Testing Highly Instrumented Floating Interrogators (HIFI) for Dense Measurement of Stream-Aquifer Interactions

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UW Extension
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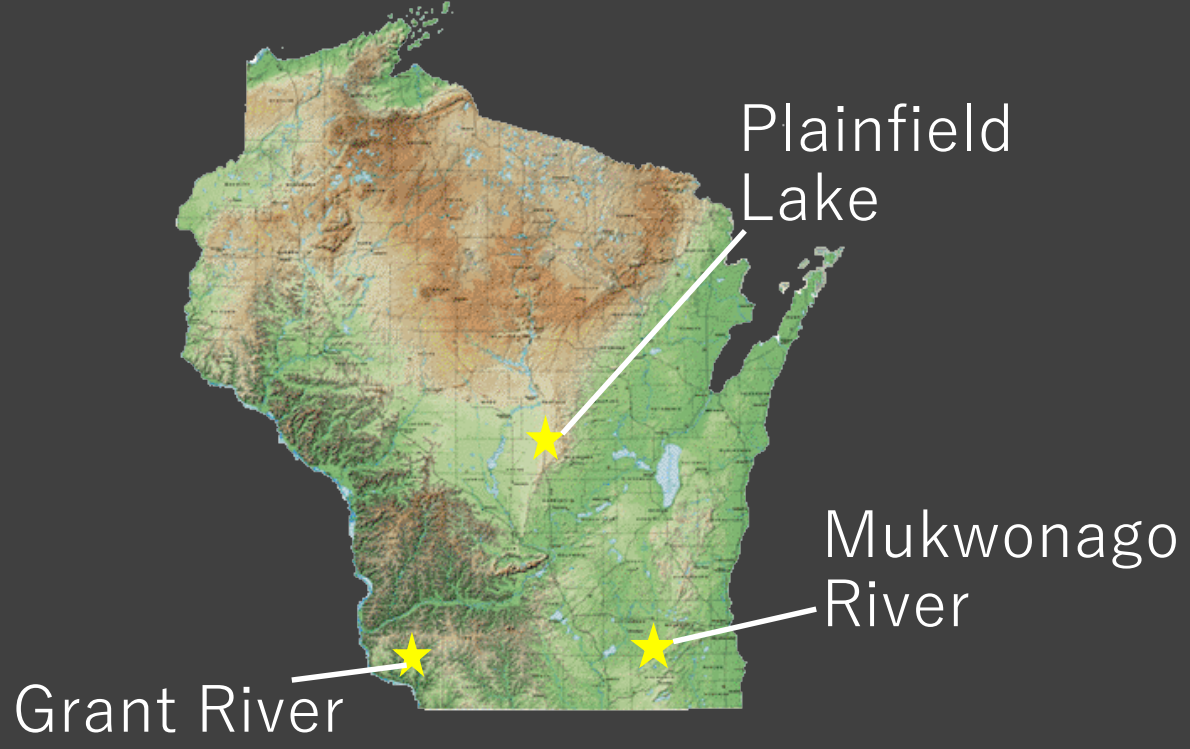
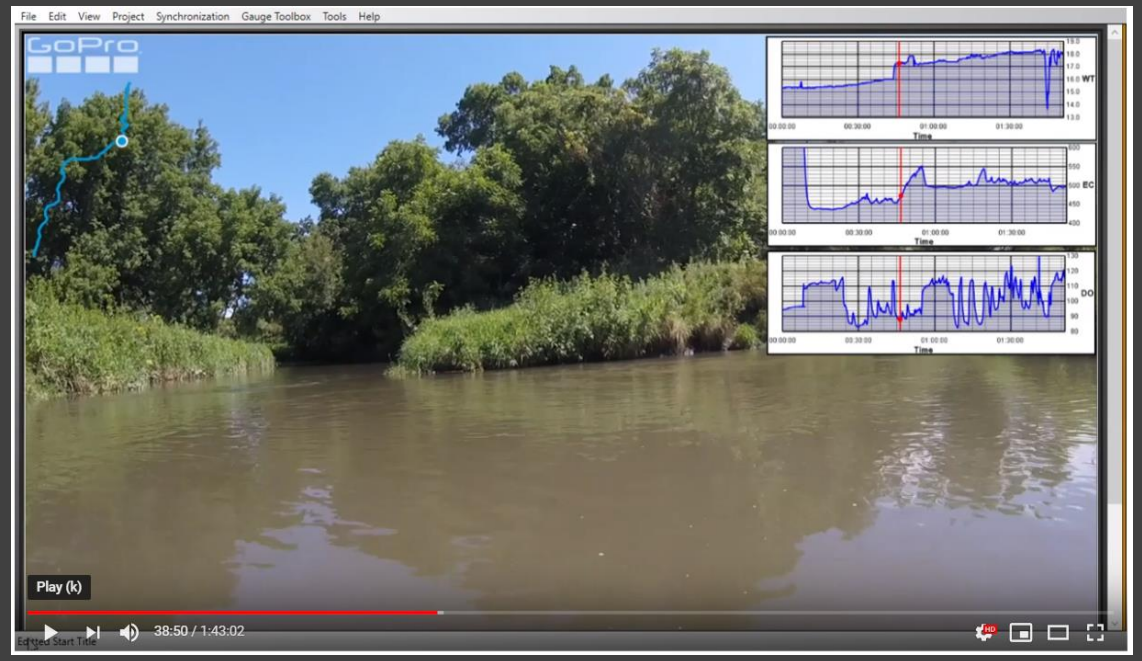
Wisconsin Geological & Natural History Survey

Outline

- Background
- Method
- Results
  - Grant River
  - Plainfield Lake
  - Mukwonago River
- Data Value
- Future Applications

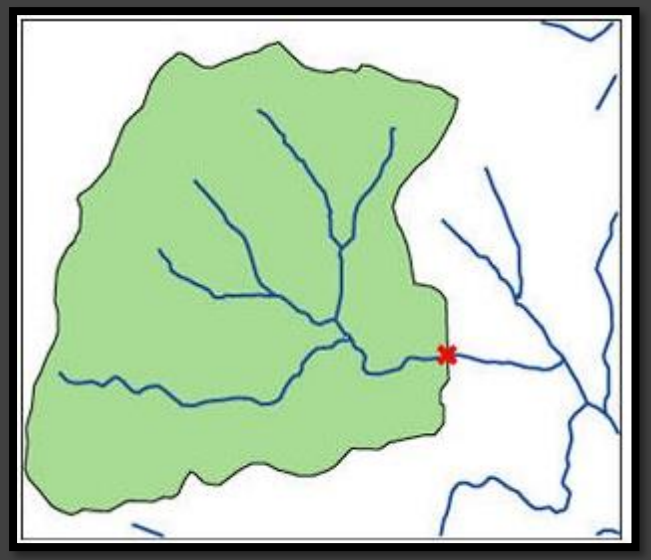




Background

- Hydrologic data most common collected as point scale measurements
  - Snapshot in time
  - Logging through time at a “fixed” station

- Collecting data in a “Lagrangian” framework can fill in spatial gaps within a stream network



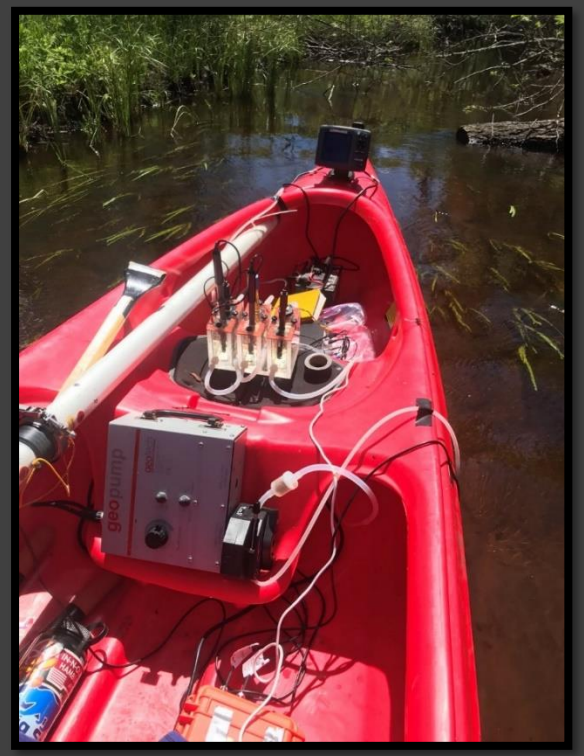
Research Question

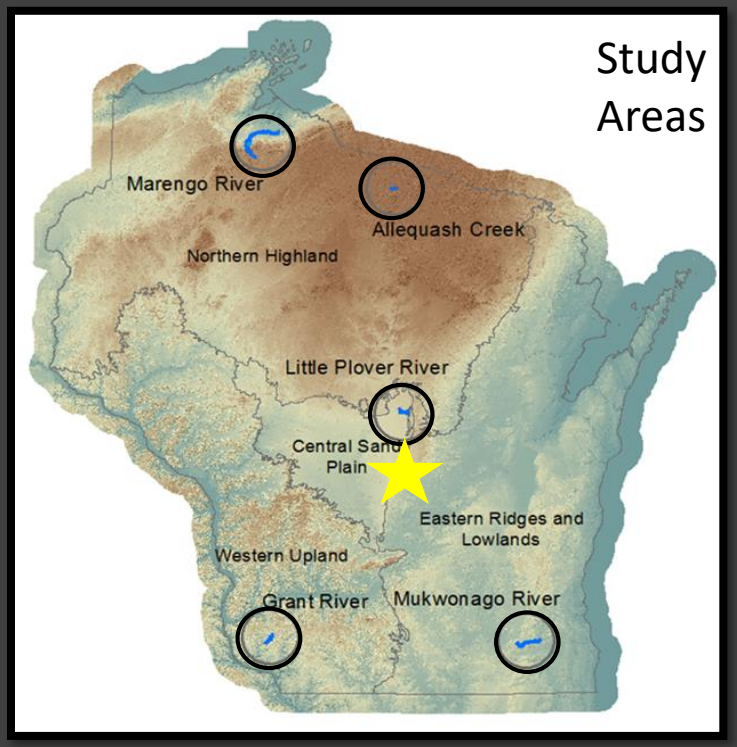
Can we design a method to collect spatially and temporally dense geolocated sets of hydrologic data on small streams to help understand stream quality and gw/sw interaction?

Collected Parameters

Water Quality

- Temperature
- Dissolved Oxygen
- pH
- Electrical Conductivity
- Nitrate*
- Chloride*





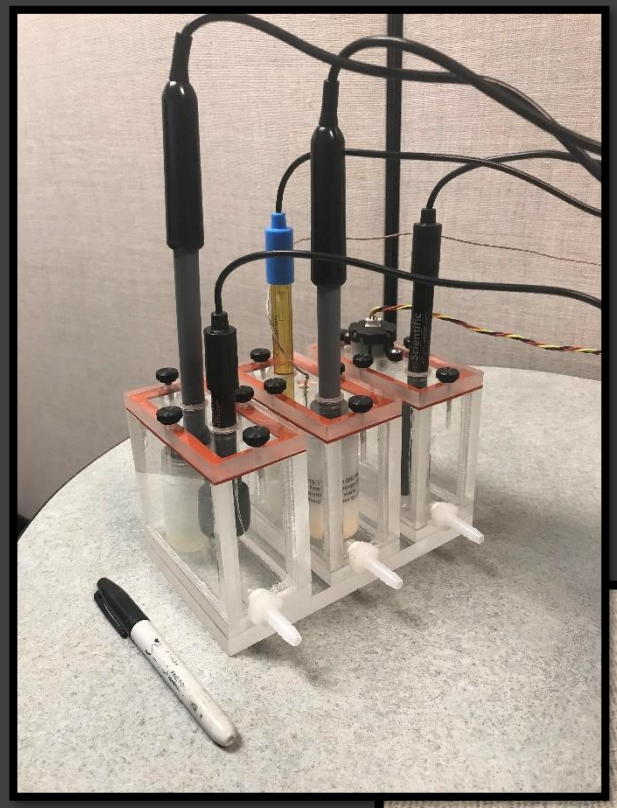
- GoPro Video

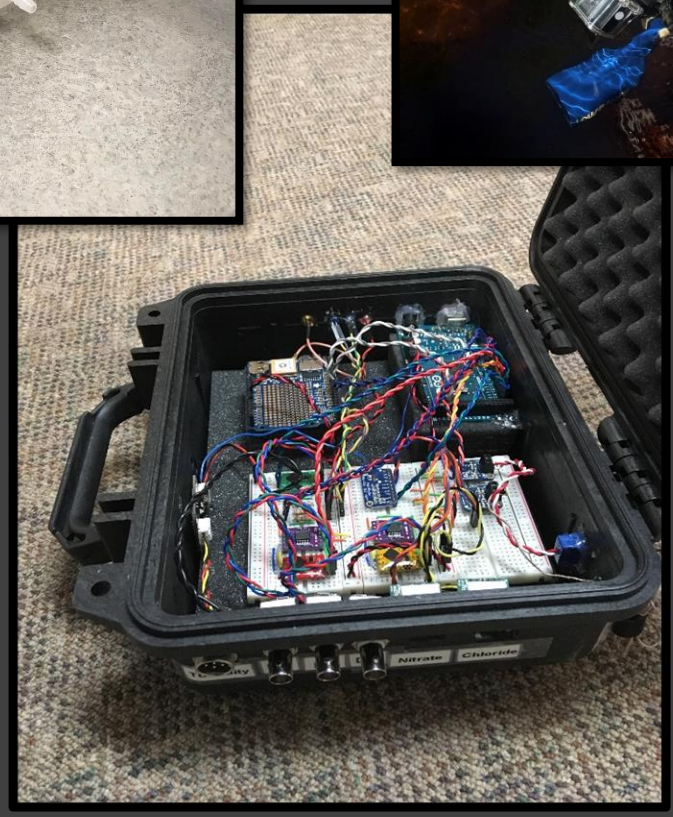
Geophysical

- Streambed Conductivity
- Depth of Water

Overall Method

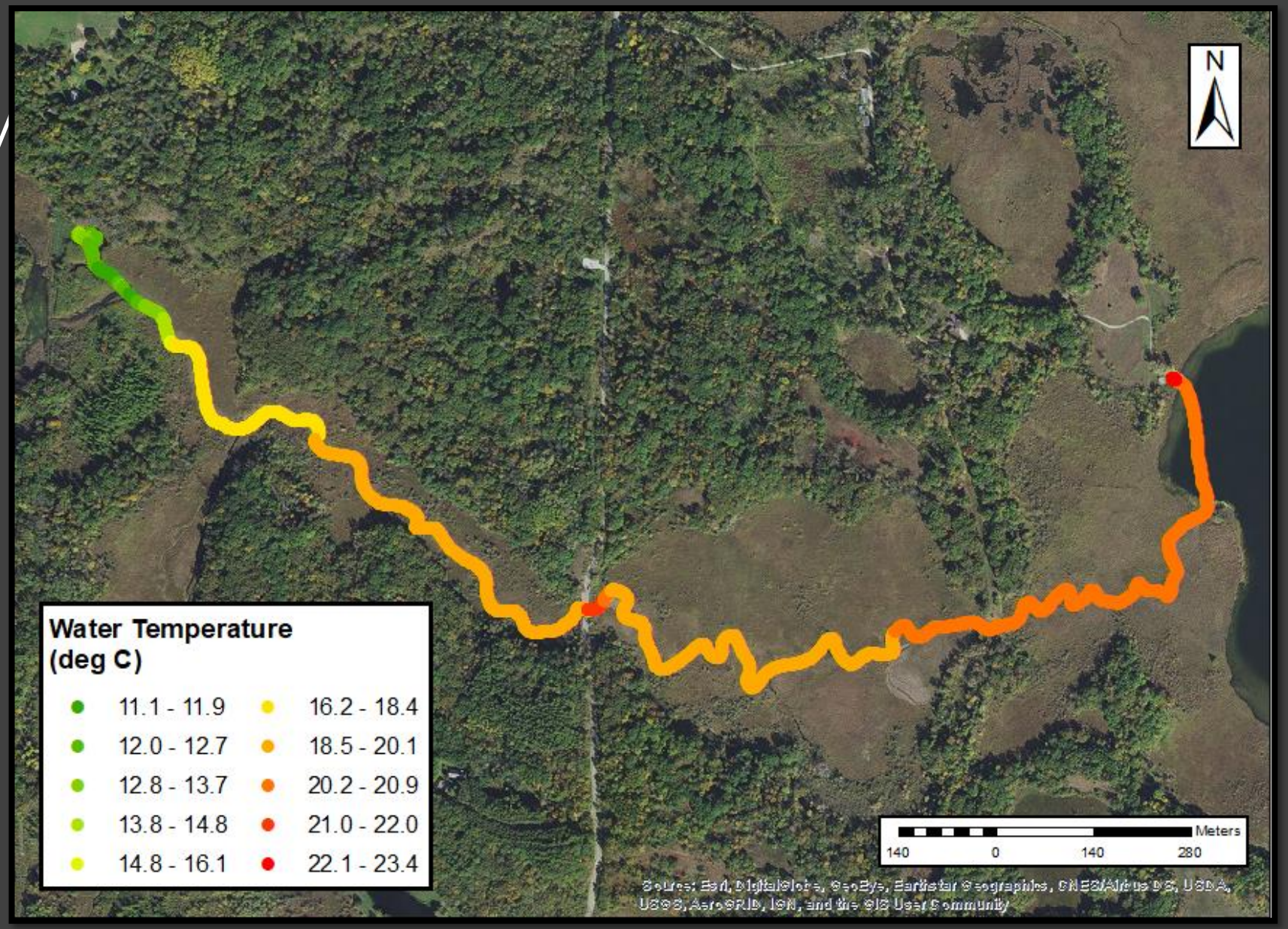
- Collecting geo-located suite of hydrologic data in a mounted canoe float
- Utilizing low-cost equipment and open-source Arduino technology





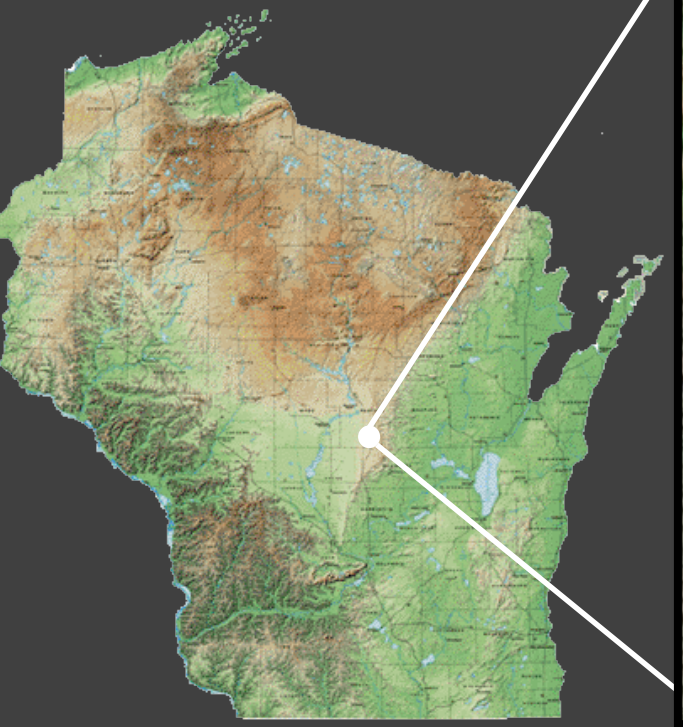
Mukwonago River

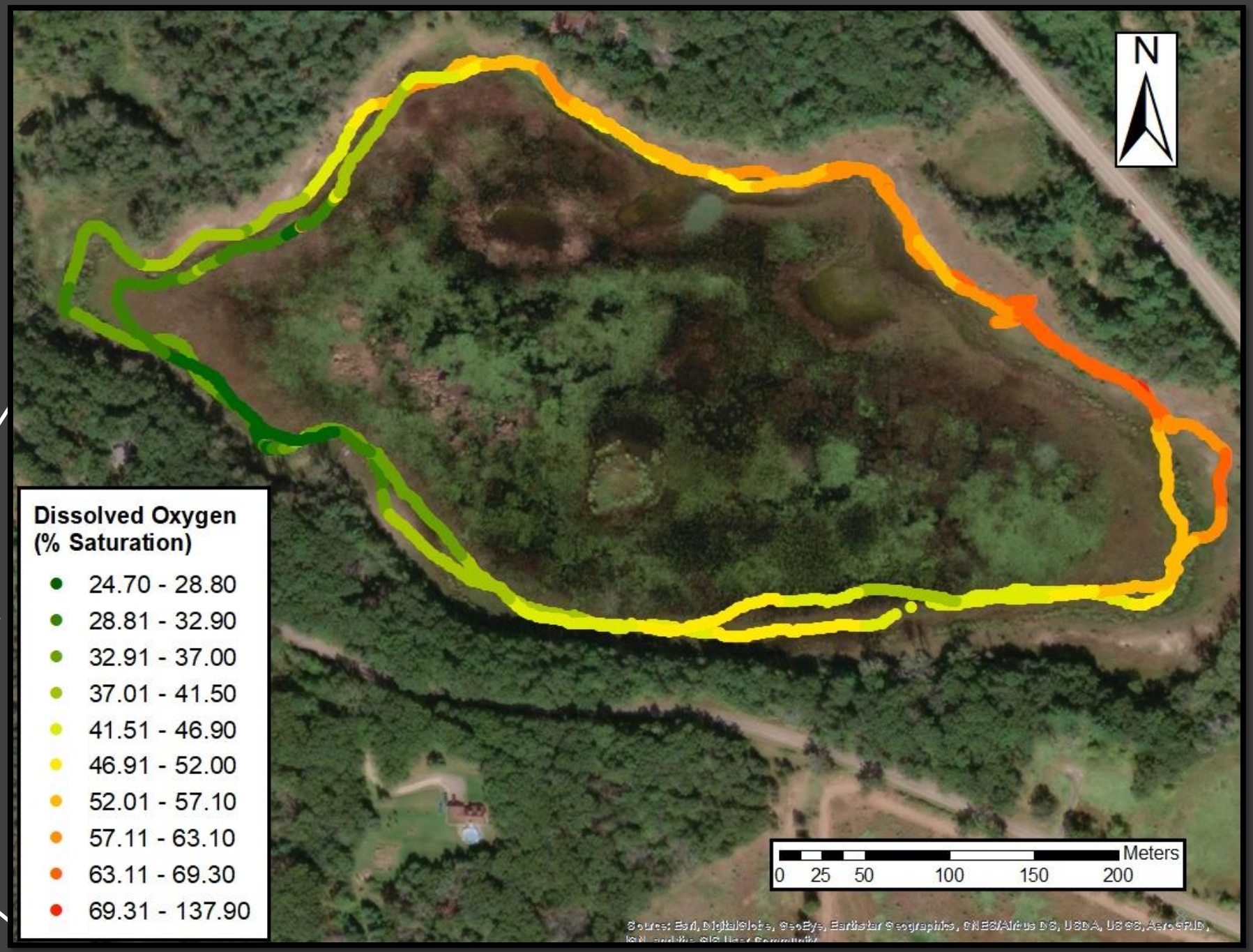
6/27/2018



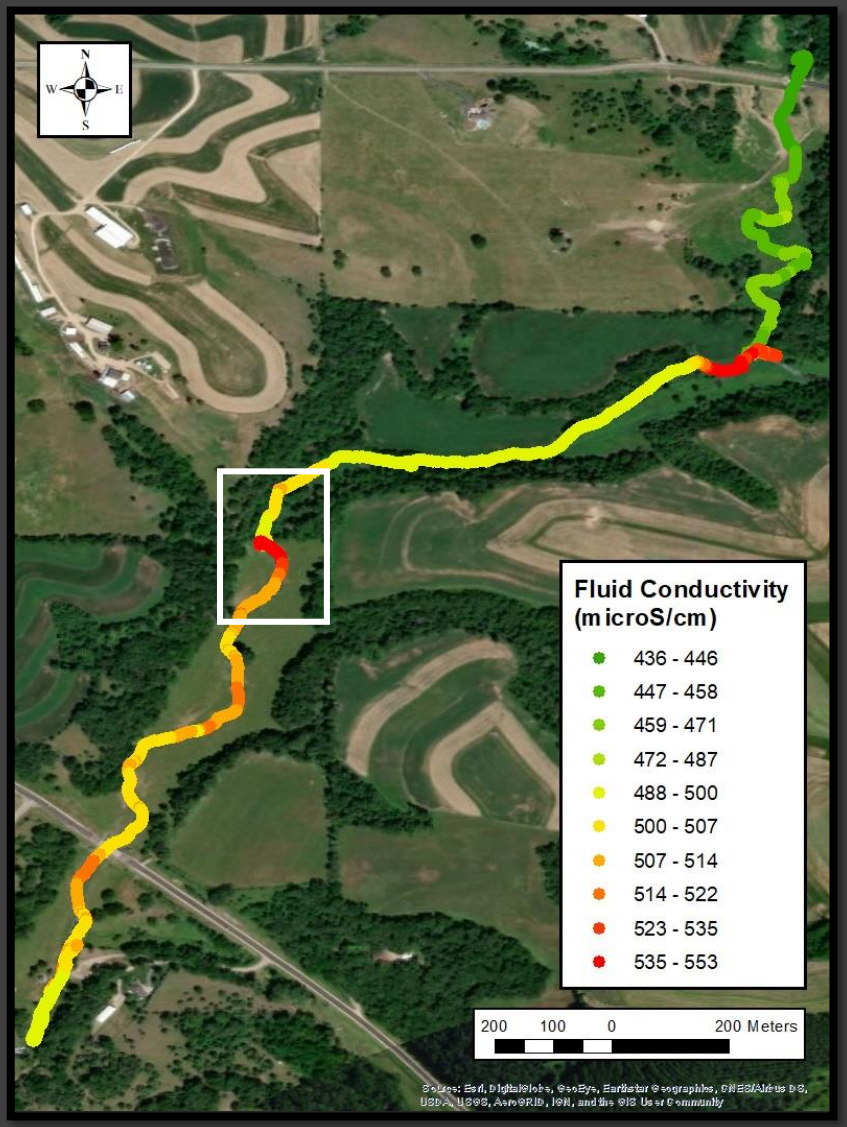
Plainfield Lake, Central Sands Region, WI

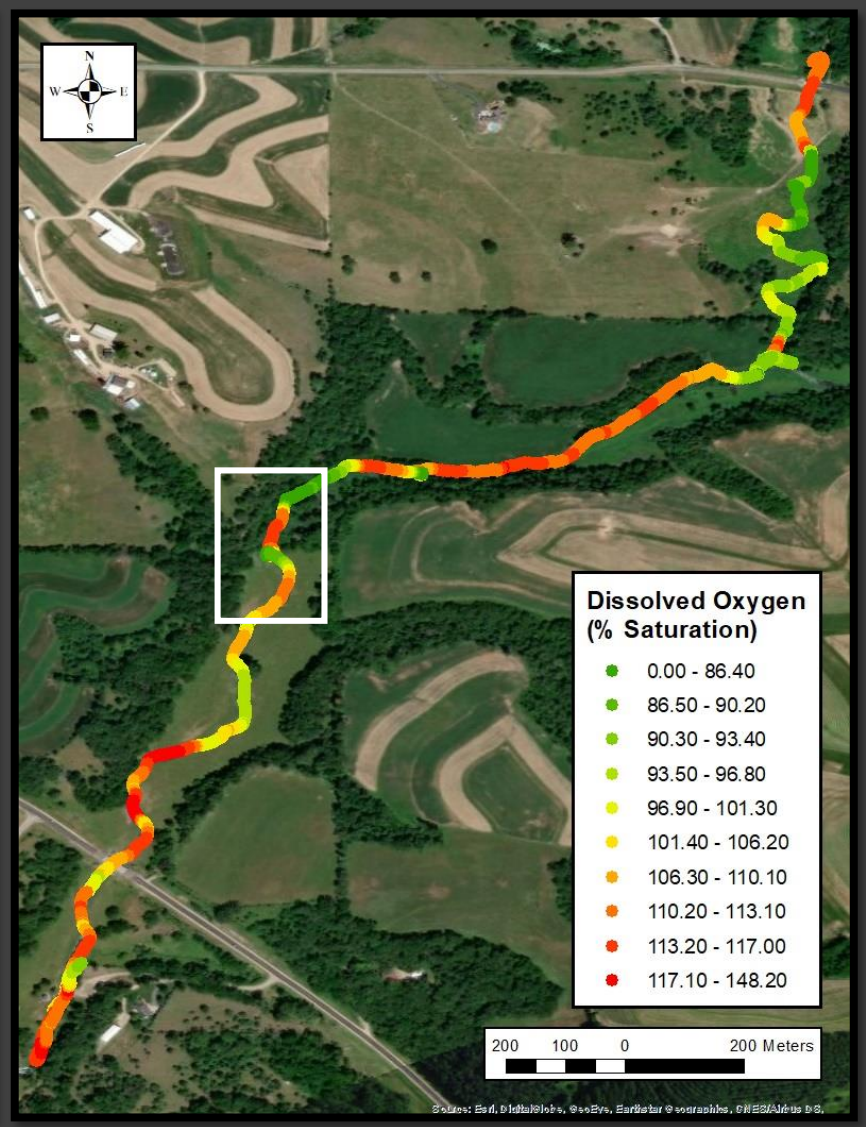
9/20/2018

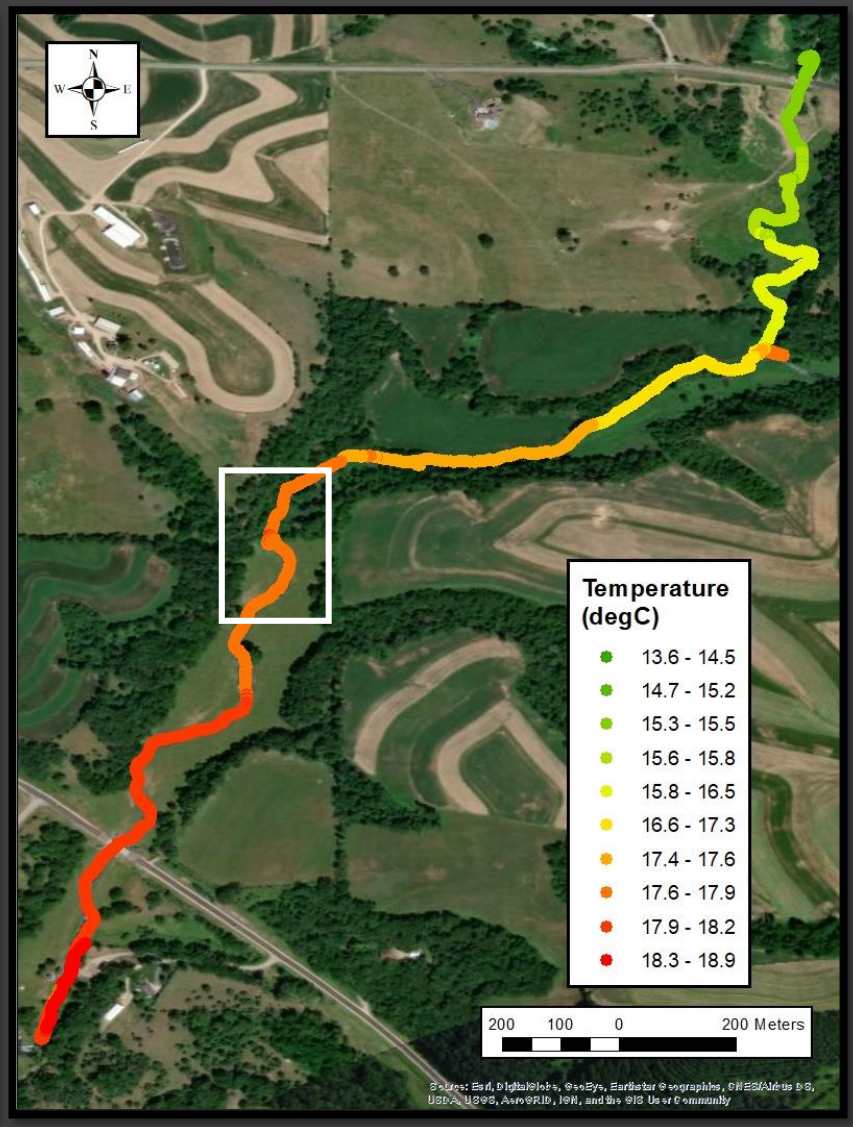




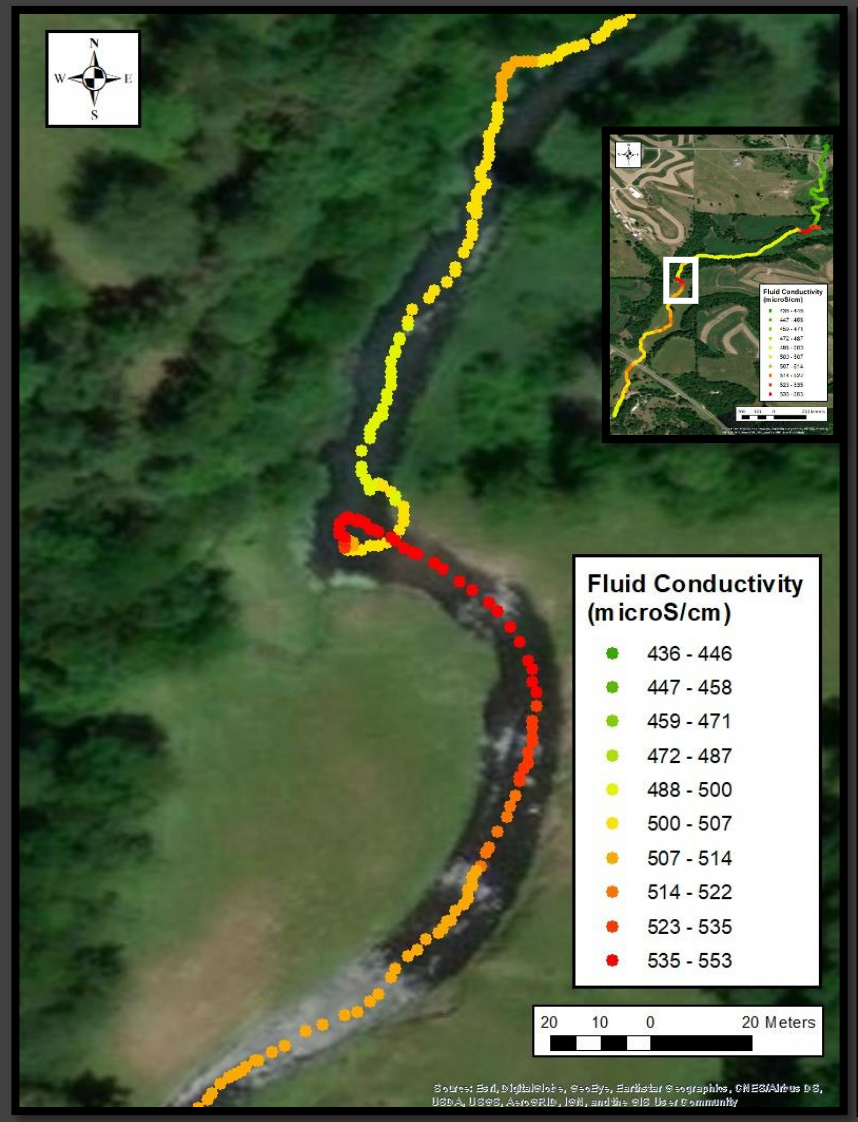
Grant River Results
7/25/18

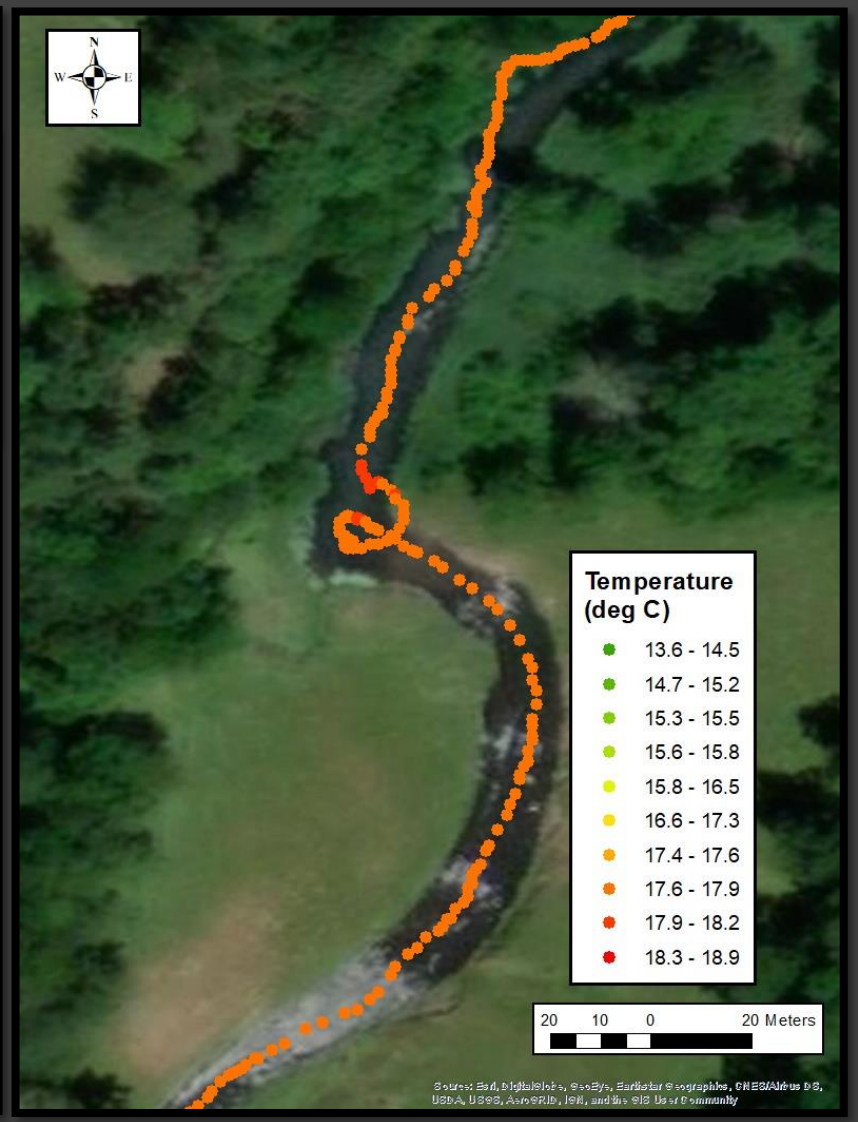


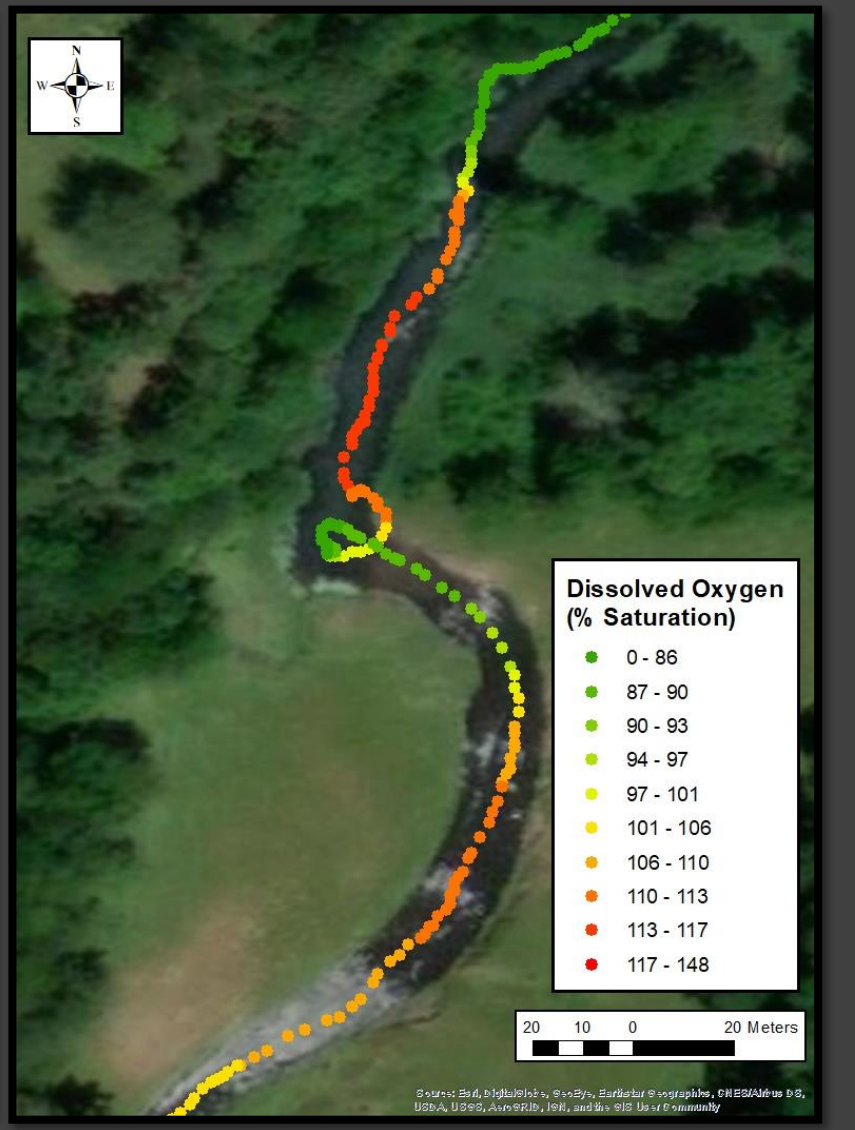




Grant River Results – zoomed in

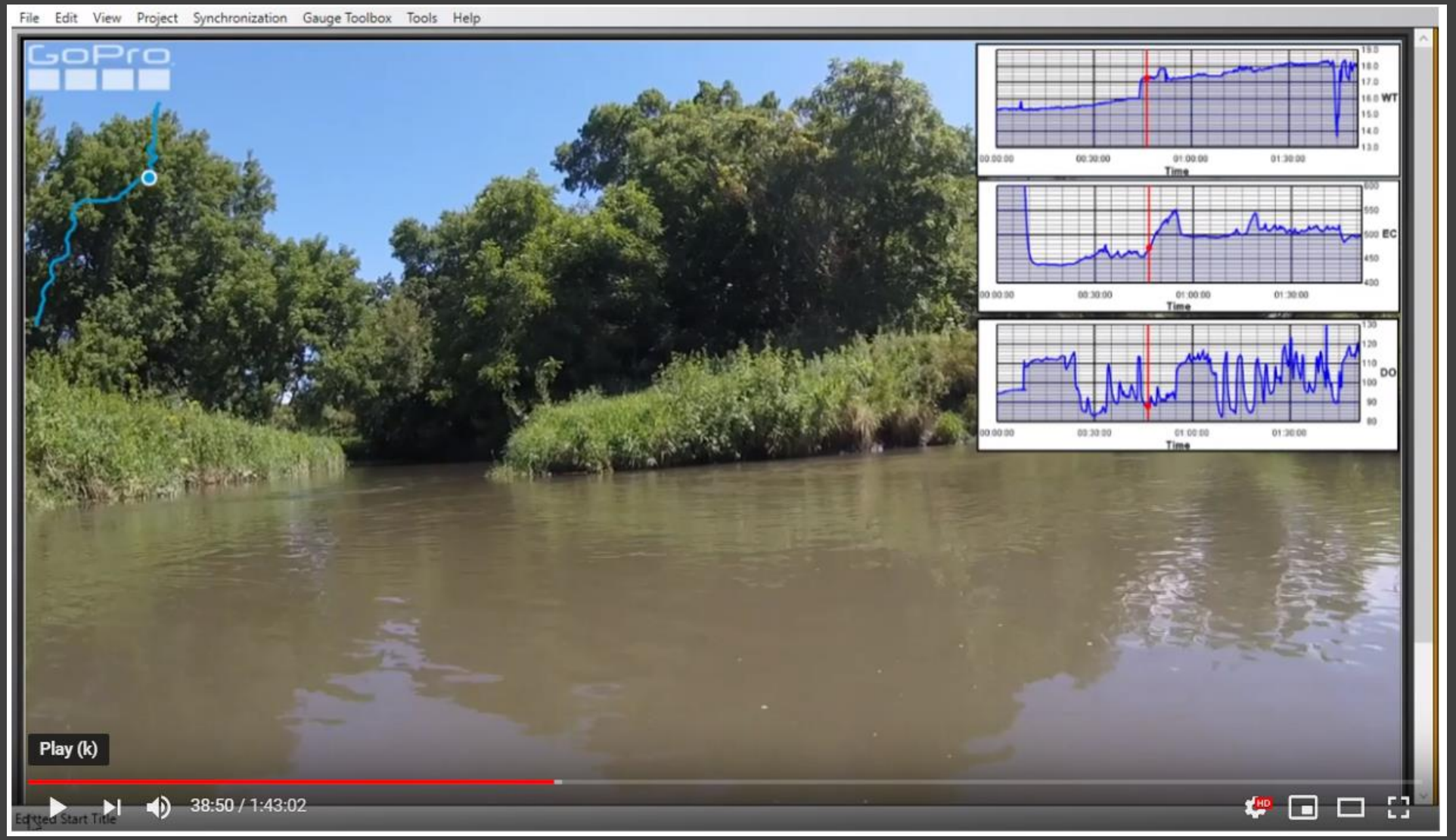






Video

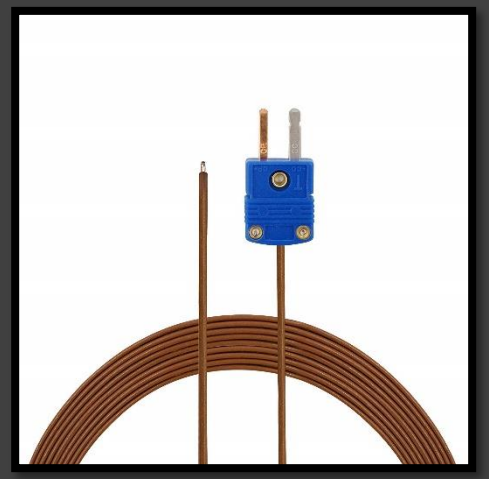
https://www.youtube.com/watch?v=sEjaggUVrc8



Google: “Grant River Float 7/25/2018”

Method Limitations

- Site Accessibility
- Probe Response Time
- Probe Precision/Quality



Method Utility & Future Applications

- Developed method that is low-cost, easy to process compared to other methods
- Provides guidance to areas of interest within a surface water body related to groundwater discharge and water quality changes
- Repeated stream floats can help understand stream quality and dynamics under differing hydrologic conditions

Questions?

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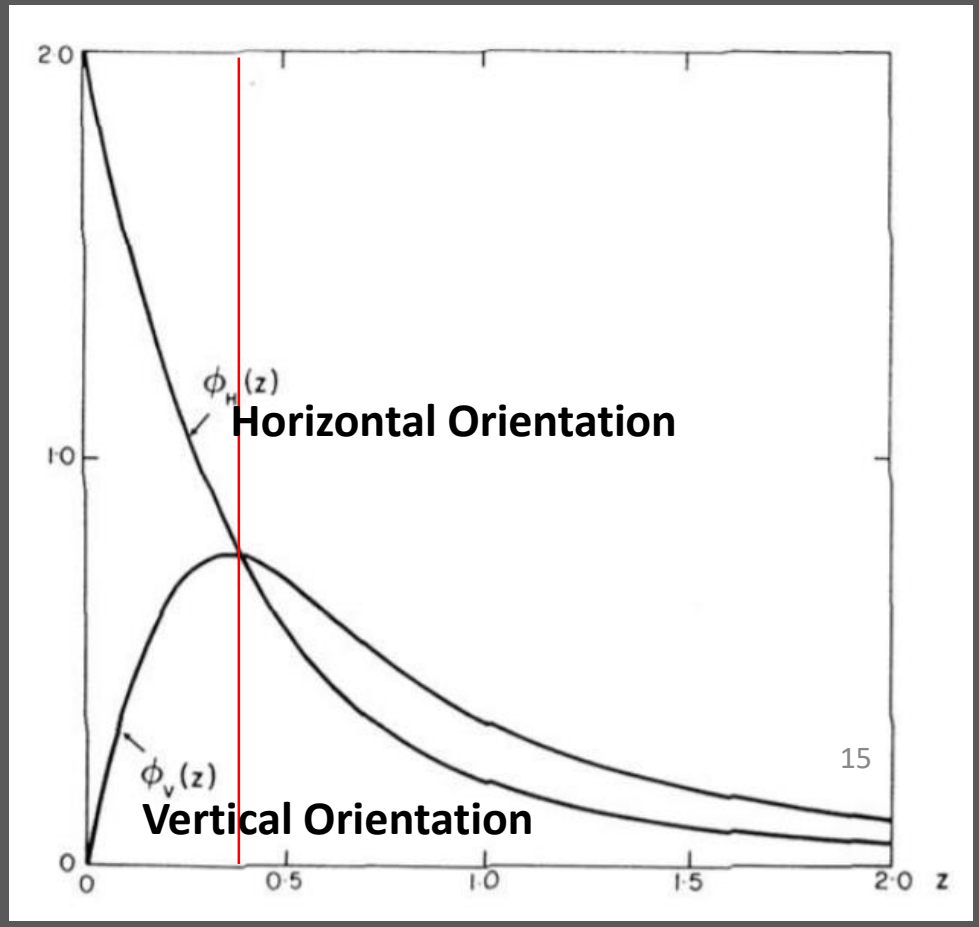
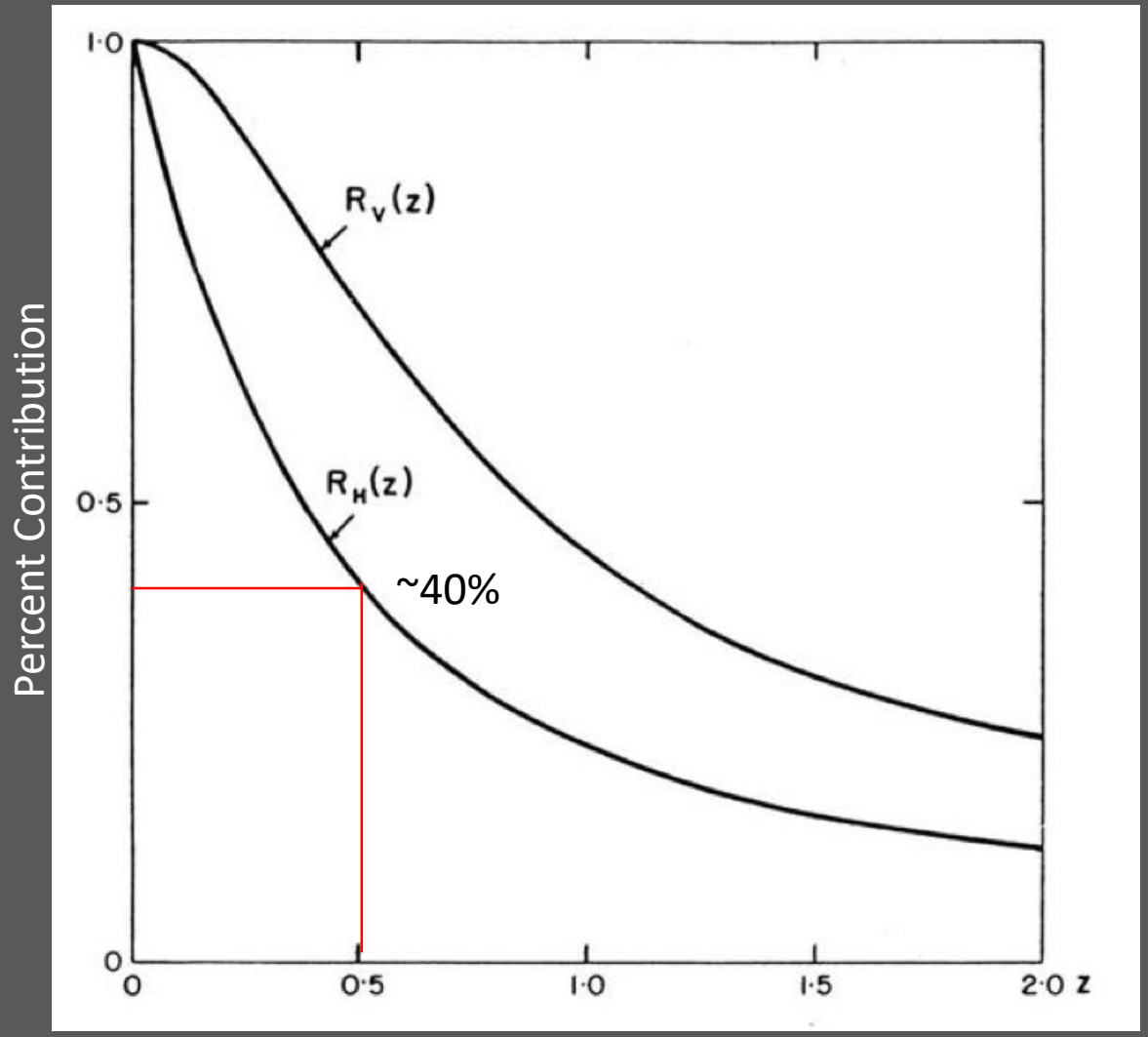
EM31 Operating Principles

- Instrument induces electrical current in earth with alternating current in coil in one end of instrument (No direct contact with ground)
- More induced current ➔ Better conductor
- Changing coil orientation ➔ changes depths sensed

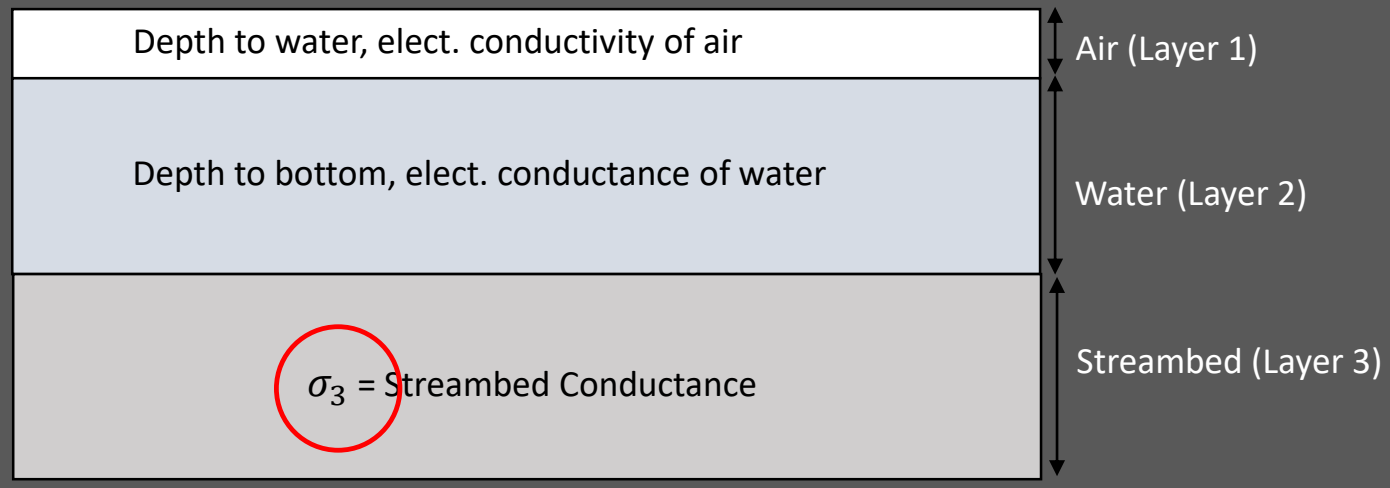


Normalized Depth (d/intercoil spacing)

Cumulative Response Curve



Streambed Conductance from 3-layer system



$$\sigma_t = \sigma_1[1 - R_H(z_1)] + \sigma_2[R_H(z_1) - R_H(z_2 + z_1)] + \sigma_3 R_H(z_2 + z_1)$$

σ = conductivity of the layer

z = normalized depth (depth/intercoil spacing)

R_H = relative influence of current flow as a function of depth

$$R_H(z) = (4z^2 + 1)^{1/2} - 2z$$

McNeil, 1980: http://www.geonics.com/pdfs/technicalnotes/tn6.pdf

Video

https://www.youtube.com/watch?v=sEjaggUVrc8

Google: “Grant River Float 7/25/2018”