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
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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
Topography of the United States

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

- Fen Plant Community
- Sedge Meadow
- Fen Plant Community
- Cattails
- Spring
- Spring
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.

Organic Soil

Well graded sand with gravel
Mink River Wetland

Home to endangered species of dragonfly.
Depth to bedrock needed to understand groundwater flow.
Three Layer System including air

\[ d_{\text{air}} = 0.85 \text{ m} \]

\[ d = d_{\text{marl}} + d_{\text{air}} \]

Air
\[ \sigma_{\text{air}} = 0 \text{ mS/m} \]

Marl/Organic Sediment
\[ \sigma_1 = 57 \text{ mS/m} \text{ (adjusted from 50 mS/m to fit depths)} \]

Dolomite Bedrock
\[ \sigma_2 = 4 \text{ mS/m} \]
Three Layer System

Air
Marl/Organic Sediment
Dolomite Bedrock

Equations for \( R_v \) and \( R_h \) can be found in McNeill, 1980.

\[
\sigma_a = \sigma_{air} \left[ 1 - R_v(z_{air}) \right] + \sigma_1 \left[ R_v(z_{air}) - R_v(z_{marl} + z_{air}) \right] + \sigma_2 R_v(z_{marl} + z_{air})
\]
Three Layer System

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

- Measured by EM-31
- Estimated and assumed from resistivity lines
- Estimated instrument height for \( z_{air} = \frac{d_{air}}{\text{coil spacing}} \); \( R_v(z_{air}) \) from graph of \( R_v(z) \)

Only unknown left.
Do algebra to solve for \( R_v(z_{marl} + z_{air}) \).
Once known, then can find \( z_{marl} \) and finally \( z_{marl} \times \text{coil spacing of 3.7 m} = d_{marl} \)
Poor Estimate
Wells show sand over dolomite

Poor Estimate
More peat, less marl along creek
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?