United States Department of Agriculture

Soil Conservation Service

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

Subject: ENG - Sedimentation Survey, Baker River Watershed, New Hampshire, 24-26 February, 1986

Date: March 21, 1986

To: David L. Wussulman
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PURPOSE

To perform reservoir sediment surveys with ground-penetrating radar (GPR) on sites 8 and 11 within the Baker River Watershed.

PARTICIPANTS

Bruce Champeon, Geologist, SCS, NENRPS, Durham, NH
James Doolittle, Soil Specialist (GPR), SCS, Chester, PA
Nick Luhtala, Project Engineer, SCS, Meredith, NH
Dean Sherman, Civil Engineering Technician, SCS, Meredith, NH

Equipment

The equipment used during this field trip was the SIR System-8, the ADTEK SR-8004H graphic recorder, and the ADTEK DT-6688 tape recorder. The 120 MHz antenna with the Model 705DA2 transceiver was used. The scanning time on the control unit was 290 nanoseconds, which, assuming a dielectric constant of 81 for water, provided an approximated scanning depth of 4.8 meters.

The Honda, Model EM600 generator failed to turn-over and to provide a steady source of power for the GPR system in the field on 24 February. The unit was taken into Laconia for repairs. Field operations resumed on the afternoon of 25 February. On the morning of the 26 February, the generator began operating erratically, surging, and outputting 150 volts rather than 120 volts of power. A power surge damaged the Model 06 Power Supply and curtailed further field operations.

As a result of these power-related problems, marine batteries have been purchased to provide a more dependable, portable source of power. The Model 06 Power Supply has been returned to the manufacturer for repairs.

DISCUSSION

This survey represents the first attempt by SCS to monitor lake sedimentation with ground-penetrating radar (GPR). Earlier studies conducted in Florida, Oklahoma, and Texas were exploratory in nature and did not attempt to produce useable data.

Presently, sedimentation in lakes is being measured with the aid of fathometers. Fathometers are highly effective and reliable geophysical tools. The depth of penetration of fathometers is greater than that of the GPR. However, for many of the watershed, monitored by SCS, depths are relatively shallow and depth of penetration is not a concern with either system. Fathometers operate at lower frequencies than GPR and consequently provide poorer resolution of bottom conditions and no sub-bottom information. The fathometer, unlike GPR, can not penetrate ice. Unlike the GPR, it can not take advantage of the speed and flexibility afforded by winter conditions. This study has documented the limitations and advantages of using GPR techniques to perform lake sedimentation surveys.

This study was hindered by several mishaps. We have learned from our mistakes. To measure distances across lakes, a nylon line with markers affixed at ten foot interval was stretched between measured stakes on each shore. Unfortunately, the nylon line stretched under strain and the markers slid along the line making absolute positioning impossible. This design will have to be modified for future operations.

The snowmobile failed to pull the heavily laden equipment sled and antenna sled through the snow (1.5 inches) at slow speeds. Nick Lohtala provided a more suitable sled for pulling the radar system through the snow. Still, the speed of travel across the ice was considered too rapid by the operator who ran beside the equipment.

Slow speeds are necessary as the operator is required to walk (run) beside the antenna sled and depress an event marker as the antenna passes each marker affixed to the nylon line. The event marker impresses a vertical pattern of marks and spaces across the radar's graphic profile at each observation site (see enclosed figure). Latter, depth of measurements were scaled from each of these sites. Slight spatial discrepancies often exist between the sites of measurements, the track of the antenna, and the marks impressed on the graphic profile by the operator. The required speed of advance across the ice added additional error to these measurements.

The portable generator proved to be unsuitable for this operation. As mentioned in the equipment section, repeated failures of the generator to provide a steady source of power for the GPR delayed and eventually curtailed field work. Marine batteries have been purchased as an alternative source of power.

RESULTS

Baker Site 11 was surveyed with the GPR in one hour. An additional hour and one-half was required to obtain 12 ground-truth depth measurements through the ice. This number of observation is normally considered excessive, but were collected to insure the accuracy of the GPR data for this study.

The depths of the 12 ground-truth observations were compared with the scaled depth values on the radar's graphic profile. The enclosed scatter diagram show the near perfect, positive correlation which exists between

the ground truth observations and the scaled depths for the 12 observation sites. The coefficient of determination for these values is extremely high (0.989). The high value is related to the precision of the GPR and to the covariation of the two variables. The regression line approximates a straight line in the scatter diagram except at shallow depth values. The resolution of the 120 MHz antenna is more imperfect at shallow depths and accounts for the slight disparity.

The regression equation of the scatter diagram was used to calculate lake bottom depths at each observation site. Using the regression equation (Depth = 1.08 + 0.0044xscaled value), 85 percent of the observation sites were within 0.2 foot, and 46 percent were within 0.1 foot of the ground truth values. The absolute difference between the ground truth depths and the scaled imagery ranged from 0.0 to 0.6 foot at the 12 sites.

A typical profile of the lake bottom at Baker site #11 is enclosed. The lake bottom has been highlighted with a dark line. The hyperbolic patterns in the upper left-hand corner correspond with auger holes which were drilled through the 2.2 feet of ice. As the radar antenna passed within 2 feet of each of these holes, some side reflections from these holes were picked up and recorded on the radar's profile.

Differences in the bottom sediment can be noted on most profiles. Recently deposited sediments are admixtures of organics, mineral matter, and water. These sediments are less contrasting than the firm earthen materials and produce gray reflections on the graphic profiles.

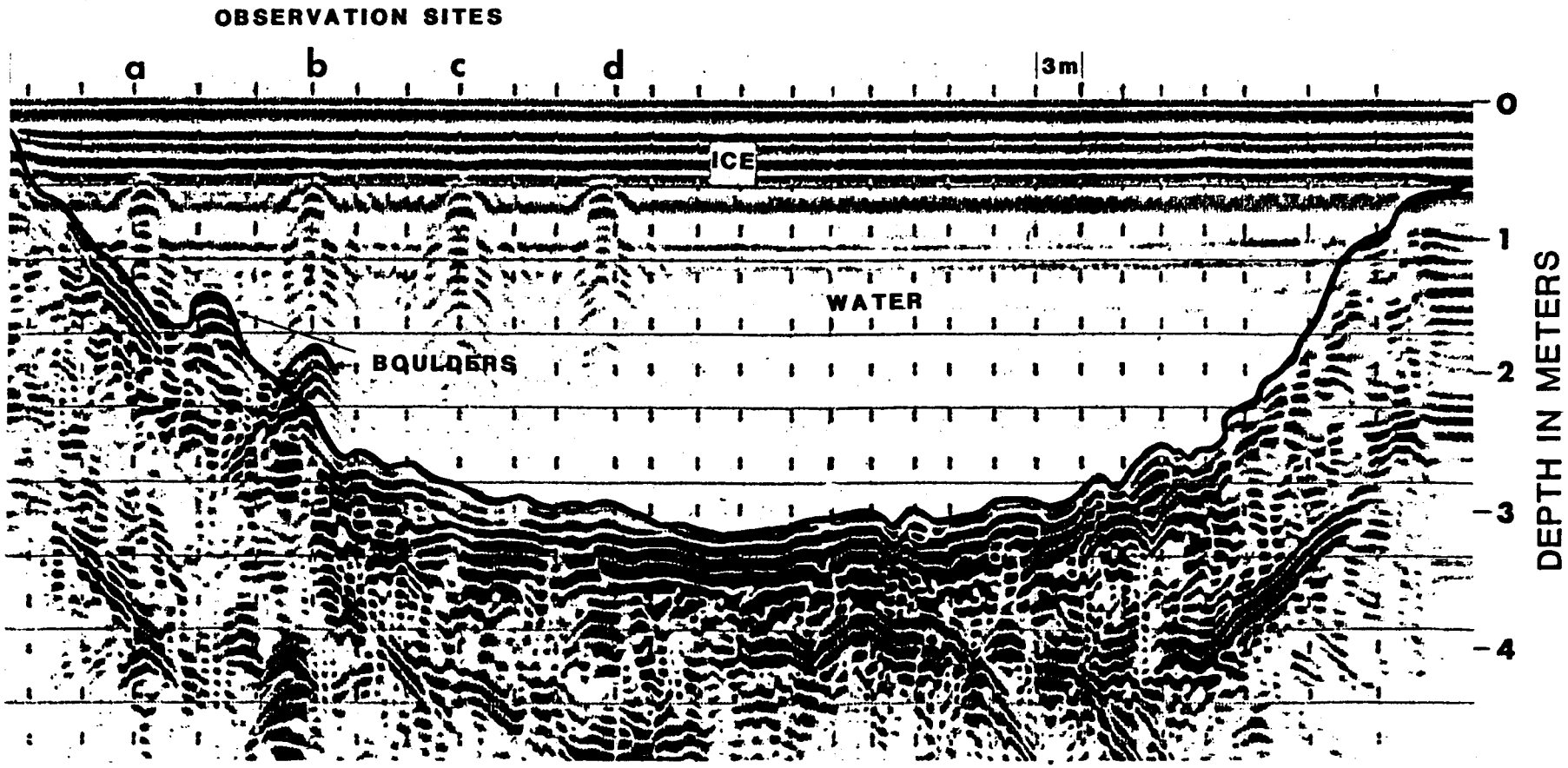
The application of GPR techniques to monitor lake sedimentation in New Hampshire has been established. Compared with fathometer methods, the GPR can be operated on ice and is therefore more flexible and faster. Resolution of lake bottom features is improved with the GPR. The use of the GPR on similar surveys will depend upon refinements in surveying techniques, equipment, and user awareness.

All data has been turned over to Tom Ilvari, Geologist, NENTC, for processing. A complete record of the graphic profiles has been returned to Bruce Champeon under a separate cover letter. Thank you for this opportunity to work in New Hampshire and with members of your staff.

James A. Doolittle,
Soil Specialist (GPR)

cc
A. Holland
B. Champeon

JADoolittle/ef



LAKE BOTTOM PROFILE

BAKER RIVER WATERSHED, NEW HAMPSHIRE