United States Department of Agriculture | **Natural Resources Conservation Service** | **11 Campus Boulevard, Suite 200 Newtown Square, PA 19073**

Subject: SOI – Geophysical Field Assistance **Date:** 11 June 2005

To: Dr. Henry Lin
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Purpose:
Electromagnetic induction (EMI) was used to provide data for a soil hydropedological research project that is being conducted within highly instrumented fields at Pennsylvania State University's Kleper Farm in Centre County.

Participants:
Jim Doolittle, Research Soil Scientist, USDA-NRCS-NSSC, Newtown Square, PA
Nan Hong, Postdoctoral Scholar, Crop & Soil Sciences Department, PSU, University Park, PA
Henry Lin, Assistant Professor of Hydropedology/Soil Hydrology, PSU, University Park, PA

Activities:
All field activities were completed on 1 June 2005.

Summary:

1. The National Soil Survey Center provided geophysical field assistance to Drs Lin and Hong at Pennsylvania State University's Kleper Research Farm. A survey was completed on highly instrumented fields with an EM31 meter operated in the vertical dipole orientation along established traverse lines of varying lengths that crossed different landscape components.

2. All apparent conductivity (EC_a) data has been forwarded to Dr Hong for analysis and interpretation.

It was my pleasure to participate in this study and to be of assistance to Drs Lin and Hong of Pennsylvania State University.

With kind regards,

James A. Doolittle
Research Soil Scientist
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cc:
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Background:

Spatial and temporal variations in soil moisture contents and water movement are being investigated within highly instrumented fields at Pennsylvania State University's Kleper Farm. The research plan includes the installation of 142 TDR tubes, 40 nested tensiometers, piezometers and wells, 5 automatic soil moisture monitoring systems, and 6 rain gauges. The specific objectives of this research are (i) to characterize spatial and temporal patterns of surface and subsurface soil moisture both in the non-cropping and cropping season, (ii) link observed spatial patterns to soil types, surface topography, bedrock topography, and crop yield, and the interactions of these parameters at the pedon, hillslope and landscape scales, (iii) link observed temporal patterns to rainfall intensity, soil types, surface topography, bedrock topography, water table depth, and crop type at daily, weekly and monthly scales, and (iv) predict dominant subsurface flow pathways based on spatial-temporal dynamics of soil moisture and crop yield responses. The results of this research will be used to develop a conceptual model describing the dominant surface and subsurface water flow paths within this landscape.

In 1996 and 1997, the National Soil Survey Center conducted EMI surveys at the Rock Spring Agronomy Farm, Pennsylvania State University, Centre County, Pennsylvania. Electromagnetic induction surveys of the fields containing the present research area were completed during these periods. In these rather coarse surveys (30-m grid interval), measurements were obtained in the station-to- station mode with EM31 and EM38 meters in both the horizontal and vertical dipole orientations.

Equipment:

An EM31 meter, manufactured by Geonics Limited (Mississauga, Ontario) was used in this investigation. [1] McNeill (1980) has described the principles of operation of the EM31 meter. The EM31 meter has a 3.66-m intercoil spacing and operates at a frequency of 9,810 Hz. When placed on the soil surface, the EM31 meter provides theoretical penetration depths of about 3-m and 6-m in the horizontal and vertical dipole orientations, respectively (McNeill, 1980). No ground contact is required with this meter. Lateral resolution is approximately equal to the intercoil spacing.

The Geonics DAS70 Data Acquisition System (Geonics Limited, Mississauga, Ontario) was used with the EM31 meter to record and store both apparent conductivity (EC_a) and GPS data.[1] The acquisition system consists of the EM31 meter, an Allegro field computer (Juniper Systems, Logan, Utah), and a Garmin Global Positioning System Map 76 receiver (with a CSI Radio Beacon receiver, antenna, and accessories that are fitted into a backpack) (Garmin International, Inc., Olathe, Kansas). [1] With the acquisition system, the EM31 meter is keypad operated and measurements were automatically triggered at 1 second intervals.

Field Methods:

Ten transect lines connecting the various arrays of instruments had been previously laid out across the research site. These transect lines cross different landscape components. The EM31 meter was operated in the vertical dipole orientation with geo-referenced, EC_a measurements automatically recorded at 1-sec intervals. The EM31 meter was held at hip-height with its long axis broadside (perpendicular) to the direction of travel. Walking at a fairly brisk pace, along each transect line completed an EMI survey. Measurements obtained in the field were not corrected to a temperature of 25^{o} C.

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[1] Manufacturer's names are provided for specific information; use does not constitute endorsement.

Study Site:
The study site is located in the northern part of soil map that is shown in Figure 1. The names of the soil map units that are delineated within the study site are shown in Table 1 (Braker, 1981). The present taxonomic classifications of the soils recognized in the research site are listed in Table 2.

Table 1. Soil Map Units occurring within the Study Site

Symbol	Name
HaA	Hagerstown silt loam, 0 to 3 percent slopes
HaB	Hagerstown silt loam, 3 to 8 percent slopes
HcB	Hagerstown silty clay loam, 3 to 8 percent slopes
Mm	Melvin silt loam
MuA	Murrill channery silt loam, 0 to 3 percent slopes
MuB	Murrill channery silt loam, 3 to 8 percent slopes
No	Nolin silt loam, local alluvium, 0 to 5 percent slopes
OhB	Opequon-Hagerstown complex, 3 to 8 percent slopes
OhC	Opequon-Hagerstown complex, 8 to 15 percent slopes

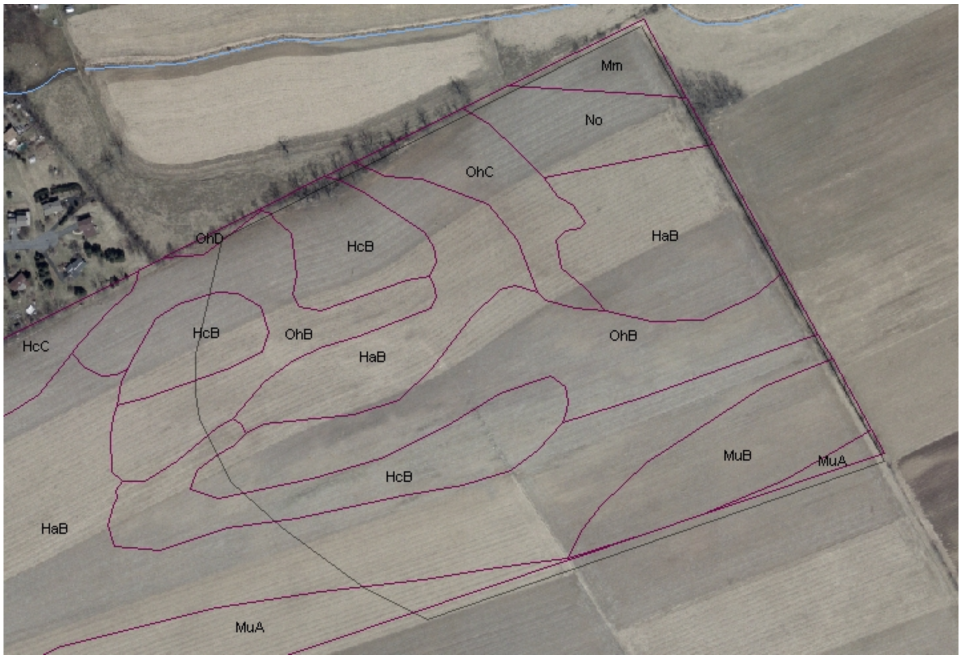

Figure 1. This ortho-photograph of the research site shows the soil lines and map unit symbols from the 1981 soil survey.

Table 2. Taxonomic Classification of Soils

Series	Family
Hagerstown	Fine, mixed, mesic Typic Hapludalfs
Melvin	Fine-silty, mixed, nonacid, mesic Typic Fluvaquents
Murrill	Fine-loamy, mixed, mesic Typic Hapludults
Nolin	Fine-silty, mixed, mesic Dystric Fluventic Eutrochrepts
Opequon	Clayey, mixed, mesic Lithic Hapludalfs

Results:

Based on prior knowledge of soil-landscape relationships within the research site, Nan Hong, with reasonable confidence, was able to associated soil series with EMI response. This distinction of soils by EC_a is shown in Table 3. The shallow to bedrock, well drained Opequon soil has EC_a less than 5 mS/m. The deep to bedrock, well drained Hagerstown have an EC_a that ranges from about 10 to 13 mS/m. The very deep to bedrock, poorly drained Nolin and Melvin soils have EC_a ranging from 18-22 and 25-35 mS/m, respectively.

Table 3. Range in EC_a for Recognized Soils

Soil	EC_a
Opequon	< 5 mS/m
Hagerstown	10 – 13 mS/m
Nolin	18 – 22 mS/m
Melvin	25 -35 mS/m
Hagerstown & Opequon	7 – 9 mS/m

Figure 2 is a plot of the EC_a data collected with the EM31 meter in the vertical dipole orientation. The spatial patterns of EC_a appearing in Figure 2 are principally related to differences in soil wetness, thickness of the residuum, and depth to limestone. Areas with low EC_a are on higher-lying, more sloping, better drained landscape positions. These areas are inferred to have thinner caps of residuum and shallower depths to limestone bedrock. Areas with higher EC_a are on lower-lying, plane and concave, more imperfectly drained landscape components. These areas are wetter and were inferred to have thicker caps of residuum or deeper depths to bedrock. A small area of wetter soils can be observed in the extreme northern corner of the site. Soils were ponded in the northeast corner. In these areas, higher moisture contents contributed to the higher measured values of apparent conductivity.

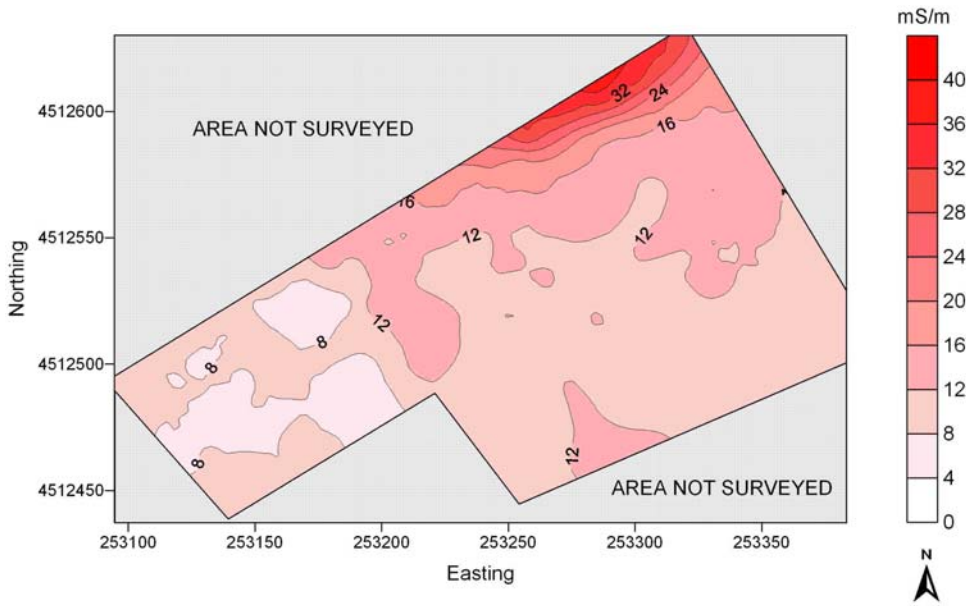

Figure 2. Plot of EC_a data collected with the EM31 meter in the vertical dipole orientation.

References:

Braker, W. L. 1981. Soil Survey of Centre County, Pennsylvania. USDA-Soil Conservation Service, Washington DC.

McNeill, J. D. 1980. Electromagnetic terrain conductivity measurement at low induction numbers. Technical Note TN-6.

Geonics Limited, Mississauga, Ontario.