United States Department of Agriculture

Soil Conservation Service

Northeast NTC
160 E. 7th Street
Chester, PA 19013

Subject: SOI - GPR Trip Summary - Vermont, July 8-12, 1985

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PURPOSE

To field test the ground-penetrating radar (GPR) on selected sites within Vermont and to access the effectiveness of the system for determining the depth to bedrock.

PARTICIPANTS

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EQUIPMENT

The equipment utilized during this field trip was the SIR System-8, the ADTEK SR-8004H graphic recorder, and the ADTEK DT-6000 tape recorder. The 80, 120, and 300 MH_z antennas were used at various times and under differing soil conditions. The 80 MH_z antenna provided the best combination of resolution and penetrating depth in soils formed in loamy tills derived from phyllites and schists. The GPR system operated well with no observable malfunctions.

ACTIVITIES

Prior to the arrival of the GPR unit, sites were selected in Washington and Windsor Counties. Multiple transects were conducted on the 9th and 10th of July in areas of Dummerston (coarse-loamy, mixed, frigid Typic Dystrochrepts) and Fullam (coarse-loamy, mixed, frigid Aquic Dystrochrepts) soils; and the proposed Bartlett (loamy, mixed, frigid Lithic Dystrochrepts) and Lords (coarse-loamy, mixed, frigid Typic Dystrochrepts) soils in Washington County. On the 11th and 12th of July, the radar profiled areas of Houghtonville (coarse-loamy, mixed, frigid

Typic Haplorthods), Killington (loamy-skeletal, mixed, frigid Lithic Haplorthods), Marlow (coarse-loamy, mixed, frigid Typic Haplorthods), Peru (coarse-loamy, mixed, frigid Aquic Haplorthods), and Rawsonville (coarse-loamy, mixed, frigid Typic Haplorthods) soils in Windsor County.

DISCUSSION

Imagery of the soil/bedrock interface was considered distinct and interpretable in 55 to 100 percent of the observation sites in each transect. Generally, the imagery was considered distinct in 71 percent of all observation sites. In the remaining 29 percent of the observation sites, interpretations were more difficult as a result of (1) unfavorable soil conditions, (2) the equipment being temporarily out of optimal adjustment for the underlying soil conditions, or (3) the equipment being pushed beyond its limits.

It is hard to impress the merits of techniques such as GPR when anything less than a 100 percent level of confidence is attained. Table 1 is based on a field study, conducted in Washington County, comparing ground-truth auger data with scaled GPR imagery. This table is based on the depth to bedrock at thirty-one observation sites along three transect lines. The transects were conducted in areas of Lords-Bartlett complex, 8 to 15 percent slopes.

Table 1

Frequency distribution of observation sites as measured by traditional and GPR Methods.

Method of Measurements	Depth to Bedrock			
	0-10"	10-20"	20-40"	40-60"
Auger Boring	3%	32%	39%	26%
Radar Imagery	0	26%	55%	19%
Difference	3%	6%	16%	7%

The apparent disparity between the frequency distributions obtained by the two methods is due, in part, to (1) normal observation errors, (2) the highly irregular bedrock surface, and (3) the proximity of many of the measured and scaled depths to critical depths (10, 20, 40, and 60 inches).

Presently, ground-truth soil boring measurement provides the basis upon which the radar imagery is scaled and compared. Regardless of degree of confidence, auger measurements are considered true, while radar imagery inexact. However, auger measurements can and often do contain an inherent degree of error. Measurement errors can be attributed to the habit of rounding off measurements or guesstimating depths, nonvertical probing, and slight spatial discrepancies between the site of auger boring(s) and the radar track. As a result of these and other factors, slight discrepancies often exist between auger measurements and the depth scaled on graphic profiles.

Multiple auger measurements within a 24-inch radius of several observation sites revealed a variation in the depth to bedrock as great as 20 inches. With such variability in the depth to bedrock over short distances, it is improbable the ground-truth measurements and scale radar imagery would match.

Depths to bedrock of 10, 20, 40, and 60 inches differentiate soil depth classes and are series criteria. Of the 31 ground-truth measurements, 45 percent were within 4 inches, 39 percent were within 3 inches, and 29 percent were within 2 inches of one of these critical depths. The close proximity of many measurements to these critical depths, the variable depth to bedrock, and normal observation errors help to explain some of the differences evident in Table 1.

Table II compares the average depth to bedrock as derived by the two methods over the thirty-one observation sites. The variation in data is slightly more than 1 inch and is considered insignificant. The match between auger boring and radar imagery is considered remarkable, and attests to the reliability of the GPR.

Table II
Comparison of Traditional and GPR Methods

Parameters	Methods	
	Auger	GPR
Number of observations	31	31
Average depth to bedrock	29	30.2
Standard deviation	13.9	12.8

The potential application of the GPR will depend upon its need, use, and program development. Compared with traditional sampling methods the GPR is (1) many times faster, (2) minimizes required borings, (3) allows greater areas to be sampled per observation, and (4) is less likely to miss or miscalculate depths to bedrock in deeper zones (greater than 40 inches).

Though portable, the equipment is cumbersome. Unless accessible by trails, long transect in wooded, mountainous areas are impractical with the present radar system. A more practical approach would be short, multiple transects in undisturbed areas adjacent to roads or trails.

RESULTS

Enclosures 1 through 3 provide a statistical summary of the data collected for three map units in Washington and Windsor Counties.

Two map units, Lords-Bartlett complex, 8 to 15 percent slopes (Washington County) and Rawsonville-Killington complex, 15 to 35 percent slopes (Windsor County) have been sampled sufficiently to attain a desirable level of accuracy.

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These enclosures illustrate an established method for grouping similar soils and expressing the confidence level and limits of soils mapped as complexes. While expressions of confidence levels and limits have been discouraged from the nontechnical portions of soil survey reports, statistical information can be included in tabular form in the technical portion or in supplements.

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Enclosures

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