Applications Of Geophysical Tools Within NRCS

National Soil Survey Center

- Soil Survey Investigations Staff
  - Jim Doolittle – Research Soil Scientist
  - Wes Tuttle – Soil Scientist (Geophysical)
- Provide Geophysical Technical Assistance to the States

ELECTROMAGNETIC INDUCTION

(EMI)

Salinity Survey

Randy Lewis
(Soil Scientist)
Great Salt Lake Basin, UT

EM-38 meter, Allegro Data Recorder, Trimble AG-114 GPR Receiver

How EMI Tools Work

- A primary electromagnetic current is induced into the soil.
- The soil responds with a secondary current which is measured by the EMI instruments.
- We compare the spatial conductivity patterns (ECa measurements) across a given area.

EMI

- We associate changes in spatial ECa patterns with changes in soil characteristics.
- Apparent conductivity is a weighted, average conductivity measurement for a column of earthen materials to a specific depth.


Chuck Natsuhara
(Soil Scientist), Puyallup, WA
Puget Sound Region
Washington
GEM-300 sensor


Mojave Desert
California
Dualem-4 meter


EM-34 meter

Kent Sutcliffe, Assistant State Soil Scientist, Utah (USDA/NRCS) conducts an EMI salinity survey with the Geonics EM38 meter, the Garmin GPS backpack and receiver, and the Allegro field data recorder. The survey is conducted in an area of Uvada silty clay loam, 0 to 2 percent slopes.

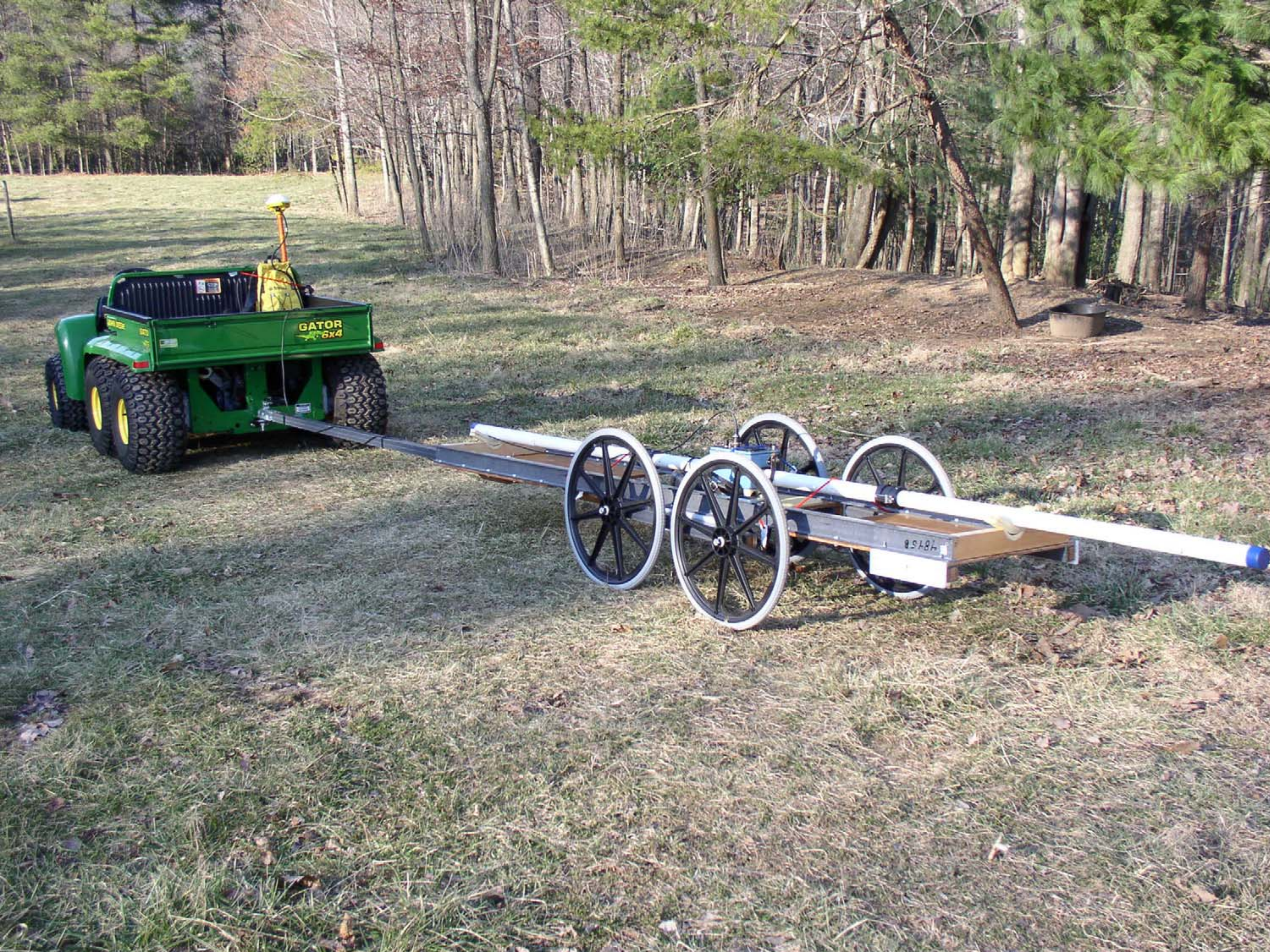
Factors Influencing ECa

- Salt Content
- Clay Content & Clay Mineralogy
- Moisture Content
- Temperature

- The apparent conductivity of soils increases with an increase in soluble salts, clay, and water contents.

- The presence of salts will dominate the other factors.
- When salts are not present, changes in clay content/mineralogy and changes in soil moisture attribute to changes in ECa.
- ECa – measured in millisiemens per meter (mS/m)


EM-31 meter


GATOR
6x4

What are the differences in these tools?

- Observation Depth

  Change in instrument length results in change in observation depth – Longer EMI instruments (greater intercoil spacing) result in greater observation depths

- Dual-Dipole Orientation

  Simultaneous collection of 2 observation depths with one pass of the instrument

  Advantage - time savings

EMI APPLICATIONS

- Map soil salinity and salt water intrusions
- Bedrock topography
- Archaeological investigations
- Locate buried metallic objects (drums, tanks, etc.)
- Quality control tool for soil surveys

EMI APPLICATIONS

- Map leachate plumes (waste storage lagoons)
- Delineate landfill and trench boundaries
- Map soil and groundwater contaminants
- Precision farming and high intensity soil surveys
- Identify karst bedrock features

Advantages of EMI (and GPR) techniques over traditional hand augering methods

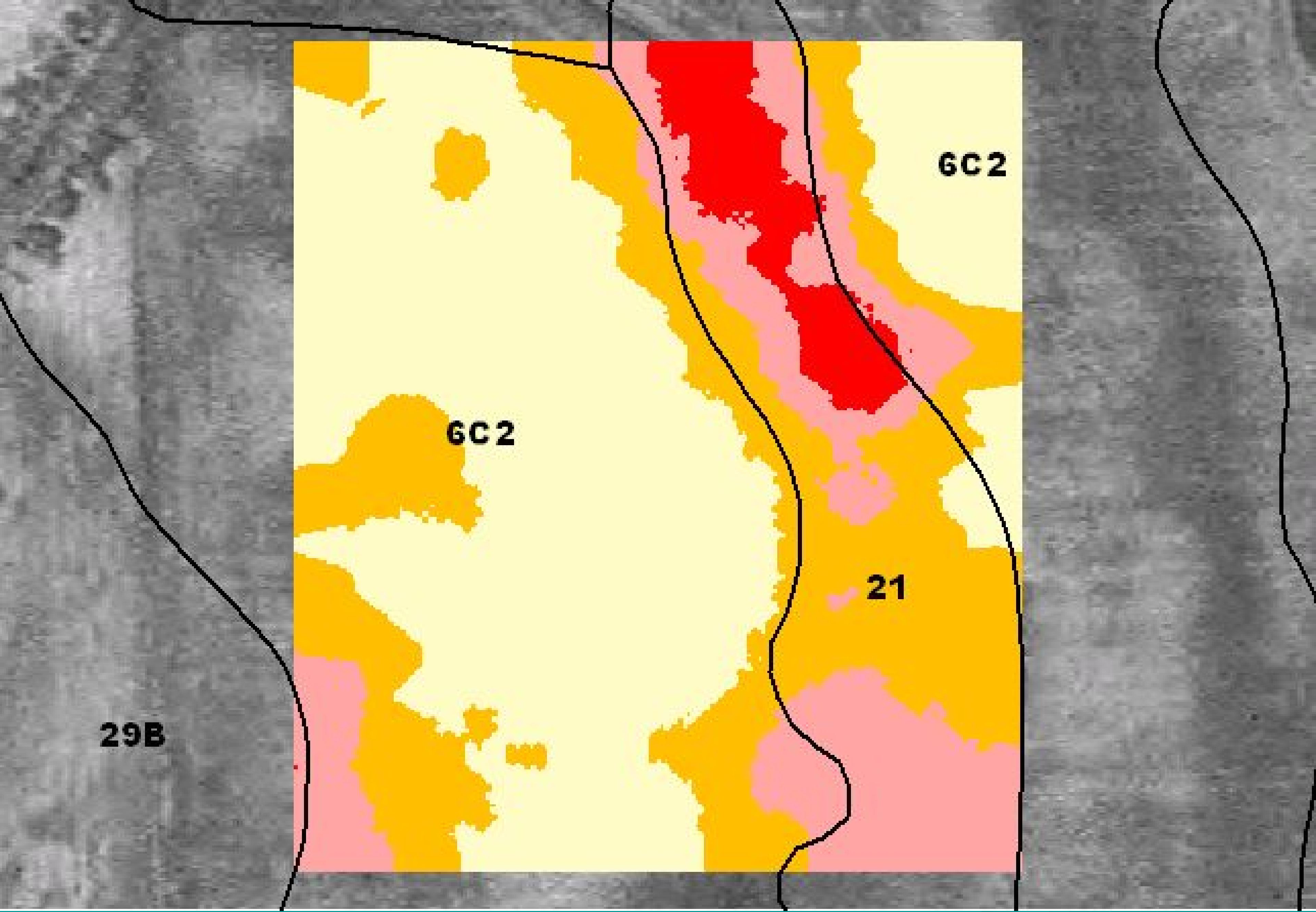
- Noninvasive
- Fast and expedient method of data collection
- Limited number soil borings and excavations while collecting large amounts of data (ground truthing)
- Develop improved soil-landscape models

Inventory (EMI Meters)

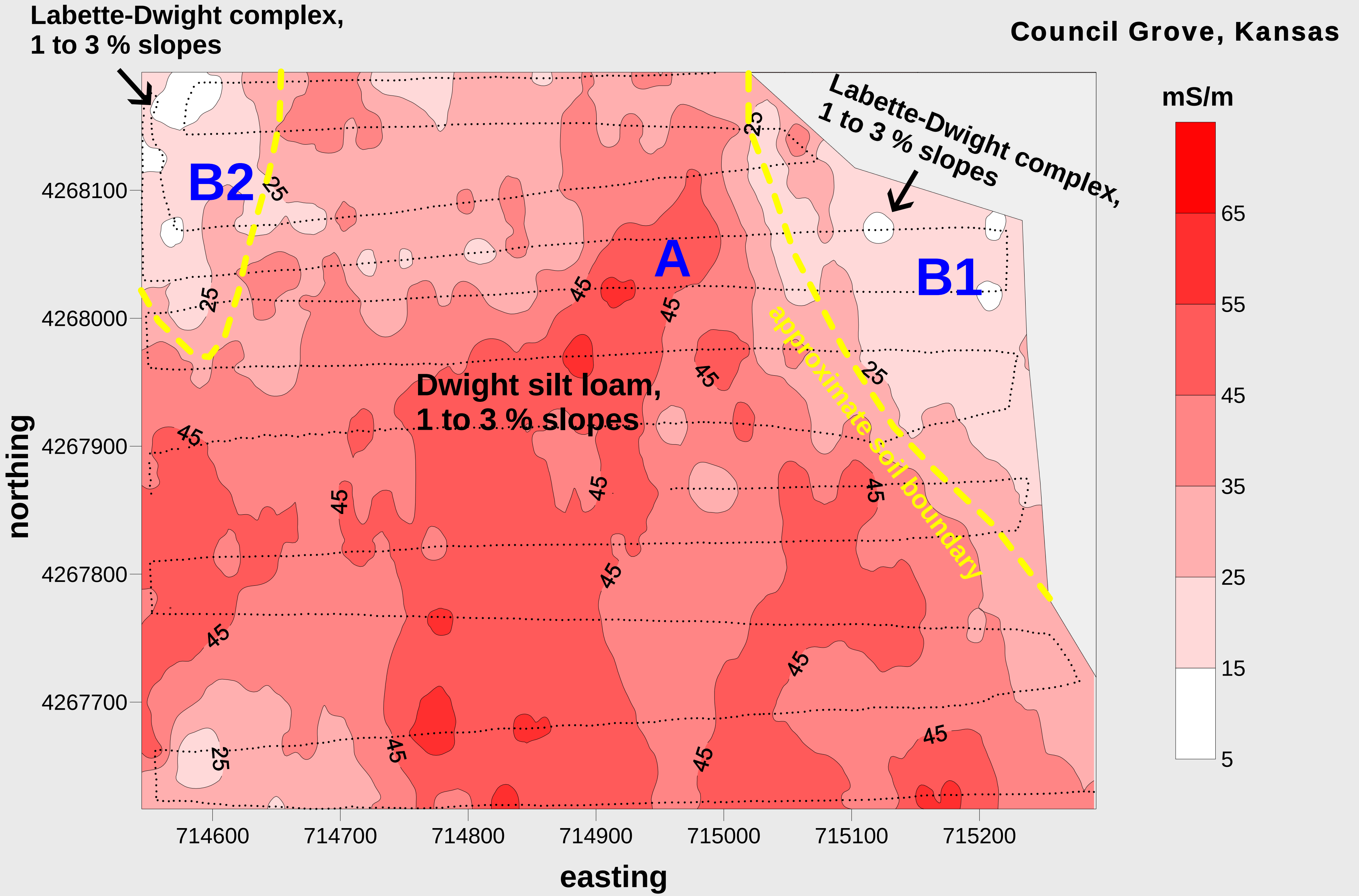
- <u>**Inventory by State and Contact Person**</u>
- **AR** - EM38, Allegro CX (S.O., Little Rock, AR-(Larry Kichler, Edgar Mersiovsky) Reed Cripps, Jonesboro, AR), EM34 & EM39, (S.O., Little Rock, AR-(Phil Hayes))
- **CO** - GEM 300 sensor, Dualem 2/4 meters (S.O., Lakewood, CO-(Tom Weber))
- **CT** - GEM 300, Tolland, CT (Shawn McVey, S.O.)
- **IA** - EM31 & Allegro CE/DOS, (NSSC loaner), (Waverly, IA)-Bob Vabora
- **IL** - *(7)EM38, (1)EM31 - (S.O., Champaign, IL), Veris, (S.O., Champaign, IL)-contact person-Bob McLeese (S.O.)
- **KS -** EM38, Salina, KS-(John Warner, Bill Wehmueller, S.O.)
- **KY** - EM38, Allegro CE/DOS (S.O., Lexington, KY)-Bob Eigel (Lawrenceburg)
- **MN** – EM38, Thief River Falls, MN (Rod Heschke)
- Allegro CX field computer-Dave Potts (Thief River Falls)
- **MO** - EM38, Allegro CX (Dexter, MO) contact persons-Dan Childers (Dexter), Scott Larsen (Palmyra)
- **MT** - (2)EM38, Rick Bandy Great Falls, MT; Dawn Wickham(SWCD), Chester, MT
- **NC** - NSSC staff - 2 EM31, 2 EM38, 1 GEM 300 sensor, 1 Dualem 2/4 meter (Wilkesboro -Wes Tuttle)
- **ND** - (5)EM38, Dickinson, ND contact-Darrell VanderBusch; Jamestown, ND contact-Fred Aziz; Devils Lake, ND, contact-Alan Gulsvig; Grand Forks, ND (meter is temporarily located in Thief River Falls, MN), contact-Dave Potts(Thief River Falls, MN); Fargo, ND, (meter is temporarily located in Thief River Falls, MN) contact- Dave Potts(Thief River Falls, MN)
- **NV** - EM38, Allegro CE/DOS (Fallon, NV) - Steve Herriman
- **OK** – EM38, Altus Soil Survey Office, Altus, OK-(Richard Gelnar)
- **PA** - NSSC staff - 1 EM31, 1 EM38, 1 38DD, 1 EM34, (Newtown Square, PA- Jim Doolittle)
- **SD** - EM31, Huron SD (S.O.)-(Jay Cobb, State Cons. Engineer)
- **TX -** (2)EM38, Corpus Christi, TX; MLRA office 9, Temple Texas, (loan to Texas A&M Univ.)
- **UT** - (3) EM38, (3) Allegro CE/DOS (Tremonton-(Randy Lewis), Price-(Leland Sasser), Richfield-(Victor Parslow))
- **VA** - EM31 (S.O., Richmond, VA), EM38 (Buchanan, Co.)-David Kriz-S.O.
- **WA** - GEM 300 sensor, Puyallup-(Chuck Natsuhara), WA (NSSC loaner), EM31- S.O., Spokane, WA-Paul Pedone
- * EM38 meters (3 with Resource Soil Scientists, 1 in MLRA Project office, 2 in Field Offices, 1 in SO)

Inventory (EMI Meters)							
Equipment	EM38	EM38DD	EM31	EM34-3	GEM300	DUALEM 2/4	VERIS
STATE							
AR	1						
CA							
CO	3	1			1	1	
CT					1		
IA							
IL	7		1				1
KS	1						
KY	1						
MN	1						
MO	1						
MT	2						
NE	1						
NC							
ND	5						
NV	1						
OK	1						
PA							
RI	1						
SD			1				
TX	2						
UT	3						
VA	1		1				
WA			1		1		


Salinity is not always this easy to observe.
Ute Mountain Ute Indian Reservation
Cortez, CO



ArcGIS presentation of soils and EMI data (Dexter, MO)



Spatial pattern of apparent conductivity measured with the EM38 meter in the vertical dipole orientation in an area of Dwight silt loam, 1 to 3 percent slopes and Labette - Dwight complex, 1 to 3 percent slopes. Apparent conductivity is measured in mS / m (millisiemens / meter).

Council Grove, Kansas

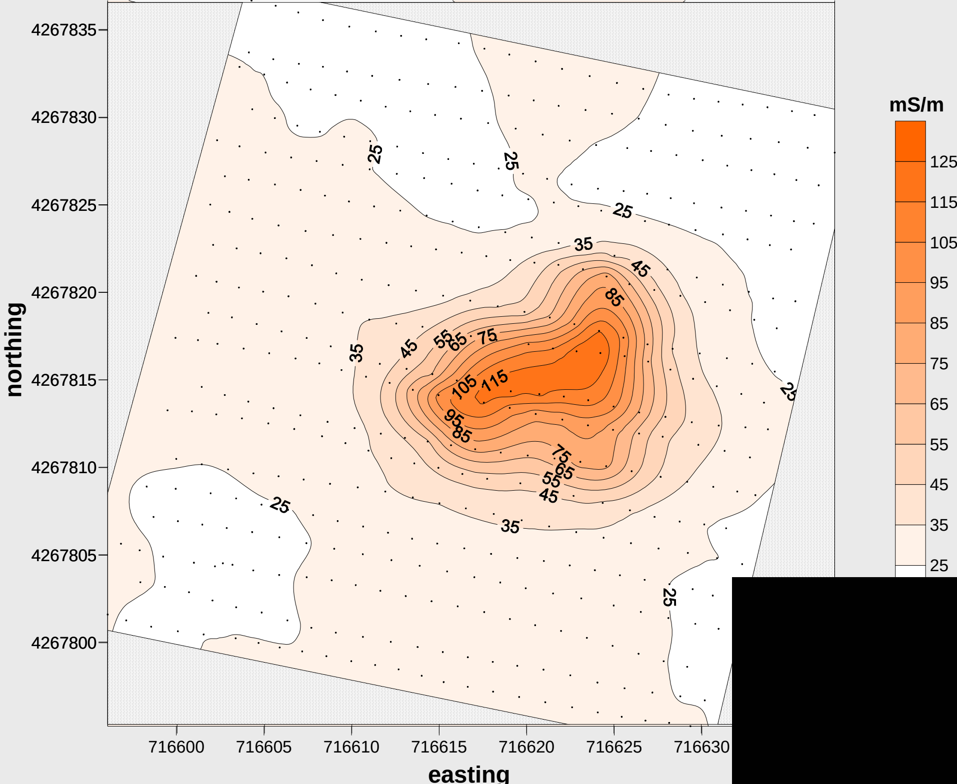


Figure 1. Spatial pattern of apparent conductivity measured with the EM38 meter in the vertical dipole orientation in an area of Irwin silty clay loam, 1 to 3 percent slopes.

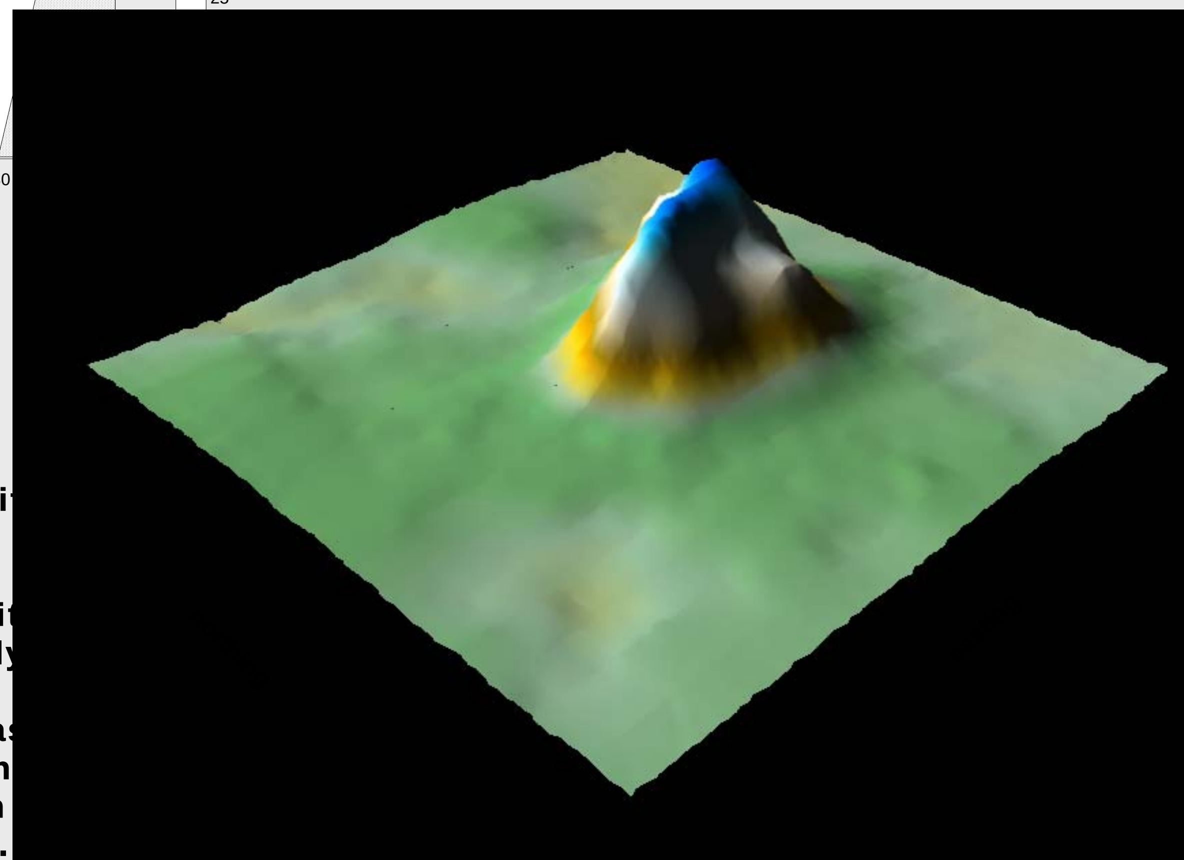
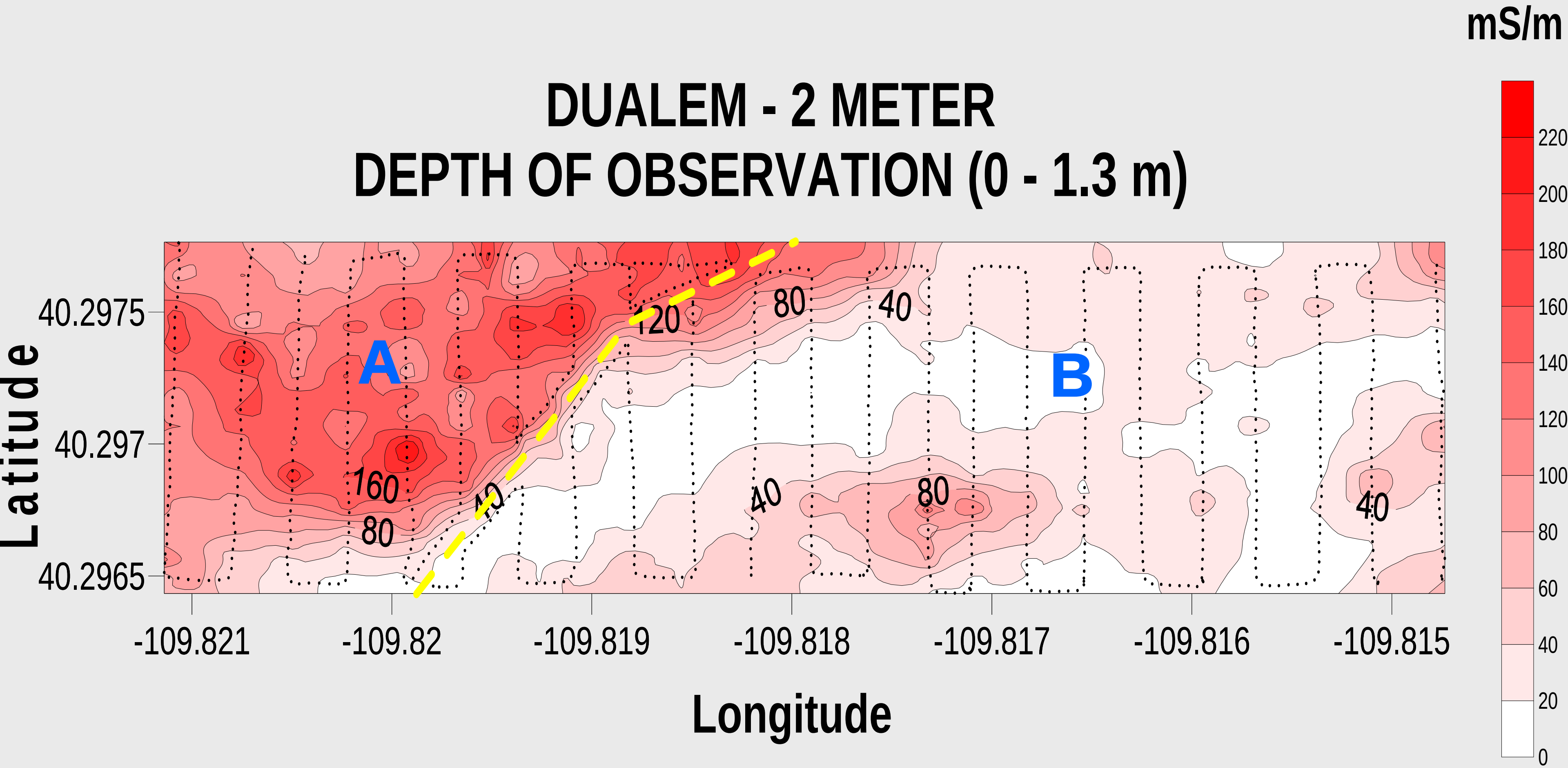


Figure 2. This figure demonstrates an alternative display of spatial conductivit patterns to Figure 1. The "peak-like feature" (area containing higher apparent conductivity) is associated wit the area thought to contain significantl higher amounts of sodium. This figure represents the same survey grid area as Figure 1. Multiple displays often give th user additional information from which to make more accurate interpretations.



Spatial pattern of apparent conductivity measured with the Dualem-2 meter in the PRP (perpendicular) geometry (0 – 1.3 m) in an area of Ohtog-Parahtog complex, 0 to 2 percent slopes, and Parahtog loam, 0 to 2 percent slopes. Apparent conductivity is measured in mS/m (millisiemens/meter).

A
Non-irrigated

B
Irrigated

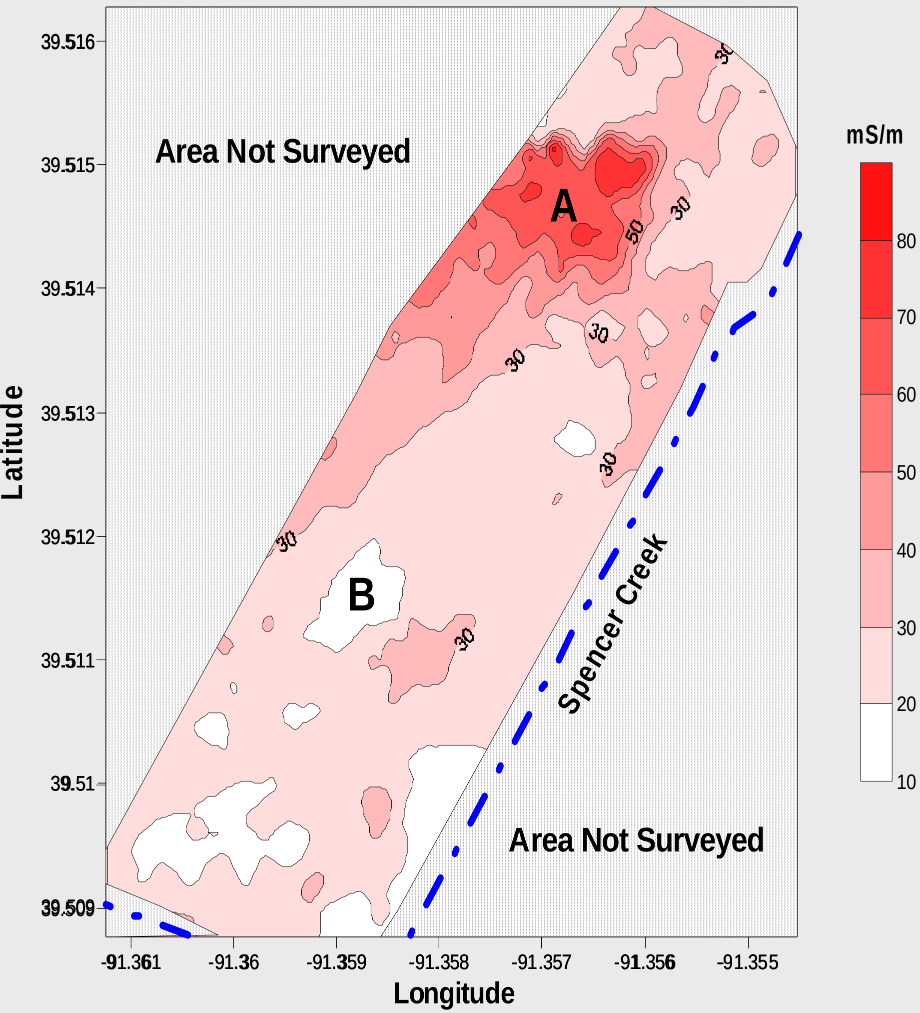
Salinity Survey (EMI)

Uintah County, UT

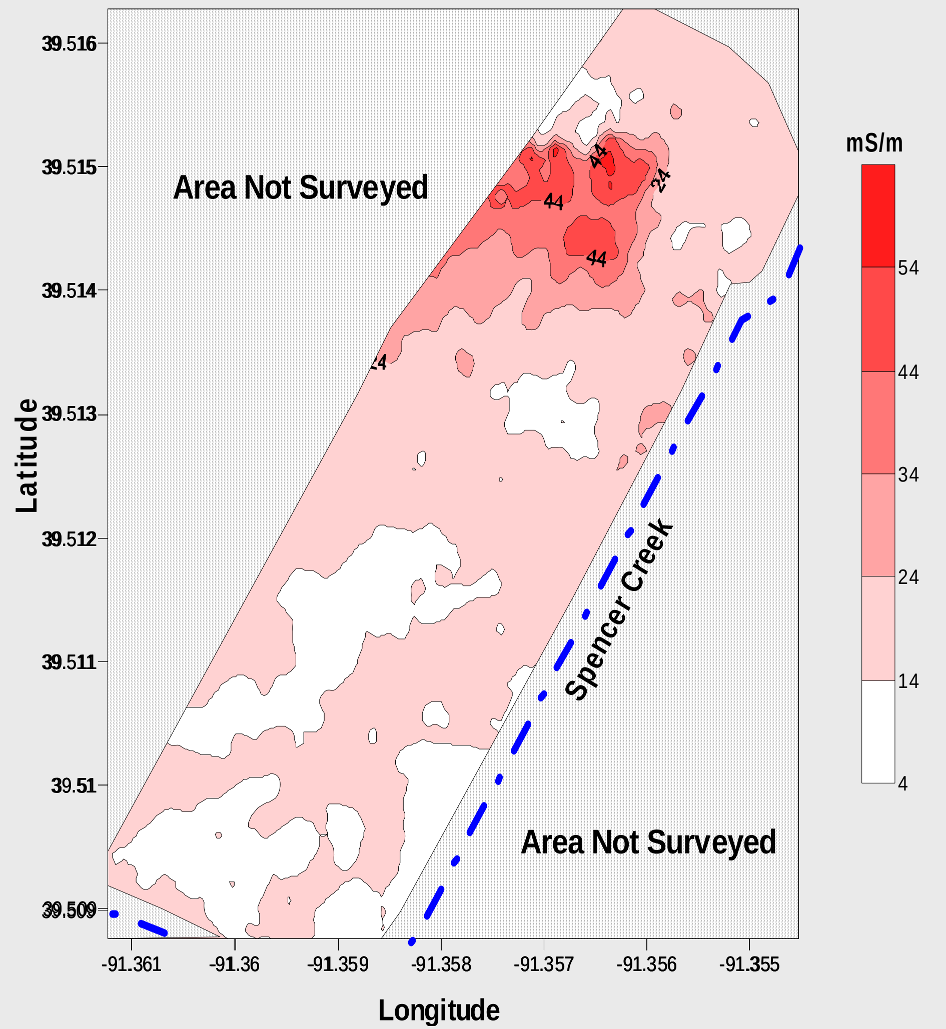

Flood Plain
Fatima Soils
(45 acre field)
Survey Time (Mobile Survey): 1 hour, 10 Min.
Estimated Time by Foot: 3-4 hours

Palmyra, MO
Mobile ECa Survey
Dualem-2 meter
Fatima Soils

HCP Geometry
(0 - 3.0 meters)



PRP Geometry
(0 - 1.2 meters)



***Area "A" was associated with higher concentrations of salts**

Ground-Penetrating Radar

(GPR)

Jim Doolittle (NRCS – Research Soil Scientist)


Iredell County, NC

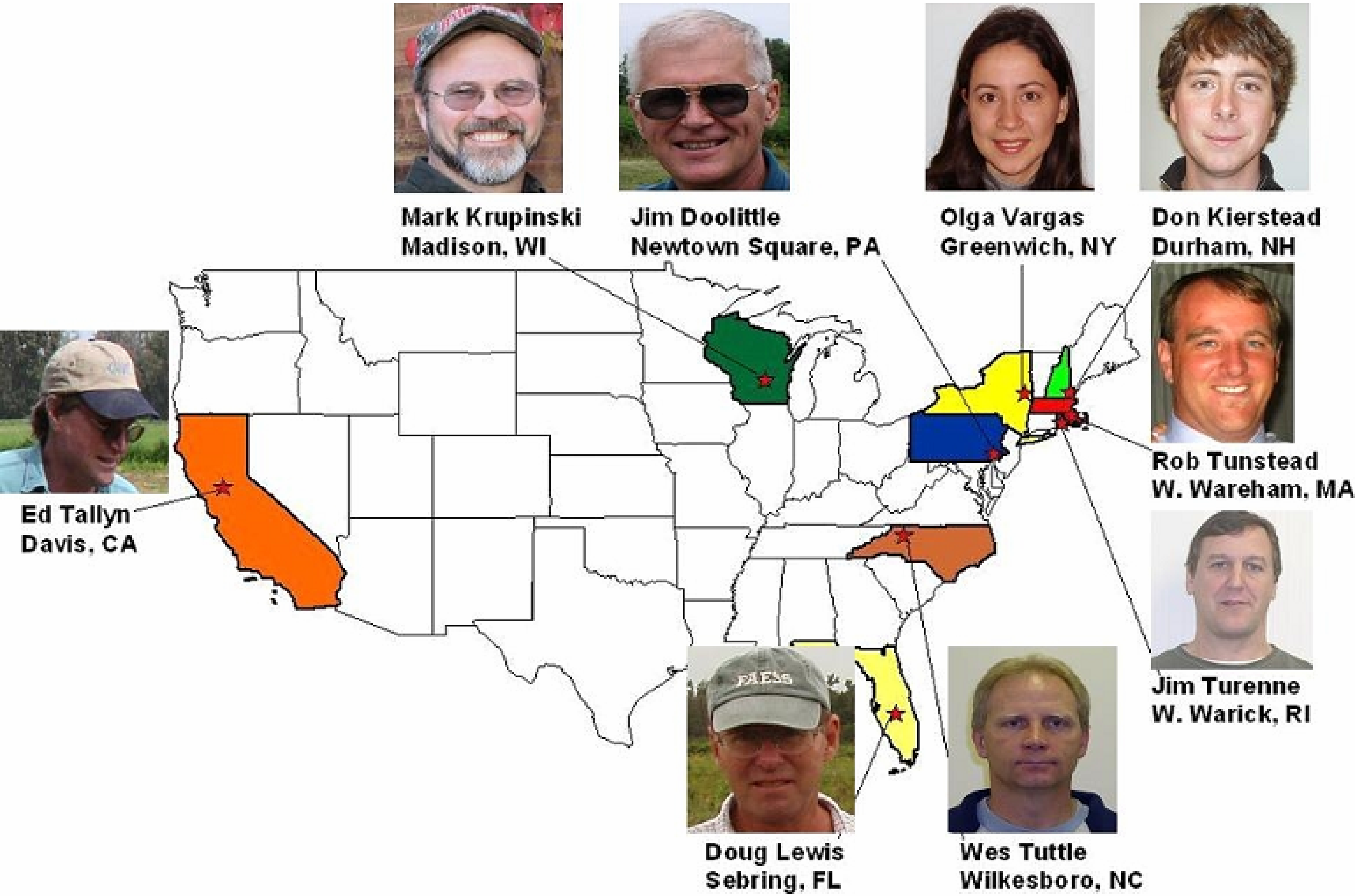
GPR

- The system measures the time it takes electromagnetic energy to travel from an antenna to an interface (i.e., soil horizon, stratigraphic layer) and back
- GPR does not perform well in highly conductive soils (saline, clayey-high shrink swell soils)
- GPR performs best in coarse textured soils
- EMI and GPR are complimentary tools (where the GPR signal is attenuated-EMI techniques can provide ECa data for interpretations)

GPR Applications

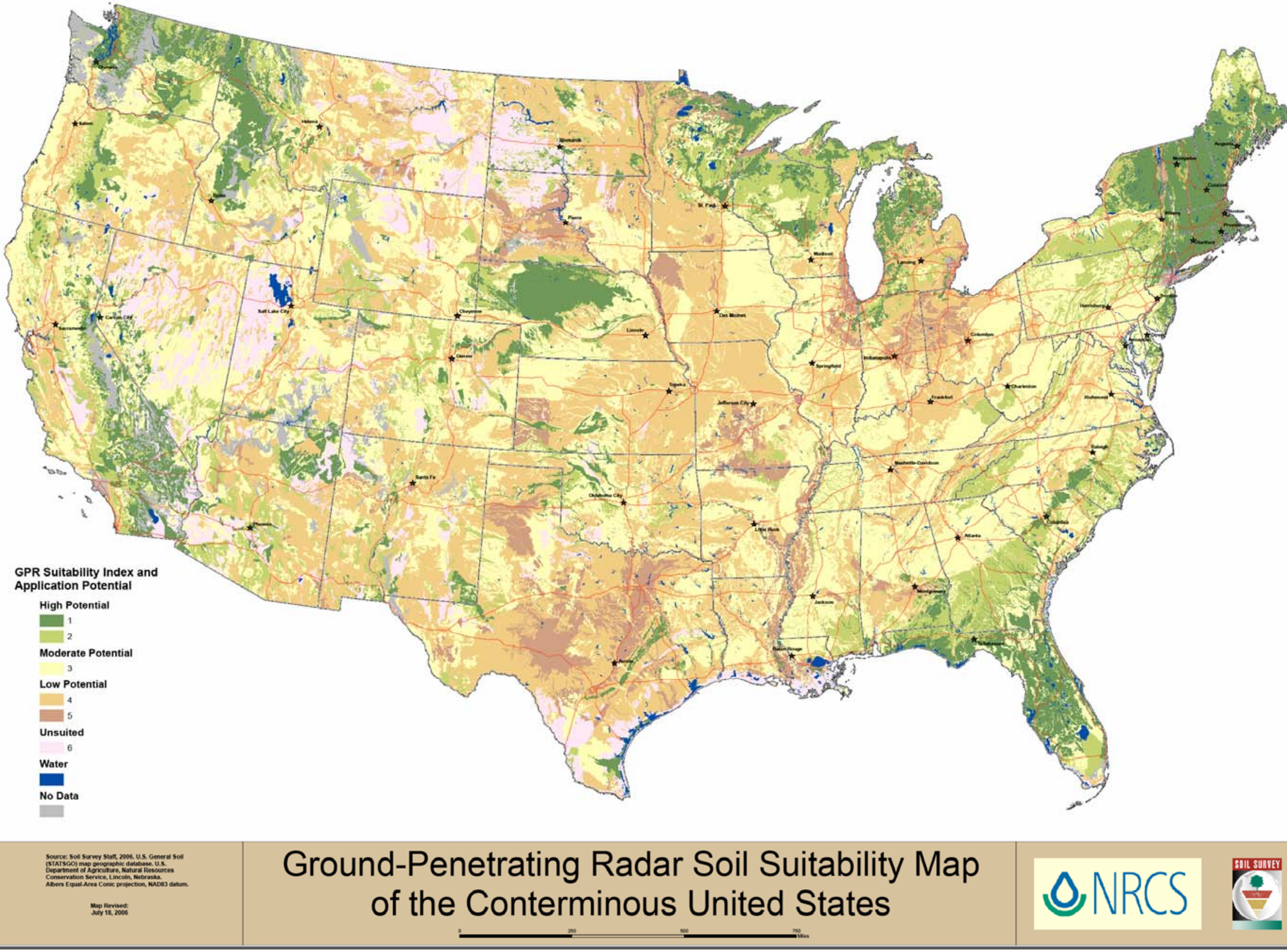
- Depth to bedrock
- Depth to soil horizons
- Depth to water table
- Archaeological investigations
- Estimates of taxonomic composition
- Locate buried artifacts
- Profile geomorphic and stratigraphic features (peat, lake bottoms-assess rates of sedimentation)

USDA-NRCS GPR OPERATORS



U.S. DEPARTMENT OF AGRICULTURE

NATURAL RESOURCES CONSERVATION SERVICE

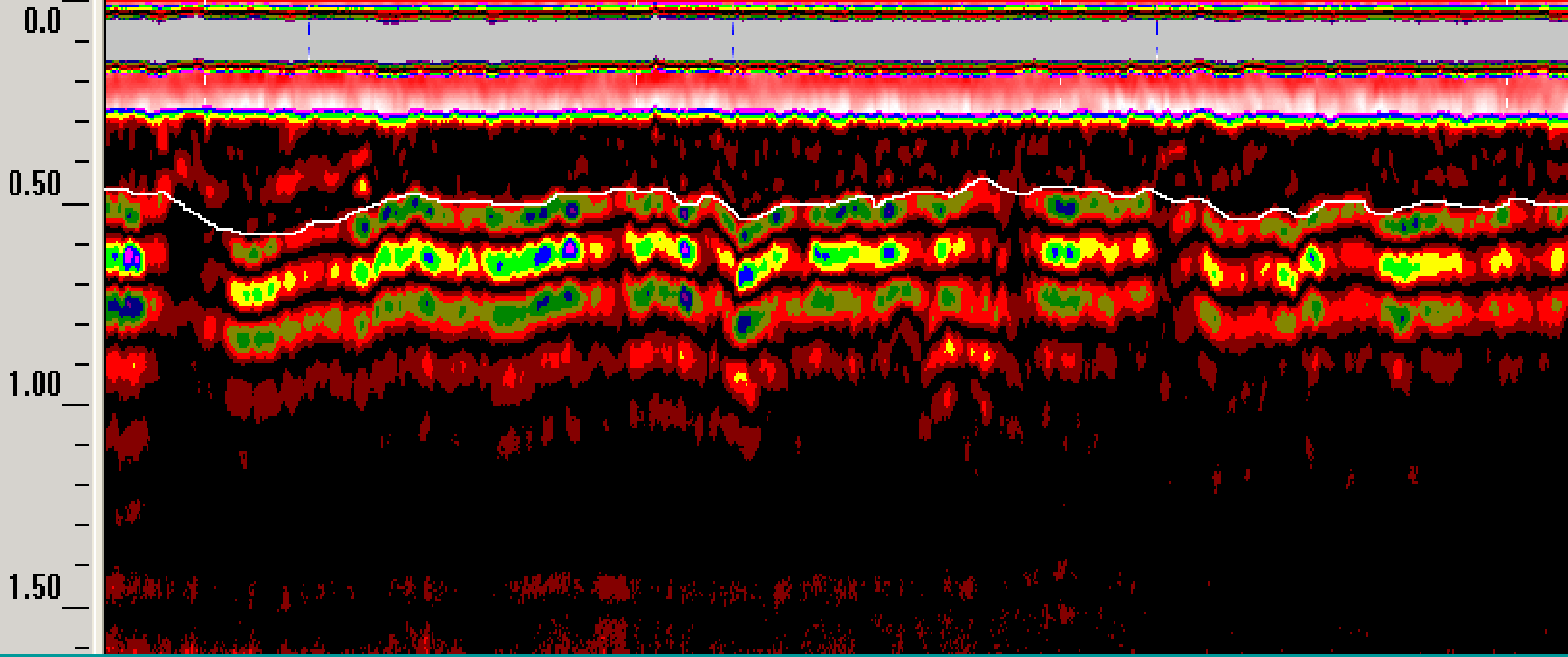


Source: Soil Survey Staff, 2006. U.S. General Soil (STATSGO) map geographic database. U.S. Department of Agriculture, Natural Resources Conservation Service, Lincoln, Nebraska. Albers Equal-Area Conic projection, NAD83 datum.

Map Revised: July 18, 2006

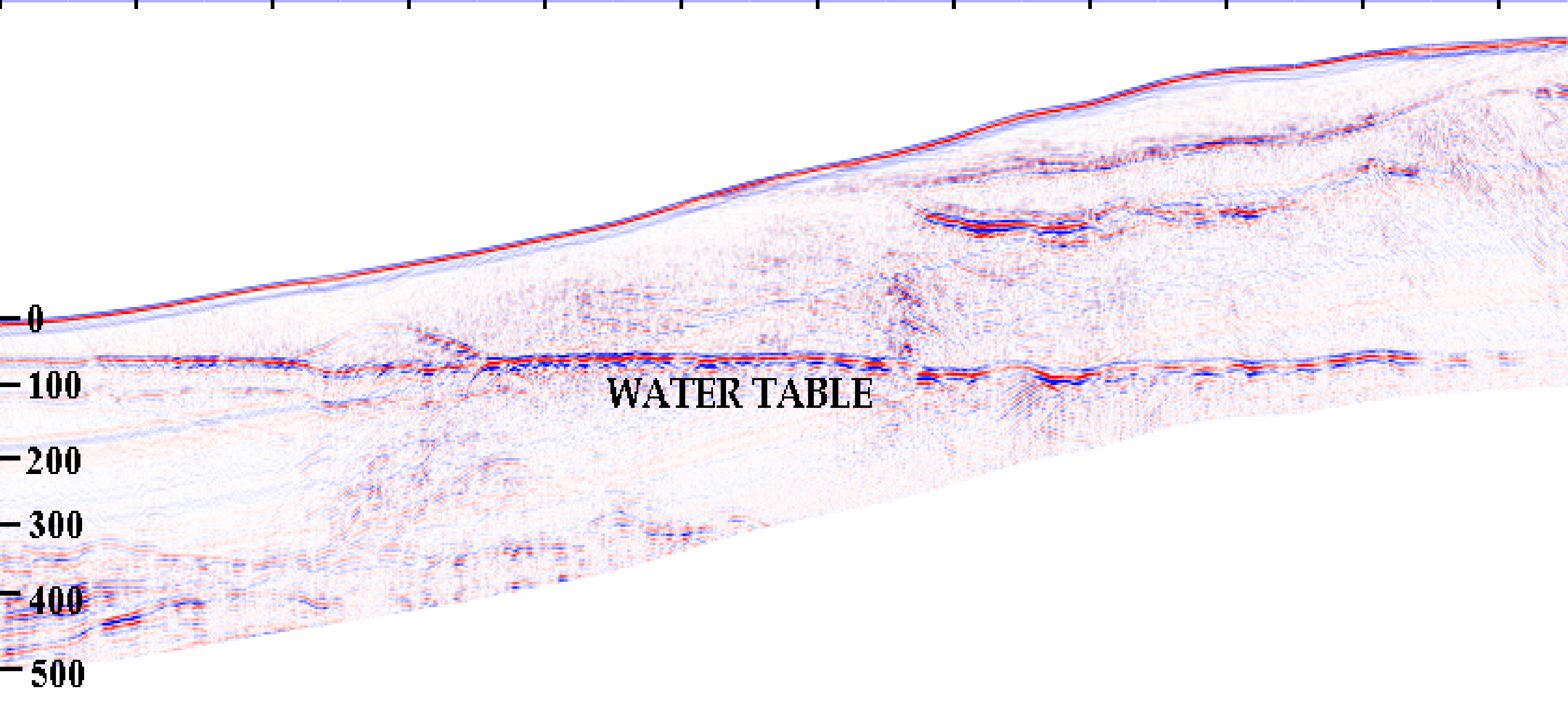
Ground-Penetrating Radar Soil Suitability Map of the Conterminous United States

Sacramento County, CA (GPR-buried surface horizon)

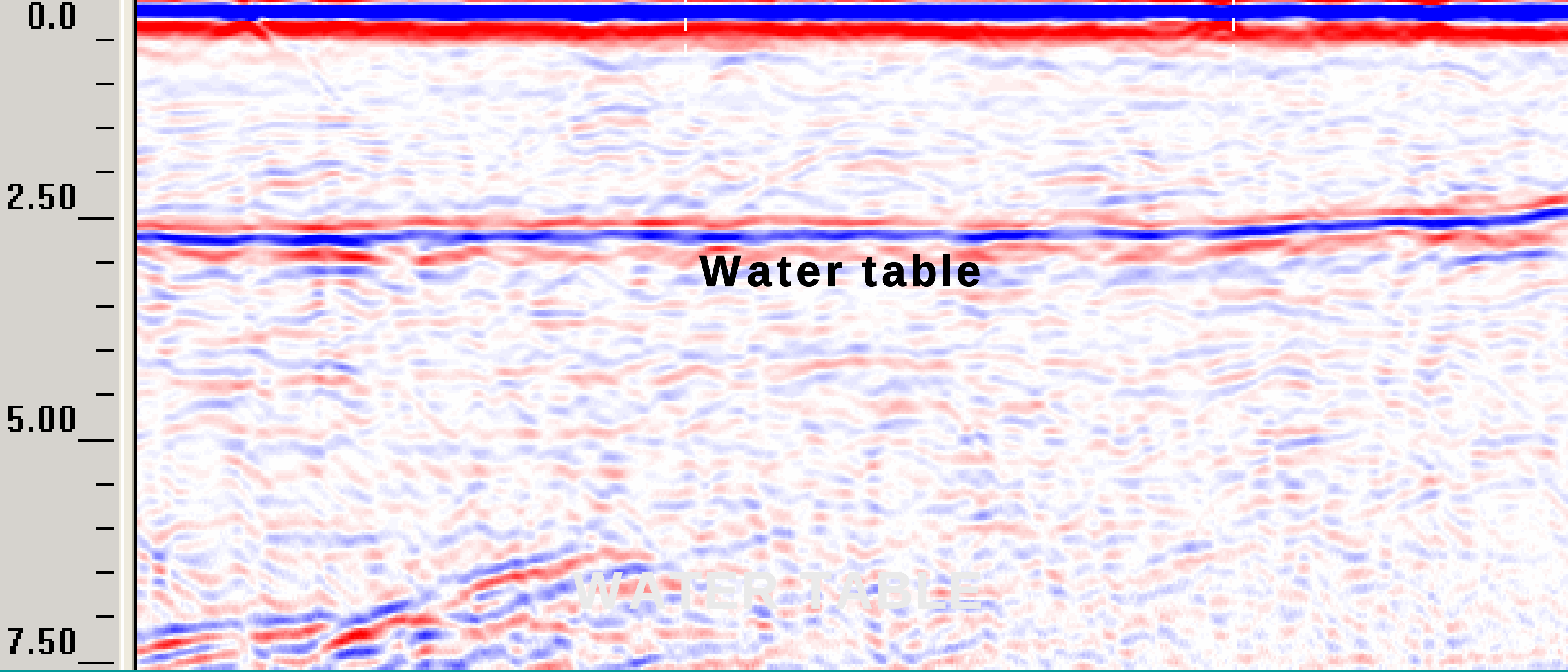


Sacramento County, CA (buried surface horizon)

Nags Head, NC (Jockey's Ridge State Park - sand dunes - 99% quartz - barrier islands) 2 to 40% slopes

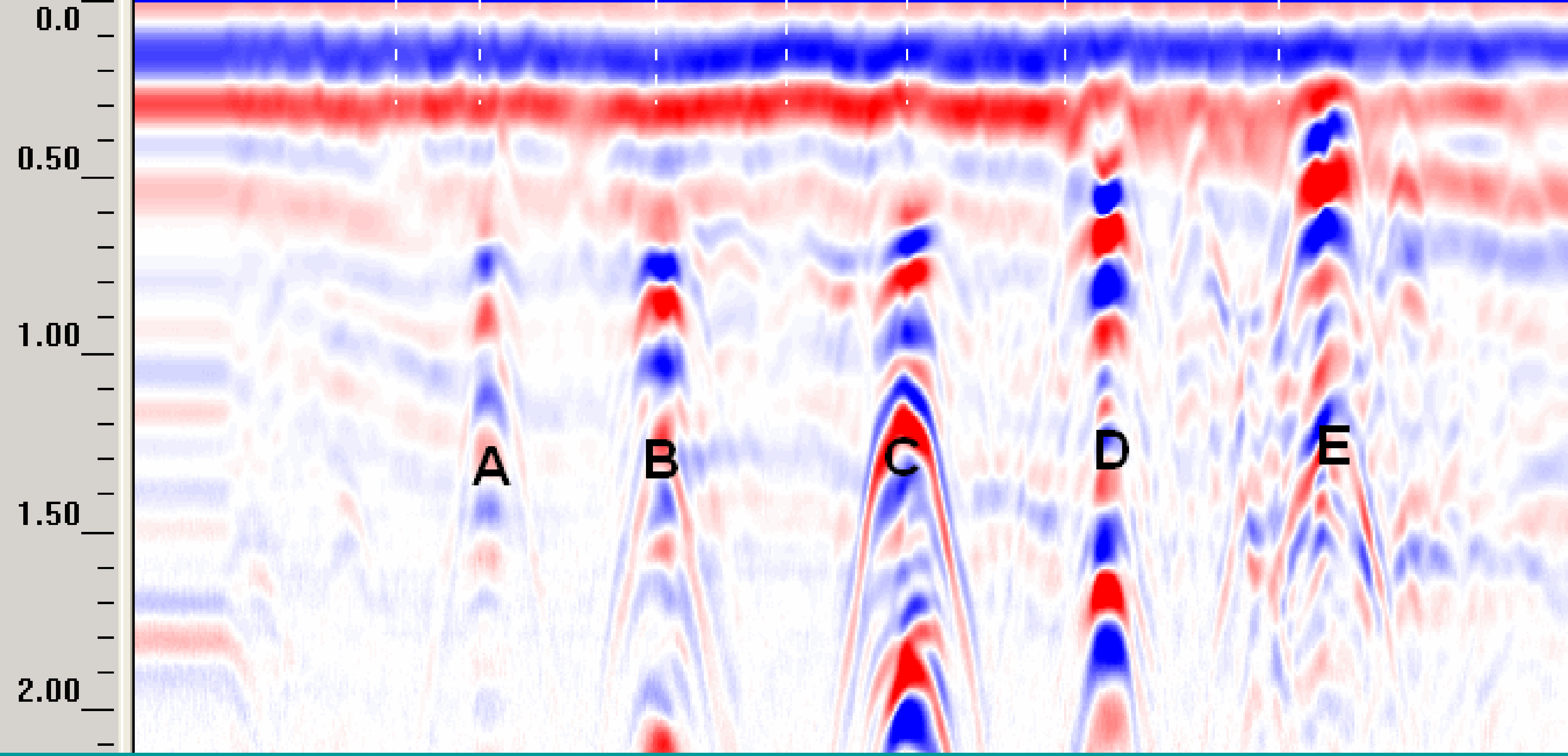


Nags Head, NC (Jockey's Ridge State Park)
(sand dunes - 99% quartz) 2 to 40% slopes



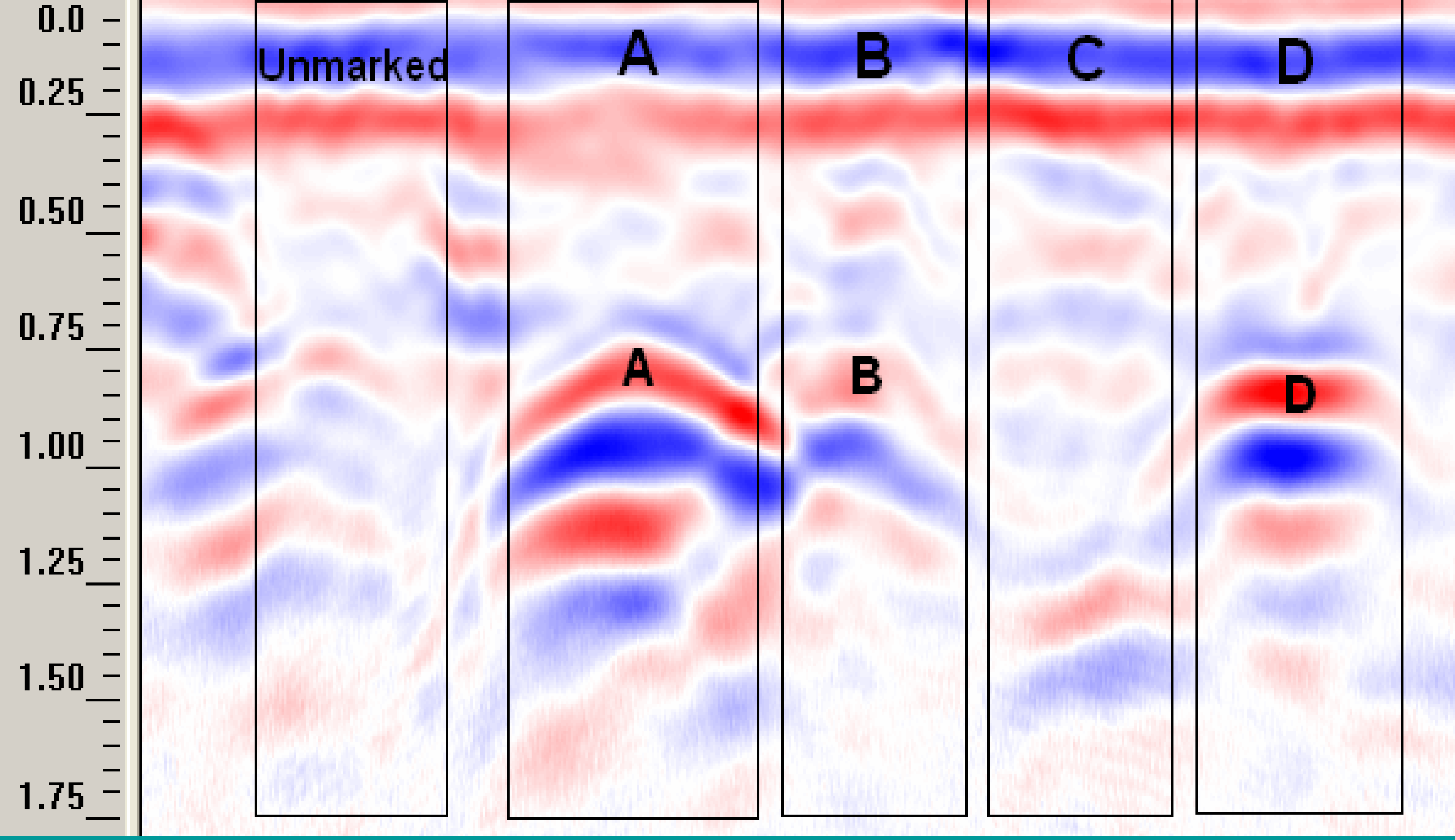
Representative radar record from an area of Alpin sand, 0 to 6 percent slopes. Scale is in meters.

Sumter, SC



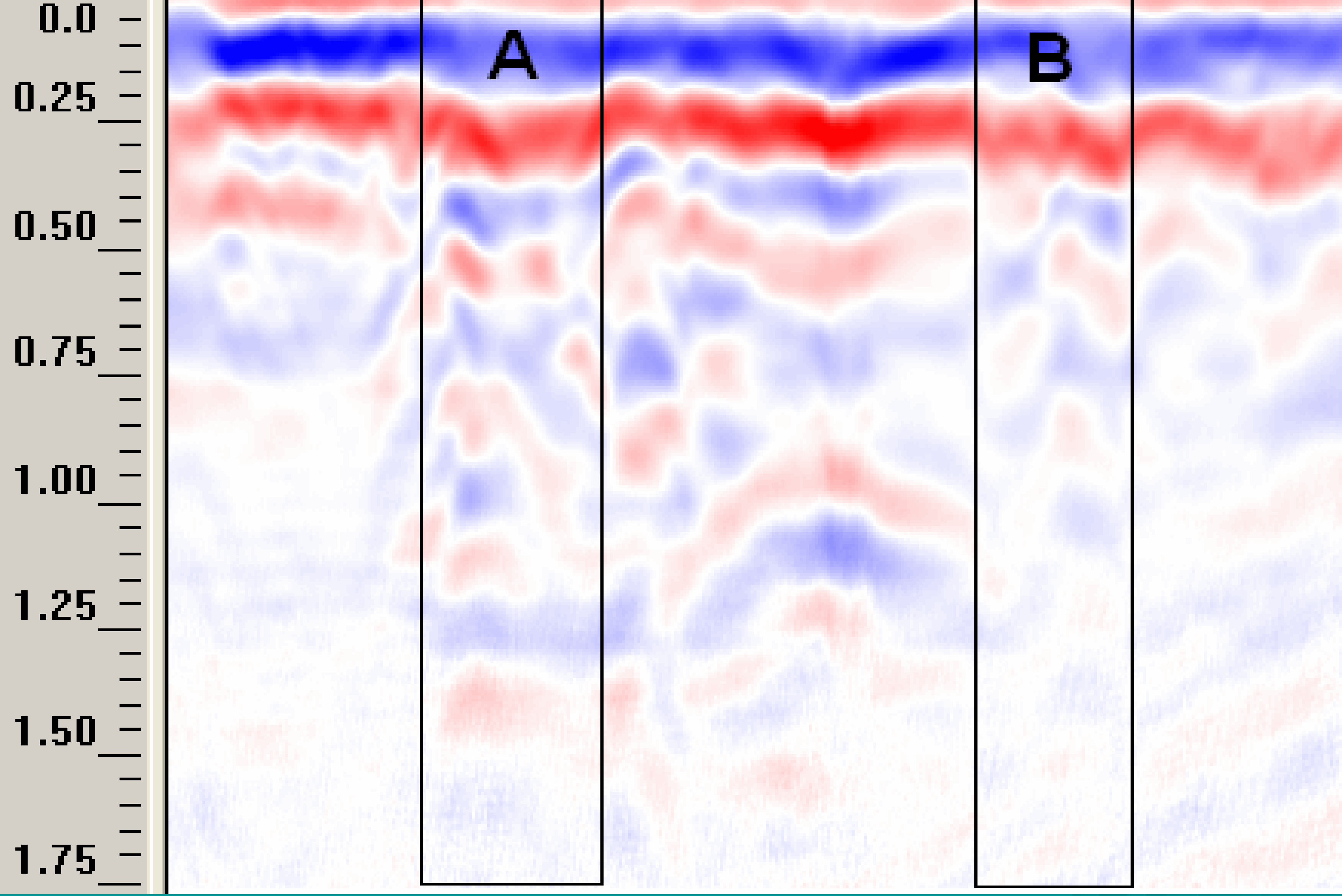
GPR Record
Wake County, NC
(septic drain lines)

Hillcrest Cemetery Winchester, KY



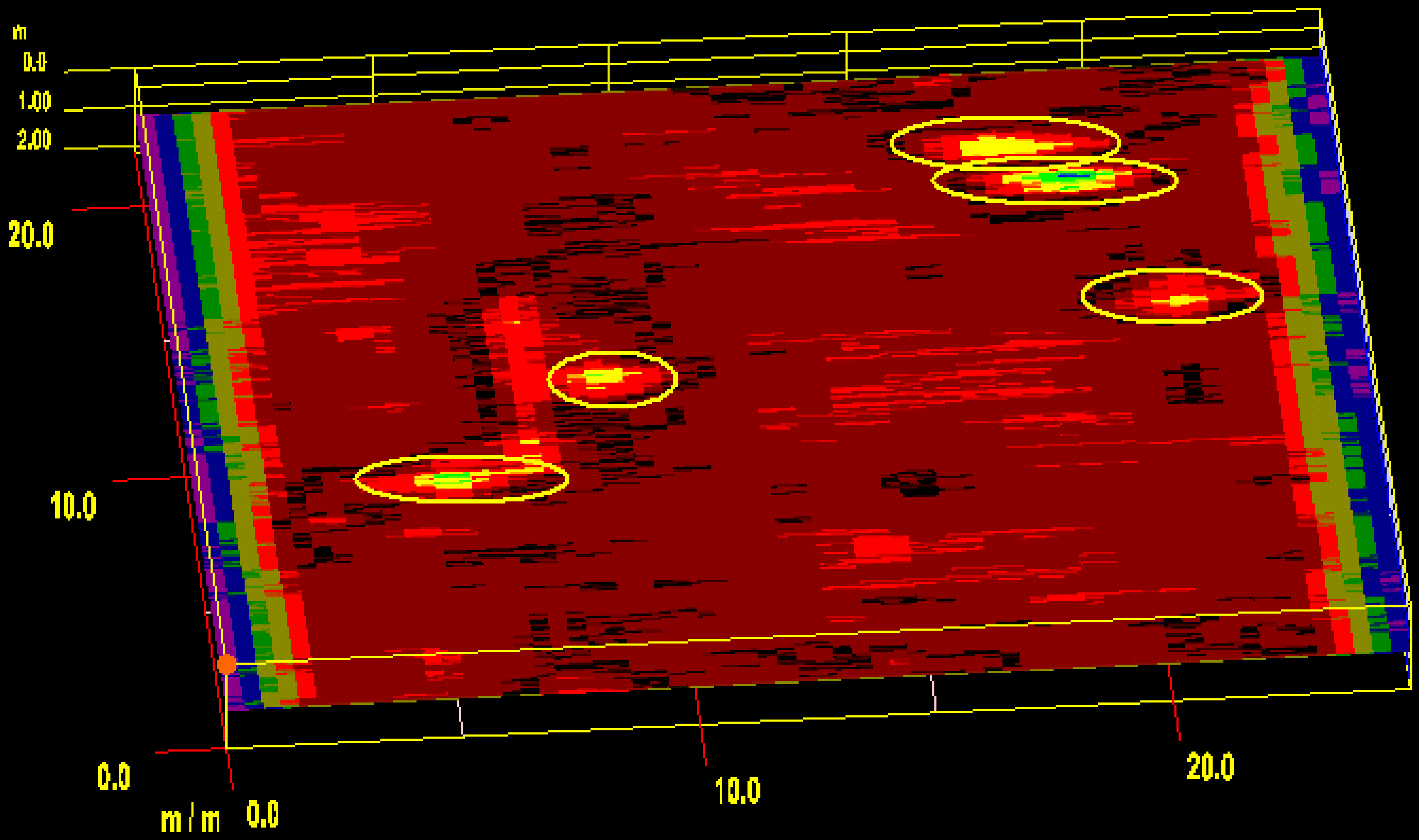
Burial markers were present at locations A, B, C, and D. Burial vaults/coffins thought to be present in burial shafts A, B, and D. Burial vaults/coffins are identified within the burial shafts at points A, B, and D and are contrasting to the surrounding soil and often appear as hyperbolic features in radar records.

Hillcrest Cemetery Winchester, KY

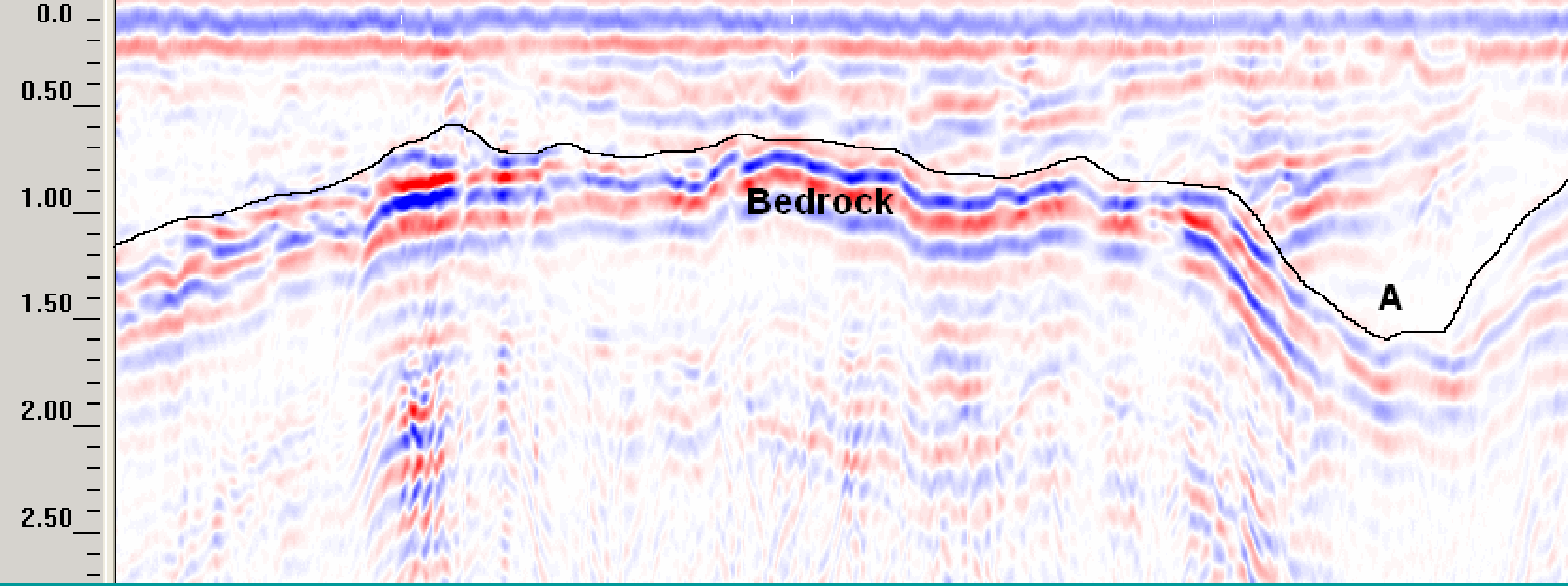


No burial markers at A or B

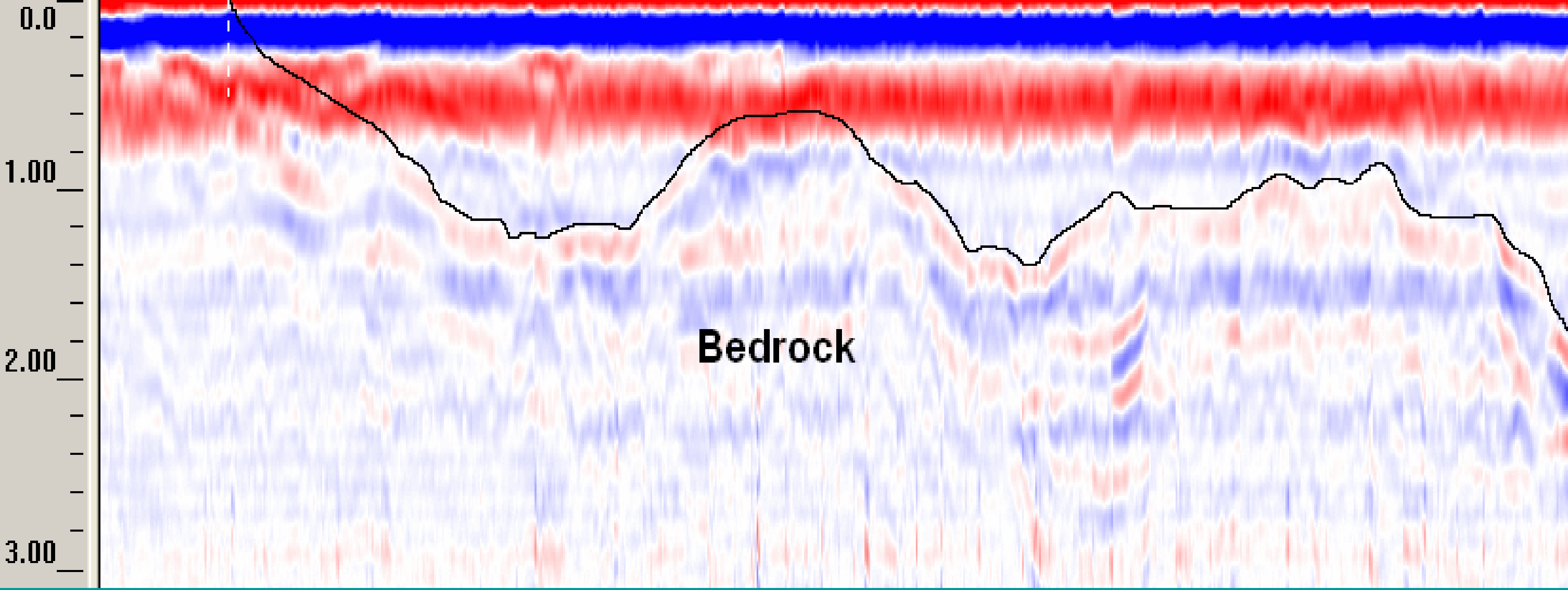
Truncated soil layers are an indicator of soil disturbance



Ground Penetrating Radar
-Potential burial sites-
Flemingsburg, KY (Cemetery)



GPR Record
Wake County, NC
(granite bedrock)

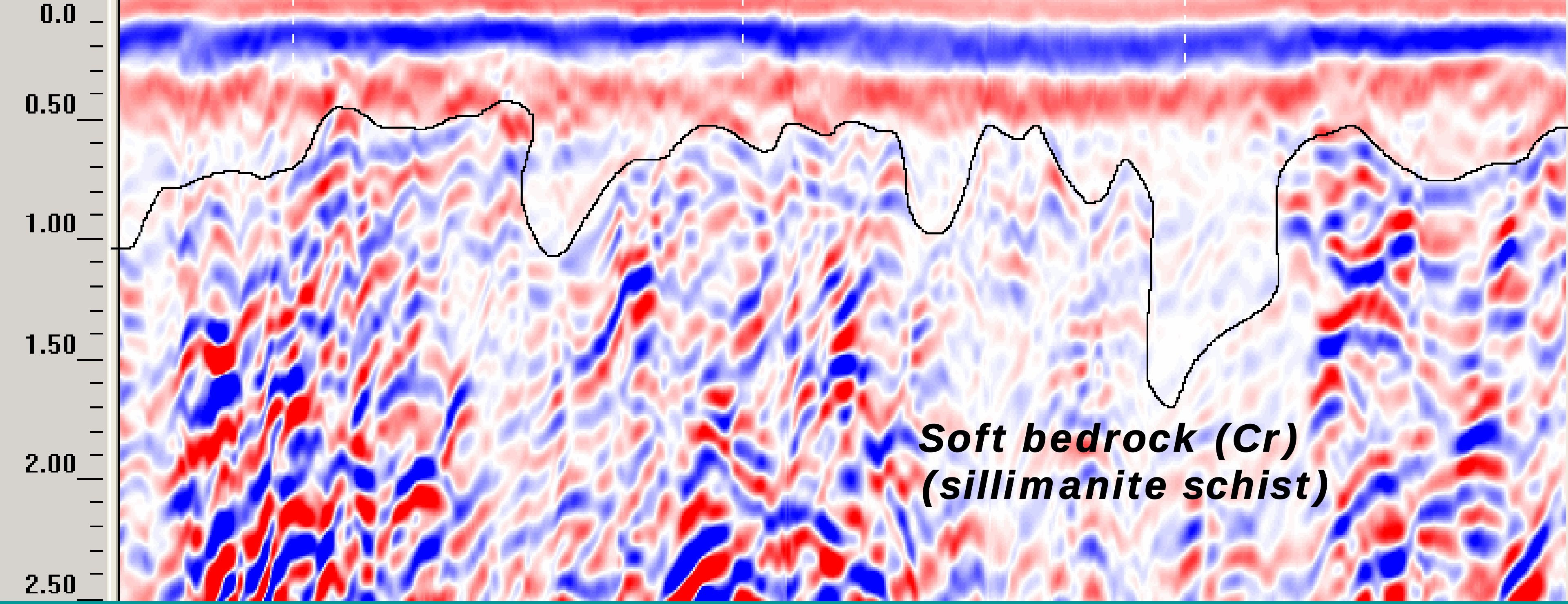


Moab, UT (Canyonlands National Park)

Based on data points along the transect (113 observations)
5328 ft. (1776m) length of transects - 8 separate transects
RESULTS (MAP UNIT COMPOSITION - DEPTH TO ROCK)

0-50 cm (Shallow)	50-100 cm (Mod. Deep)	100-150 cm (Deep)	>150 cm (V. Deep)
16%	45%	28%	14%

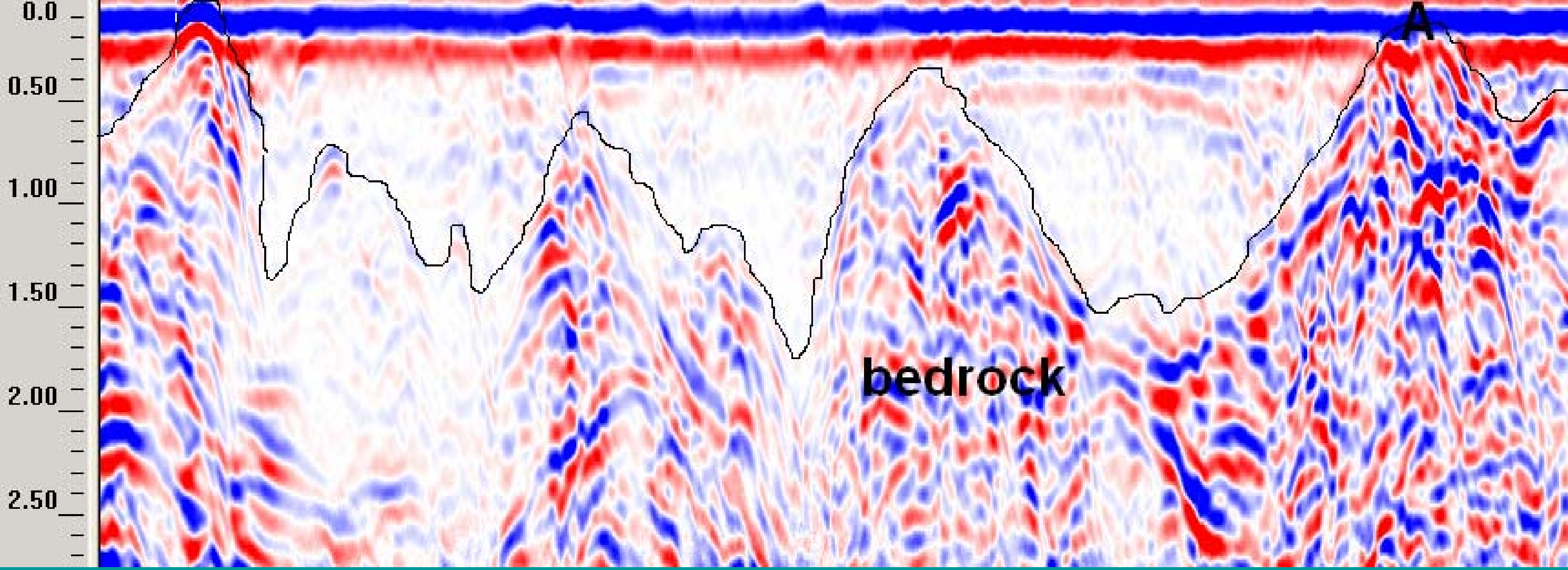
MEAN 0.97m
RANGE 0-2.47m 25-75% 0.61-1.22m
ST. DEV.0.51 VAR.0.26



A portion of a representative radar record from an area of previously Madison gravelly fine sandy loam, 2 to 6 percent slopes, eroded. Scale is in meters. The map unit will be renamed to more accurately capture the varying depths to bedrock.

Depths to Soft Bedrock	Components Observed (21 total)	Component Percentage
0 to 20 in. (0 to 50 cm)	1	5%
20 to 40 in. (50 to 100 cm)	7	33%
40 to 60 in. (100 to 150 cm)	8	38%
> 60 in. (>150 cm)	5	24%

Iredell County, NC (piedmont)



A representative portion of a radar record from an area of Pacolet-Saw complex, 6 to 10 percent slopes, bouldery. This portion of the radar record demonstrates the variability of depth to bedrock within the map unit. Depth to bedrock in this portion of the radar record ranged from 0 cm (rock outcrop) to greater than 1.5 meters. Soils borings at A revealed hard bedrock at approximately 30 cm. The depth scale is expressed in meters.

Fulton County, GA

Summary

Making Useful Interpretations Using Geophysical Tools

- EMI and GPR techniques are non-invasive tools, when used in combination with the knowledge of soils and soil properties, can result in more accurate interpretations.

- GROUND-TRUTHING is a NECESSITY!

- TEAM APPROACH.... Everyone involved contributes to interpretations

- Rely on the knowledge and expertise of the local soil scientists and other persons familiar with the area.