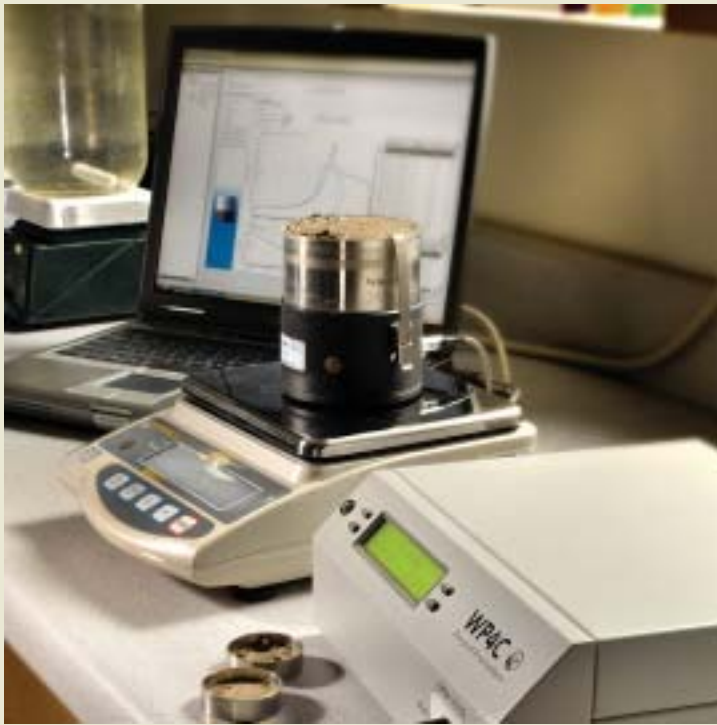
Get more details on page 18.



### CTD Sensor

The new CTD Sensor lets you continuously monitor groundwater and surface water level changes along with electrical conductivity and temperature.

Get more details on page 37.



## Hyprop/WP4C

They're two instruments, but power users put them together to generate the full-range soil moisture release curve. Now, new HydroFit Software makes it even easier by fitting multiple models to the combined data. More information on page 32.



## CTD Sensor

Conductivity Temperature Depth Sensor. Robust, accurate, and lower cost than traditional CTD sensors. How does that work? Check it out on page 37.

## CANOPY

Leaf Porometer	Page 4
LP-80	Page 6
Leaf Wetness Sensor	Page 8

## SOIL MOISTURE

DataSpring	Page 10
Soil Moisture Sensors	Page 12
Environmental Sensors	Page 16
Em50 Loggers	Page 18
DataTrac3	Page 20
Case Study: Telemetry	Page 22
Irrigation Monitoring	Page 24
Water Balance	Page 26

## WATER POTENTIAL

WP4C	Page 28
MPS-2	Page 30
Hydrofit Software	Page 31
Hyprop	Page 32
Vapor Sorption Analyzer	Page 33

## HYDROLOGY

Infiltrometer	Page 35
CTD Sensor	Page 37

## THERMAL

KD2 Pro	Page 39
Distributors	Page 43



# Porometer Research for Everyone

GET HIGH QUALITY DATA  
WITHOUT FANS, TUBES,  
OR PUMPS.

**B**REAKTHROUGH Steady State technology (see details at right) makes accurate stomatal conductance measurements affordable and practical for everyday research. Features detailed water use, indicates water stress and compares physiological varieties. Add stomatal conductance data to any canopy study with this elegantly designed Leaf Porometer.

## Applications

- Water Stress Measurements
- Variety Testing & Comparison
- Fundamental Research on Stomatal Function
- Teaching and Student Labs

## Benefits

- Automatic sampling mode eliminates user subjectivity.
- Accurate Steady-State measurement.
- No tubes, pumps, or fans.

## Leaf Porometer Specifications

Conductance range

0 to 1000  $\text{mmol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$

Accuracy  $\pm 10\%$

Operating Environment

5 to 40 °C, 10 to 90% RH, non-condensing

Units  $\text{mmol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ,  $\text{m}^2\cdot\text{s}\cdot\text{mol}^{-1}$ , s/m

Measurement diameter 6.3 mm

Sensor head cable length 1.2 m (4 ft.)

Measurement time in Auto mode 30 s

Power 4 AA alkaline cells, 3 years life (approximate)

Data Storage 4095 measurements in flash memory



Learn more about the LP-80  
Porometer by scanning the  
QR code with your smartphone.

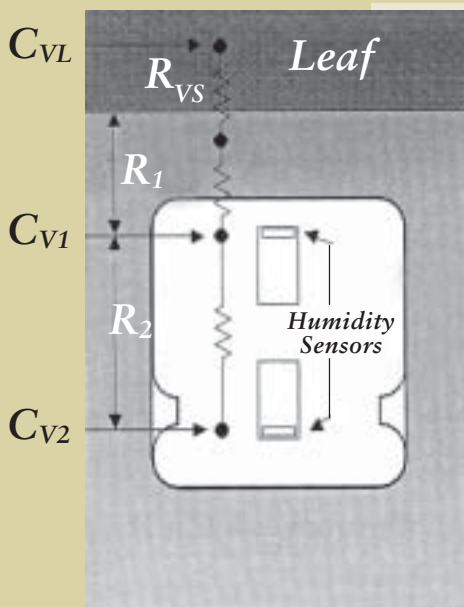
Decagon's Steady State porometer measures stomatal conductance using a sensor head with a fixed diffusion path to the leaf. It measures the vapor concentration at two different locations in the diffusion path. It computes vapor flux from the vapor concentration measurements and the known conductance of the diffusion path using the following equation:

$$\frac{C_{vL} - C_{v1}}{R_{vs} + R_1} = \frac{C_{v1} - C_{v2}}{R_2}$$

Where  $C_{vL}$  is the vapor concentration at the leaf,  $C_{v1}$  and  $C_{v2}$  are the concentrations at the two sensor locations,  $R_s$  is the stomatal resistance,  $R_{v1}$  is the resistance between the leaf and the first sensor, and  $R_2$  is the resistance between the two sensors. If the temperatures of the two sensors are the same, vapor concentration can be replaced with relative humidity, giving

$$R_{vs} = \frac{1 - h_1}{h_2 - h_1} R_2 - R_1$$

Conductance is the reciprocal of resistance, so  $C_{vs} = 1/R_{vs}$ . ■



Schematic illustrating how the porometer measures stomatal conductance.

# Canopy Measurements PAR / LAI

Photosynthetically  
Active Radiation &  
Leaf Area Index



## MEASURE BOTH PAR AND LAI WITH THE ACCUPAR LP-80 CEPTOMETER

USE PAR DATA to estimate biomass production without destroying the crop (see details at right). Measure photosynthetically active radiation (PAR) and get leaf area index (LAI) values simultaneously in real time. Store approximately 9000 data points manually by pressing a button or automatically in unattended sampling mode.

### AccuPAR LP-80 SPECIFICATIONS

Operating environment  
0° to 50°C (32°-122°F),  
0 to 100% relative humidity  
Probe length 86.5 cm  
Number of sensors 80  
Overall length 102 cm (40.25 in)  
Microcontroller dimensions  
15.8 x 9.5 x 3.3 cm (6.2 x 3.75 x 1.3 in)  
PAR range 0 to >2,500  $\mu\text{mol m}^{-2}\text{s}^{-1}$   
Resolution 1  $\mu\text{mol m}^{-2}\text{s}^{-1}$   
Minimum spatial resolution 1 cm  
Data storage capacity 1MB RAM, 9000 readings  
Unattended logging interval  
User selectable, between 1 and 60 minutes  
Instrument weight 1.22 kg (2.7 lbs)  
Data retrieval Direct via RS-232 cable  
Power 4, AA Alkaline cells  
External PAR sensor connector  
Locking 3-pin circular connector (2 m cable)  
Extension cable option 7.6 m (25 ft)

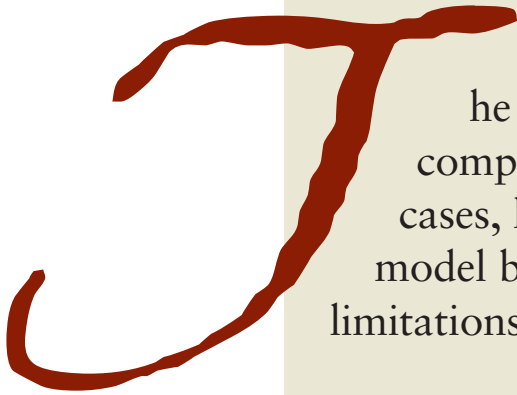
### INCLUDED ACCESSORIES

- EXTERNAL PAR SENSOR  
2 meter cable with connector for direct connection to the external port. Calibrated to provide an output of about 0.1 mV per  $\mu\text{mol m}^{-2}\text{s}^{-1}$  (calibration label provided).
- RS-232 CABLE— for interfacing between your computer and the AccuPAR.
- CARRYING CASE  
Polyethylene hardened case with custom foam cutouts allow the instrument and its accessories to be safely stored inside. 3.6 kg, 11.8 x 24 x 109 cm.



Learn more about the AccuPAR LP-80 by scanning the QR code with your smartphone.





The detailed processes in photosynthesis are complicated and hard to model. In many cases, however, it's possible to simplify the model by focusing on one or more of the limitations to assimilation.

### **Limited by Light, Limited by Water: Two Separate Approaches**

We could postulate situations where light would be the limiting factor in assimilation, and others where water would be the limiting factor. Our models, in words, might be: assimilation is proportional to the plant's ability to capture light, or assimilation is proportional to the plant's ability to capture water. Both approaches can be useful in modeling biomass production.

### **Knowing Which Model to Use**

The most efficient way to determine whether light or water is the limiting factor is to simply run both mathematical models daily to see which one predicts the lowest value. That value is the best predictor of dry matter production for the particular day on which it is run. The May 2011 Virtual Seminar, *Model Carbon Assimilation by Plants*, hosted by Drs. Colin and Gaylon Campbell, describes the math involved and climatic data needed to run these two alternative predictors of dry matter accumulation and shows how to use them together to give the most accurate result. ■

To view the archived version of the free virtual seminar, *Model Carbon Assimilation by Plants*, visit [learn.decagon.com/assimilation](http://learn.decagon.com/assimilation)

# Ready-to-Use Leaf Wetness Sensor



DETECT LEAF WETNESS DURATION WITH A SENSITIVE, CALIBRATED, STANDARDIZED SENSOR

**M**ANY DISEASES affect plants only when moisture is present on the leaf surface. The Dielectric Leaf Wetness Sensor determines the presence and duration of wetness on a leaf's surface, enabling researchers and growers to forecast disease and protect plant canopies. The Leaf Wetness Sensor approximates the thermal mass and radiative properties of leaves to closely mimic the wetness state of a real leaf. Because the sensor does not take resistance-based measurements, it requires no painting or user calibration, and it can detect ice formation as well.

## Leaf Wetness Sensor Specifications

**Measurement time** 10 ms

**Power** 2.5 VDC @ 10 mA to 5 VDC @ 7 mA

**Output** 250 to 1500 mV

**Operating Environment** -20 to 60°C

**Expected Lifetime**

2+ years continuous use

**Probe Dimensions**

11.2 x 5.8 x 0.075 cm (4.4 x 2.3 x 0.029 in)

**Cable Length**

5 m standard, extension cables available

**Connector type** 3.5 mm plug

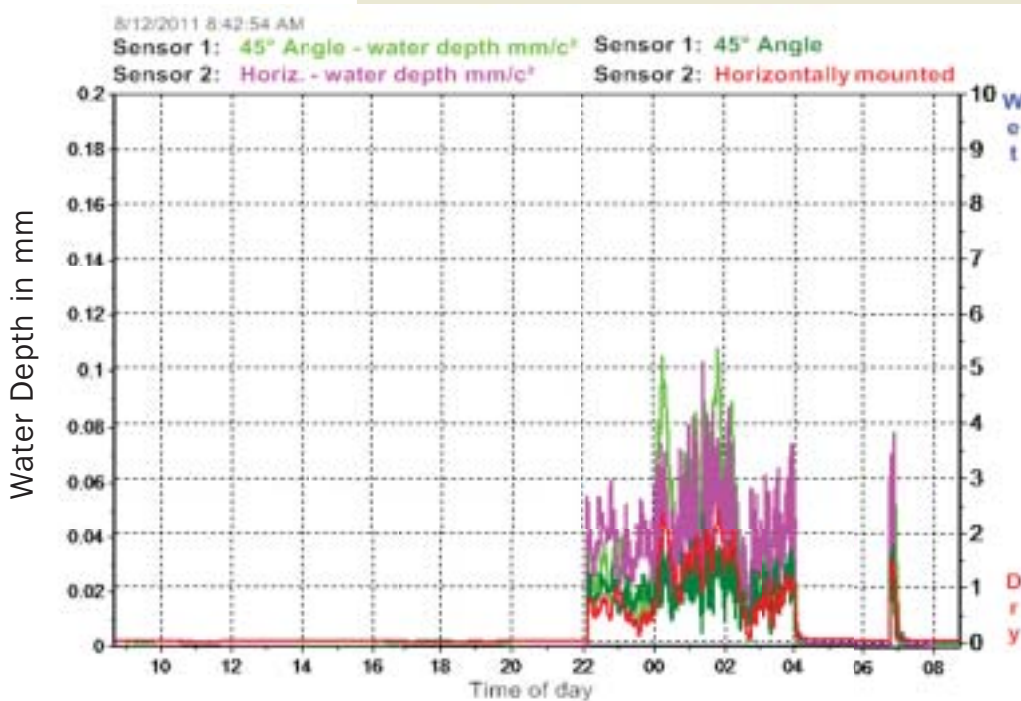
**Datalogger Compatibility (not exclusive)**

Decagon Em50, Em50R, Em50G

Campbell Scientific CR10, 10X, 21X, 23X, 1000, 3000, 5000

Applications

- Disease forecasting and modeling
- Ecological and Agricultural Research



Water Depth in mm

## Using leaf wetness in lieu of a rain gauge?

A standard tipping-bucket rain gauge requires around 0.2 mm of water before it records rain fall. The leaf wetness sensor (LWS), on the other hand, can measure trace amounts

Leaf wetness is shown in both degree of wetness on a relative scale of 1–10, and water depth in mm. One sensor is mounted at a 45° angle, while the other is horizontally oriented. The above graph shows dew formation at approximately 10:00 PM when temperatures drop below the dew point.

of moisture, including dew and ice. Dr. Bruce Bugbee and his colleagues at Utah State University get precipitation measurements with a resolution of 0.02 mm—10 times that of a rain gauge—by using an LWS in their solar powered environmental observatory. Because the surface of the LWS measures dielectric, it can be calibrated to measure tiny amounts of moisture quite accurately. It can also warn students and maintenance workers that walkways might be slippery or icy.

See Dr. Bugbee's live leaf wetness data, as well as other measurements, by visiting [weather.usu.edu](http://weather.usu.edu).



[learn.decagon.com](http://learn.decagon.com)

885-722-0129

# DataSpring

DATASPRING BRINGS THE DATA RIGHT TO YOUR DESKTOP. IT MAKES CHECKING DATA AS EASY AS CHECKING EMAIL.



## Available Sensors

pages 12–17

See the new rugged soil moisture sensor line plus standard soil moisture probes and a range of above-ground sensors.



## Data Loggers

pages 18–19

Hassle-free access to your data—set up the logger in less than 30 minutes.



## Software

pages 20–21

DataTrac 3 gives you an almost real-time graphical window on your data.

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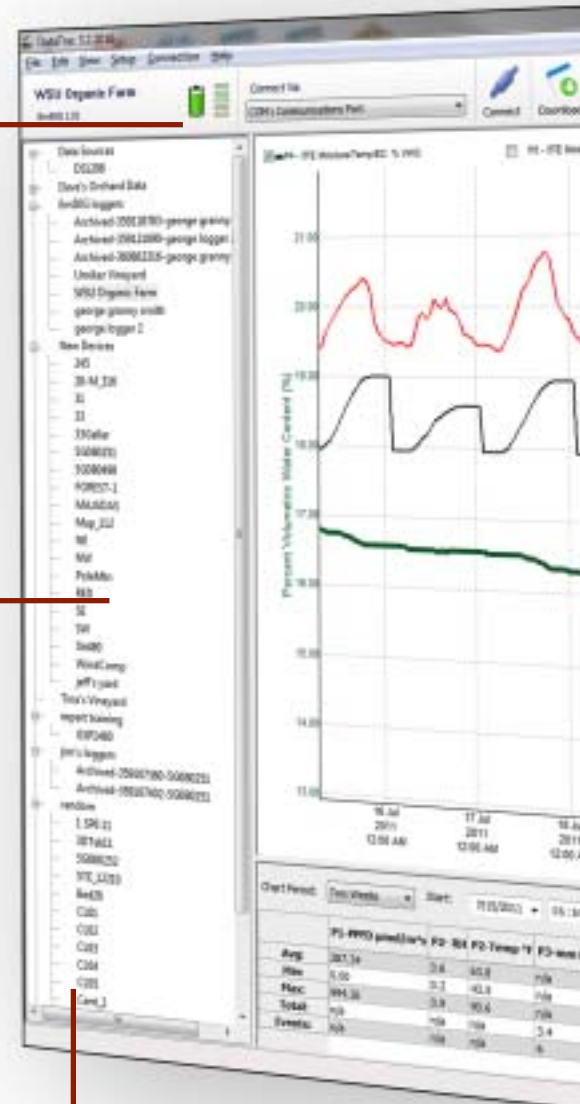
**Know** the status of the loggers in your network. When you click on a logger in the device tree, you'll see all of the data from the logger, the battery level, and the transmission strength.

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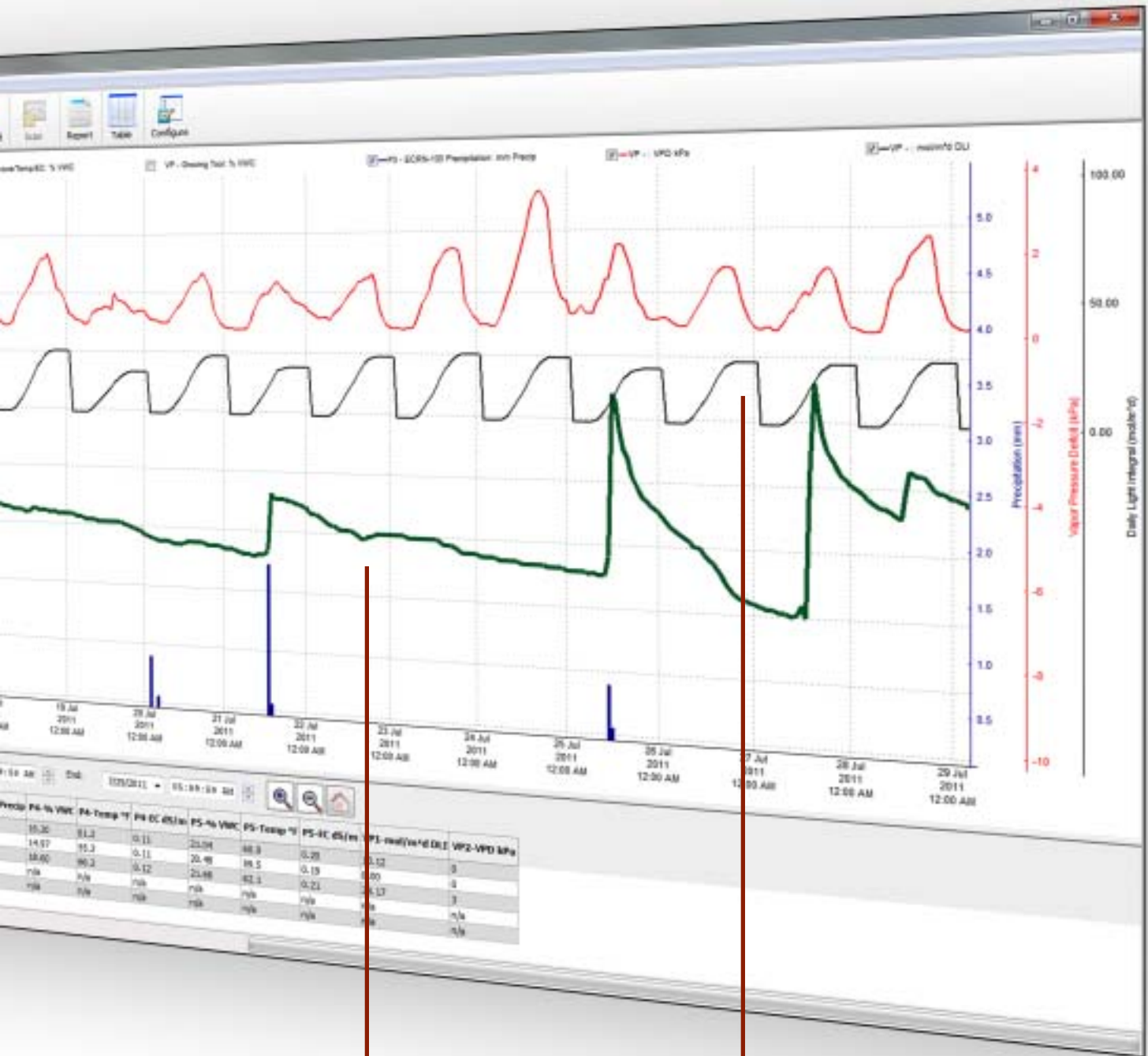
**Manage** your wireless network. The device tree lets you organize your loggers for quick data access.

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**Share** data with colleagues. When you allow colleagues to subscribe to your data stream, they can view all data and download a copy for analysis.

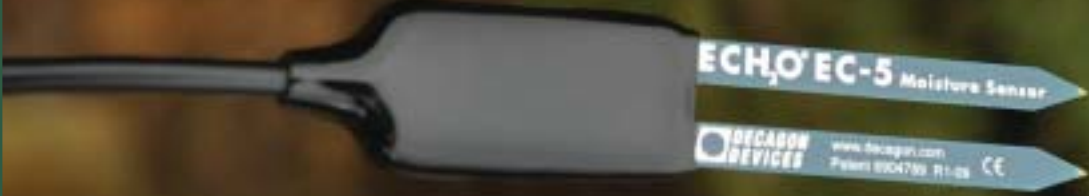


# Your Soil Moisture Data, Delivered



**Create** meaningful metrics such as daily light integral and vapor pressure deficit.

**Learn** what's driving changes in soil moisture by seeing all of your metrics on one graph.



# Soil Moisture Sensors



All sensor electrical interface: 3.5 mm plug or 3-wire.

MODEL	LENGTH	MEASUREMENT	RANGE	ACCURACY	BENEFITS
<b>5TE*</b>	5 cm	Volumetric water content, Temperature, Electrical conductivity, Dielectric Permittivity	Apparent dielectric permittivity ( $\epsilon_a$ ): 1 (air) to 80, VWC: 0 to Saturation Temperature -40 to 50 °C EC 0 to 23 dS/m (bulk)	( $\epsilon_a$ ): $\pm 1 \epsilon_a$ (unitless) from 1–40 (soil range) $\pm 15\%$ from 40–80 VWC $\pm 3\%$ , typical mineral soils up to 8 dS/m Bulk EC $\pm 10\%$ Temperature $\pm 1$ °C	Manage salts and fertilizers in your system.
<b>5TM*</b>	5 cm	Volumetric water content, Temperature, Dielectric Permittivity	Apparent dielectric permittivity ( $\epsilon_a$ ): 1 (air) to 80, VWC: 0 to Saturation Temperature -40 to 50 °C	( $\epsilon_a$ ): $\pm 1 \epsilon_a$ (unitless) from 1–40 (soil range) $\pm 15\%$ from 40–80 VWC $\pm 3\%$ , typical mineral soils up to 8 dS/m Temperature $\pm 1$ °C	Include temperature dependencies in your study.
<b>10HS</b>	10 cm	Dielectric permittivity, Volumetric water content	Apparent dielectric permittivity ( $\epsilon_a$ ): 1 (air) to 50, VWC: 0 to Saturation	( $\epsilon_a$ ): $\pm 0.5$ from $\epsilon_a$ of 2 to 10 $\pm 2.5$ from $\epsilon_a$ of 10 to 50 VWC $\pm 3\%$ , typical mineral soils up to 8 dS/m	Largest volume of influence decreases effects of heterogeneity.
<b>EC-5</b>	5 cm	Volumetric water content	VWC: 0 to Saturation	Rockwool VWC $\pm 3\%$ , 0.5 to 8 dS/m  Potting Soil VWC $\pm 3\%$ , 3 to 14 dS/m	Lowest cost for large sensor networks.
<b>MPS-2*</b>	5 cm	Soil matric potential	matric potential -5 to -500 kPa  Temperature -40 to 50 °C	$\pm 25\%$ of reading from -5 to -50 kPa  temperature $\pm 1$ °C	Maintenance-free water potential measurements that do not drift over time.

- All sensors plug and log with Decagon DataLoggers.
- Sensors compatible with most CSI DataLoggers.
- Call to verify compatibility.
- \* SDI12 compatible.

# Soil Moisture Sensors



The sensors on page 12–13 work well for most applications, but there are unique challenges to making moisture measurements in substances such as landfill material and greenhouse substrates. These sensors are built for tougher environments.



## RS3 Soil Moisture Sensor

Soil Moisture, Temperature, EC in Rugged Environments

**T**he RS3 is a rugged sensor designed for extreme environments and long term installations (greater than 10 years). Stainless steel needles resist bending or breakage while heavy 20 gauge cable ensures a reliable connection to the logger.



## GS3 Soil Moisture Sensor

Soil Moisture, Temperature and EC in the Greenhouse

**W**hile the GS3 can work in any soil type, it was specifically designed to work in soilless substrates such as peat, perlite, potting soil, and rock wool. Stainless steel needles have an extended surface area to optimize EC measurements while minimizing substrate disturbance during insertion.



Learn more about our Soil Moisture Sensors by scanning the QR code with your smartphone.

## LARGE INSTALLATIONS

# Expanded Spatial Characterization

As wireless monitoring becomes more practical and affordable, many researchers are starting to expand spatial characterization. A large installation can turn up interesting spatial trends.

DataSpring has some features specially designed for large installations.

- Sensors are calibrated in 5 different dielectric standards. You don't need to

worry if the variability you're seeing between sites is caused by the sensors.

- DataTrac 3 automatically appends and graphs data as they are received. You focus on reading the data, not managing it.

- Digital sensors are SDI-12 compatible. This protocol is not for everyone, but in certain situations, it can allow more dense instrumentation of a site. Call Decagon or visit [www.decagonsdi12.com](http://www.decagonsdi12.com) for more information.



## ProCheck

### INDISPENSABLE TOOL FOR LARGE INSTALLATIONS

ProCheck is a Decagon staff favorite because it lets you:

- Check sensors quickly during installation. Know if the installation is good before you start backfilling.
- Troubleshoot sensors in the field.
- Program SDI-12 addresses.



# Environmental Sensors

Characterize the environment above the soil surface with these DataSpring sensors.

All sensors are plug-and-log with Em50 series dataloggers.



The **Leaf Wetness Sensor** measures duration of leaf wetness and requires no painting or calibration and detects trace amounts of water or ice on the sensor surface. **Operating Environment** -20 to 60° C

## Measure Soil Temperature

The rugged RT-1 soil temperature sensor is an easy-to-use sensor for measuring the temperature of soil or other materials. The sensor is stainless steel, completely water proof, submersible, and designed for continuous outdoor use.

**Resolution** 0.1° C

**Range** -40° C to 80° C

**Type** Thermistor

**Output** 320-1000mV @ 3V excitation



The **Pyranometer Model PYR** and the **PAR Photon Flux Sensor** are completely water proof, submersible and designed for continuous outdoor use. A leveling plate is included.

**Cable length** 1m

**Range** 0 to 2000  $\mu\text{mol} / \text{m}^2 \text{s}$  (PAR)

**Range** 0 to 1750  $\text{W m}^{-2}$  (PYR)

**Dimensions** 24mm diameter, 29 mm deep.

**Accuracy**  $\pm 5\%$



### Cup Anemometer

The anemometer measures both wind speed (using windcups and a magnetic switch) and wind direction (with windvane and potentiometer). Includes sealed stainless-steel bearings for long life. The range and accuracy specifications of this unit have been verified in wind-tunnel tests (information available upon request).

**Resolution** 1 mph (0.45m/s)

**Range** 0 to 129 mph

**Accuracy**  $\pm 5\%$



**TEMP/RH** Durable sensor measures relative humidity and temperature and outputs both values as a digital signal.

**Probe RH Range** 0 to 100% RH

**RH Accuracy**

$\pm 2\%$  from 10-90% RH

$\pm 3\%$  from 0-10% RH and 90-100% RH

**Temperature Range** -40 to 60 °C



learn.decagon.com

885-722-0129

# Spend more time with your data...

## EM50 SERIES DATA LOGGERS



### Pre-programmed

- No user programming necessary.

### Powered by

5 AA Batteries

- No external power source required.

### Weatherproof

- No extra enclosure needed.

**J**ust plug in any DataSpring sensor, set your sensor type and measurement intervals using drop down menus, and start logging data.

Can it really be that easy?

Watch a 3 minute video online to see Ross, a research associate, set up an Em50G without any advance prep. He goes from unboxing the logger to receiving data in his office in about 27 minutes.

[www.learn.decagon.com/27minutes](http://www.learn.decagon.com/27minutes)

### Data Logger

Universal Specifications

Channels 5

### Interface

Each channel can accept all digital, analog, or pulse Decagon sensors.

### Storage

>36,000 scans, each scan includes logger name, date, time, and sensor measurements.

### Scan interval

User programmable from 1 measurement/minute to 1 measurement/day (minimum Em50G scan interval every 5 minutes).

### Power

5 AA batteries.

### Enclosure rating

IP55, NEMA3.



See our range of Data Loggers by scanning the QR code with your smartphone.



# not your data logger.

## Em50G



### Options

Cellular transmission worldwide,  
Direct connect



### Storage

Automatic logger storage (36,000 scans),  
Decagon data server,  
Local DataTrac 3 with every download

### Applications

- Large-scale and small-scale studies where daily access to data is advantageous.
- Studies with multiple researchers requiring access to the same data set

## Em50R

with DataStation



Radio transmission 900 MHz, 2.4 GHz,  
Direct connect



Logger storage (36,000 scans),  
DataStation storage (1 MB),  
local DataTrac 3 storage with every download from DataStation or direct connect

- Small-scale (less than 2 km<sup>2</sup>) studies with a central data collection location.
- Studies that do not have cellular coverage.

## Em50

Direct connect



Logger storage (36,000 scans),  
local DataTrac 3 storage with every download

- Studies where data access is only necessary once or twice per year.



# DataTrac 3

## Complete Soil Moisture Analysis

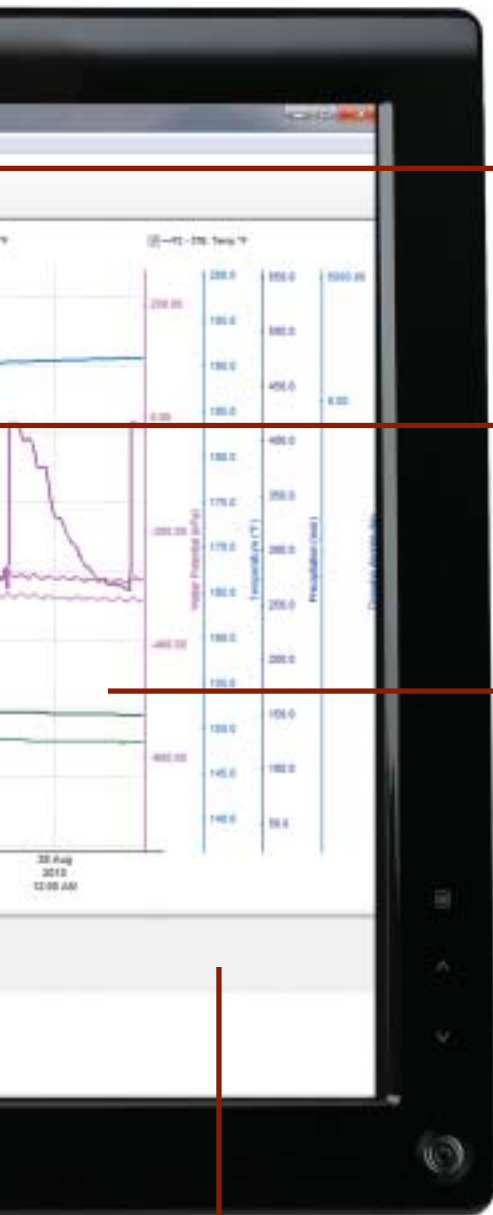


Use Growing Tools to combine data streams and track meaningful indicators. For example, plot vapor pressure deficit instead of just temperature and humidity. Or track growing degree days, plant available water, pore water EC, etc.

Automatically collect data from your Em50G and Em50R loggers. All data—including manually collected data—will be automatically organized and added to your files chronologically.

# DATATRAC 3 TRANSFORMS ENDLESS COLUMNS AND ROWS OF RAW DATA INTO MEANINGFUL, EASILY-INTERPRETED GRAPHS.

SOIL MOISTURE



Educate and inform your team efficiently. DataTrac 3's graphics reduce the time and expertise needed to understand soil moisture data.

Add notes and ideas to the data stream. Comments and reminders can help you make sense of a growing season's data later.

Adjust date ranges, add or subtract data from specific sensors, and change target bands to illustrate and explore your findings.



**Download a free 30 day trial at [learn.decagon.com/datatracc3](http://learn.decagon.com/datatracc3)**

Watch your data in real time. DataTrac 3 updates automatically while it's running and every time it starts up.

**DECAGON DEVICES**  
[learn.decagon.com](http://learn.decagon.com)  
885-722-0129

## CASE STUDY: COMPLEX HYDROLOGY ON THE PALOUSE

At Cook Farm, Decagon scientists and Washington State University researchers are calibrating, refining and testing an existing hydrologic model for the Palouse.

“We have soil moisture sensors buried at the same depths all over the farm, but the volumetric water content readings can be different from location to location. Sometimes they seem almost random. When I flew over the farm this summer, suddenly I could see those variations in living color. Patterns of wheat senescence showed exactly what the sensors had been telling us—golden wheat in the dry areas, greener wheat in the valleys and every variation in between.”



### ▲ SOIL MOISTURE SYSTEM WITH TEMPERATURE / EC OPTION

Each node has 5 soil moisture sensors monitoring the soil profile at one foot vertical intervals—the shallowest is a foot below the surface; the deepest five feet down. The sensors measure volumetric water content, soil temperature, and Electrical Conductivity. The Em50R logger stores the data internally and transmits it to the DataStation.

See sensors specifications on page 12.



**42**  
wireless logger nodes

**200+**  
soil moisture sensors



Watch a 5 minute video of a Soil Moisture System installation at [learn.decagon.com/sensor-install](https://learn.decagon.com/sensor-install)

# “Hassle Free” Telemetry



SOIL MOISTURE

▲ **DATASTATION  
INTEGRATED WITH  
AN EXISTING  
METEOROLOGICAL TOWER**  
The station gathers soil  
moisture, temperature, and  
EC data from all  
42 loggers hourly.

YOU CAN SEE SIGNAL STRENGTH AND CONNECTION  
SPEED IN REAL-TIME AS YOU PICK THE BEST SPOT  
FOR A DATA LOGGER NODE SITE. IT'S SIMPLE.  
TEST FIRST AND INSTALL SECOND.

 **DECAGON  
DEVICES**  
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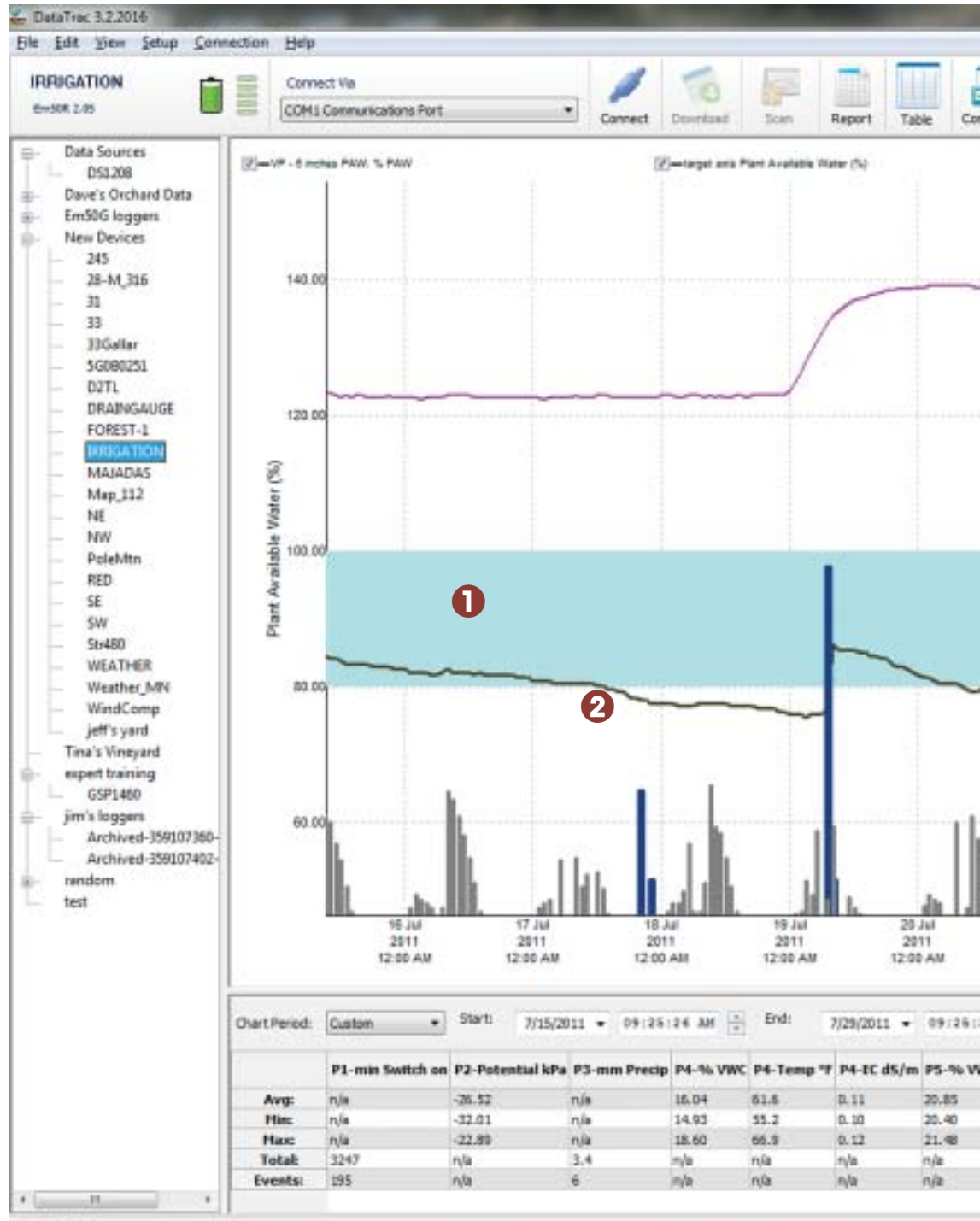
# Manage Irrigation Without Leaving Your Desk

**1** Know when to turn the irrigation on and off with customizable target zones.

See both how much water is in the soil and how much of that water is available to plants.

Soil moisture sensors only measure volumetric water content. Use the matric potential sensor to monitor plant available water.

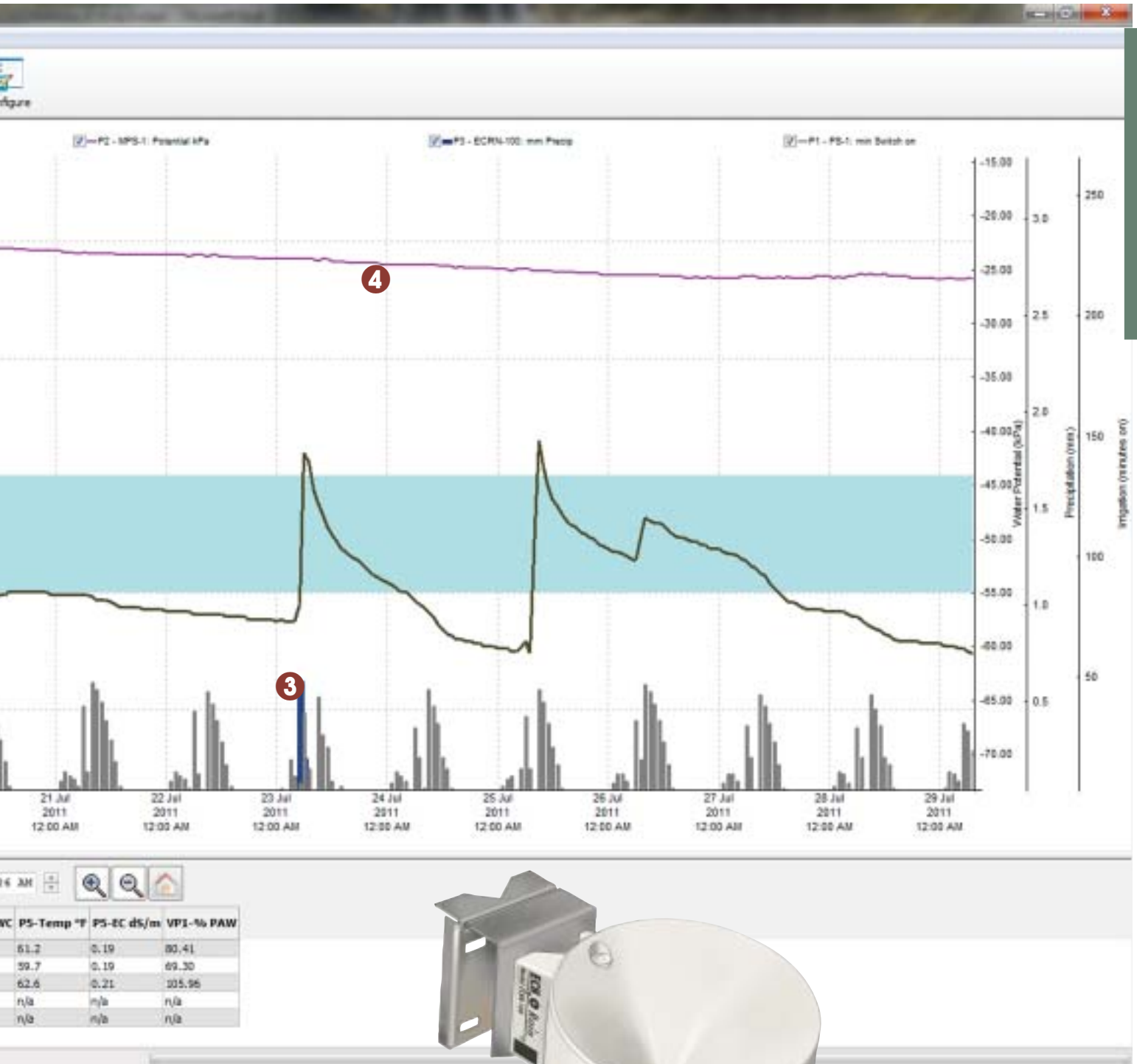
Fast-response soil moisture sensors let you track plant water use in real time and set an accurate full-point that minimizes wasted water.



**2** Track water in the root zone with Decagon soil moisture sensors. Plant available water is calculated automatically with DataTrac 3's Growing Tools option.



**4** Focus on key stress levels with the extended range water potential sensor.



SOIL MOISTURE

**3** Rain gauges and irrigation pressure switch data on the same graph as soil moisture show how each event affects the water available to your plants.



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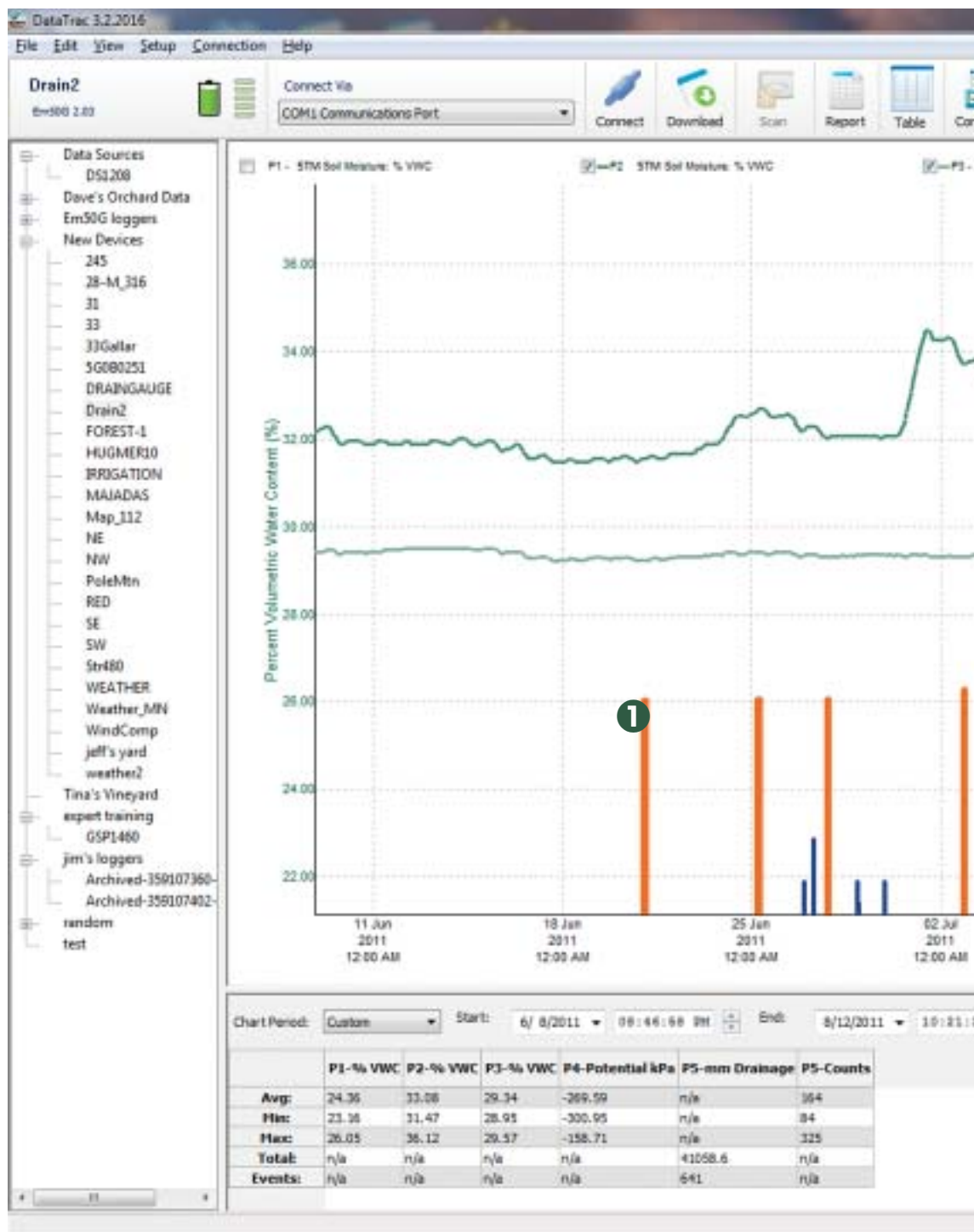
# Close Your Water Balance

WITH PRECIPITATION, SOIL WATER STORAGE, AND DEEP DRAINAGE

Two tough components of the water balance are storage and deep percolation.

Collect the data you need to calculate water input, storage, and drainage in the vadose zone.

Measure deep drainage rather than estimating to reduce errors in water balance calculation



**1** Quantify drainage past the root zone with the G3 Drain Gauge. Water samples are also held in the Drain gauge's reservoir for chemical flux calculations.



**2** Add local precipitation data to your calculations for water contributions to the root zone.



**SOIL MOISTURE**

**3** Measure soil water storage in the root zone with 5TM. Sensors can be placed throughout the soil profile to further quantify soil profile water storage.



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# Essential Water Potential Data

## MAKE FAST, ACCURATE WATER POTENTIAL MEASUREMENTS IN THE LAB

**M**easure the water potential of soil, soilless substrate, plant tissue, or any porous material in 5 to 10 minutes. Effective range: -0.1 to -300 MPa.\*

The WP4C measures water potential by determining the relative humidity of the air above a sample in a closed chamber (an AOAC-approved method, conforms to ASTM 6836).

### WP4C SPECIFICATIONS

#### Operating Environment

5 to 43°C (41 to 110°F)

#### Temperature Control

15° to 40°C ± 0.2 °C

**Sensors** 1. Infrared temperature. 2. Chilled-mirror dewpoint.

**Range** 0 to -300 MPa\*

**Accuracy** ± 0.05 MPa from 0 to -5 MPa, ± 1% from -5 to -300 MPa

**Read time** Typically 5 to 10 minutes

**Interface Cable** Serial cable (included)

#### Data Communications

RS232 compatible, 8-bit ASCII code, 9600 baud, no parity, 1 stop bit

**Weight** 3.2 kg (5.2 kg shipping weight)

**Universal Power** 110/ 220V AC, 50/60Hz

**Sample dish capacity** 7ml recommended (15ml full)

25 plastic cups and 10 stainless steel cups included

**Calibration Standard** 0.5 molal KCl (-2.19MPa)

*\*Note WP4C will read to 0 MPa, but readings of samples wetter than -0.1 MPa will have an increasing, and typically unacceptable, percentage of error. Some users may be able to make useful measurements in samples wetter than -0.1 MPa using special techniques. For more information, see the WP4C User Manual.*

### NEW FEATURES

- **Precise Mode**—verifies full equilibrium before displaying a final reading.
- **Speedy Equilibration**—new hydrophobic teflon impregnated nickel alloy sample chamber coating reduces equilibration time.
- **Finely-Tuned Adjustments**—new algorithms allow precision calibration and ± 0.05 MPa (or better) accuracy.
- **Better range and accuracy**—resolves temperatures to a thousandth of a degree to push the functional range to -0.1 MPa.



### Applications

- Soil moisture characteristic curves
- Root zone water potential profiles
- Expansive soil characterization
- Leaf water potential
- Seed priming
- Seed water relations

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DEVICES**

[learn.decagon.com](http://learn.decagon.com)

885-722-0129



# New Digital Sensor Monitors Water Potential In Situ

## MPS-2 SIMPLIFY FIELD WATER POTENTIAL MEASUREMENTS

**G**et greater-accuracy water potential measurements from a low-maintenance, off-the-shelf water potential sensor.

- New digital sensor means more precise calibration and higher accuracy.
- On-board temperature measurements.
- SDI-12 capability lets you address each sensor and build bigger networks.
- Epoxy overmold delivers longer field performance.
- Metal mesh controls field of influence for greater accuracy and consistency.
- Continuous water potential measurement without programming or field maintenance.

### SPECIFICATIONS

Length 5 cm

Measurement Soil matric potential

Range -5 to -500 kPa

Accuracy

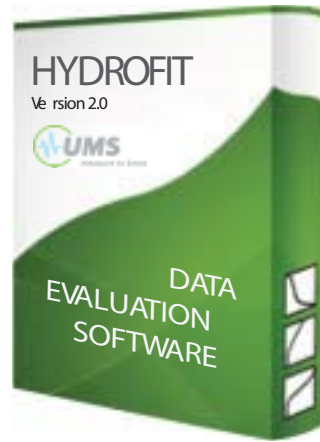
± 25% of reading from -5 to -100 kPa

### APPLICATIONS

- Water potential monitoring in vadoze zone.
- Crop stress.
- Waste water drainage studies.
- Irrigation monitoring and control.
- Plant water availability.



Watch a short video on how the Hyprop and WP4C work together at [learn.decagon.com/fullcurve](http://learn.decagon.com/fullcurve)



Free Download HydroFit

[learn.decagon.com/hydrofit](http://learn.decagon.com/hydrofit)

# Curve Fits for All Water Potential Data

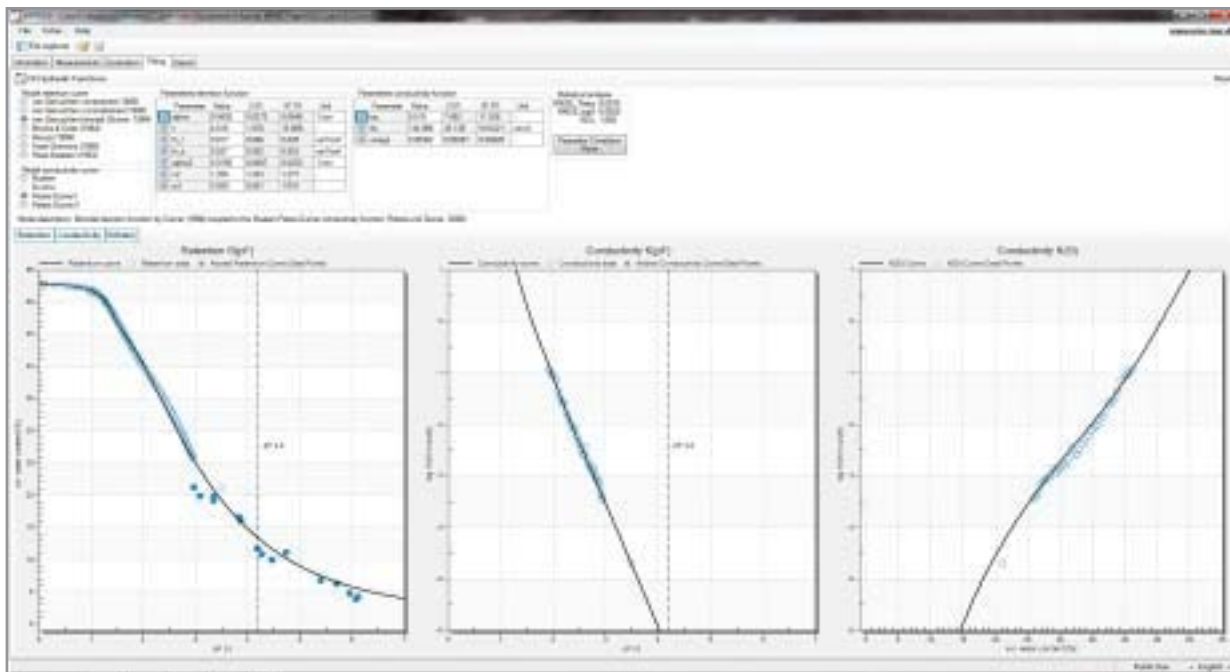
## NEW HYDROFIT MOISTURE RELEASE CURVE SOFTWARE

**H**ydroFit makes it easy to use the Hyprop with the new WP4C to generate a complete moisture release curve and parameters for use in modeling.

Put all your data together. New HydroFit software takes data generated by the Hyprop, WP4C,

tensiometer, or any other water potential instrument and creates a moisture release curve.

Generate curve fits based on van Genuchten, van Genuchten Bimodal, Brooks and Corey, and other models. HydroFit finds the optimal parameter sets without initial parameter guesses.



x Drying portion of the moisture curve generated by Hyprop.



# Hyprop

## CREATE SWCC USING NATURAL EVAPORATION

**F**orget the pain of using pressure plates. Use Hyprop to generate detailed soil-water characteristic curves.

Just take your undisturbed sample, insert the measurement head, put it on the balance, and in less than a week, you have a detailed moisture release curve.

- Uses undisturbed soil samples.
- Works in all soil types.
- Bonus feature gives unsaturated hydraulic conductivity values for the soil sample.

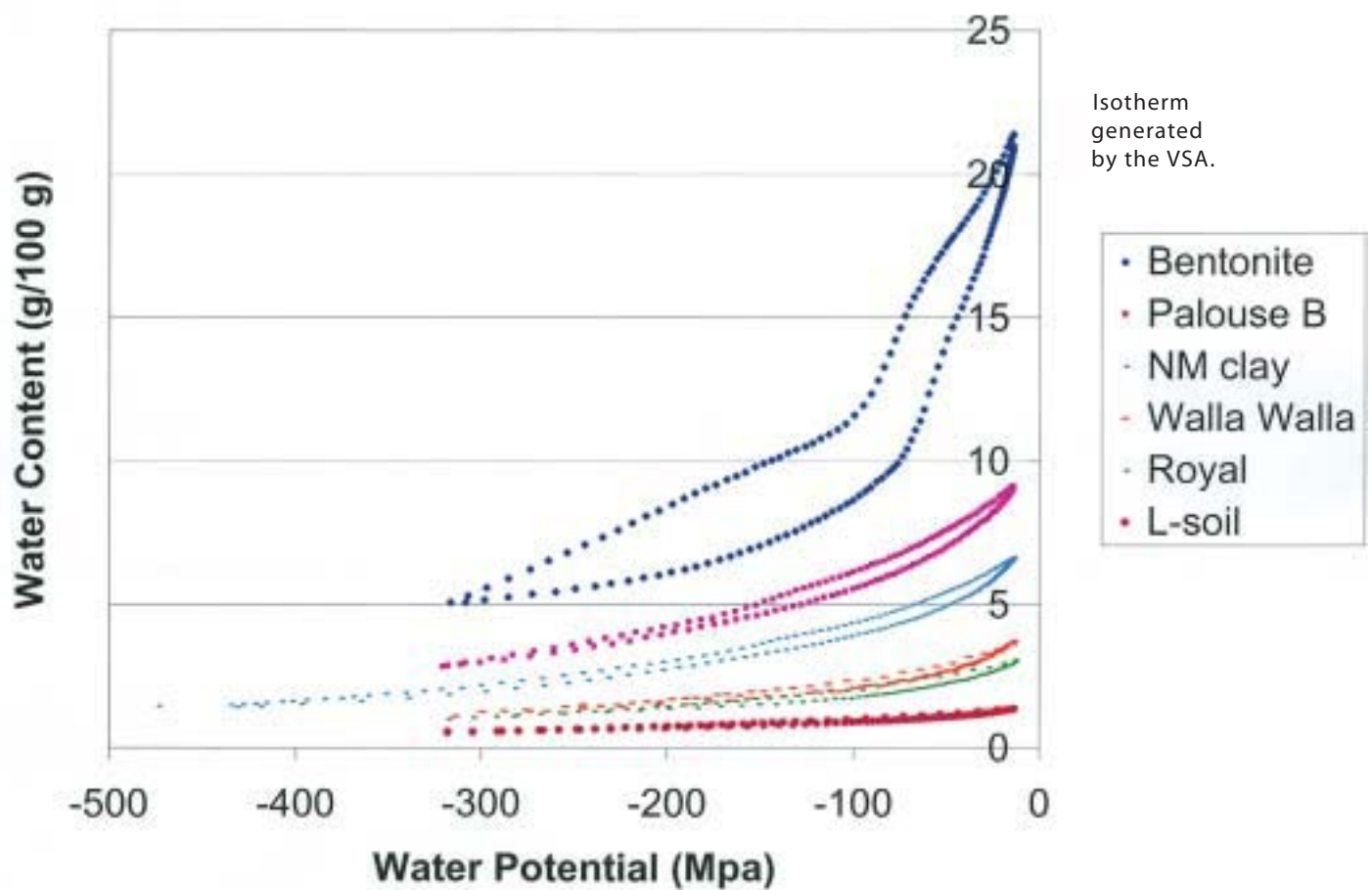
### HYPROP SPECIFICATIONS

Range +2 kPa to -120 kPa / -250 kPa  
 Resolution 0.001 kPa  
 Accuracy  $\pm$  0.15 kPa

### OPTIONAL LABORATORY SCALE SPECIFICATIONS

Measuring range 0 to 2.5kg  
 Resolution 0.01g  
 Accuracy  $\pm$  0.1g  
 Interface RS232





# Create Static and Dynamic Isotherms Automatically

## NEW VAPOR SORPTION ANALYZER

The Vapor Sorption Analyzer (VSA) brings click and read efficiency to soil isotherms. In 24 to 48 hours, VSA generates up to 200 data points (water potential vs. water content) for both adsorption and desorption.

The VSA works in the dry (-10 to 475 MPa) range. You can create automated soil-water characteristic curves and generate all the correlations with clay activity, surface area, and swelling potential.

With the new static feature, you can hold humidity constant and look at the way soil takes up water into its crystal structure (2:1 clays) and monitor water content change over time.

### SPECIFICATIONS

Range -10 to -475 MPa.

Accuracy  $\pm 1$ MPa or  $\pm 1\%$

Temperature Operating Range 15 to 40°C

Size 44 w x 38 d x 28 h cm

Weight 19 kg

### BENEFITS

- Rapid isotherm generation.
- Fast expansive soil characterization.



Learn more about the VSA by scanning the QR code with your smartphone.

# Measure Soil Hydraulic Conductivity

## QUANTIFY SPATIAL VARIABILITY OF SOIL HYDRAULIC CONDUCTIVITY

**W**ater movement in soil is spatially variable. The Mini Disk Infiltrometer is a quick way to test hydraulic conductivity and infiltration rates.

### Backpackable

Small, compact, and simple, the Mini Disk Infiltrometer is a true field instrument. It can be tossed into a backpack with a bottle of water.

### Quick Setup

Just fill the reservoir, set the suction, and start measuring infiltration. You don't have to pre-saturate the disk.

### Straightforward Calculations

Enter infiltration and elapsed time data in the included spreadsheet calculator to find hydraulic conductivity.

### Reliable

Both scientists and technicians have used the Mini Disk Infiltrometer to design irrigation systems, demonstrate hydraulic conductivity, evaluate erosion hazard, and gauge the impact of forest fires.

### SPECIFICATIONS

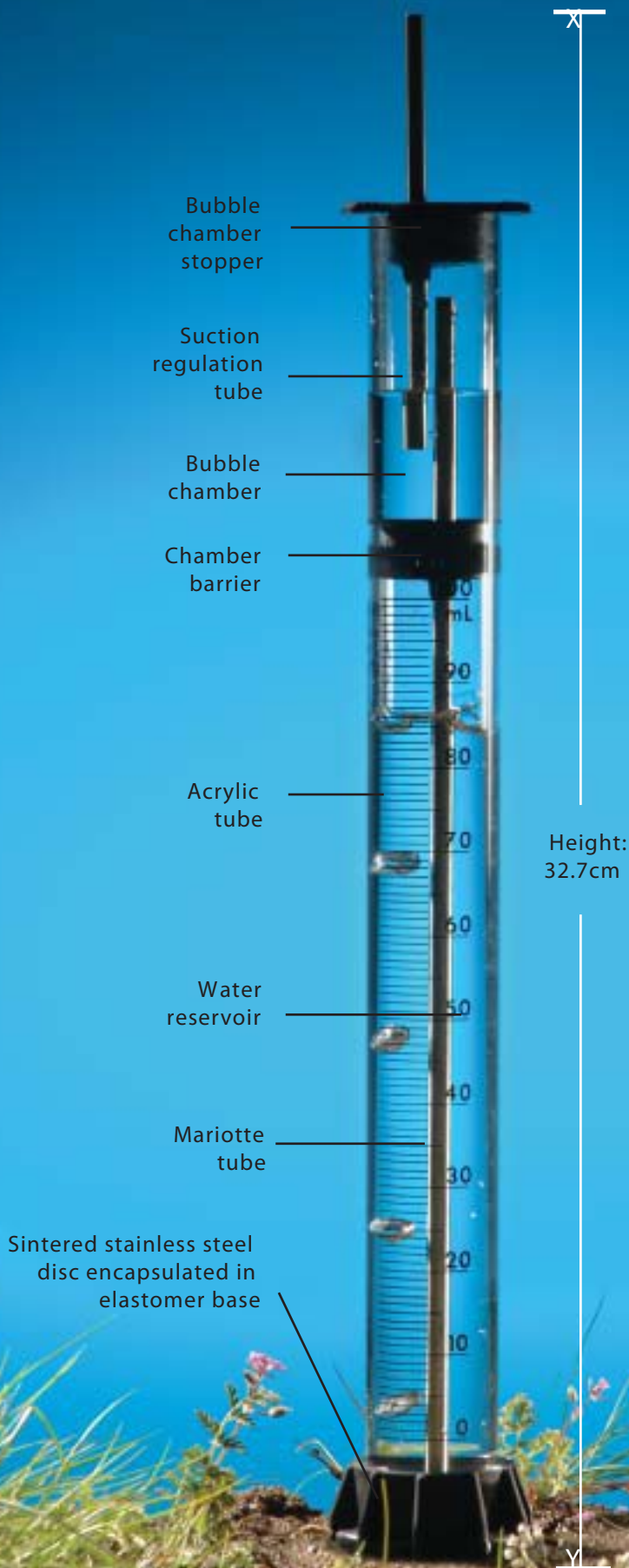
Total Length 32.7 cm

Suction Range 0.5 to 7 cm of suction

Water Volume for Operation 135 mL

Diameter of Sintered Stainless Steel Disc

4.5 cm dia., 3 mm thick



# And After the Fire...

## USING THE INFILTROMETER TO ASSESS EROSION RISK

**F**lagstaff, Arizona is typically a dry place. In August 2010, Flagstaff's residents experienced severe floods. Video footage shows churning rivers flowing down roadways and around and through homes. August's monsoon rains contributed the water, but the floods were actually caused by the 15,000 acre Shultz fire that raged around Flagstaff from April to July.

### Floods Follow Fires

To Forest Service research engineer Dr. Peter Robichaud, the setup is classic. Robichaud, who studies post-fire erosion processes, says that after a fire, soil commonly becomes water repellent. That, together with loss of forest floor matter and ash clogging soil pores, creates a dramatic increase in runoff. "It's not just a 100% increase," he says. "It's orders of magnitude."

### Modeling to Improve Response

Robichaud's work in modeling post-fire erosion is used by many practitioners to assess the impacts of a fire, predict erosion, and make plans to manage and reduce the associated risks. Robichaud uses the Mini Disk Infiltrometer as a tool to characterize changes in the soil after a fire. "It's a practical instrument for fire assessment teams to use. It provides the information they need to help them determine the changes in infiltration characteristics."



After a fire, soil commonly becomes water repellent, just one factor in increased runoff.



2010's Shultz Fire burned 15,000 acres of Arizona forest land.

Read the full article about Dr. Robichaud's research at [learn.decagon.com/robichaud](http://learn.decagon.com/robichaud) or access his online Erosion Risk Management Tool at [forest.moscowfsl.wsu.edu](http://forest.moscowfsl.wsu.edu)



Residents of Flagstaff experienced significant flooding. "When you have steep slopes and high velocities, things can converge rather quickly," Dr. Robichaud says.



# Measure Conductivity, Temperature, and Depth

CONTINUOUSLY MONITOR GROUNDWATER AND SURFACE WATER LEVEL CHANGES ALONG WITH ELECTRICAL CONDUCTIVITY AND TEMPERATURE.

**D**ecagon's CTD sensor puts much of the complex circuitry in an above-water data logger. This lowers the per-sensor cost without impacting accuracy and resolution. So instead of relying on a single measurement, you can measure in several different locations without exceeding your budget.

## APPLICATIONS

- Aquifer recharge and recovery.
- Saltwater intrusion, desalination, and wastewater.
- Wetland monitoring.
- Groundwater contamination monitoring.
- Surface water monitoring.

## FEATURES

- Robust marine-grade epoxy overmold to resist corrosion in tough environments.
- Compact 3.4 cm diameter sensor body to fit into tight spaces.
- External logger with remote transmission option to deliver the data to your desktop.
- Permanent connection to collect data continuously without pulling up the sensor.

## SPECIFICATIONS

Water Depth  
Range 0 to 3.5 m  
Accuracy  $\pm 0.2\%$  of span  
Resolution 1 mm

Electrical Conductivity  
Range 0 to 120 dS/m (mS/cm)  
Accuracy  $\pm 5\%$  of reading  
Resolution 1.2% of reading

Temperature  
Range -40 to + 50°C  
Accuracy  $\pm 1^\circ\text{C}$   
Resolution 0.1°C

Datalogger Compatibility  
Em50/Em50R/Em50G  
Call for compatibility of dataloggers.



NEW CTD  
•Conductivity  
•Temperature  
•Depth Sensor



Learn more about the CTD by scanning the QR code with your smartphone.

# Model Heat Movement

## GET A HANDLE ON HEAT TRANSFER

**F**OLLOW THE HEAT transfer in the soil plant atmosphere continuum with the KD2 Pro Thermal Properties Analyzer. The KD2 Pro has three interchangeable sensors which measure thermal conductivity, thermal diffusivity and specific heat (heat capacity) along with data storage capabilities and an automatic data collection mode.

- Heated Needle Technology
- Requires No Calibration
- Displays in Engineering Units
- Small Needle Minimizes Soil Disturbance

### KD2 Pro Specifications

Measurement 90 Seconds

Accuracy\*

± 5% to ± 10% Conductivity / Resistivity

± 10% Thermal Diffusivity

± 10% Specific Heat

Ranges\*

K: 0.02 to 4 Wm<sup>-1</sup> C<sup>-1</sup>

D: 0.1 to 1.0 mm<sup>2</sup> s<sup>-1</sup>

R: 0.5 to 50 mC<sup>-1</sup>W

C: 0.5 to 4 MJ m<sup>-3</sup> C<sup>-1</sup>

Data Storage 4095 readings

Environment -50 to 150° C

Case Size 15.5 x 9.5 x 3.5 cm

Power 4, AA Batteries

Cable 1m

Sensors

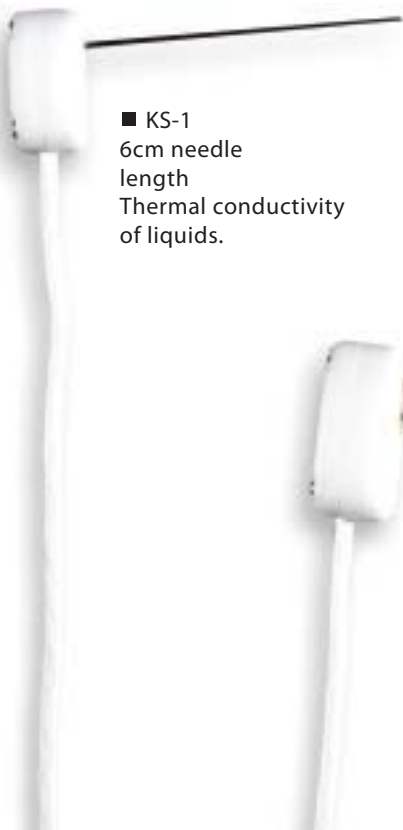
KS-1, 6 cm, 1.27 mm Dia. needle

TR-1, 10 cm, 1.27 mm Dia. needle

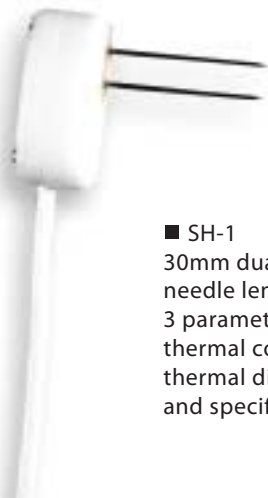
SH-1, 30 mm, 1.27 mm Dia. 2 needles

\*Accuracy and measurement range vary with sensor type.

Each KD2 Pro comes factory calibrated and includes performance verification standards.



■ KS-1  
6cm needle  
length  
Thermal conductivity  
of liquids.



■ SH-1  
30mm dual  
needle length  
3 parameters-  
thermal conducti  
thermal diffusivity  
and specific heat.



■ TR-1  
10cm needle  
length  
Thermal conductivity  
or thermal resistivity  
of soil or porous  
materials. ASTM and  
IEEE compliant.



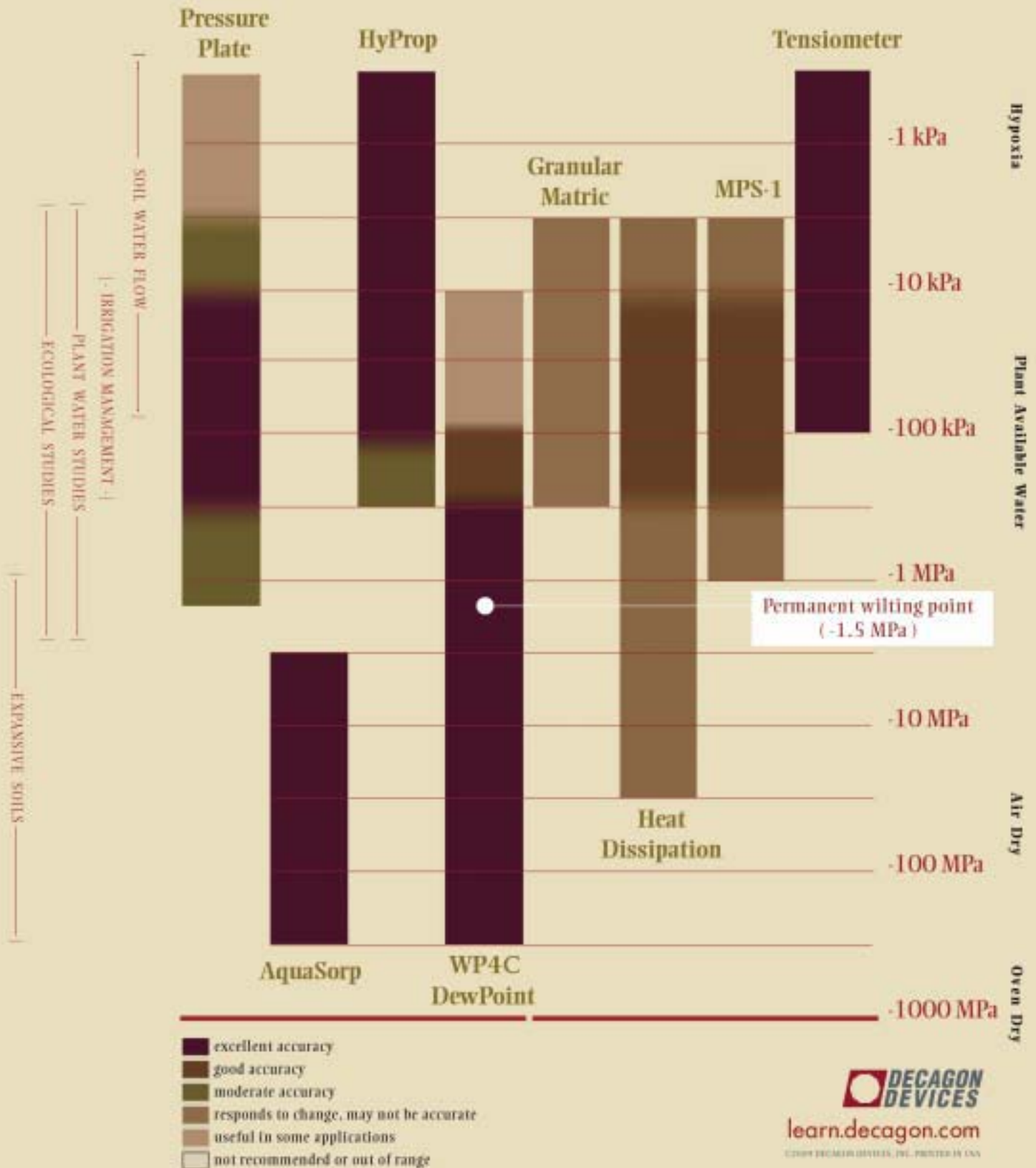
Learn more about the KD2-Pro by scanning the QR code with your smartphone.



# WATER POTENTIAL INSTRUMENT RANGES

## WATER POTENTIAL

Laboratory Instruments    Field Instruments



## MICROORGANISM GROWTH LIMITS

pF*	Water Potential MPa	Water Activity $a_w$	
2.7	-0.05	0.9996	Zoospore movement ceases 
3.2	-0.14	0.9990	Motility of bacteria ceases 
3.9	-0.70	0.9949	Mean minimum to support bacterial growth 
4.2	-1.50	0.9891	Lower limit of plant available water 
4.3	-1.80	0.9869	Microcoleus growth Inhibited 
4.5	-2.80	0.9798	Microcoleus photosynthesis inhibited 
4.6	-4.20	0.9698	Nitrification and sulphur oxidation cease 
4.7	-5.00	0.9642	Bacterial respiration ceases 
4.9	-7.03	0.9500	Pseudomonas etc. inhibited 
5.1	-12.92	0.9100	Salmonella, some molds inhibited 
5.3	-19.08	0.8700	Many yeasts inhibited 
5.5	-30.57	0.8000	Most molds inhibited 
5.6	-39.41	0.7500	Most halophilic bacteria inhibited 
5.8	-59.02	0.6500	Xerophilic molds inhibited 
5.9	-69.98	0.6000	All microbial proliferation ceases 

\*pF is the base 10 logarithm of the water potential in cm

The biological limits are taken from L.R. Beuchat, Cereal Foods World, 26:345 (1981) and M. Potts, Microbiological Reviews, 58:768 (1994).

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Nick Mower  
thermal products manager  
*Nick*



Jordan Tanasse  
canopy products manager  
*Jordan*

# What's New?

When we meet customers at tradeshows, one of their first questions for us is, "What's new?"

## Read About What's New

The answer this year is, "Plenty!" Check out the list on the inside front cover of this catalog for the details. But I think it's also relevant to ask about what hasn't changed.

## Some Things Don't Change

When you call us, you'll still have access to our scientists, who will be glad to talk about instruments, experimental challenges, ideas, and even what the data mean.

## Passionate About Science

If you visit us, you'll see that Decagon scientists are still researching in the lab and in the field. Their passion for the instruments and the science continue to drive everything we do.

## Practical, Research Grade

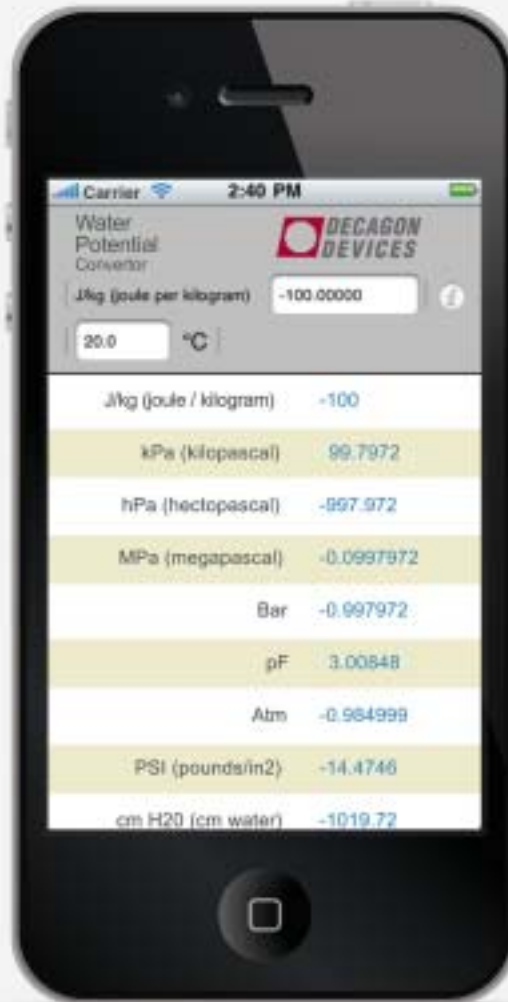
And if you get your hands on one of the new instruments or sensors, you'll discover that we still believe that research grade instruments should be easy to use and hassle-free.

Check out what's new in this catalog—and feel free to appreciate what remains the same.

Sincerely,



Bryan Wacker  
Marketing Manager



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