United States Department of Agriculture
Soil Conservation Service — Chester, PA 19013

Subject: Geophysical Investigations- Orange County, New York 30 November to 1 December 1993.

Date: 3 December 1993

To: Will Hanna
State Soil Scientist
SCS, Syracuse, NY

Donald Lake
State Conservation Engineer
SCS, Syracuse, NY

Purpose:
To conduct soil investigations using electromagnetic induction (EM) and ground-penetrating radar (GPR) techniques. To demonstrate the use of the EM38 meter to characterize and map the dissemination of contaminants from animal waste holding areas by surface runoff.

Participants:
Scott Anderson, Soil Correlator, SCS, Syracuse, NY
Robert Dibble, District Conservationist, SCS, White Plains, NY
Jim Doolittle, Soil Specialist, SCS, Chester, PA
Mary Doolittle, Earth Team Volunteer, Chester, PA
Charles Galgowski, Area Engineer, SCS, Middletown, NY
Larry Larson, District Conservationist, SCS, Middletown, NY
Richard Mall, Civil Engineering Technician, SCS, Middletown, NY
Stefan Seifried, Soil Party Leader, SCS, Walton, NY
Edward Stein, Area Resource Soil Specialist, SCS, Utica, NY
Kevin Sumner, Manager, Soil & Water Conservation District, Middletown, NY

Activities:
On 30 November, areas of organic soils were examined using both EM and GPR techniques. The purpose of this survey was to assess the potentials of using these techniques to estimate the thickness of organic materials. On the morning of 1 December, a demonstration of the use of EM38 meter to detect surface contaminants emanating from a manure stacking area was conducted at a farm near Unionville. On the afternoon of 1 December, a GPR survey was conducted across a dam site near Guymard. The purpose of this investigation was to characterize internal structural features and detect possible areas of seepage through the structure.

Equipment:
The radar units used in this study were the Subsurface Interface Radar (SIR) System-8 manufactured by Geophysical Survey Systems, Inc. The system was powered by a 12-volt vehicular battery. The model 3110 (120 mHz) antenna with a Model 705DA transceiver were used in the field studies. Scanning times of 150 and 100 nanoseconds (ns) were used.

The electromagnetic induction meter was the EM38 manufactured by Geonics Limited+. The meter is portable and requires only one person to operate. The depth of penetration is dependent upon the intercoil spacing, transmission frequency, and coil orientation relative to the ground surface. The EM38 meter integrates values of apparent conductivity over the upper 0.75 m in the horizontal dipole orientation, and over the upper 1.5 m in the vertical dipole orientation.

Discussion:

Assessing the thickness of organic soil materials.

An area of organic soils known as the "drown land" or "black dirt" in Goshen and Wawayanda Townships were examined with GPR and EM techniques. Soils profiled included Carlisle, Palms, and Wallkill. Carlisle is a member of the euic, mesic Typic Medisaprists. Palms is a member of the loamy, mixed, euic, mesic Terric Medisaprists. Wallkill is a member of fine-loamy, mixed, nonacid, mesic Thapto-Histic Fluvaquents. These soils formed from well decomposed remnants of woody and herbaceous plants on lowland lake plains. Surveyed mapping units included areas of Carlisle muck (Cd); Carlisle muck, very deep (Ce); and Palms muck (Pa)

Areas with organic materials greater than 51 inches thick are assumed to be better suited to vegetable (such as onions, celery, and lettuce) and are presently being appraised at a higher tax rate. Field work for the soil survey of Orange County was completed in 1974. [1]. Subsidence associated with decomposition and wind erosion have reduced the thickness of organic materials on cultivated areas of the lake plain.

The Soil Conservation Service has been asked to re-map (200 foot grid interval) and provide high intensity maps of organic soils areas within Orange County. The purpose of this survey is to re-evaluate the thickness of organic materials. Field work associated with the high intensity soil survey has been very slow and labor intensive. Soil scientists are in need of a faster, less labor intensive techniques to chart the thickness of organic materials. Soil Scientist requested an evaluation of the appropriateness of EM and GPR techniques.

In many areas, the depth of organic materials exceeded the observation depth of the EM38 meter (1.5 m, vertical dipole orientation). In these areas the EM31 meter is considered a more appropriate instrument for estimating peat thicknesses.

+ Trade names have been used to provide specific information. Their mention does not constitute endorsement.

1. Olsson, Karl S. 1981. Soil Survey of Orange County, New York. USDA - Soil Conservation Service. U.S. Government Printing Office, Washington, D.C. pp. 192

In areas where the organic materials were very deep, no relationship was found between the depth to limnic materials and the EM response (see Figure 1, upper). Based on seven observations, the coefficient of determination, r^2, between the depth to limnic materials and values of apparent conductivity was 0.098 in the horizontal dipole orientation and 0.221 in the vertical dipole orientation. It was assumed from these low correlations that hemic, sapric, and limnic materials have similar EM responses. It is likely that the mineralized soil water has masked any variation in response attributable to the origin or nature of the organic deposits.

In areas of Wallkill soils, no relationship was found between the thickness of the mineral surface layers and the EM response (see Figure 1, upper). Based on eight observations, the coefficient of determination, r^2, between the thickness of the mineral surface layers and values of apparent conductivity was 0.0921 in the horizontal dipole orientation and 0.186 in the vertical dipole orientation. It was assumed that the silt loam surface layers had similar EM responses to the underlying organic layers.

In areas where the organic materials were underlain by mineral layers within depths of 70 inches, a strong relationship was found between the depth to coarse or moderately coarse textured soil materials and the EM response (see Figure 1, lower). Based on six observations, the coefficient of determination, r^2, between the depth to coarse or moderately coarse textured soil materials and values of apparent conductivity was 0.737 in the horizontal dipole orientation and 0.849 in the vertical dipole orientation. Significant and detectable differences in electromagnetic responses appear to exit between organic and mineral soil materials. With the appropriate meter, these differences can be used to estimate the thickness of organic materials.

At a given location, values of apparent conductivity obtained with different coil orientations were strongly inter-dependent (r^2 = 0.915). Since a stronger relationship existed between the apparent conductivity values obtained with the EM38 meter in the vertical dipole orientation and depths to mineral soil materials, these values were used to develop regression equations to predict the thickness of organic materials or then depth to mineral soil materials. In areas having mineral soil layers within depths of 70 inches, based on six observations (a paltry number), the following equation has been developed:

$$D = 8.35 - 0.767\ X$$

where "D" is the thickness of organic materials (inches) and X is the apparent conductivity measured by the EM38 meter in the vertical dipole orientation (milliSiemens/meter). Based on the limited sample population, using this equation, the difference between observed and estimated depths to mineral soil materials averaged 7.84 inches with a range of 2.87 to 12 inches. It appears that, in some areas, the EM38 meter can be used to estimate the thickness of organic materials and facilitate soil survey field work.

EM survey of a manure stacking area near Unionville.
The purpose of this survey was to provide training on the use of the EM meter and to chart the extent of surface contamination by runoff from a small manure stacking area. The stacking area was located on a summit of a low hill in an upland area. The surrounding area was in pasture. The grid interval was 10 feet. The grid extended down slope from the stacking area.

Figures 2 and 3 simulates the results of the survey. In each figure the contour interval is 2 mS/m. A spot symbol has been used to indicate the location of the stacking area. There is no evidence to support contamination of the soil by waste products from the stacking area. Patterns evident in both figures are believed to represent variations in soil types or properties.

GPR survey of a earthen dam site near Guymard.
The depth of observation across the dam site was believed to be restricted by the relatively high clay content of the embankment materials. The observation depth was estimated to ranged from 10 to 15 feet. Within these depths, the observed imagery was highly complex and provided little information suggesting the presence of a subsurface drain or seepage area. The radar survey provided little information about the dam site.

Results:
1. In areas of Carlisle soils, GPR is an inappropriate tool for determining the thickness of organic materials or the depth to underlying mineral soil materials. The relatively high conductivity of this soils limited the effective profiling depth to less than 1 meter.

2. After analyzing the field data, EM techniques appear to be suitable for determining the thickness of organic materials and the depth to mineral soil materials. However, more testing of EM techniques on organic soils is required to confirm and improve the observed relationships. The data base used to construct the predictive regression equation is exceedingly small (6). The EM31 meter may be a more suitable tool for estimating the depths to mineral soil materials, particularly, in areas where organic soils materials are greater than 1.5 meter thick. It is recommended that additional testing of EM techniques be carried out in Orange County. This testing can be accomplished at the beginning of the mapping season. Test should evaluate the appropriateness of using EM techniques and the EM31 meter to map organic soils.

3. An EM38 meter (serial number 8906008) has been loaned to Ed Stein for the period of 1 December 1993 to 1 March 1994. Use of this meter by all interested personnel is encouraged. At the conclusion of this period, the meter will be returned to me in Chester, Pennsylvania.

4. Results from the EM demonstration support the use of the EM38 meter to assess the dissemination of contaminants from animal-waste

holding areas by surface runoff. However, for most engineering and geologic investigations, the EM31 meter is a more appropriate tool. Additional field studies in New York with the EM31 meter are encouraged. Dave Sullivan has shown interest in receiving training on the use of this meter for groundwater contamination and geologic investigations. I have provided training to geologists in several states on the use of EM meters. Following training meters have been loaned to states for periods of one to three months.

It was my pleasure to work in New York.

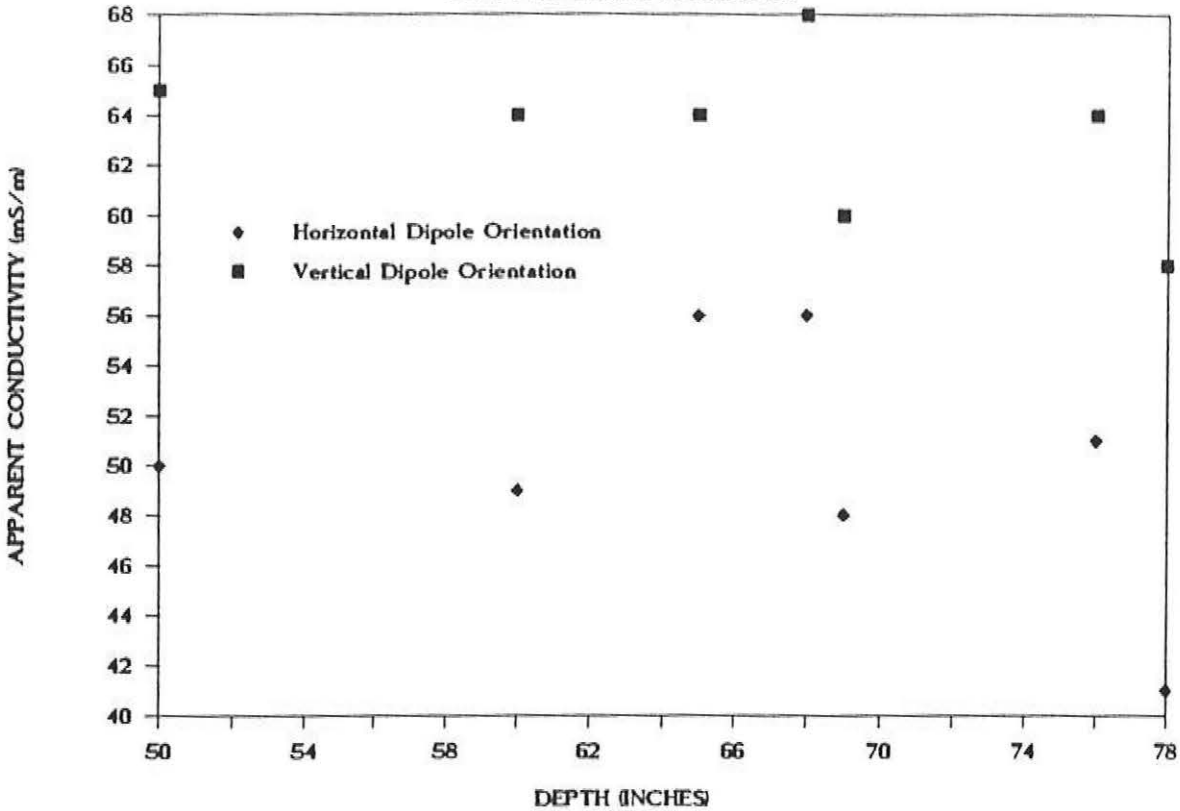
With kind regards

James A. Doolittle
Soil Specialist

cc:
James Culver, National Leader, SSQAS, NSSC, SCS, Lincoln, NE
Ed Stein, USDA-Soil Conservation Service, 100 Lomond Court, Utica, NY 13502
Richard Mall, Civil Eng. Tech., USDA-Soil Conservation Service, Gina Bldg., 3rd Floor, 453 Route 211 East, Middletown, NY 10940

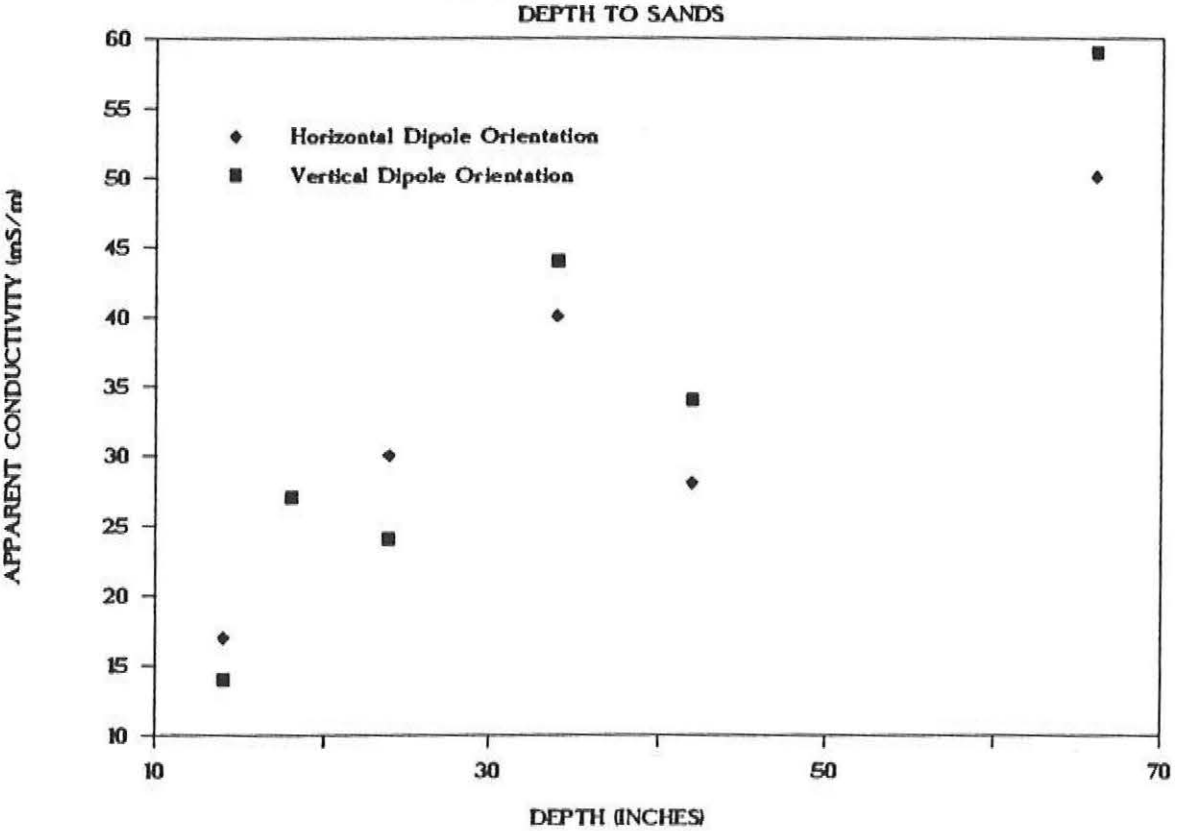
EM-38 SURVEY OF ORGANIC DEPOSITS

DEPTH TO LIMNIC MATERIALS

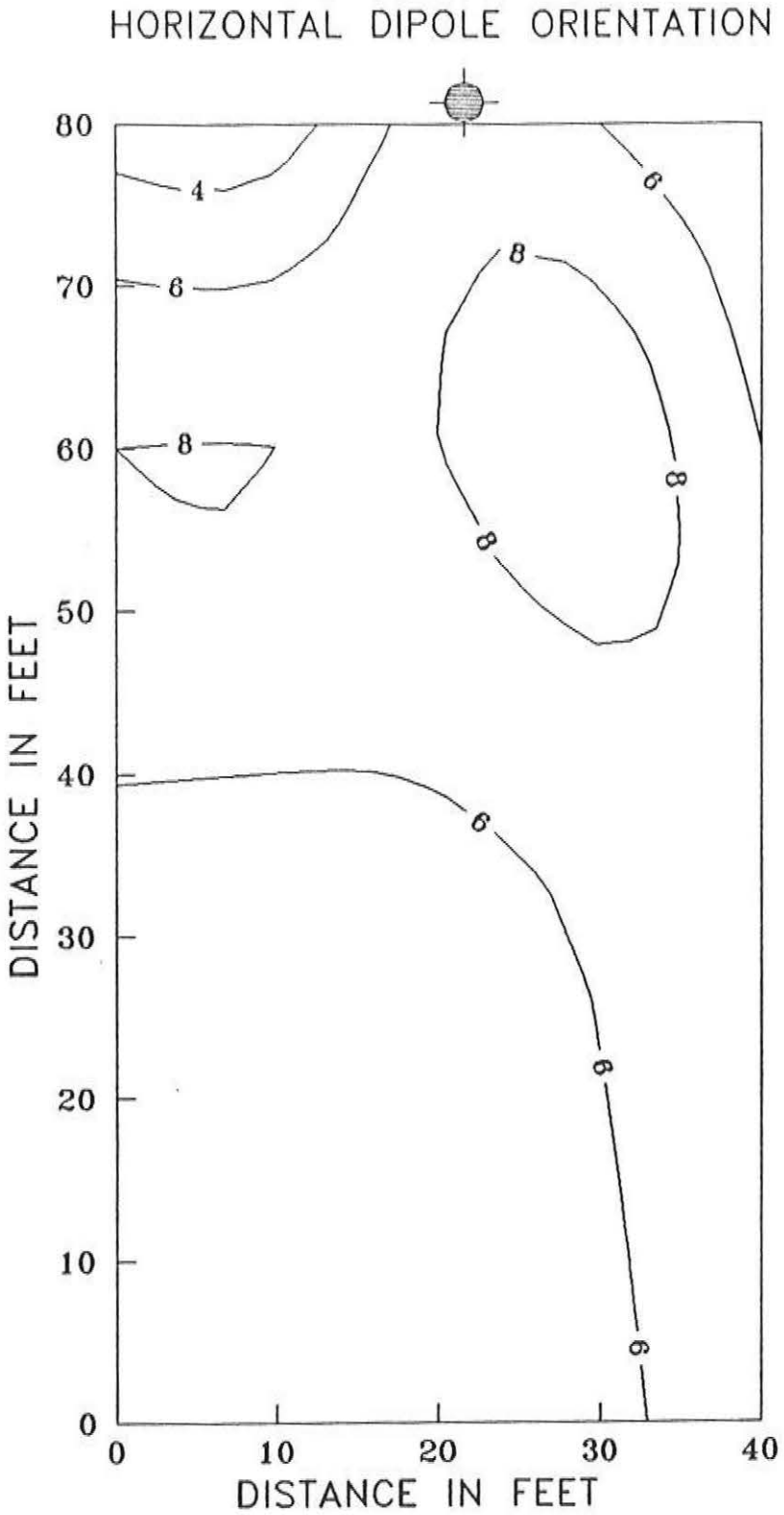


EM-38 SURVEY OF ORGANIC DEPOSITS

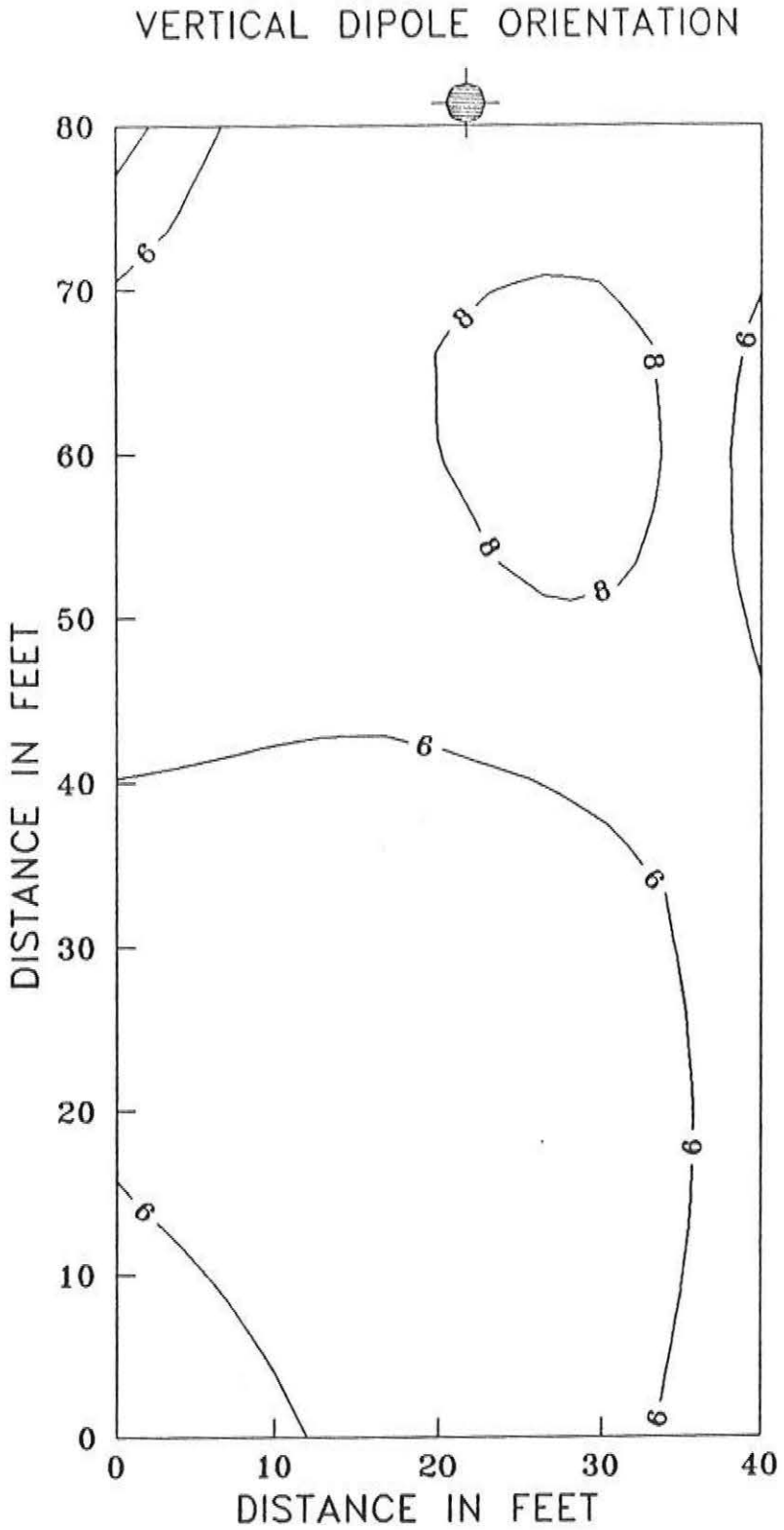
DEPTH TO SANDS



EM38 SURVEY OF MANURE STACKING AREA



EM38 SURVEY OF MANURE STACKING AREA



UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
100 Lomond Court
Utica, NY 13502

Subject: Use of EM induction meter **Date:** August 11, 1993

To: James A. Doolittle
Soil Specialist
160 East 7th Street
Chester, PA 19013-6092

EM38 available mid November

As we discussed last fall, it may be possible that I could schedule an electromagnetic induction meter for SCS projects in New York. I would like to possibly borrow the EM31 equipment for the first two weeks of November.

EM31 available late October

We have a soil mapping project on organic soils that the EM31 may be useful. We need to determine the thickness of the organic soil materials in an area of muck in Orange County that has been drained and farmed for many years. The upper 2 meters of the soil is our main concern.

Could come up on 30 day

I plan on using GPS equipment referenced to a ground base station to provide accurate location points and to establish a grid. Ground truth of the soil profile will be determined through a number of hand augured holes. These will correspond to the GPS grid points and locations also measured with the electromagnetic induction meter.

In addition, there may be other projects in NY that an EM induction meter could be used for during November.

With just a brief refresher of instructions over the phone, I should be able to operate the equipment. We do not have the computer software to plot the data. If we establish the data files, could your office plot the conductivity values for us?

If this equipment would be available in November please let me know. Also, since we are not going to need a lot of depth, would another meter work better such as the EM38?

Sincerely,

Ed Stein

Ed Stein
Area Soils Resource Specialist

cc:
J. Culver, National Leader, SSQAS, NSSC, SCS, Lincoln, NE
W. Hanna, State Soil Scientist, SCS, Syracuse, NY
B. Hopkins, Area Conservationist, SCS, Utica, NY

HORIZONTAL VS DEPTH TO SAND

66 Regression Output:

42 Constant	15.05114
24 Std Err of Y Est	6.579512
18 R Squared	0.736838
14 No. of Observations	6
34 Degrees of Freedom	4
X Coefficient(s)	0.513601
Std Err of Coef.	0.153469

VERTICAL VS DEPTH TO SAND
Regression Output:

Constant	8.351106
Std Err of Y Est	6.922219
R Squared	0.849475
No. of Observations	6
Degrees of Freedom	4
X Coefficient(s)	0.767138
Std Err of Coef.	0.161462

Hort vs Vertical
Regression Output:

Constant	-0.07664
Std Err of Y Est	5.703931
R Squared	0.914677
No. of Observations	22
Degrees of Freedom	20
X Coefficient(s)	1.221055
Std Err of Coef.	0.083390

HORIZONTAL VS DEPTH TO limnic
Regression Output:

Constant	61.39436
Std Err of Y Est	5.351845
R Squared	0.098490
No. of Observations	7
Degrees of Freedom	5
X Coefficient(s)	-0.16901
Std Err of Coef.	0.228679

VERTICAL VS DEPTH TO limnic
Regression Output:

Constant	74.12050
Std Err of Y Est	3.191243
R Squared	0.221743
No. of Observations	7
Degrees of Freedom	5
X Coefficient(s)	-0.16275
Std Err of Coef.	0.136358

HORIZONTAL VS thickness of mineral
Regression Output:

Constant	25.44444
Std Err of Y Est	6.618376
R Squared	0.092167
No. of Observations	8
Degrees of Freedom	6
X Coefficient(s)	-0.32539
Std Err of Coef.	0.416918

VERTICAL VS thickness of mineral