United States Department of Agriculture
Soil Conservation Service
Northeast NTC
160 E. 7th Street
Chester, PA 19013

Subject: SOI - GPR Investigation of Histosols in Massachusetts, March 9-13, 1987

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To: Rex O. Tracy
State Conservationist
Soil Conservation Service
Amherst, Massachusetts

File code: 430-7

PURPOSE

To explore the potential of using ground-penetrating radar techniques to characterize various peatland settings in Eastern Massachusetts.

PARTICIPANTS

Al Averill, Soil Scientist, SCS, Acton, MA
Richard Devergilio, District Conservationist, SCS,Barnstable, MA
James Doolittle, Soil Specialist, SCS, Chester, PA
David Fetterman, Geophysicist, USGS, Denver, CO
Tom Peragallo, Soil Party Leader, SCS, Acton, MA
John Portnoy, Research Biologist, NPS, S. Wellfleet, MA
Mike Soukup, Chief Scientist, NARO-NPS, Boston, MA
Steve Spear, Conservation Tech., SCS, Barnstable, MA
Eric Swenson, Soil Party Leader, SCS, Spencer, MA
William Taylor, Soil Party Leader, SCS, Spencer, MA

Equipment:

The radar system is the SIR System-8 with the 120 MHz antenna. The SIR System-8 consists of the Model 4800 control unit, ADTEK SR-8004H graphic recorder, and ADTEK DT-6000 tape recorder.

The unit was hand carried into each study site and powered from 2 12-volt marine batteries. Two sections of control cable were joined with a connector adapter, providing a 200 ft operating radius about the control and recording units.

Below freezing temperatures reduced the power output from the marine batteries. While sufficient power was available to operate the control unit and the graphic recorder, the output was too low to power the more demanding tape recorder. Field work proceeded without the use of the tape recorder. The tape recorder was returned to the manufacturer for an analysis. The system was temperature tested and the problem documented.

DISCUSSION

Ground-penetrating radar surveys were conducted on six peatland settings in Barnstable, Middlesex, and Worcester Counties. In Middlesex and Worcester Counties, the investigated peatland settings were similar in their subsurface expressions. The four investigated bogs were formed in pan-shaped depressions. These depressions have an organic/mineral interface which descends sharply along peripheral areas (generally over a lateral distance of 20 to 30 feet) onto a relatively smooth and flat central plain.

Peatland settings studied in Worcester County had been mapped as Freetown (dysic, mesic Typic Medisaprists) and Swansea (sandy or sandy-skeletal, mixed, dysic, mesic Terric Medisaprists) mucks. The first study area was in Rutland State Park. At this site, the average thickness or organic materials is 77 inches (6.4 ft) with a standard deviation of 17.1 inches. The medium thickness of organic materials is 89 inches (7.4 ft) and is nearly identical with the mean. The lower quartile is 68 inches (5.6 ft) and the upper quartile is 89 inches (7.4 ft). Within this bog, one-half of all observations occur within the interquartile range of 69 to 89 inches. This data attest to the low variability of organic material thicknesses and the relative uniform subsurface conditions prevailing in this bog. The maximum observed thickness of organic materials is 102 inches (8.5 ft). Based on the transect data, this area is 93 percent Freetown soils and 7 percent Swansea soils.

The second area investigated with GPR in Worcester County was on Greenwood Pond, south of Highway 2, near Gardner. At this site, the average thickness of organic materials is 101 inches (8.4 ft) with a standard deviation of 16.5 inches. The median thickness of organic materials is 106 inches (8.8 ft). One-half of the observations occur within the interquartile range of 101 (8.4 ft) to 109 (9.1 ft) inches. The distribution of organic thicknesses is skewed to the right confirming the relatively narrow, sharply descending peripheral zone and the more extensive and uniform central portion. The composition of this bog is 95 percent Freetown soils and 5 percent Swansea soils.

In Middlesex County, the GPR was used to determine the average thickness of organic materials in a low-lying area adjacent to Nashoba Brook at the Nashoba Hill Ski Area. This area had been mapped as Freetown soils. The owner of this facility had asked for technical assistance in determining the amount of organic materials which would have to be removed to construct a small pond. Four transects were completed with the GPR across the proposed site. The average thickness of organic materials is 31.5 inches with a standard deviation of 8.2 inches. The maximum observed thickness was 37 inches which was appreciably lower than the depth expected. The area is 100 percent Swansea soils.

Extensive investigatory field work is being carried out in Cape Cod by the Environmental Protection Agency and the US Geological Suvey. The objective of this field work is to evaluate ground water regimes and sources of contamination. Ground-penetrating radar assistance was requested by the National Park Service to help characterize some of their peatland settings within the National Seashore Park. Dr Fetterman of the USGS provided technical leadership and directed the electrical conductivity portion of the geophysical survey.

To insure that the natural environment was not disturbed, the radar survey was conducted along an elevated, wooden nature-walk structure. Sixty observation sites were established at 10 foot intervals along this structure. The radar system was towed in a sled along the walkway.

The radar profiled the organic material to a depth of about 4 meters. At 4 meters the signal from the 120 MHz antenna suffered complete attenuation and the organic/mineral soil interface was no longer identifiable. This depth is not believed to represent the limits of GPR at this site. A larger, more powerful antenna, the 80 MHz antenna, is available and should provide greater depths of penetration. Also, the micoprocessor was not utilized in this study. The microprocessor has several signal enhancing and/or background removal programs which may enhance the reflected signals.

Table I is a summary of the thicknesses of organic materials within a kettle at the Marconi Station.

Table 1

Distribution of Organic Material Thicknesses

Depth Interval	Frequency	Percent
000 - 99 inches	09	15
100 - 199 inches	17	28
200 - 299 inches	07	12
300 - 399 inches	02	03
>400 inches	25	42

RESULTS

The GPR performed well at all sites and is an acceptable cost-efficient tool for determining the thickness of organic layers, profiling the topography at the base of the organic materials, or characterizing the composition of map units in Massachusetts. At each study site the radar provided high resolution, continuous profiles of the organic deposits and the underlying mineral soil materials. Six sites were studied in Barnstable, Middlesex, and Worcester Counties. The maximum thickness of organic materials probed with the 120 MHz antenna was 4 meters (13.1 ft) in a bog just north of the National Seashore Headquarters in South Wellfleet. However, probing depths as great as 18.3 meters (60 ft) were consistently achieved in areas of thinner organic deposits overlying coarse-textured glacial drift in a cranberry bog near Falmouth.

In Massachusetts, an interdisciplinary approach is being taken to solve resource management problems relating to the production of cranberries. The GPR can be effectively used to provide data for water resource management and research on cranberry bogs in eastern Massachusetts. The GPR can be used immediately to provide subsurface data necessary to develop contour maps of impervious layers which intercept and direct the flow of chemical ammendments applied to the cranberry bogs. In the surrounding coarse-textured soils,

temporal and areal variations in the water table, subsurface flow regimes, and aquifer delineation can be ascertained and characterized with GPR techniques.

Based on the success of the GPR in Massachusetts and the resource management needs expressed in Gylan Dickey's report entitled "Technical Assistance and Coordination of Cranberry Research and Planning" of 20 January 1987, the use of ground-penetrating radar techniques should be implemented in future investigations and research.

I have enclosed two articles on how the radar can be applied to subsurface investigations. The article, entitled "Ground penetrating radar studies on Cape Cod" (Wright et al., 1985), discusses how the radar has been used to trace hydrologic flow and delineate aquifiers. The second article, entitled " Underground channels mapped by radar" (Kaniuka, 1987), describes how ARS is using GPR to trace the movement of agrichemicals.

If I can provide any further assistance to your state, please do not hesitate to ask.

JAMES A. DOOLITTLE
Soil Specialist (GPR)

Enclosures

cc: w/encl.
Arthur B. Holland, Director, NENTC, SCS, Chester, PA
Gene Grice, State Soil Scientist, SCS, Amherst, MA

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