

USING THE ARDUINO MICRO-CONTROLLER TO BUILD CUSTOM INSTRUMENTATION FOR GROUNDWATER APPLICATIONS

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**UW
Extension**
Wisconsin Geological and Natural History Survey



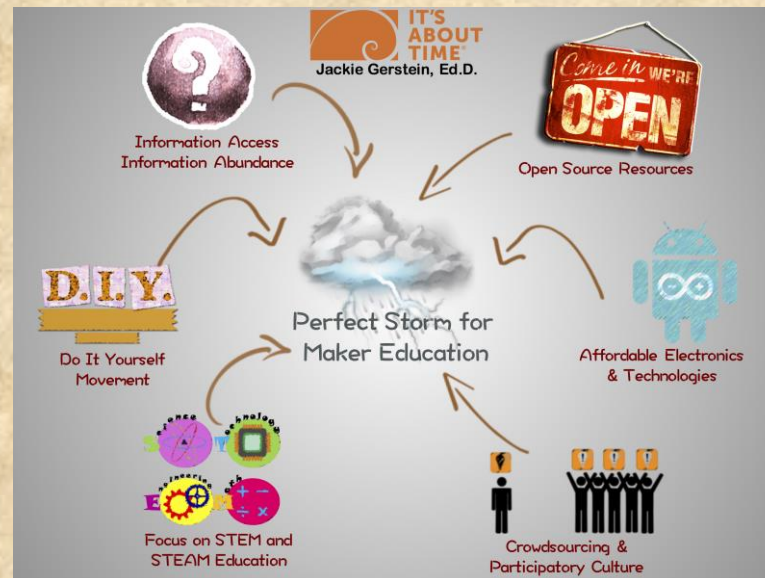
Funded by the Wisconsin
Department of Natural Resources



Maker Culture - Combination of DIY, Hacker, and Artisan Cultures.



Cut-and-paste approach to standardized hobbyist technologies



Three makerspaces in Madison

makerspace

Rating at least
Any rating

UW-Madison Makerspace
5.0 ★★★★★ (2)
Laboratory · 215 N Randall Ave
Open until 9:00 PM

The Bodgery
4.7 ★★★★★ (20)
Community center · 4444 Robertson Rd
Opens at 6:00 PM

Sector67
4.8 ★★★★★ (23)
Community center · 56 Corry St

Showing results 1 - 3

☐ Update results when map moves

SEARCH THIS AREA

UW-Madison Makerspace

Sector67

The Bodgery

Map data ©2019 Google United States Terms Send feedback 2 mi



Who We Are

We're a non-profit organization providing the tools, workspace, and guidance to people of all ages who want to make things. Whether learning a tool, honing a craft, building a business, or finding a creative group of makers – this is your place to build skills and community!

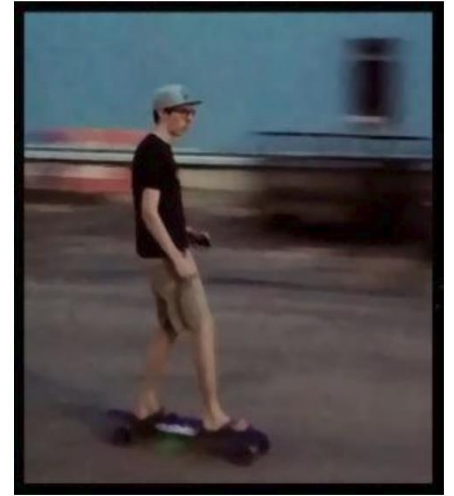
Our Tools

We have a full woodworking shop, welding and blacksmithing, a sewing studio, 3D printing, electronics lab, laser cutting/engraving, a machine shop, prop making and leather work, CNC milling and routing, screen printing, auto repair, and a giant wall of yarn.

A list of **our current tools** is on our wiki.

Check out the shop in our **Virtual Tour!**

The Bodgery



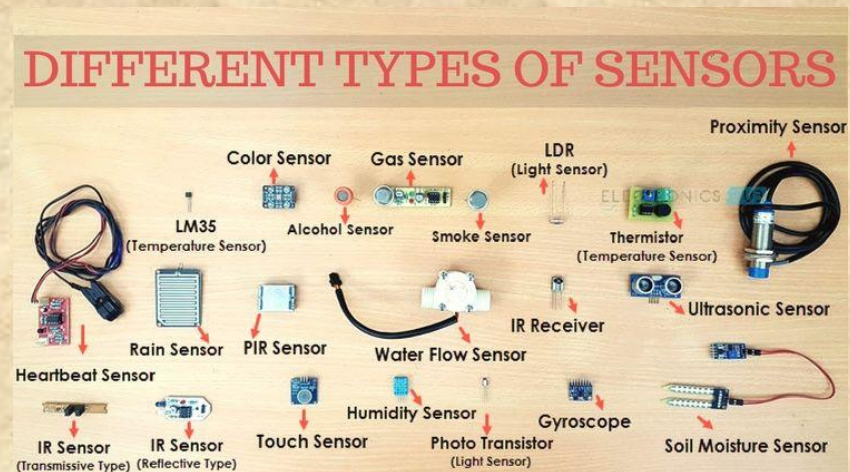
The Electric Long Board

Hi my name is Charlie and I built an electric longboard! The idea first came about a year ago when I saw a student on my campus blast past me while I was biking to class. I did a little research and learned that I desperately wanted one. Unfortunately a high quality electric skateboard is going to run around \$1,000 to \$2,000. I basically gave up hope.

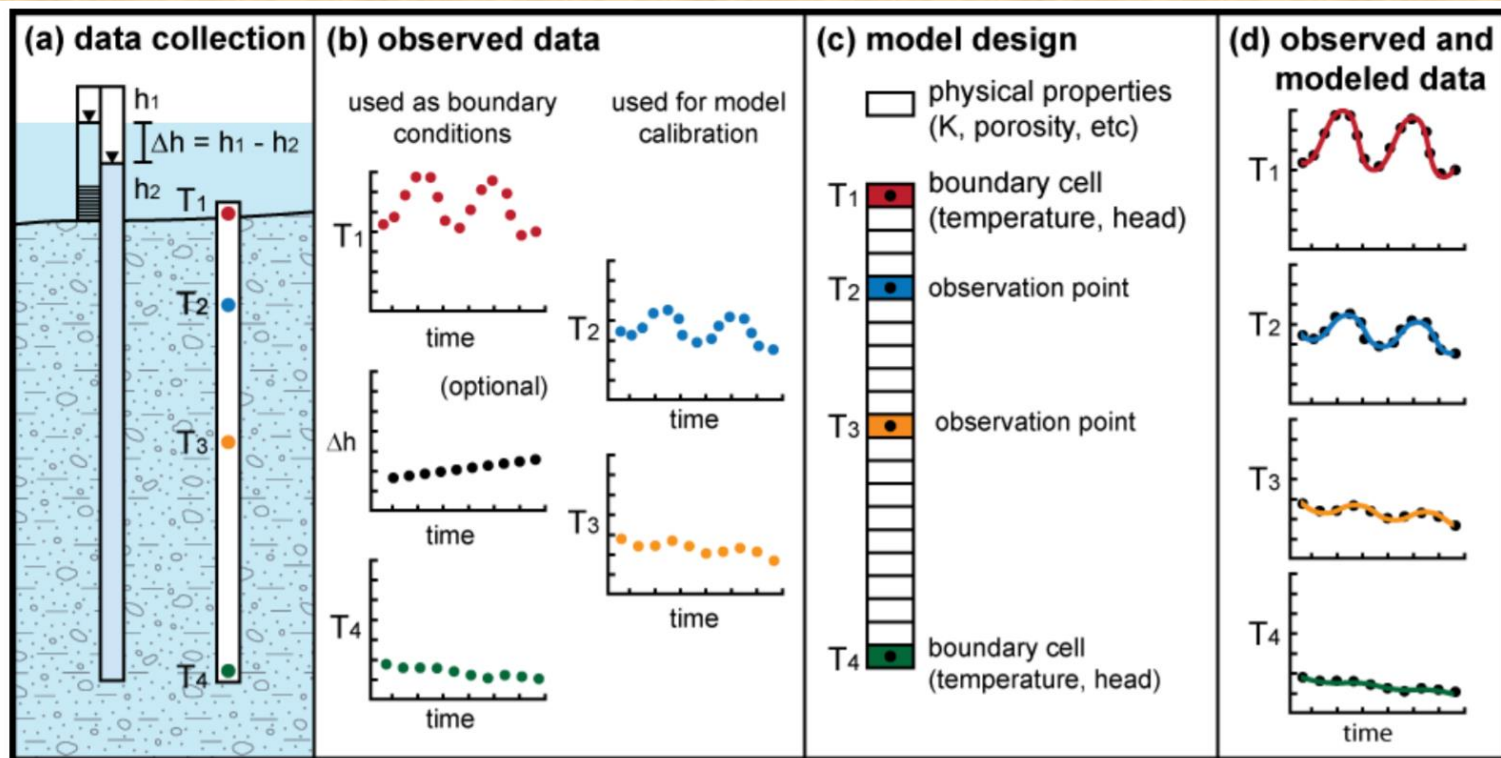
Fast forward to a month ago. I'd just moved to Madison for an internship and was looking for a project. I discovered that building your own electric skateboard isn't all that difficult. With a bit of research, and a lot of hands on learning, you can quickly and easily build a board that goes 30 mph and 10 or more miles. It all depends on your budget. I chose to go with a 6S1P battery system. Basically this meant that I can go about 7 miles, and up to 26 mph on a single charge. After completing my first board in the Bodgery shop, I'm already planning my next. In fact, as I ...

Specific to earth sciences

- Low cost micro-controllers
- Low cost memory storage
- Access to GPS
- Wide range of sensors



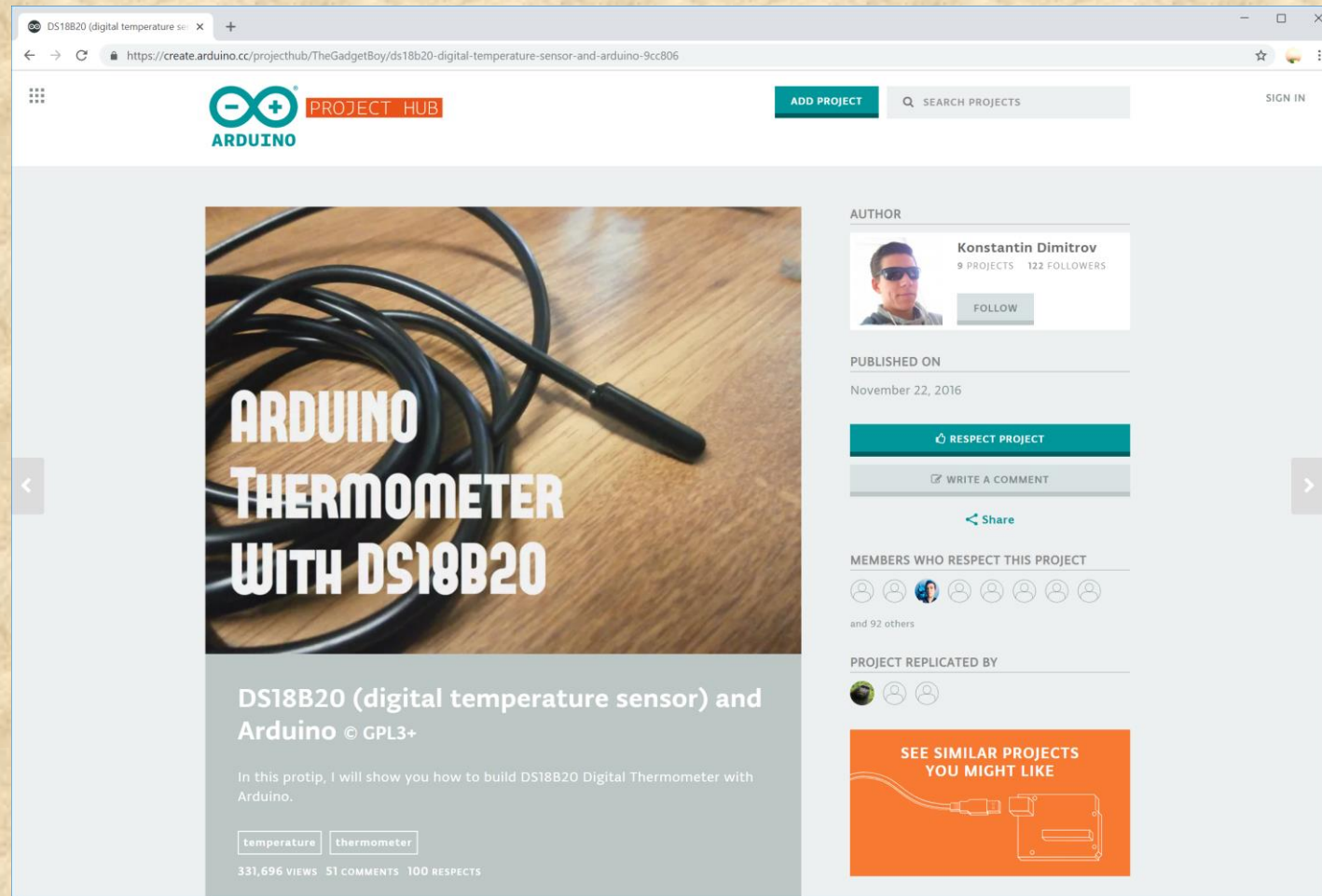
Wanted another way to measure GW/SW interaction. Temperature Flux Measurements



1DTempPro software from USGS uses temperature profile and heads to determine groundwater flux.

<https://www.ncbi.nlm.nih.gov/pubmed/26372016>

Google Arduino and temperature



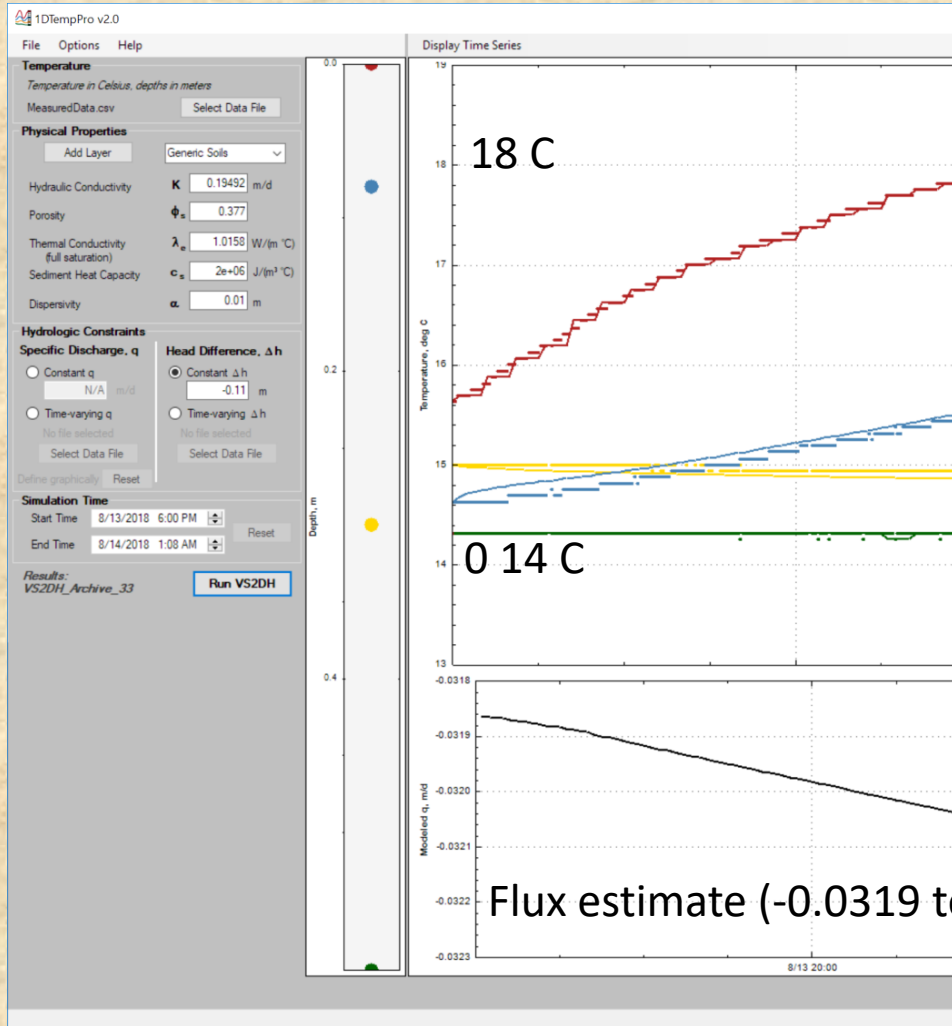
The screenshot shows a web browser displaying a project page on the Arduino Project Hub. The URL in the address bar is <https://create.arduino.cc/projecthub/TheGadgetBoy/ds18b20-digital-temperature-sensor-and-arduino-9cc806>. The page features a large image of a black DS18B20 temperature sensor cable with the text "ARDUINO THERMOMETER WITH DS18B20" overlaid. Below the image, the title "DS18B20 (digital temperature sensor) and Arduino © GPL3+" is displayed. The description states: "In this protip, I will show you how to build DS18B20 Digital Thermometer with Arduino." There are two tags: "temperature" and "thermometer". The statistics show 331,696 views, 51 comments, and 100 respects. On the right side, the author's profile is shown: Konstantin Dimitrov, 9 projects, 122 followers, with a "FOLLOW" button. Below the author's profile, it says "PUBLISHED ON November 22, 2016". There are buttons for "RESPECT PROJECT", "WRITE A COMMENT", and "Share". A section titled "MEMBERS WHO RESPECT THIS PROJECT" shows several user avatars and "and 92 others". Another section titled "PROJECT REPLICATED BY" shows three user avatars. At the bottom right, there is a button that says "SEE SIMILAR PROJECTS YOU MIGHT LIKE" with an illustration of a cable and a sensor.

This page explains what materials are needed, how to connect the sensor and provides a working program or sketch. We used the DS18B20 sensor because they are accurate, water proof, easy to install, and many can be connected into a single port pin.

Hardware and installations



Temp1D results



Lessons learned:

Use larger battery packs and collect less data. 9
Need better installation method. Difficult to ins

Physical Properties

Add Layer

Generic Soils

Hydraulic Conductivity

K 0.19492 m/d

Porosity

ϕ_s 0.377

Thermal Conductivity
(full saturation)

λ_e 1.0158 W/(m °C)

Sediment Heat Capacity

c_s 2e+06 J/(m³ °C)

Dispersivity

α 0.01 m

Hydrologic Constraints

Specific Discharge, q

☐ Constant q
N/A m/d

☐ Time-varying q

No file selected

Select Data File

Head Difference, Δh

☒ Constant Δh
-0.11 m

☐ Time-varying Δh

No file selected

Select Data File

Define graphically

Reset

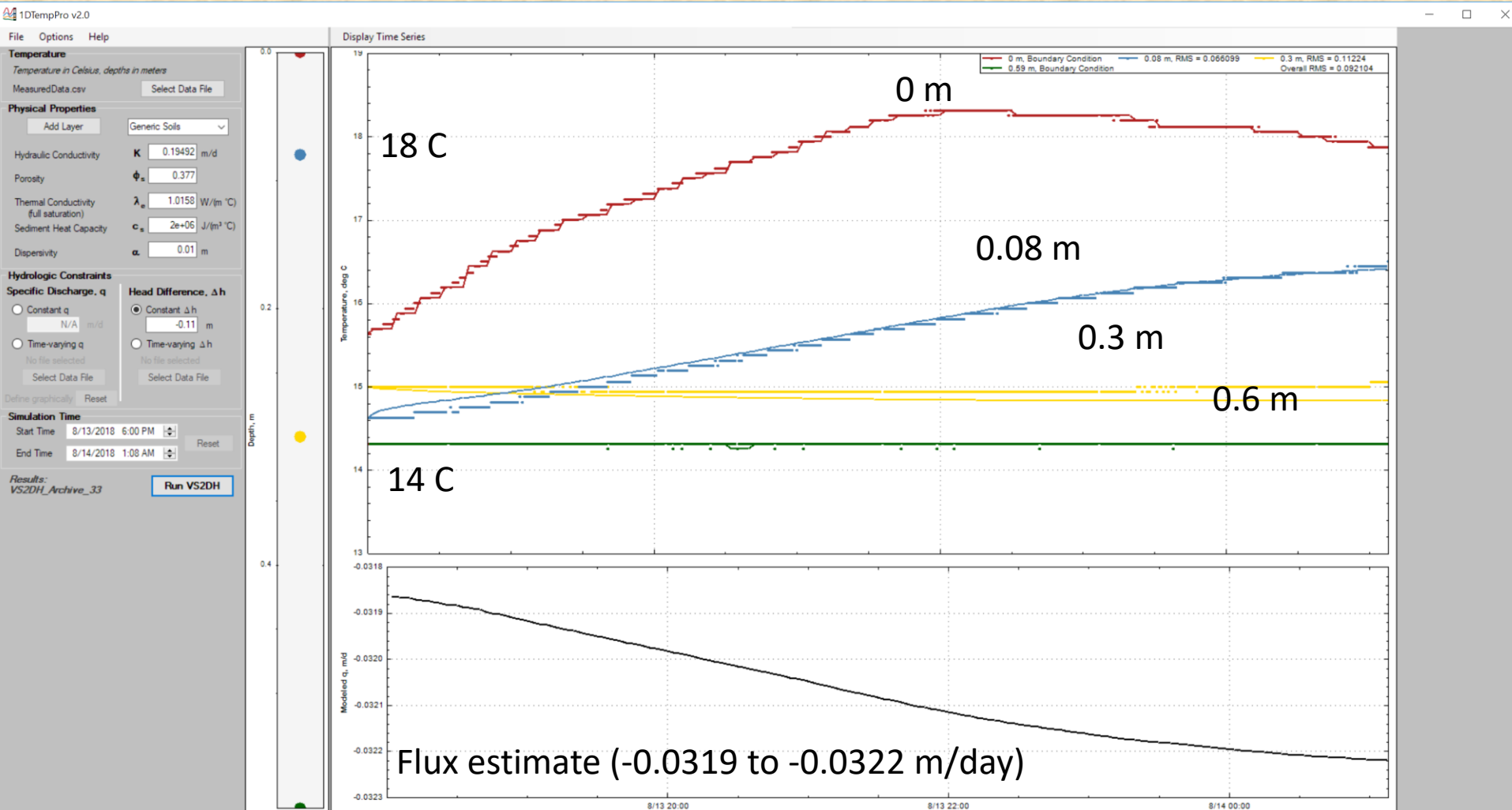
Simulation Time

Start Time 8/13/2018 6:00 PM

End Time 8/14/2018 1:08 AM

Reset

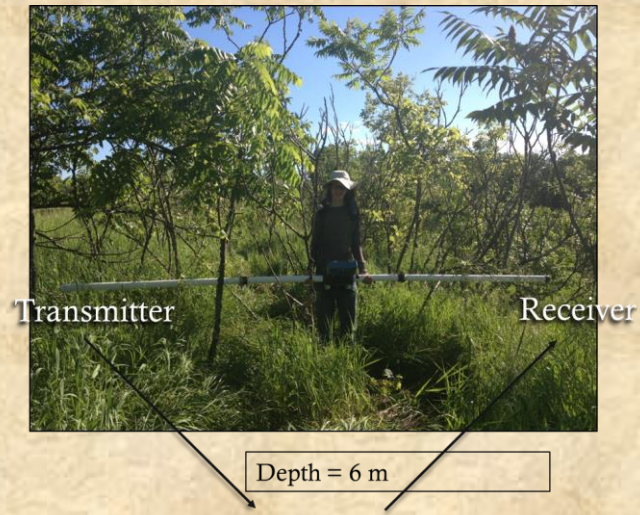
Temp1D results



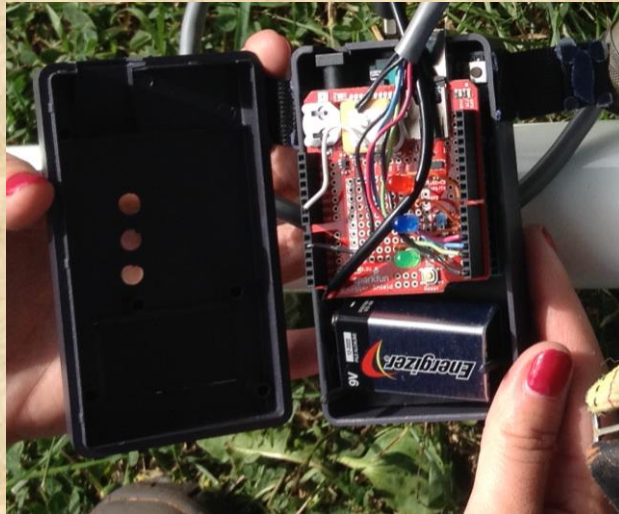
Lessons learned:

Use larger battery packs and collect less data. 9 Volt ran out after 7 hours.
Need better installation method. Difficult to install more than 0.6 meters.

EM-31 Ground Conductivity Meter



- Second example of Arduino application.
 - Record ground conductivity data, time and location.



Geonics supplied pin-out

Google Arduino and GPS

27 gps Projects - Arduino Project Hub - Arduino Create

<https://create.arduino.cc/projecthub/projects/tags/gps> ▼

Real-Time 2G/3G/LTE **Arduino GPS** Tracker +... ... **GPS** Tracking Using Helium, Azure IoT Hub, and Power... ... DIYmall GPRS/**GPS** SIM908 Module - NMEA...

62 tracking Projects - Arduino Project Hub - Arduino Create

<https://create.arduino.cc/projecthub/projects/tags/tracking> ▼

Explore 62 **projects** tagged with 'tracking'. Find these and other hardware **projects** on **Arduino Project Hub**. ... Real-Time 2G/3G/LTE **Arduino GPS** Tracker +.

132 gps Projects - Hackster.io

<https://www.hackster.io/projects/tags/gps> ▼

Interested in **gps**? Explore 132 ... '**gps**'. Find these and other hardware **projects** on Hackster.io. ... Real-Time 2G/3G/LTE **Arduino GPS** Tracker + IoT Dashboard.

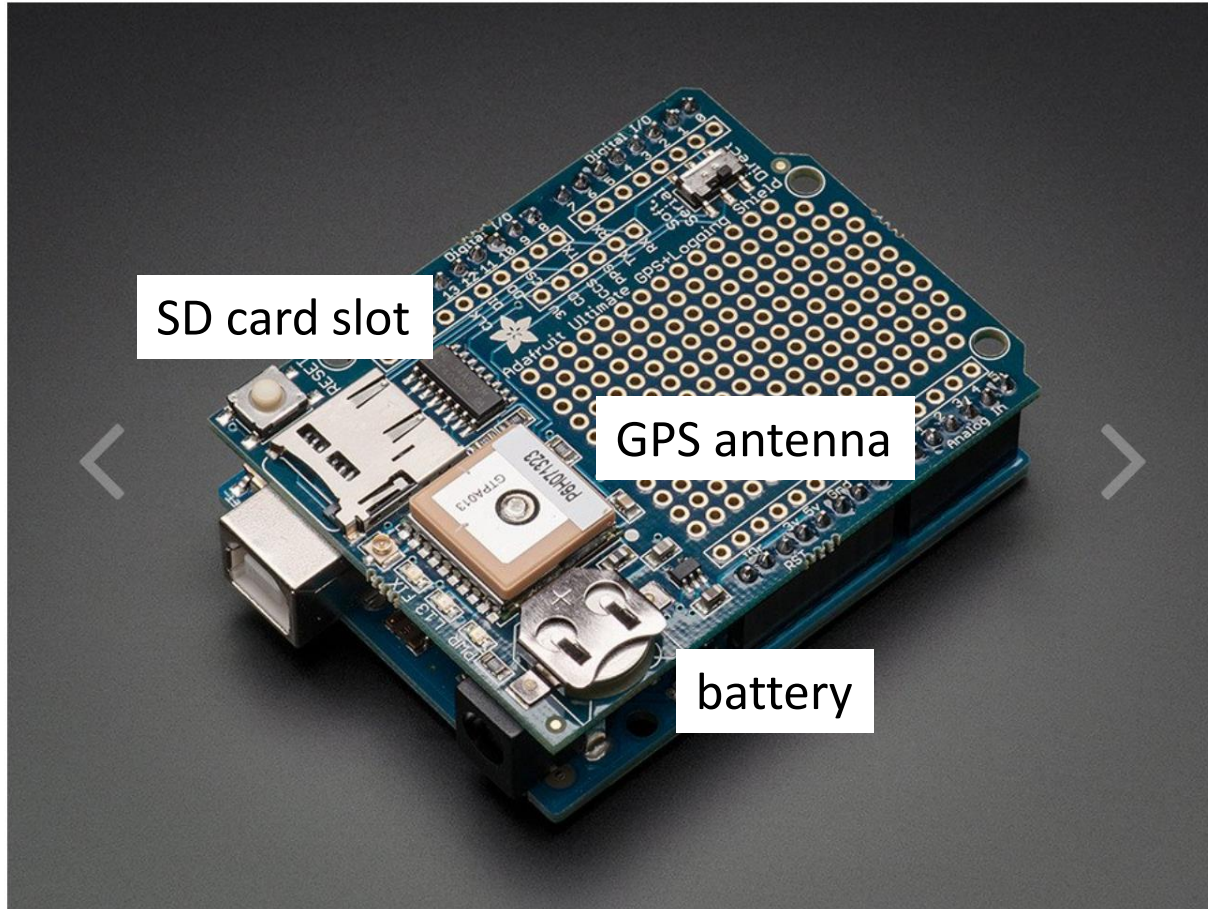
The Complete Understanding Made Simple - GPS With ARDUINO: 6 ...

<https://www.instructables.com> › technology › arduino ▼

Here i am providing with ways of connecting, testing and programming Global positioning system(**GPS**) using **Arduino**... Further, i have worked out **projects** ...

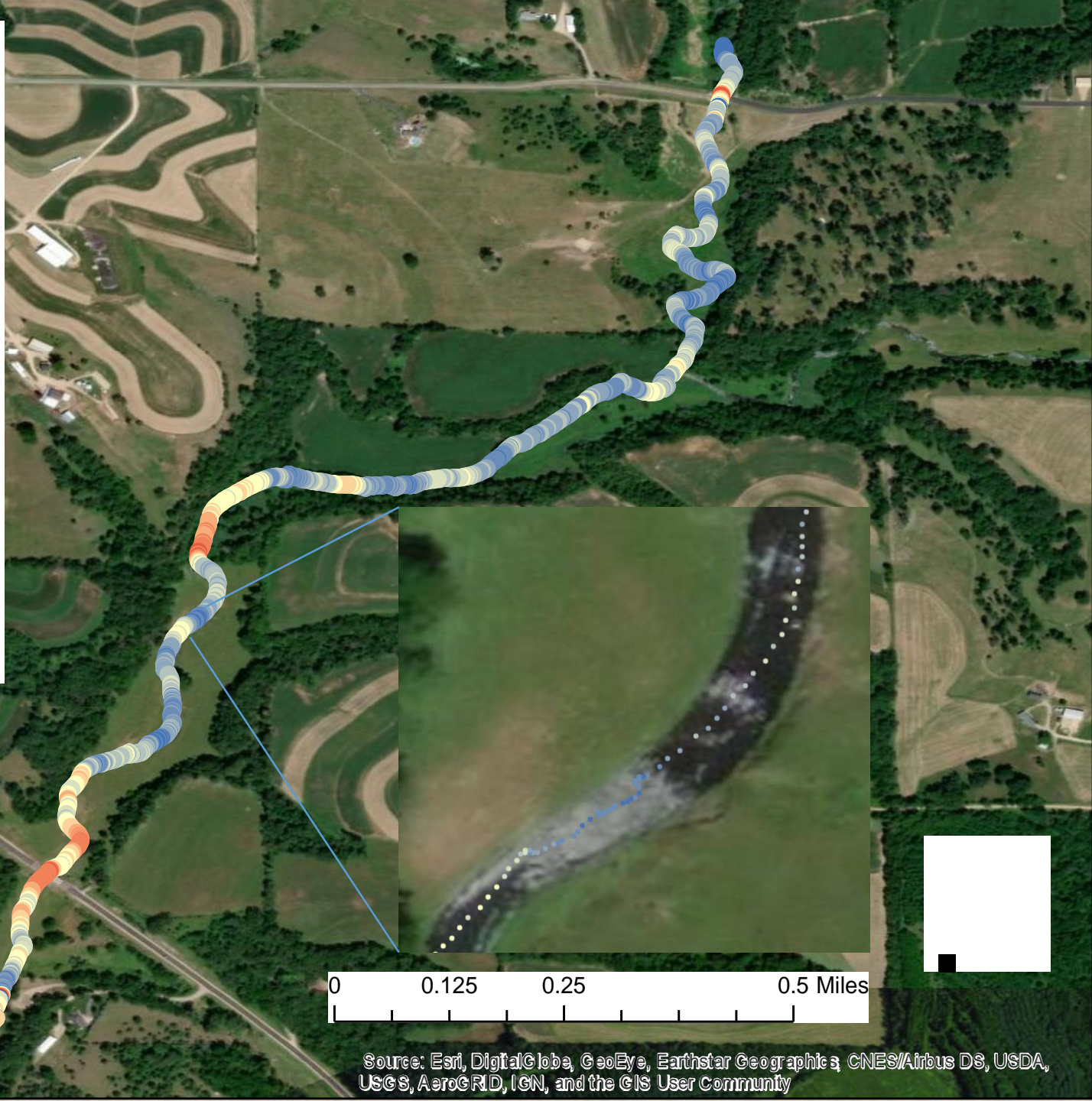
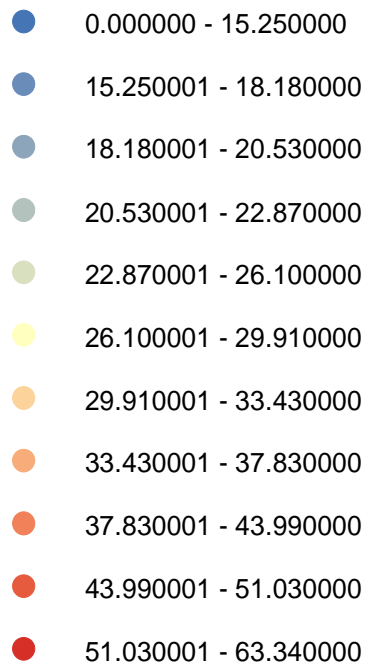
Google Arduino and GPS

ARDUINO / SHIELDS / DATA LOGGING / ADAFRUIT ULTIMATE GPS LOGGER SHIELD - INCLUDES GPS MODULE



This “shield” plugs into microcontroller. It has a keep alive battery, real time clock, SD card slot, and GPS antenna.

EM 31 Conductivity (mS/m)

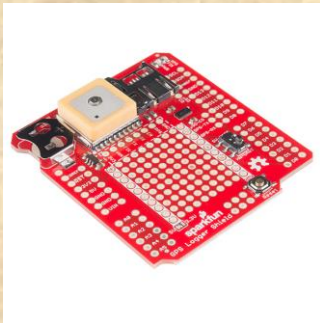


0 0.125 0.25 0.5 Miles

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Arduino water chemistry instrumentation

Multiple sensors, GPS, SD card recording



GPS

These data will be stored on the Arduino board and geolocated with GPS board at sample rate of once every 2 seconds. Total cost ~ \$1000 mostly sensors. Dr. Fratta and Susie Richmond

Arduino Mega Microcontroller



Turbidity/preliminary



pH



Temperature

Nitrate



Chloride

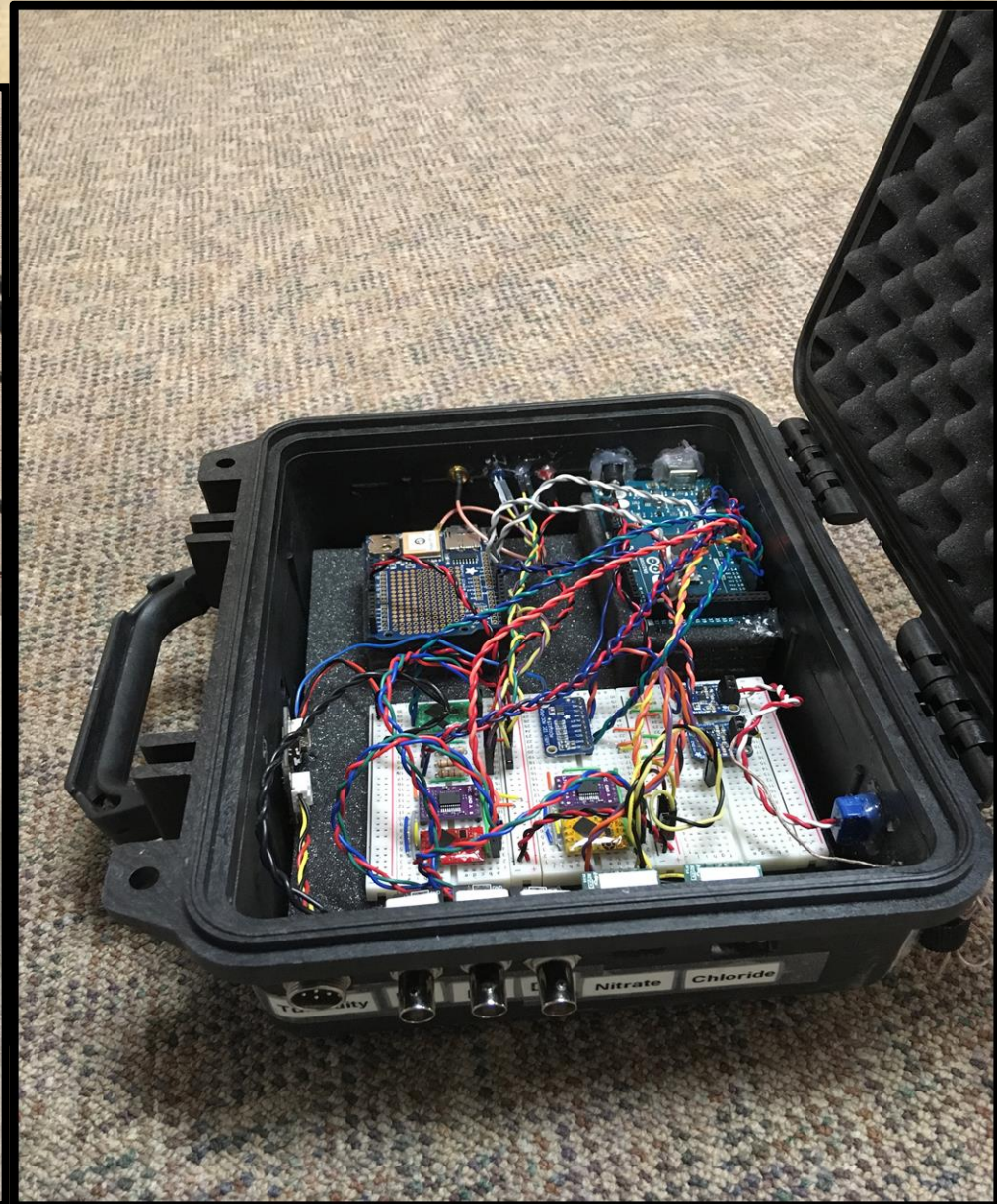
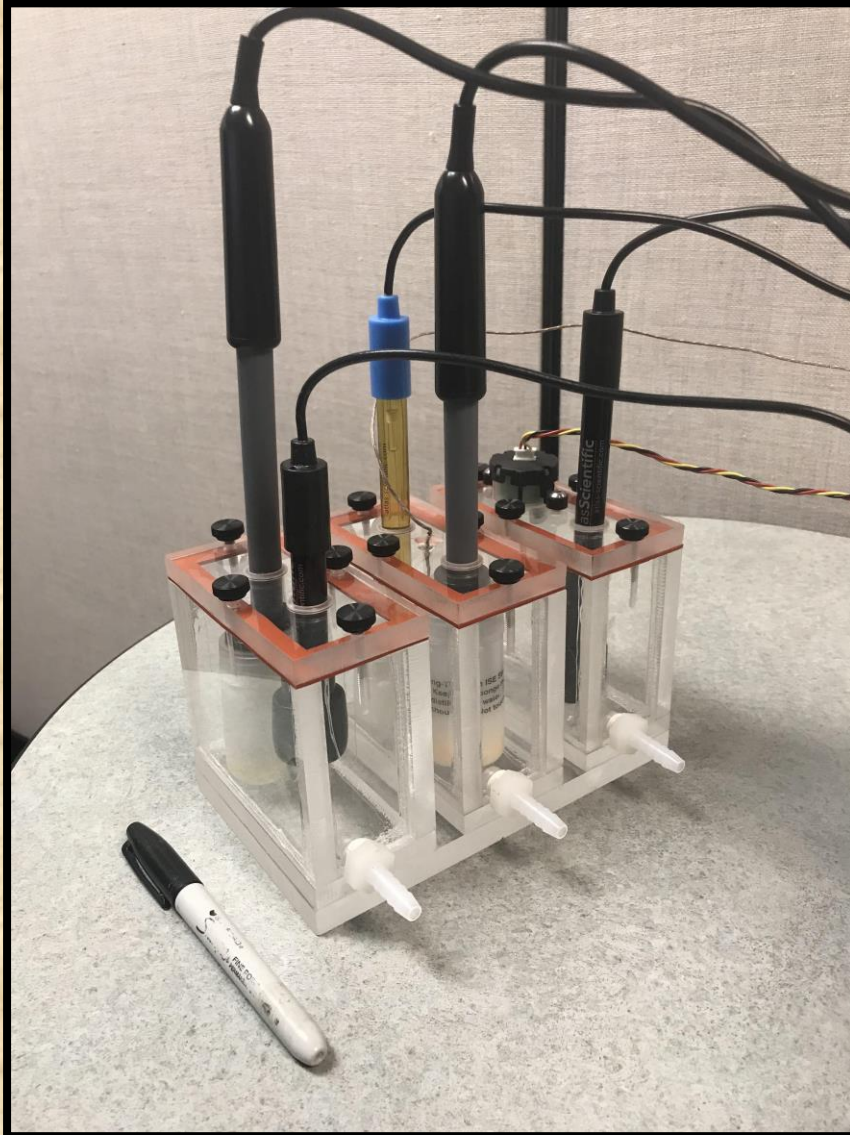


Conductivity



Dissolved Oxygen

Flow through cell and data controller





Flow through
cell

Peristaltic
Pump

Inlet

Data
controller

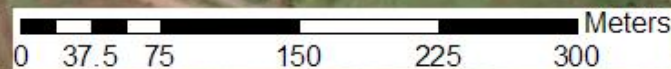
Discharge

General Groundwater Flow Direction



Fluid Conductivity (microS/cm)

- 125.5 - 128.1
- 128.2 - 129.6
- 129.7 - 131.2
- 131.3 - 132.7
- 132.8 - 134.1
- 134.2 - 135.6
- 135.7 - 137.1
- 137.2 - 138.9
- 139.0 - 140.7
- 140.8 - 142.5



Conclusions

- Pros

- Relatively easy
- Relatively low cost
- Have ability to collect very large amounts of data located in time and space
- Expect dense data sets to provide insights not otherwise available
- Great for tinkerers
- Teaching tool

- Cons

- Greater time commitment
- Learning curve can be steep
- Not as robust as engineered system
- Might just want data.

