United States Department of Agriculture | **Natural Resources Conservation Service** | **5 Radnor Corporate Center, Suite 200 Radnor, PA 19087-4585**

Subject: Ground-penetrating radar Assistance; Awbury Arboretum, Philadelphia

Date: 8 July 1998

To: Janet Oertly
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Purpose:

The purpose of this study was to evaluate the suitability of ground-penetrating radar for soil investigations and culture resource projects within Awbury Arboretum Association, Germantown, Pennsylvania. Natural Resource Conservation Service is providing assistance to the Arboretum as part of the Philadelphia Urban Resource Partnership program.

Participating Agencies:

Awbury Arboretum Association
Natural Resource Conservation Service

Participants:

John Chibirka, Soil Scientist, USDA-NRCS, Leesport, PA
Jim Doolittle, Research Soil Scientist, USDA-NRCS, Radnor, PA
Tom Manns, Facility Manager, Awbury Arboretum Association, Germantown, PA
Tom Mishler, Executive Director, Awbury Arboretum Association, Germantown, PA
Elbert Wells, Project Leader, USDA-NRCS, West Chester, PA

Activities:

All field activities were on 24 June 1998.

Awbury Arboretum:

The Arboretum is located in the Germantown and Morton areas of Philadelphia. The evaluation of the radar's suitability for soil and culture resources assessments was conducted in two separate areas of the Arboretum. One area consisted of highly disturbed soils; one area consisted of relatively undisturbed soils. The disturbed area was in a locality known as McNabbtown. The disturbed area was the former site of homes and buildings. These structures had been razed and the covered with a thin fill deposit. The undisturbed area was in an open meadow.

The dominant soils within the Arboretum are members of the Chester and the Manor series. Chester is a member of the fine loamy, mixed, mesic Typic Hapludults family. Manor is a member of the coarse-loamy, micaceous, mesic Typic Dystrochrepts family. These very deep, well drained and somewhat poorly drained soils formed in materials weathered from micaceous schist on uplands. The medium texture and micaceous mineralogy of these soils were concerns for the satisfactory operation of GPR. It was feared that these factors would reduce the radar's penetration depth.

Equipment:
The radar unit used in this study was the Subsurface Interface Radar (SIR) System-2, manufactured by Geophysical Survey Systems, Inc. The SIR System-2 consists of a digital control unit (DC-2) with keypad, VGA video screen, and connector panel. A 500 mHz and a 400 mHz antenna were used in this evaluation. The system was powered by a 12-volt battery.

Crude depth scales were calculated during field work at Awbury Arboretum. At each study area, a metallic reflector was buried at a depth of about 35 cm (14 inches). The depth to this reflector was used to determine the dielectric permittivity and velocity of propagation. This information was used to scale (depth) the radar imagery. Based on the round-trip travel time to this reflector, the averaged velocity of propagation through the upper part of the soil profile was estimated to be 0.1124 meters per nanoseconds (m/ns) at the disturbed site and 0.0948 m/ns at the undisturbed site. Based on these velocities, a scanning time of 50 ns provided a maximum observation depth of about 2.1 to 2.8 m. The dielectric permittivity was estimated to be 7.1 and 10.0 at the disturbed and undisturbed sites, respectively.

Ground-penetrating radar provided continuous, highly resolved images of the subsurface. Figure 1 is a representative radar profile from a relatively undisturbed area of Chester soils. This profile was obtained with the 400 mHz antenna. In Figure 1, the depth scale is in meters.

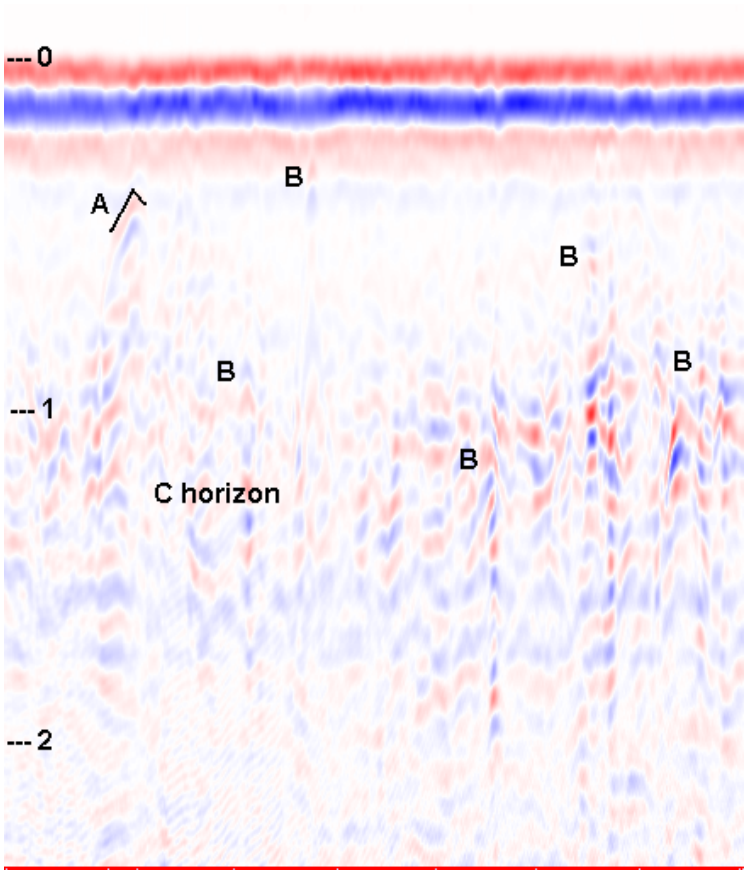

Figure 1
Radar Profile from an area of Chester soils

The radar detected a known buried metallic reflector (see “A” in Figure 1). Additional “point anomalies” are evident in Figure 1 and other radar profile. These anomalies contrast with the surrounding soil, have high signal amplitudes and appear as hyperbolic (^) patterns. The point anomalies identified on the radar profile (see “B” in

Figure 1) are believed to represent buried cultural features or rock fragments. In Figure 1, the transition from the fine-loamy B horizon to the coarse-loamy C horizon appears as a band of medium amplitude, discontinuous reflections that recur at a depth of about 1 meter.

A buried utility line and a few cultural features were detected within the undisturbed area. The utility line was buried at an estimated depth of 34 inches. Ground-penetrating radar detected suspected artifacts, rock fragments, and debris layers within the disturbed area. Also detected within the disturbed area were layers of fill and bedrock.

Results:

1. Results were better than had been anticipated. Ground-penetrating radar is a suitable tool for soil and cultural resource investigations within the Arboretum. As Awbury Arboretum is located close to my office, I can provide periodic ground-penetrating radar assistance to the NRCS staff involved in the Philadelphia Urban Resource Project. An archaeologist or cultural resource specialist should participate in this project and, if possible, be present for radar field work.

2. The participants were exposure to the use of ground-penetrating radar for archaeological investigations. Participants were provided a summary of survey techniques and interpretations at a historical site of local and regional importance. The survey demonstrated some of the limitations and advantages of GPR techniques. The value of integrating contemporary geophysical methods with traditional archaeological techniques was stressed. The integration of these technologies can provide more comprehensive site coverage, reduces the number of unsuccessful exploratory pits, and decreases field time and costs.

3. Complete records of the radar profiles have been turned over to John Chibirka.

It was my pleasure to work with and to be of assistance to members of your fine staff.

With kind regards,

James A. Doolittle
Research Soil Scientist

cc:
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