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

Subject: Soils – Geophysical Field Assistance **Date:** 2 March 2004

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Purpose:
The purpose of this investigation was to document the thickness of a silty eolian mantle in areas that had been mapped as Bridgehampton soils in southern Rhode Island. In addition, GPR training was provided to Rob Tunstead (soil, scientist, USDA-NRCS, W. Wareham, MA), and a detailed GPR survey of a cranberry bed was completed near Carver, Massachusetts.

Participants:
Phil Angell, Earth Team Volunteer, West Wareham, MA
Jim Doolittle, Research Soil Scientist, USDA-NRCS-NSSC, Newtown Square, PA
Peter Fletcher, Earth Team Volunteer, West Wareham, MA
Robert Tunstead, Resource Soil Scientist, USDA-NRCS, West Wareham, MA
Jim Turenne, Assistant State Soil Scientist, USDA-NRCS, Warwick, RI
Iain Ward, Conservation Farm Planner, Plymouth County Soil & Water Conservation District, West Wareham, MA

Activities:
All activities were completed during the period of 26 to 30 January 2004.

Summary:

1. Preliminary radar surveys in areas of Bridgehampton soils indicate that the thickness of the eolian mantle is less than original mapped. Areas of Bridgehampton soils in southern Rhode Island support a large turf farming business. Based on observations made with GPR, soils were either incorrectly mapped or turf farming has removed a significant portion of the eolian mantle.

2. Alternative field methods and data processing software were explored to improve the display of radar data and enhance the transfer of information on the depth, volume and subsurface topography of organic materials within cranberry beds.

Equipment:
The radar unit is the TerraSIRch Subsurface Interface Radar (SIR) System-3000 (here after referred to as the SIR System-3000), manufactured by Geophysical Survey Systems, Inc.[1] Morey (1974), Doolittle (1987), and Daniels (1996) have discussed the use and operation of GPR. The SIR System-3000 consists of a digital control unit (DC-3000) with keypad, SVGA video screen, and connector panel. A 10.8-volt lithium-ion rechargeable battery powers the system. The SIR System-3000 weighs about 9 lbs (4.1 kg) and is backpack portable. With an antenna, this system requires two people to operate. The 70, 120, and 200 MHz antennae were used in this study. High levels of noise were recorded on radar profiles collected with the 70 MHz antenna over peatlands. The noise was attributed to reverberations induced in the radar signal by frozen surface layers overlying saturated materials.

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

The RADAN for Windows (version 5.0) software program was used to process the radar record (Geophysical Survey Systems, Inc, 2003).[1] Processing included setting the initial pulse to time zero, color transformation, marker editing, distance normalization, and range gain adjustments. Radar records were processed into a three-dimensional image using the 3D QuickDraw for RADAN Windows NT software developed by Geophysical Survey Systems, Inc.[2] Once processed, arbitrary cross sections and time slices were viewed and selected images attached to this report.

To help summarize the results of the cranberry bed study, the SURFER for Windows, version 8.0, developed by Golden Software, Inc., was used to construct a two-dimensional simulation.[2] The grid was created using kriging methods with an octant search.

Bridgehampton and Enfield soils:
In southern Rhode Island, nearly level too gently sloping areas that have a silty eolian mantle underlain by glacial drift are used extensively for turf farming. The thickness of the eolian mantle is important to a turf industry, which commonly removes a portion of this material with each harvest. A GPR survey was conducted to investigate the thickness of the eolian mantle and the accuracy of the published soil survey (Rector, 1981). Multiple GPR transects were conducted in areas of Bridgehampton silt loam, 0 to 3 percent slopes (BhA); Bridgehampton silt loam, 3 to 8 percent slopes (BhB); and Enfield silt loam, 0 to 3 percent slopes (EfA).

The very deep, well drained and moderately well drained Bridgehampton and the well drained Enfield soils form in a thick silty mantle over glacial drift on outwash plains. Bridgehampton is a member of the coarse-silty, mixed, active, mesic Typic Dystrudepts family. Enfield is a member of the coarse-silty over sandy or sandy-skeletal, mixed, active, mesic Typic Dystrudepts family. Bridgehampton and Enfield soils have solum thickness of 40 to 56 inches and 15 to 40 inches, respectively. These depths correspond to the depth to the contrasting coarser textured and more rapidly permeable glacial till or stratified outwash deposits. Also included in the investigated map units are small areas of Hinckley soil. The very deep, excessively drained Hinckley soil formed in water-sorted material on outwash plains. Hinckley is a member of the sandy-skeletal, mixed, mesic Typic Udorthents family.

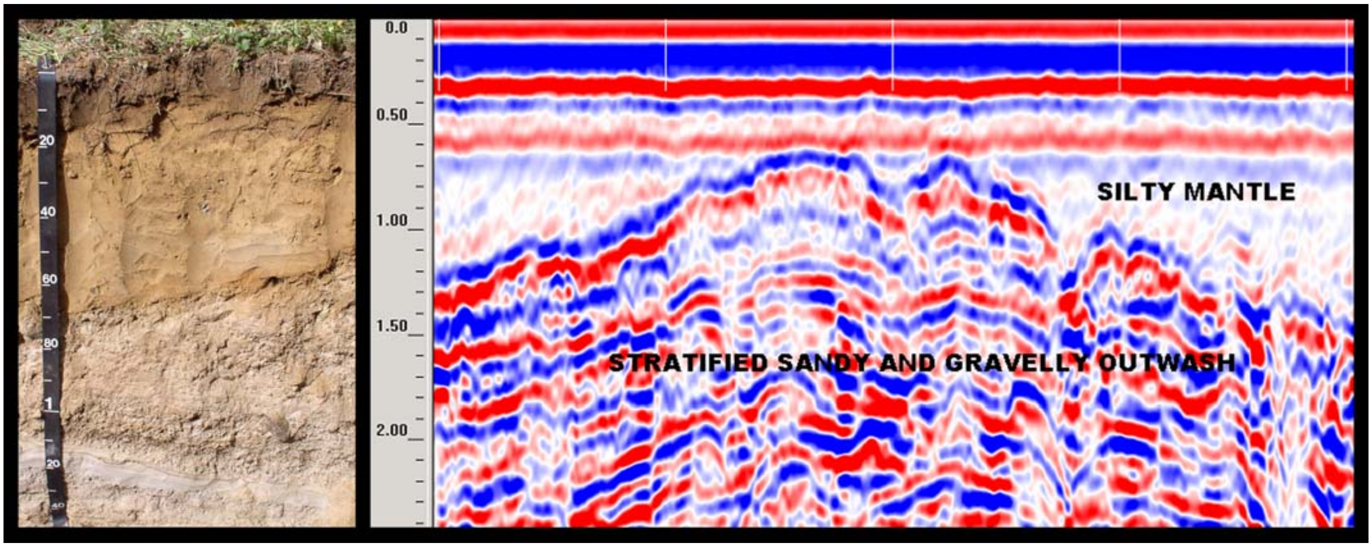

Figure 1. Picture of Enfield soil profile and a radar profile from an area of Bridgehampton and Enfield soils. Depths are in centimeters on the soil profile (left) and meters on the radar profile (right). Picture of soil profile is courtesy of Jim Turenne.

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

Figure 1 is a representative radar profile from an area of Bridgehampton silt loam, 0 to 3 percent slopes, near the town of Matunuck, Rhode Island. In Figure 1, the contact between the eolian silt mantle and the coarse textured glacial outwash is readily apparent. Other than parallel bands of reverberated signals, the eolian mantle is free of high amplitude reflections. Weakly expressed, inclined clinoforms just above the eolian/drift contact suggest some mixing. Abrupt and contrasting dielectric properties across the eolian mantle/glacial drift interface produce high amplitude reflections that are distinguishable across the radar record. Linear reflectors within the drift suggest that this material is outwash rather than till. Typically, on radar records, till displays a chaotic graphic signature characterized by an abundance of point anomalies from stones and boulders and an absence of linear features suggesting the flow of water.

Nine GPR transects were completed mostly in areas of map units BhA and BhB. However, two transects were completed in an area of EnA. Based on 176 observations the average thickness of the silt cap was 33.5 inches, with a range of 15.4 to 72 inches. One half of the observations had loess cap thickness between 28 and 37 inches. Taxonomically, 82 percent of the observations were classified as Enfield soil. Eighteen percent of the observations were classified as Bridgehampton soil. Based on these observations and assuming that representative areas were traversed with GPR, soils were either incorrectly mapped or turf farming has removed a significant portion of the eolian mantle.

Callio Cranberry Bed:
A detailed GPR survey was completed of a small cranberry bed own and operated by Callio Cranberries in the town of Carver, Massachusetts. The bed is mapped as Freetown coarse sand, 0 to 3 percent slopes (map unit 55A). The very deep, very poorly drained Freetown soil formed in more than 51 inches of highly decomposed organic material. Freetown is a member of the dysic, mesic Typic Haplosaprists family.

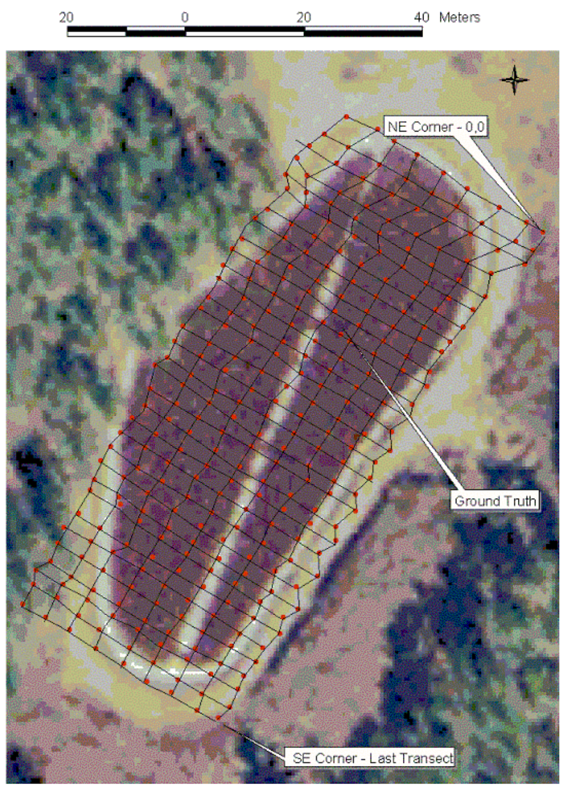

Figure 2. The Callio bed study site in Carver, Massachusetts. Red dots indicate the approximate locations of the reference points used in the GPR survey.

A 40 by 96 m grid was established across the cranberry bed. The purpose of this survey was to provide imagery of the thickness of organics and the general geometry of the peat basin. The grid intervals were 5 and 2 m. The grid consisted of thirty-three, 40 m lines. The origin of the grid was located in the northeast corner. Pulling the 120 MHz antenna along thirty-three equally spaced (2-m) east-west trending grid lines in a back and forth manner completed a GPR survey. Reference points were spaced at 5 m intervals along each line. Along each line, as the antenna was towed passed a reference point, a vertical mark was impressed on the radar record. This provided 297 reference points. At each of these reference points, the thickness of the organic materials was interpreted from the radar profile.

Figure 2 is an aerial photo of the cranberry bed prepared in ArcView GIS. The grid and the locations of the 297 reference points used for the GPR survey are also shown in this image. The locations of the reference points were obtained with a Garmin GPS receiver. The origin of the grid is located in the northeast corner of the site (upper right-hand corner). At the time of the survey, the bed was snow covered. The white diagonal line that stretches across the bed is believed to be a drainage line, which was neither apparent at the time of the survey nor evident on all radar profiles.

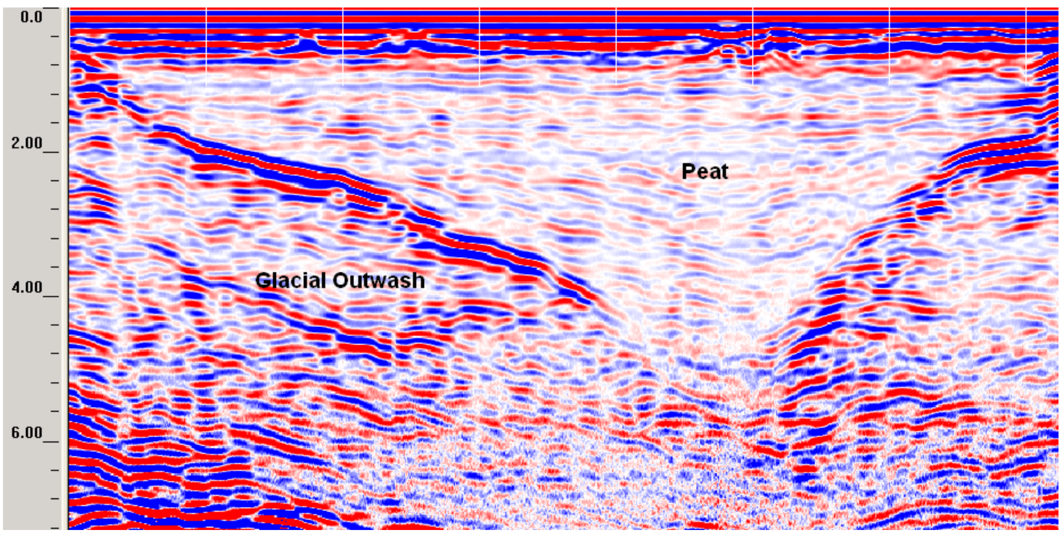

Figure 3. A representative radar record from the Callio Cranberry Bed. Depth scale is in meters.

Figure 3 is a representative radar record from the cranberry bed. In Figure 3, the depth scale is in meters. The white vertical lines at the top of the radar profile represent equally spaced (5 m) reference points. The vertical scale is exaggerated. Abrupt and strongly contrasting changes in water content makes the organic/mineral interface distinguishable on radar profiles. In Figure 3, this interface forms a conspicuous reflector and varies in depth from about 0.6 to 6.4 m. The feature producing the white line that diagonally crosses the cranberry bed in Figure 2 is evident near the third reference point from the right.

Organic deposits display considerable anisotropy in moisture content, bulk density and often have uneven or sloping layer boundaries (Hanninen, 1992). Differences in moisture contents have allowed some to distinguish layers with differences in degree of humification, bulk density and dielectric permittivity (Hanninen, 1992; Chernetsov et al., 1988; Tolonen et al., 1982). However, in other surveys, peat layers could not be clearly associated with radar reflections (Worsfold al., 1986; Remotec Applications Inc., 1982). In Figure 3, weak planar reflectors are evident within the organic materials. While the more uniform reflections are presumed to represent noise, the more irregular or wavy reflectors suggest layering within the organic materials. These interfaces are commonly observed in peatlands of southeastern Massachusetts.

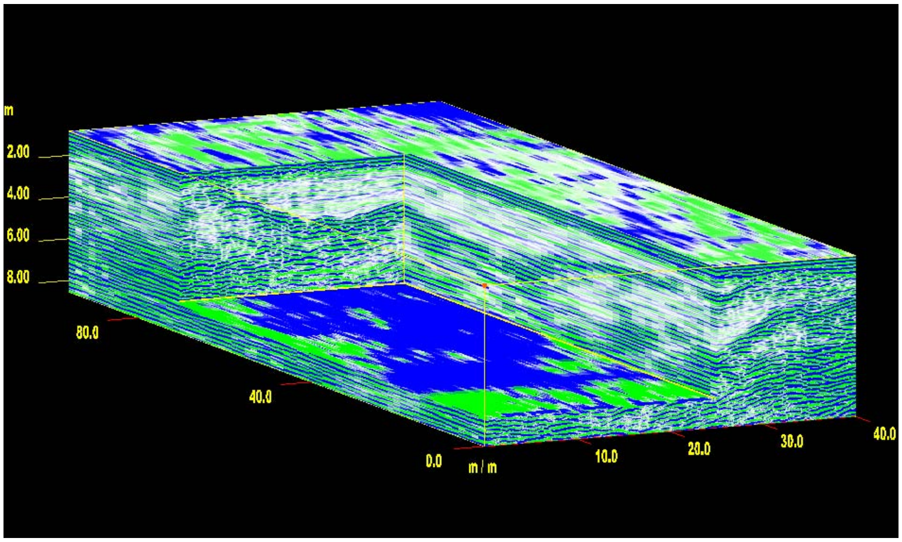

Figure 4. A three-dimensional presentation of radar data collected in the Callio cranberry bed.

Figure 4 is a three-dimensional block diagram of the organic deposit that was generated from the radar data. The origin of this block diagram is located in the northeast corner of the cranberry bed. In Figure 4, all values are in meters. To construct this block diagram, the imagery between adjoining radar traverses is interpolated. In this study the spacing between radar traverse lines was 2 m. This represents the most comprehensive study known of an organic deposit. In Figure 4 a sub-block has been removed from the cube along different X and Y axes coordinates.

Although processing radar data into three dimensional presentations provide interesting, colorful and eye-catching presentations, little additional information is provided. Processing requires additional expenditures of resources and does not seem to be warranted for use and management decisions for cranberry beds. Two-dimensional presentations such as seen in Figure 5 provide more useful information to cranberry producers. The data used to prepare the two-dimensional presentation were based on organic thicknesses measured at each of the 297 reference points on radar profiles.

Based on survey measurements, Callio cranberry bed has an estimated area of about 6080 square meters. Base on radar interpretations, the peatland has a volume of about 5668 cubic meters. The subsurface topography of the organic deposit is regular and predictable as it conforms to the long axis of the depression. The slope of the deposit’s base is steeper along the eastern (right-hand) side.

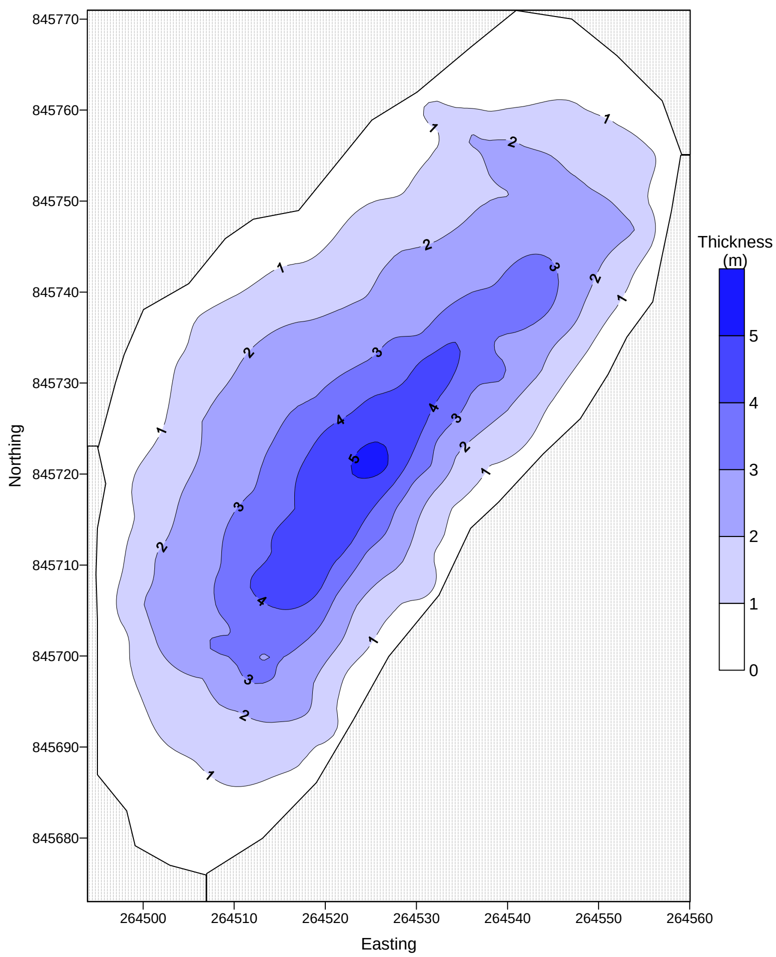

Figure 5. Two-dimensional map showing the distribution of organic materials thicknesses within Callio cranberry bed.

It was my pleasure to work in Rhodes Island and Massachusetts and to be of assistance to Jim Turenne.

With kind regards,

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