Using geophysics to better understand wetland hydrogeology

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Geophysics is often a good choice for wetland studies

- Flat
- Often no trees or other obstructions
- No “cultural” interference
- Equipment is relatively portable and unlikely to become stuck

Photo - Ken Bradbury

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http://www.independenttestingtech.com/drilling_services

tow411.yuku.com

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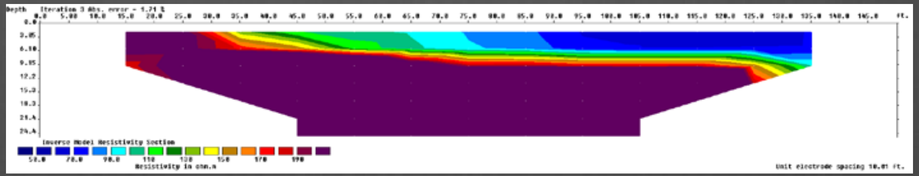
- Equipment is relatively portable and unlikely to become stuck
- Helps locate boreholes and piezometers for better information.

Geophysics Used

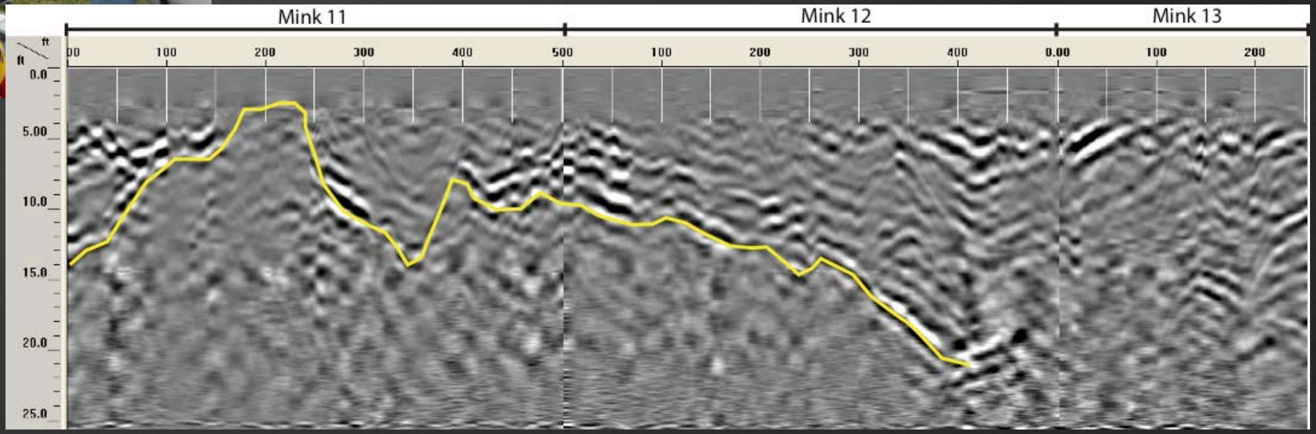
- Electrical Resistivity Imaging



- EM-31 Ground Conductivity Meter

- Seismic Refraction

- Ground Penetrating Radar



EM-31 Examples

Mink River Estuary

Lulu Lake Nature Preserve

EM-31 Qualitative Example

Mukwonago Wetland at Lulu Lake Nature Preserve

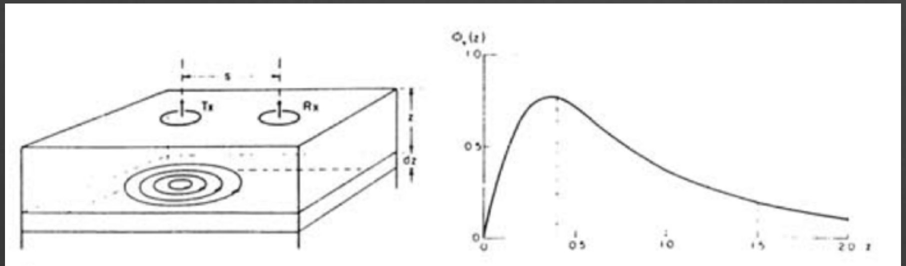
EM-31 Qualitative Example

Mukwonago Wetland at Lulu Lake Nature Preserve

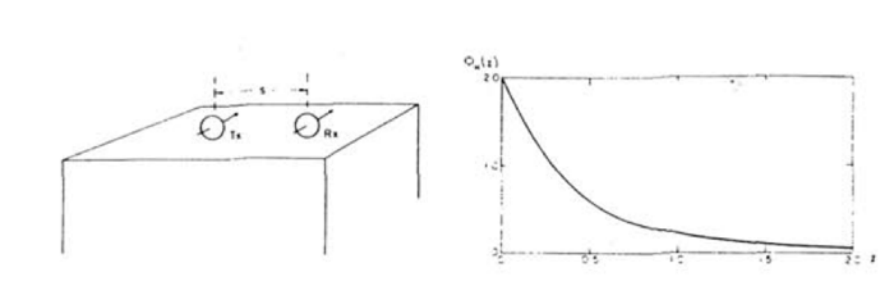
EM-31 Operation

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

Vertical

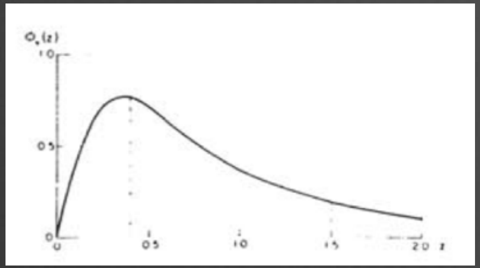


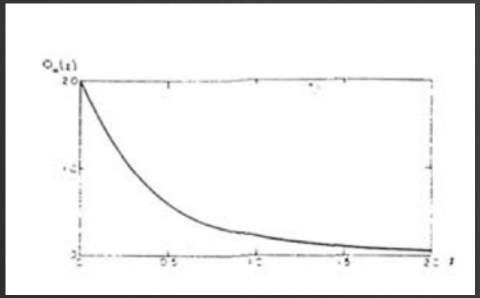
Horizontal



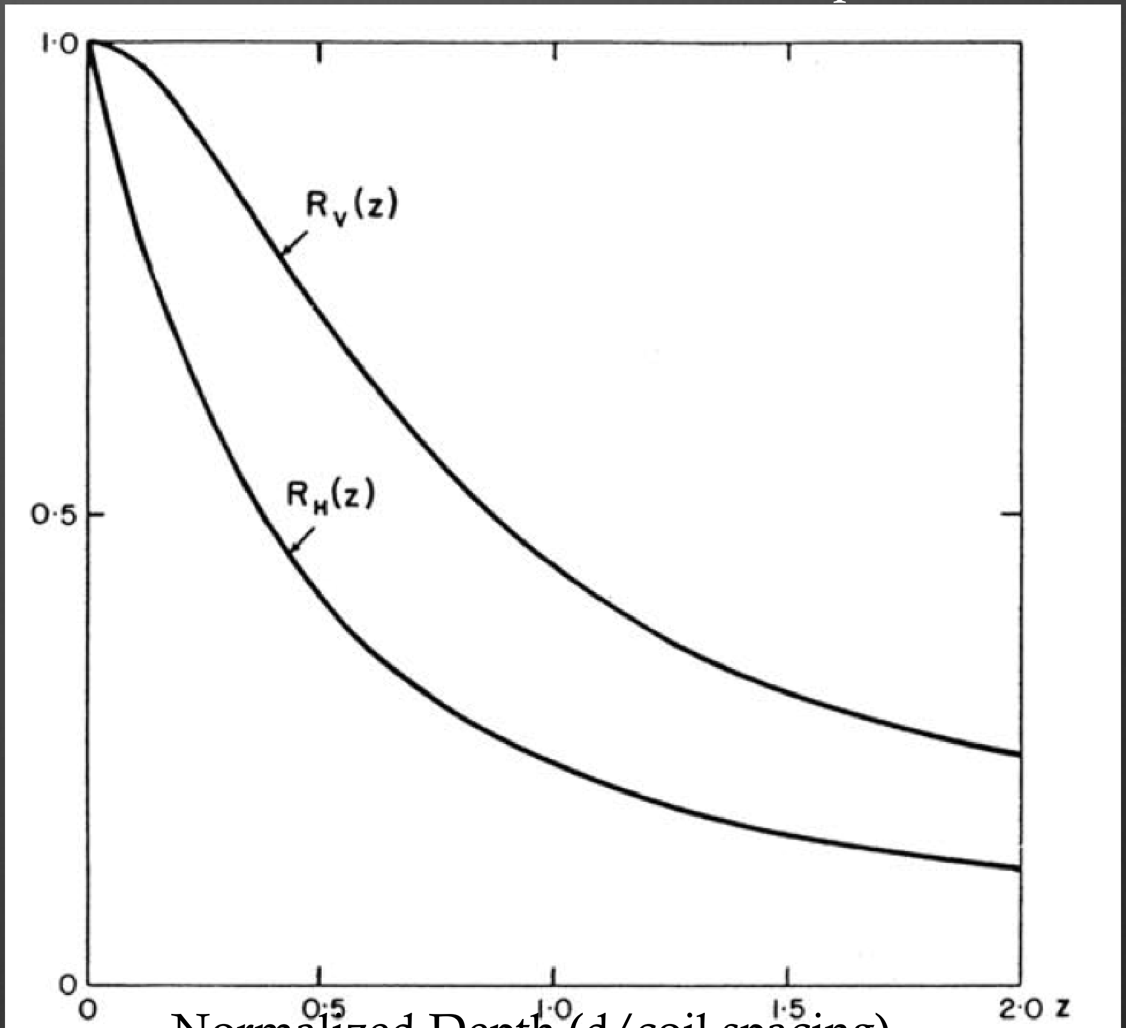
EM-31 Operation

Integrate depth response to get cumulative response





Contribution from all material below depth on x-axis



Normalized Depth (d/coil spacing)

1.8 3.7 5.5 7.4 m

Taken from McNeill, 1980.

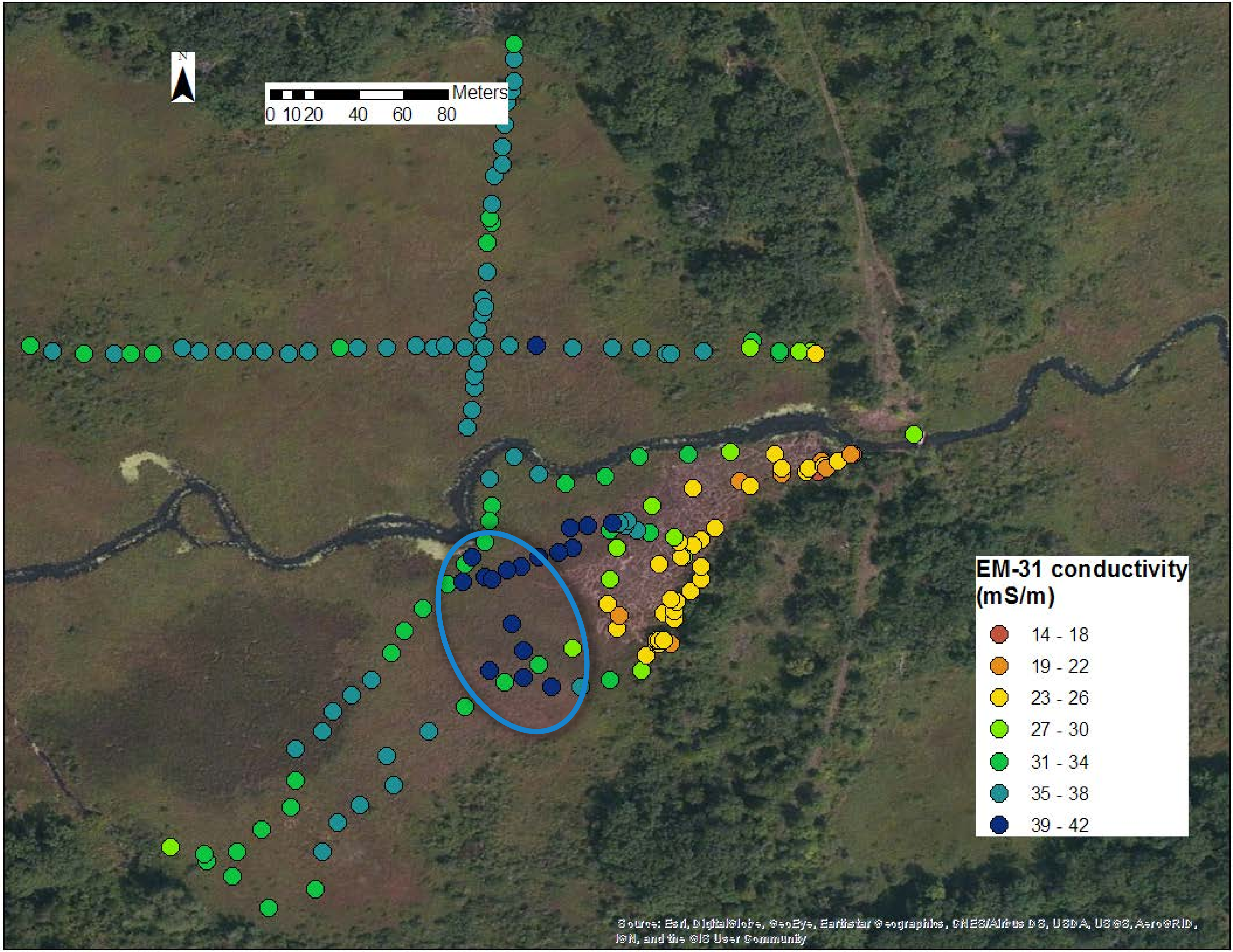
Some site features

EM-31 results

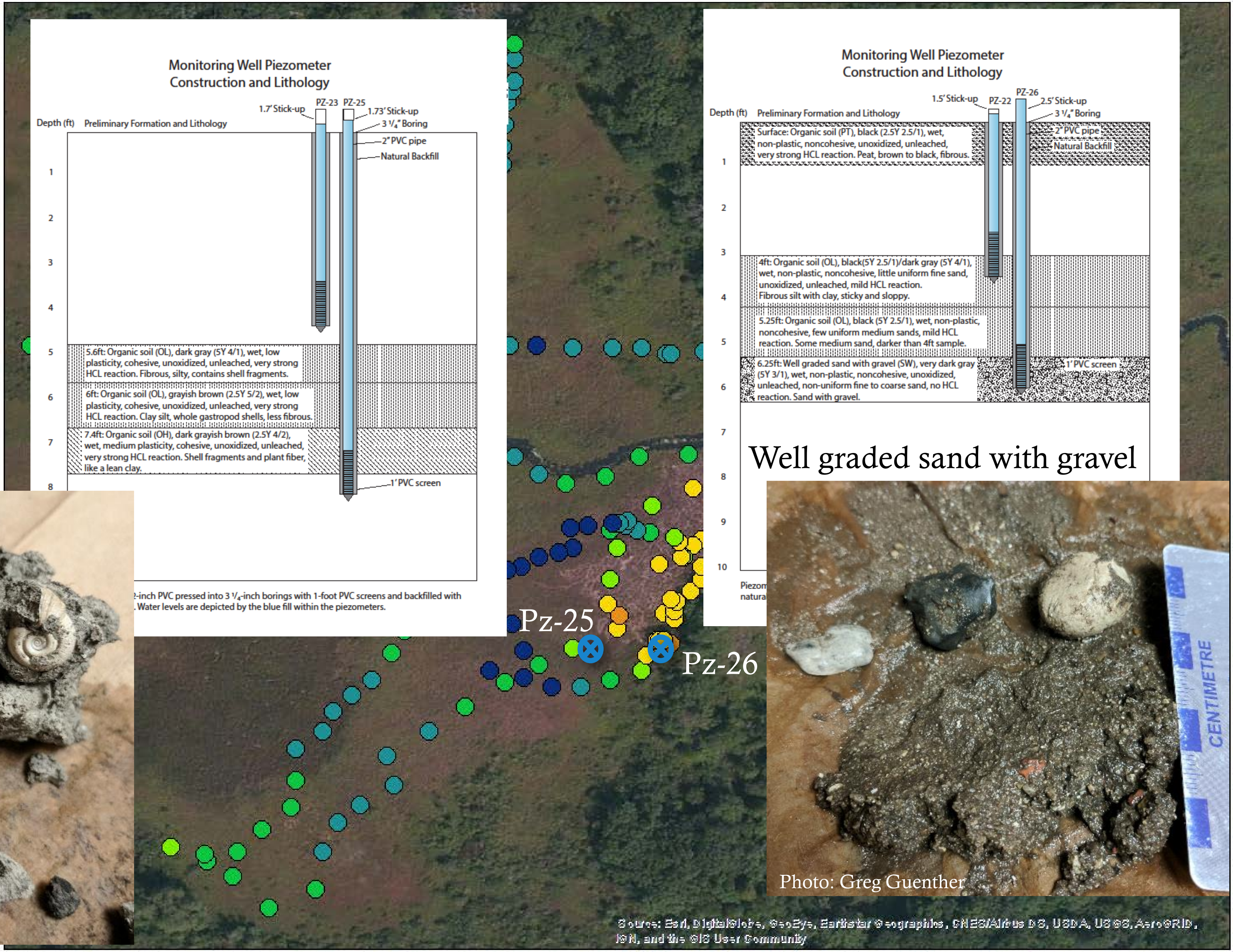
- High conductivity
  - higher water content,
  - more ions
  - more clay
- Low conductivity
  - lower water content,
  - fewer ions
  - less clay

Mismatch is due to data collection at two different times.

Lower conductivity is after ground has frozen



Auger borings show low conductivity is from sands and gravels



Well graded sand with gravel

Photo: Greg Guenther

Organic Soil

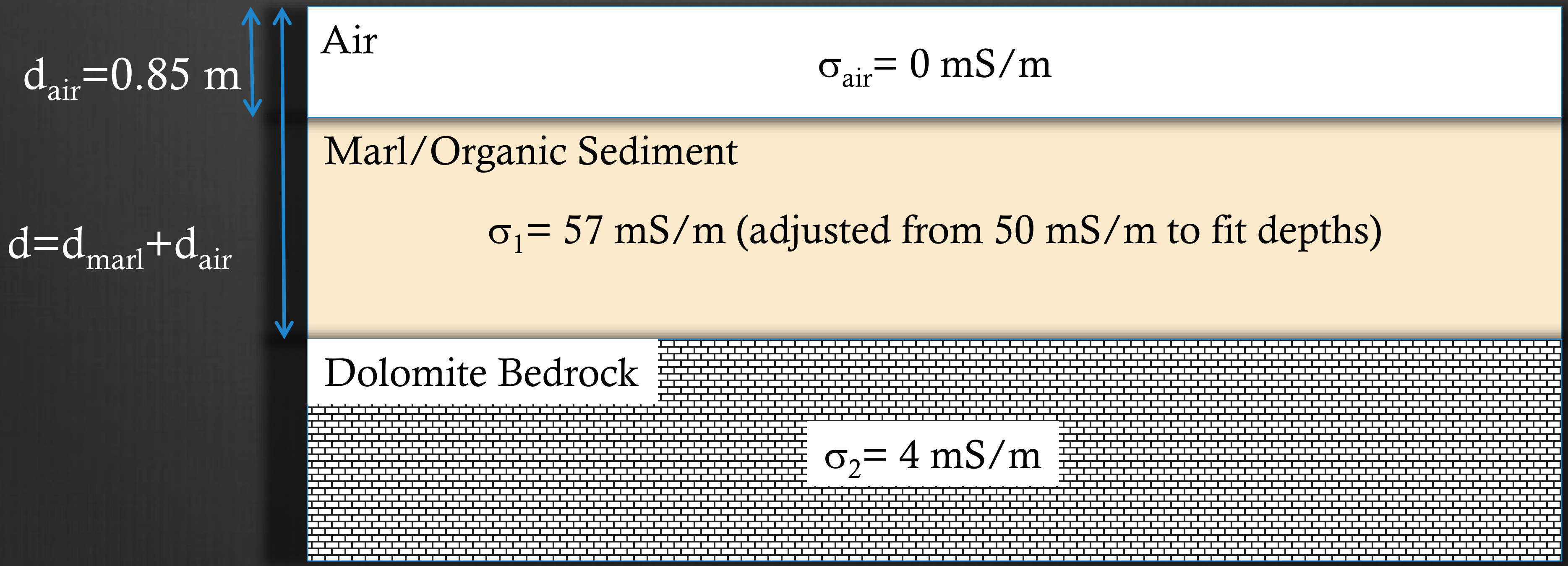
Photo: Greg Guenther

Mink River Wetland

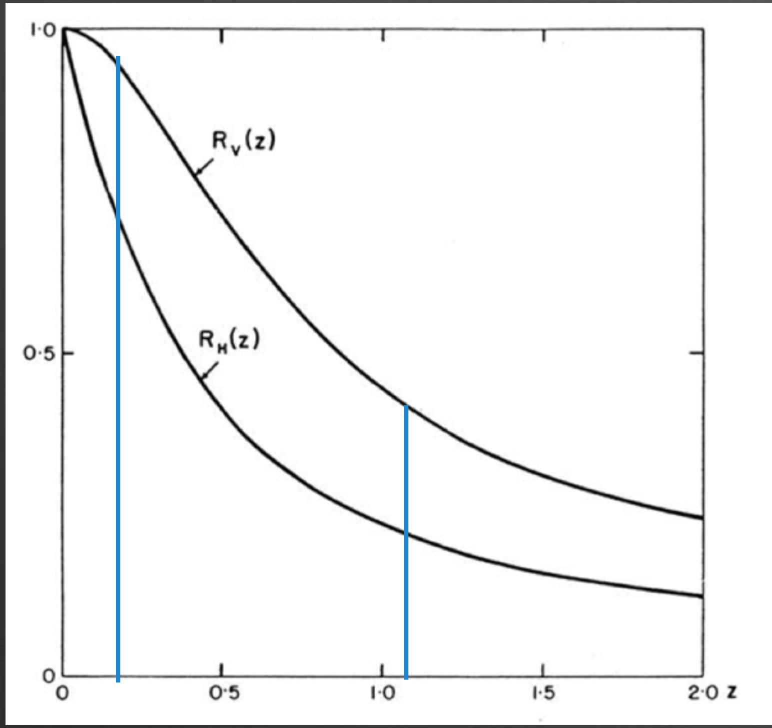
Home to endangered species of dragonfly.
Depth to bedrock needed to understand groundwater flow.
http://wisconsingeologicalsurvey.org/wofrs/WOFR2008-04.pdf

Three Layer System
including air

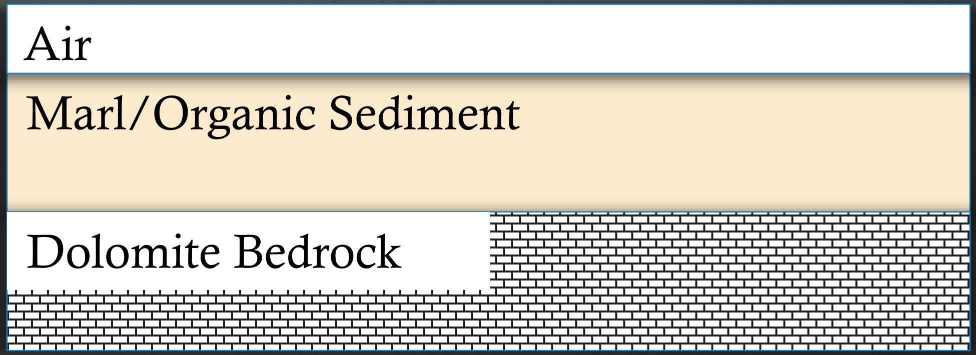
Photo – Ken Bradbury



Three Layer System



z_{air} $\quad$ $z_{air\_} + z_{marl}$



Equations for Rv and Rh can be found in McNeill, 1980.
http://www.geonics.com/pdfs/technicalnotes/tn6.pdf

$$\sigma_a = \sigma_{air}\left[1 - R_V\left(z_{air}\right)\right] + \sigma_1\left[R_V\left(z_{air}\right) - R_V\left(z_{marl} + z_{air}\right)\right] + \sigma_2 R_V\left(z_{marl} + z_{air}\right)$$

Three Layer System

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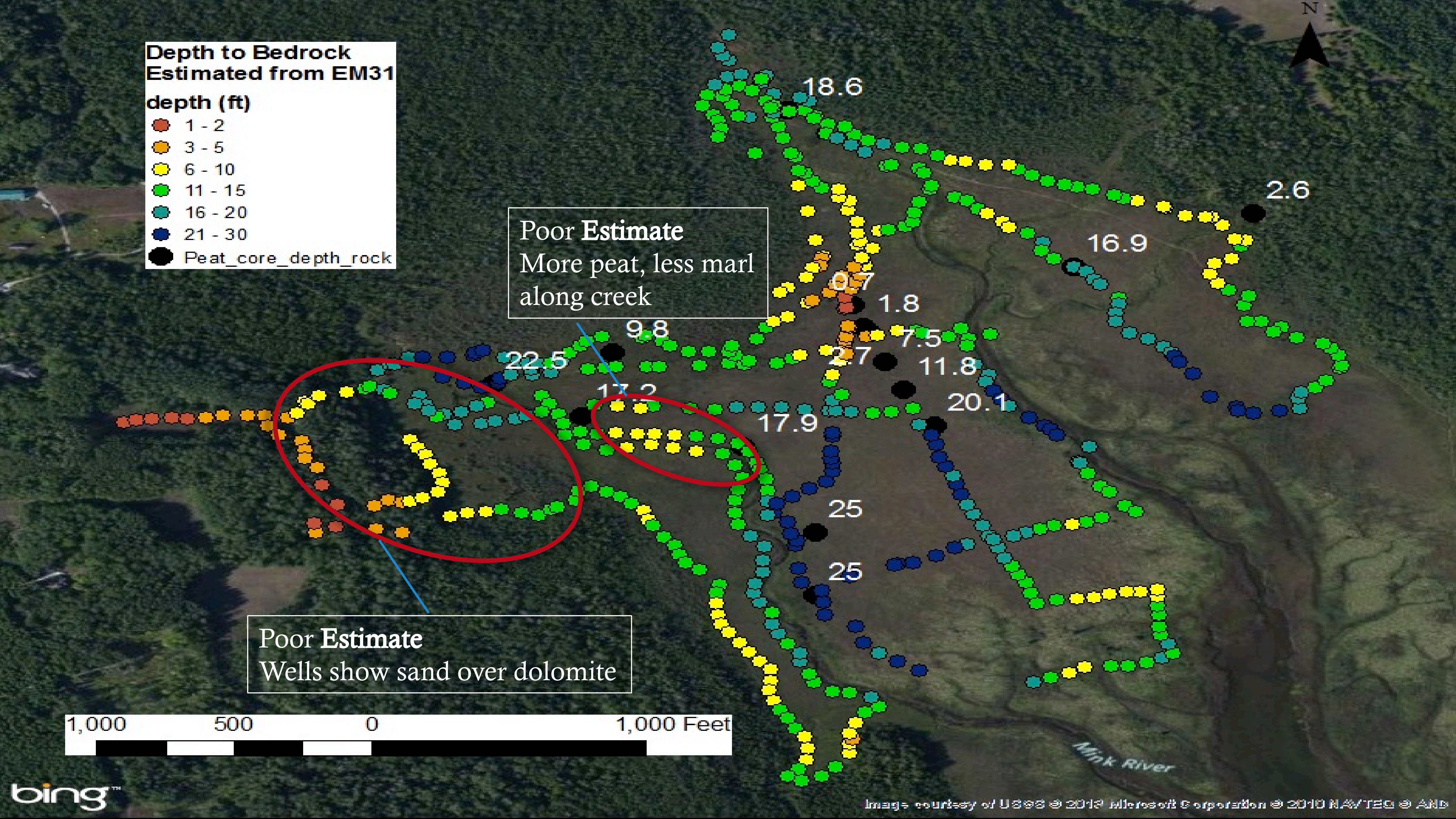
Measured by EM-31

Estimated and assumed from resistivity lines

Estimated instrument height for $z_{air}=d_{air}$/coil spacing;
Rv (z_{air}) from graph of Rv(z)

$$\boxed{R_V\left(z_{marl} + z_{air}\right)}$$

Only unknown left.
Do algebra to solve for $R_V(z_{marl}+z_{air})$.
Once known, then can find z_{marl}
and finally z_{marl} x coil spacing of 3.7 m = d_{marl}



Depth to Bedrock
Estimated from EM31
depth (ft)
1 - 2
3 - 5
6 - 10
11 - 15
16 - 20
21 - 30
Peat_core_depth_rock
Poor Estimate
More peat, less marl
along creek
Poor Estimate
Wells show sand over dolomite
18.6
2.6
16.9
0.7
1.8
9.8
7.5
22.5
2.7
11.8
17.2
20.1
17.9
25
25
1,000
500
0
1,000 Feet
N
Mink River
bing
Image courtesy of USGS © 2013 Microsoft Corporation © 2010 NAVTEQ © AND

Conclusions

- EM-31 provided qualitative information for locating borings and wells
- EM-31 and ERI provided estimates of depth to bedrock over much of the wetland.

Questions?