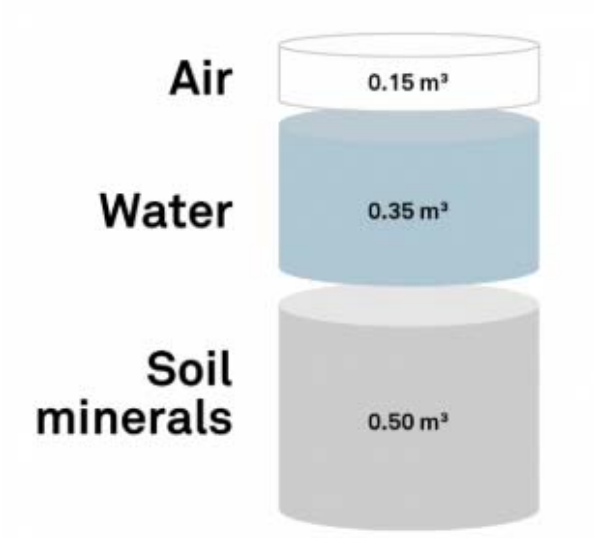
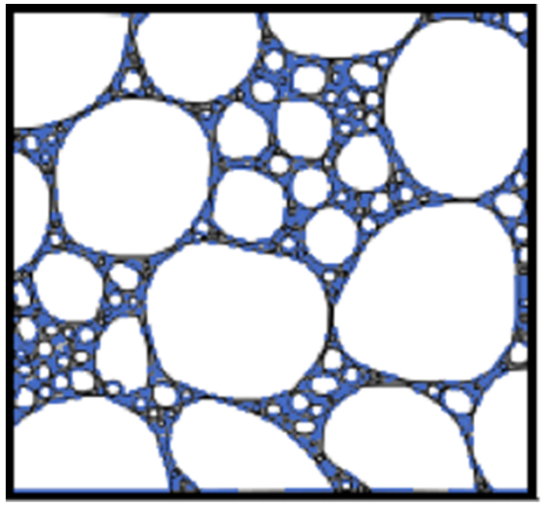
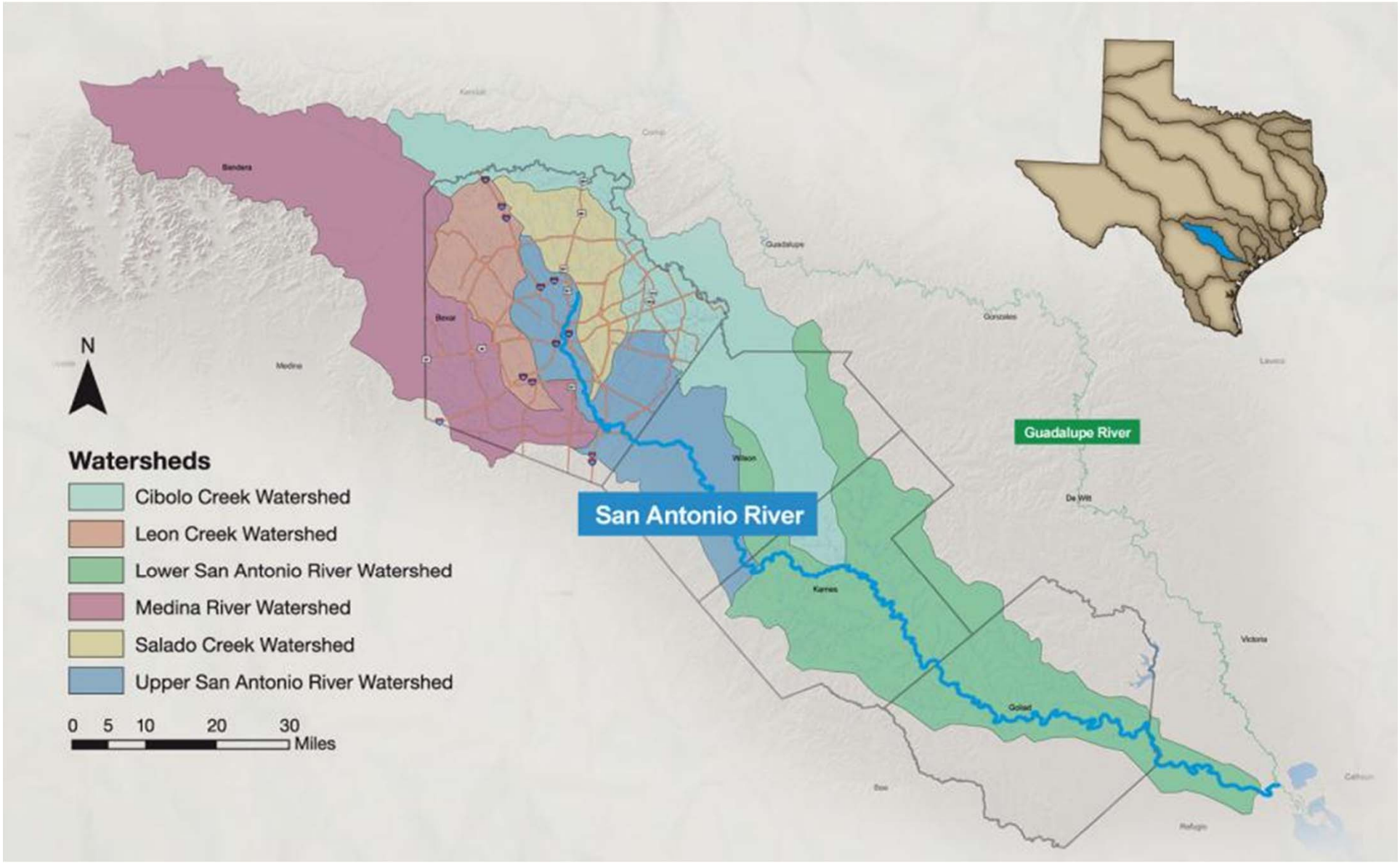
Monitoring Real-Time Soil Moisture





August 8, 2019

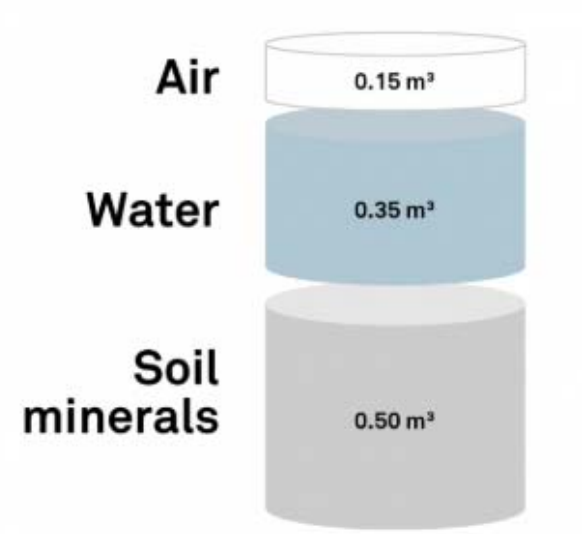
San Antonio River Authority



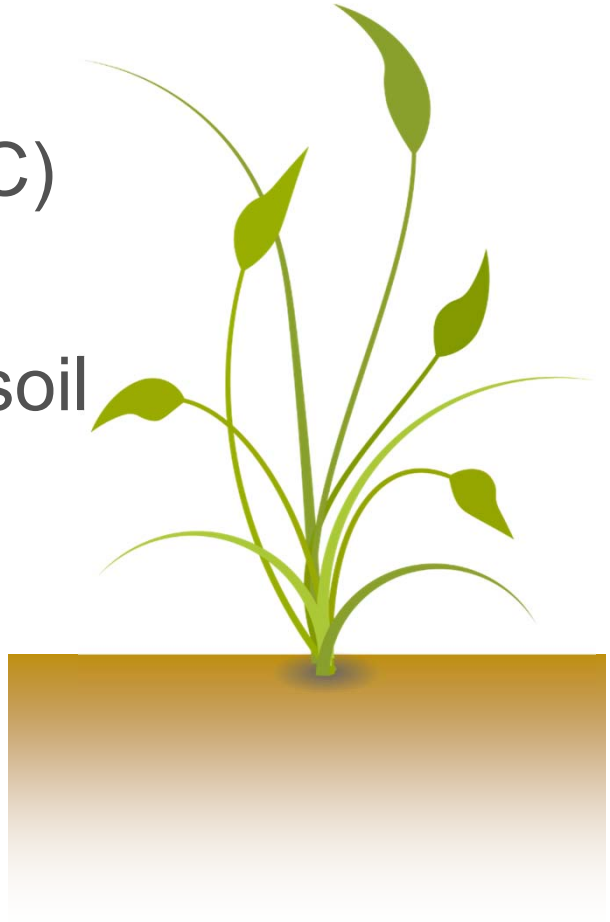
Soil Moisture

Volumetric Water Content (VWC)

= Volume of water / Volume of soil

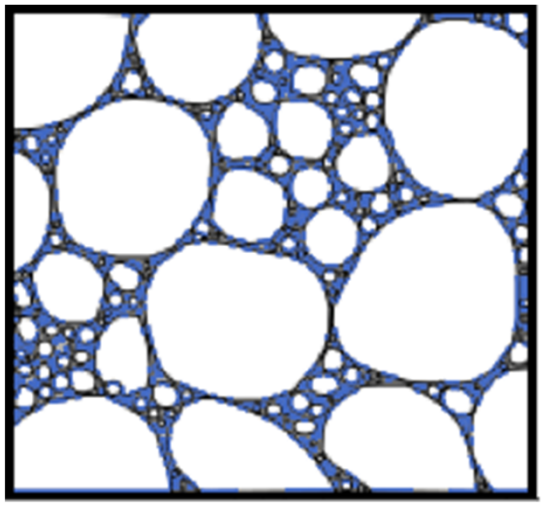


VWC = 35%



Gravimetric Method

- Sample
  - Weigh
    - Heat to evaporate water
      - Weigh
        - Calculate



$$w = \frac{M_{moist} - M_{dry}}{M_{dry}}$$

$$\theta = w \times \rho_b$$

Capacitive Sensor

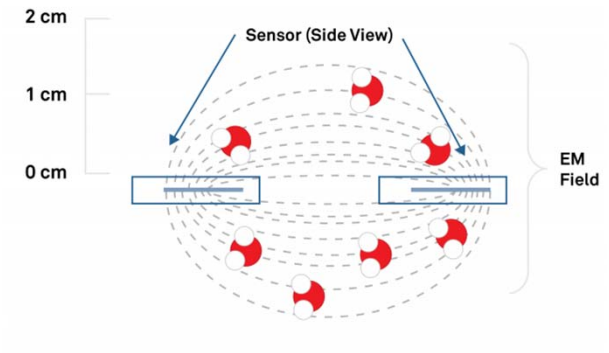
- Quantify Changes in Electro-Magnetic Field
- Capacitance ∝ Permittivity

$$C = \varepsilon l \frac{K(\sqrt{1-k^2})}{K(k)}$$

ε : permittivity

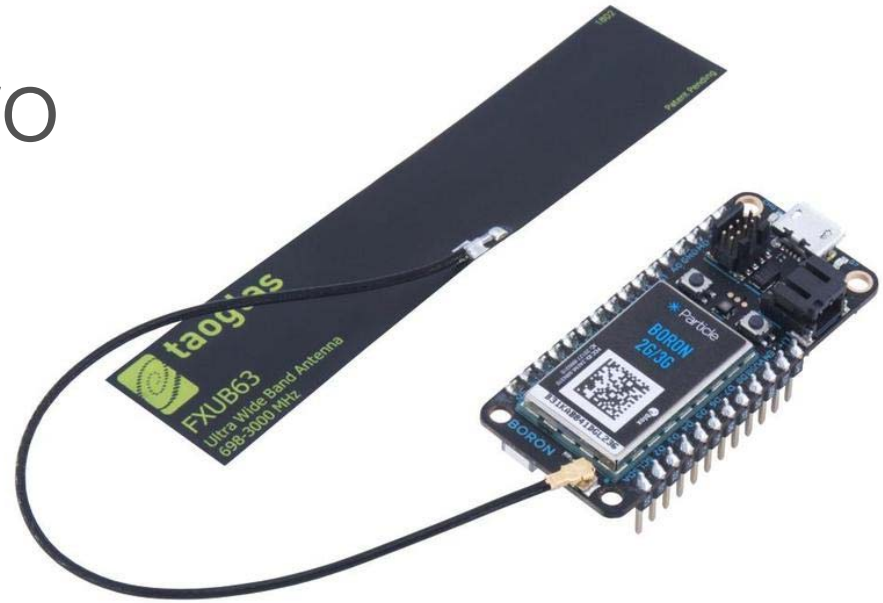
$\varepsilon : \varepsilon_0 \varepsilon_r$

Material	Relative Dielectric Permittivity ε_r
Air	1
Soil Minerals	3 -16
Organic Matter	2 – 5
Ice	5
Water	80



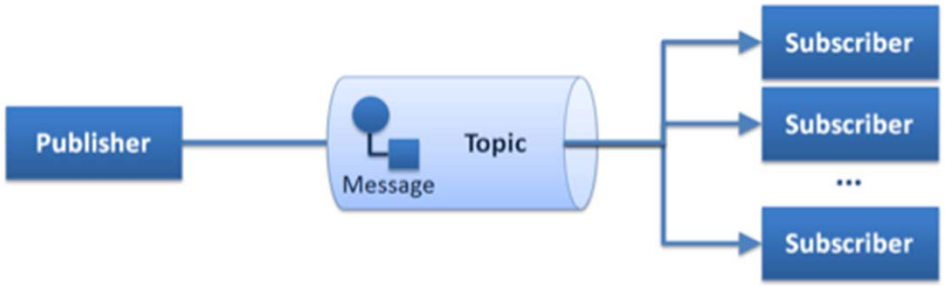
Microcontroller (μC)

- Processor
- Memory
- General Purpose I/O
- Connectivity



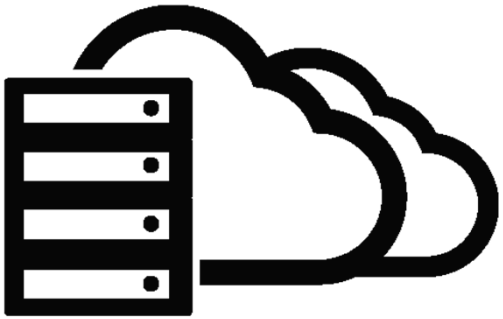
Connectivity

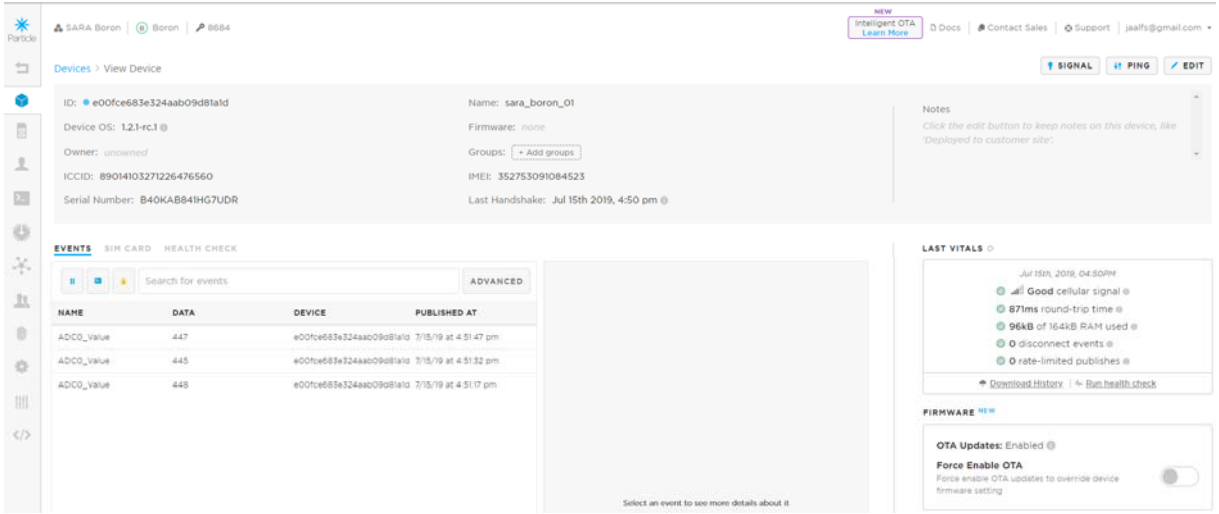
- Send / Receive Data
- Updates
- Mesh Networks
- Events

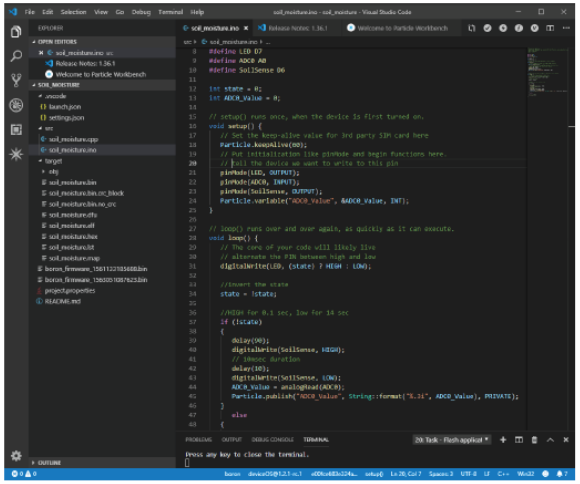


Web Server

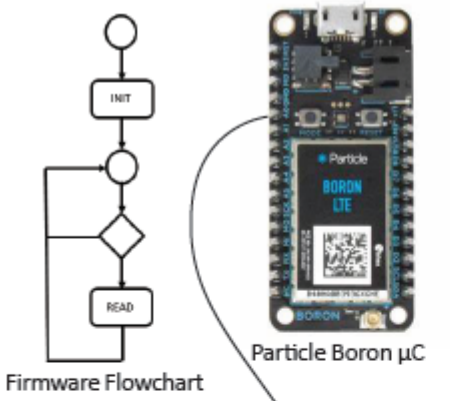
- Manage Devices
- Manage Events





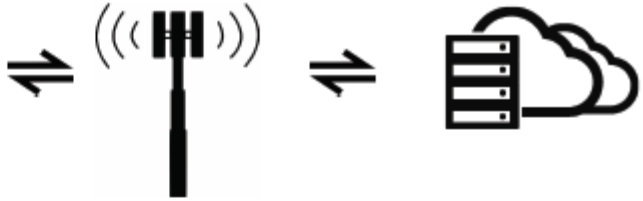


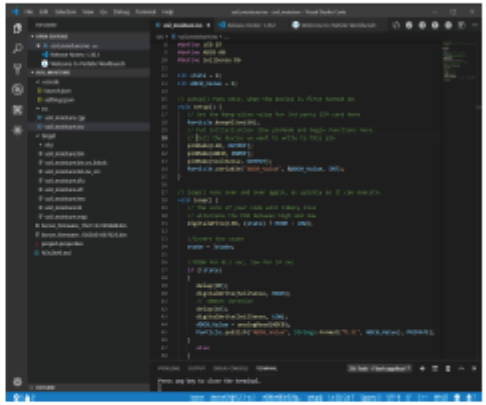
Internet of Things (IoT)



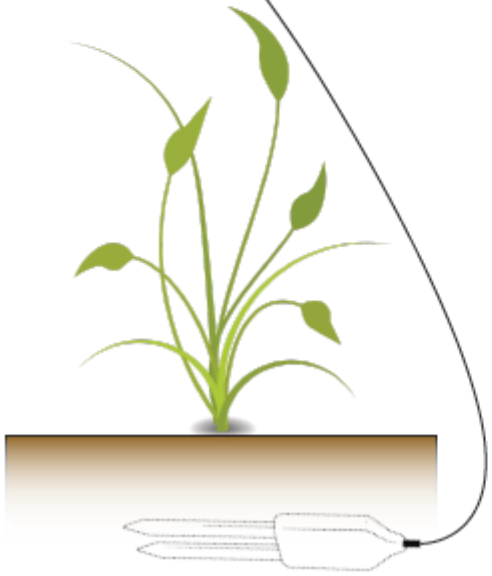
Firmware Flowchart

Particle Boron µC





Firmware Program



Meter EC-5 Soil Moisture Sensor

Display of Published Events with Data

Internet of Things (IoT)

- Bi-Directional Communication
- Send
  - Firmware Program Update
  - Control Signals
- Receive
  - Sensor Data
  - Status

Internet of Things (IoT)

- Cost
- Size
- Scalable

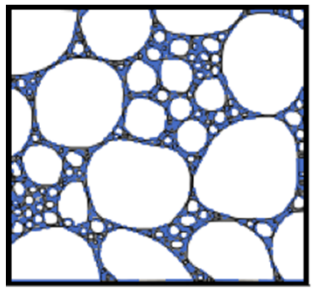
Philadelphia Water District and Drexel University – 2017
Project: Monitor soil moisture to determine when to irrigate green stormwater infrastructure

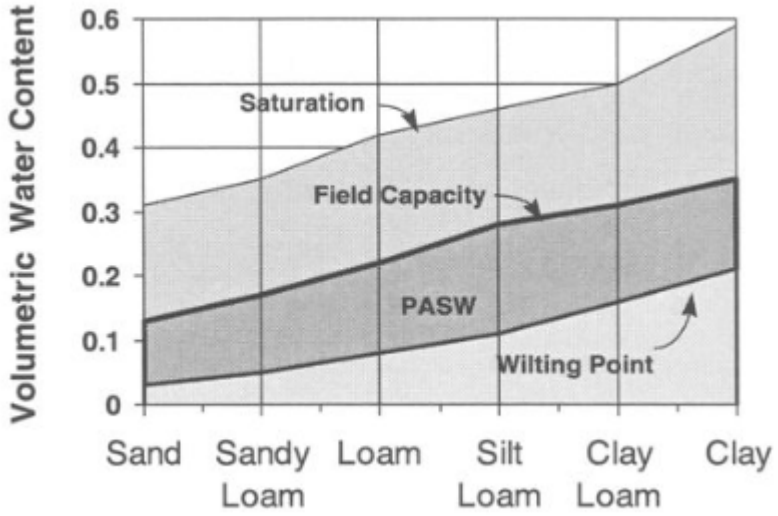
Internet of Things (IoT)

- Applications
  - Flood
  - Water Quality
  - Security
  - Control

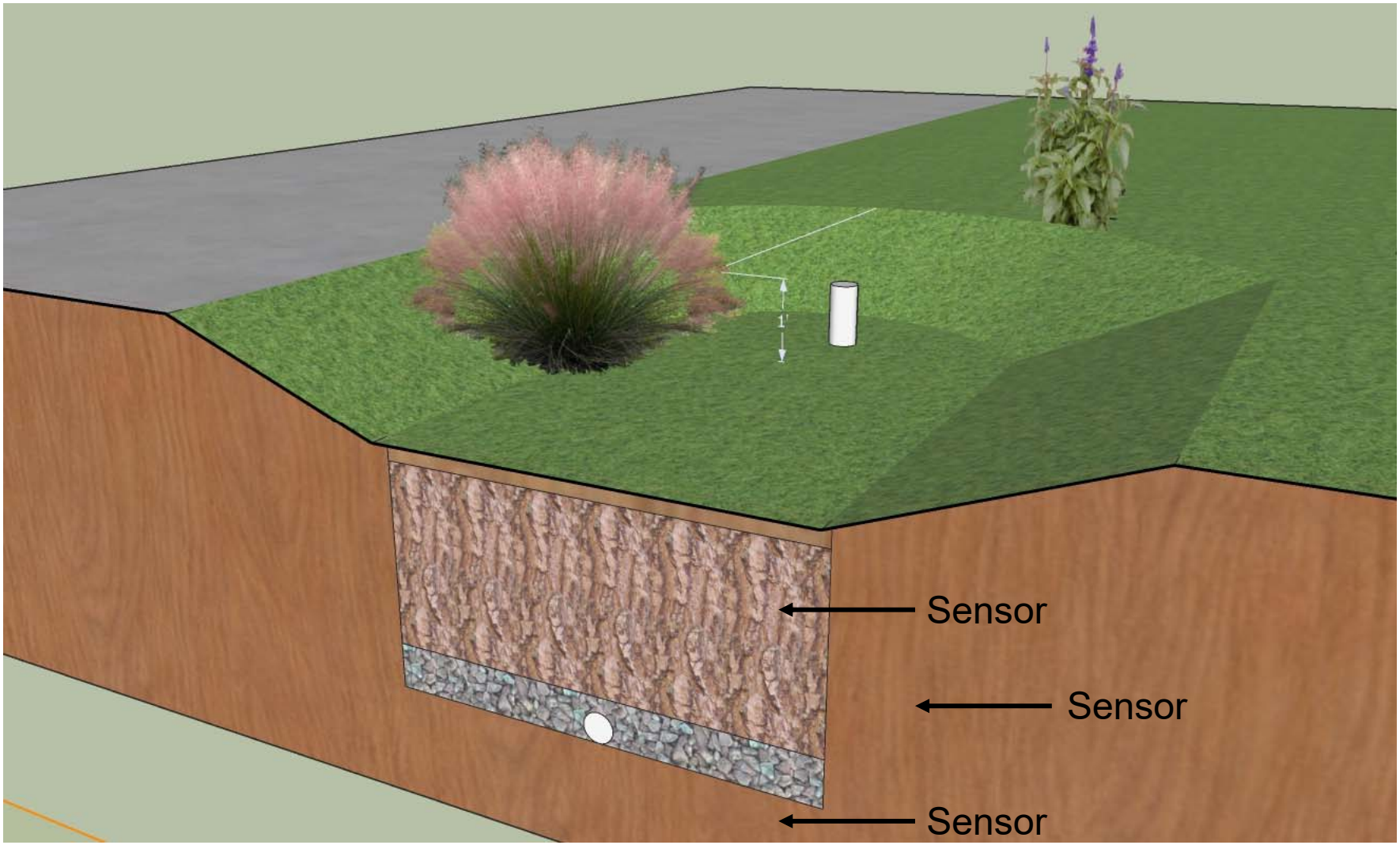
Soil Moisture Data

- Estimate Stormwater Retention
  - Bioretention
  - Green Roof
- Calculate Plant Available Water





Bioretention Example



Bioretention Example

Lessons

- Sensor Interface
- Calibration

What's Next

- Calibration
- Temperature Sensor
- Solar Power
- Integration

Resources

Particle - All-in-One IoT Platform
https://www.particle.io/

Meter EC-5 Soil Moisture Sensor
https://www.metergroup.com/environment/products/ec-5-soil-moisture-sensor/

Equation for capacitance of two parallel coplanar strips
Binns; Lawrenson (1973). Analysis and computation of electric and magnetic field problems. Pergamon Press. ISBN 978-0-08-016638-4.

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