United States Department of Agriculture **Northeast NTC**
Soil Conservation Service **Chester, PA 19013**

Subject: Ground-penetrating radar field study Elkart County, Indiana, April 15-19 1991 Date: 29 April 1991

To: Bobby J. Ward
State Soil Scientist
Soil Conservation Service
6013 Lakeside Boulevard
Indianapolis, Indiana 46278

Purpose:
To explore the potential of using ground-penetrating radar (GPR) techniques to assist soil survey operations in areas of coarse and moderately coarse textured soils in northern Indiana.

Participants:
Rex Brock, Soil Project Leader, SCS, Goshen, IN
James Doolittle, Soil Specialist, SCS, Chester, PA
Franklin Furr, Soil Scientist, SCS, Winamac, IN
Debra Jimison, Earth Team Volunteer, Goshen, IN
Jerry Larson, Soil Specialist, SCS, Indianapolis, IN
Mark, McClain, Consultant, Layfette, IN
Don Ruesch, Area Soil Scientist, SCS, Huntington, IN
Gary Struben, Soil Project Leader, SCS, Muncie, IN
Bobby Ward, State Soil Scientist, SCS, Indianapolis, IN
Tom Ziegler, Area Soil Scientist, SCS, Rensselear, IN

Activities:
I travelled to Goshen, Indiana, 14 April 1991. Field studies were conducted on 15 to 18 April 1991. I returned to Chester, Pennsylvania on 19 April 1991.

Equipment:
The ground-penetrating radar unit used in this study is the Subsurface Interface Radar (SIR) System-8 manufactured by Geophysical Survey Systems, Inc. [1]. Components of the SIR System-8 used in this study were the model 4800 control unit, ADTEK SR 8004H graphic recorder, ADTEK DT 6000 tape recorder, power distribution unit, transmission cable (30 m), and the model 3110 (120 MHz) antenna. The system was powered by a 12-volt vehicular battery.

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1. Use of trade names in this report is for identification purposes only and does not constitute endorsement by the authors or their institutions.

Results:
In the predominantly coarse and moderately-coarse textured soils profiled in northern Elkart County, the ground-penetrating radar provided data to depths of 28 feet or to the water table. Beneath the water table, radar signals were weakly expressed and highly attenuated. It was suspected that highly mineralized ground water absorbed the radar signal.

The GPR was found to be an excellent tool for charting the spatial and temporal variations in the depth to the water table in areas of coarse textured glacial outwash deposits (see enclosed figure). Depths to the water table reported in this study reflect conditions at the time of the survey. Soil scientist observed that the upper limit of the zone of mottling occurred 20 inches above the water table. This observation was confirmed at all sites where the water table was observed in auger borings.

Resolution of most subsurface features occurring within the soil profile was good. In similar soils, the GPR can be used to conduct transect, to increase confidence in site interpretations, and as a quality control tool in soil survey investigations. However, because of the occurrence of numerous, short, segmented soil horizons and strata in areas of Oshtemo and Ormas soils, use of the GPR in these soils would require a prohibitive number of auger borings to identify soil features. The large number of auger observations would negate the utility of the GPR. However, within delineations of Ormas and Oshtemo soils, the GPR did confirm the complexity of soil patterns.

I enjoyed the field work and camaraderie of the Indiana soil scientist who I had the opportunity to work with. Thank you for the opportunity to explore the potential of the GPR in Indiana.

With kind regards.

James A. Doolittle
Soil Specialist

cc:
Jim Culver, Soil Scientist, QAS, NSSC, SCS, Lincoln, NE
Ellis Knox, Head of Staff, SSI, NSSC, SCS, Lincoln, NE
Carolyn Olson, Research Soil Scientist, SSI, NSSC, SCS, Lincoln, NE

Discussion:

Site were selected in areas of coarse and moderately-coarse textured soils formed in glacial outwash deposits in the northern part of Elkart County. The first site was located in the northern half of Section 13, T. 38 N., R. 4 E. An 1100 foot transect line was established across areas of map unit OsA, Oshtemo loamy sands, 0 to 2 percent slopes, and map unit TyB, Tyner loamy sand, 2 to 6 percent slopes. Dominant soils within these map units included Oshtemo (coarse-loamy, mixed, mesic Typic Hapludalfs), Tyner (mixed, mesic Typic Udipsamments), and Ormas (coarse-loamy, mixed, mesic Arenic Hapludalfs) soils.

At Sites 1, the 120 MHz antenna was able to discern the water table. The water table ranged in depths from about 4.5 to 15.8 feet. Generally, because of their higher clay contents, rates of signal attenuation were higher in the Hapludalfs than in Udipsamments. This resulted in weak subsurface reflection in the lower part of the Oshtemo and Ormas profiles. Generally, subsurface reflections were observed throughout the Tyner profiles.

Site 2 was located in the northwest quarter of Section 19, T. 38 N., R. 4 E. A 1550 foot transect line was established across areas of map units OsA, Oshtemo loamy sands, 0 to 2 percent slopes, and TyA, Tyner loamy sand, 0 to 2 percent slopes.

At Sites 1 and 2, interpretations of the radar profiles were made difficult by the numerous, discontinuous strata in the upper part of the soil profiles. On the basis of limited ground truthing, and after reviewing the radar profile, no estimate of the taxonomic composition of Site 1 and Site 2 were made.

Site 3 was located in the southern half of Section 9, T. 38 N., R. 6 E. A 2550 foot transect line was established across an area of map unit OsA, Oshtemo loamy sands, 0 to 2 percent slopes. Observation flags were inserted in the ground at 50 foot intervals along this transect line. Taxonomic composition, as estimated by radar interpretations, was 40 percent Ormas, 29 percent Coloma (mixed, mesic Alfic Udipsamments), 23 percent Oshtemo, 4 percent Spinks (mixed, mesic Psammentic Hapludalfs), and 4 percent Grossarenic Hapludalfs. The average depth to the argillic horizon was 30 inches for Ormas soils and 18 inches for Oshtemo soils.

Coloma soils are excessively drained. However, at Site 3, sixty percent of the Coloma soils had a water table within depths of 80 inches. For the moderately well drained Coloma soils, the water table was at an average depth of 72 inches and ranged from 65 to 78 inches.

Site 4 was located in the southwest quarter of Section 8, T. 38 N., R. 6 E. An 1450 foot transect line was established across areas of map unit PiA, Plainfield fine sand, 0 to 2 percent slopes. This area has been resurveyed as Tyner, wet substratum. Observation flags were inserted in the ground at 50 foot intervals along this transect line.

The taxonomic composition was 93 percent Tyner and 7 percent Coloma soils.

At Site 4, an area of Plainfield fine sand, 0 to 2 percent slopes, had been remapped into Tyner moderately well drained and Tyner somewhat excessively drained delineations. The moderately well drained unit occupied the western 450 foot section of this transect. Here, the water table was at average depth of 82 inches and ranged from 79 to 86 inches. The somewhat excessively drained unit occurred on slightly higher-lying positions within the landscape. Within the somewhat excessively drained delineation, the water table was at average depth of 98 inches and ranged from 94 to 108 inches.

Site 5 was located in the northwest quarter of Section 22, T. 38 N., R. 5 E. A 2750 foot transect line was established across areas of map unit PiA, Plainfield fine sand, 0 to 2 percent slopes, and map unit Br, Brady sandy loam. Observation flags were inserted in the ground at 50 foot intervals along this transect line. The area was remapped into units of moderately well drained Brems (mixed, mesic Aquic Udipsamments) and somewhat poorly drained Tedrow (mixed, mesic Aquic Udipsamments) soils. The purpose of this survey was to determine the depth to the water table beneath each map unit.

In areas of Tedrow soils, the average depth to the water table was 31 inches. In these lower-lying areas, the water table ranged in depth from 24 to 40 inches. In areas of Brems soils, the average depth to the water table was 55 inches. In these slightly higher-lying areas, the water table ranged in depth from 39 to 63 inches.

Site 6 was located in the southwest quarter of Section 11, T. 38 N., R. 5 E. A 1150 foot transect line was established across areas of map unit PiA, Plainfield fine sand, 0 to 2 percent slopes. This area had recently been surveyed as Coloma loamy sand. Observation flags were inserted in the ground at 50 foot intervals along this transect line. The taxonomic composition was 92 percent Coloma and 8 percent Spinks soils. In areas of Coloma soils, the average depth to the water table was 102 inches. The water table ranged in depth from 82 to 123 inches.

Site 7 was located in the southern half of Section 11, T. 38 N., R. 5 E. A 2500 foot transect line was established across an area of map unit PiA, Plainfield fine sand, 0 to 2 percent slopes. This area had recently been remapped into delineations of Coloma and Tyner, wet substratum phase. Observation flags were inserted in the ground at 50 foot intervals along this transect line.

The taxonomic composition within the delineation of Coloma soils was 31 percent Coloma, 25 percent Spinks, 25 percent Tyner (wet substratum) and 19 percent Tyner soils. The taxonomic composition within the delineation of Tyner, wet substratum phase was 91 percent Tyner wet substratum and 9 percent Spinks soils. Within this delineation the observed average depth to the water table was 77 inches with a range of 53 to 104 inches.

Site 8 was located in the northeast quarter of Section 29, T. 38 N., R. 6 E. A 3000 foot transect line was established across areas of Oshtemo loamy sands (map units OsA, OsB, and OsD). Observation flags were inserted in the ground at 50 foot intervals along this transect line.

The transect at Site 8 traversed two large delineations of Oshtemo soils. The taxonomic composition of the units were:

	Unit 1	Unit 2
Ormas	32%	17%
Oshtemo	39%	25%
Tyner, gravelly substratum	29%	58%

Site 9 was located in the northeast quarter of Section 24, T. 38 N., R. 5 E. A 1650 foot (approximated) transect line was established across areas of map unit PiA, Plainfield fine sand, 0 to 2 percent slopes, and map unit TyA, Tyner loam sand, 0 to 2 percent slopes. Observations within the cultivated field were parallel with the approximate location of telephone poles along the field boundary.

Site 9 has been remapped into a unit of Tyner, wet substratum phase. Within this delineation the observed average depth to the water table was 79 inches with a range of 71 to 92 inches.

Site 10 was located in the southeast quarter of Section 13, T. 38 N., R. 5 E. A 1200 foot (approximated) transect line was established across areas which had been resurveyed into units of Tyner, wet substratum phase, Brems, and Tedrow soils. Within these delineations the observed average depth to the water table was 81, 56, and 40 inches for Tyner (wet substratum phase), Brems, and Tedrow soils, respectively. At the time of this survey, the depth to the water table was observed to range from 71 to 90 inches for Tyner soils, 42 to 71 inches for Brems soils, and 34 to 42 inches for Tedrow soils.

Site 11 was located in the southwest quarter of Section 25, T. 36 N., R. 5 E. Random traverses were conducted across areas of map units RsB, Riddles sandy loam, 2 to 6 percent slopes; OsB, Oshtemo loamy sand, 2 to 6 percent slopes; and Rtb2, Riddles loam, 2 to 6 percent slopes,eroded. These soils formed in moderately coarse textured stratified drift over medium textured till.

At Site 11, the effective depth of radar profiling (with the 120 MHz antenna) ranged from about 10 to 28 feet. While the depth of penetration and resolution of the 120 MHz antenna were impressive, radar interpretations proved to be problematic. Areas of eroded soil horizons, colluvium, and soil horizons and subsurface strata of coarser and finer textured materials were evident on the radar profiles. However, the depth to till and the taxonomic identity and composition of the soils at this site were too interpretative for quantification. A prohibitive number of soil borings would be needed at this site to properly identify all of the subsurface reflections appearing within the soil profiles.

At Site 11, numerous, discontinuous strata occurred throughout most soil profiles. Strata were traced over lateral distances ranging from about 10 to over 250 feet. These strata varied in texture and grain sizes. The boundary separating the overlying stratified drift and the underlying till was indistinct (both in the field and on radar profiles). The till appeared to be stratified and water-reworked. This characteristic of the till made separation of the glacial drift deposits exceedingly difficult, if not impossible, on the radar profiles.

Site 12 was located in the southwest quarter of Section 27, T. 37 N., R. 5 E. Two 1050 foot transect lines were established across areas of map unit RsC, Riddles sandy loam, 6 to 12 percent slopes; and CrA, Crosby loam, 2 to 2 percent slopes. This area had recently been resurveyed and contains the typical Martinsville (fine-loamy, mixed, mesic Typic Hapludalfs) soil profile for the soil survey. Observation flags were inserted in the ground at 50 foot intervals along this transect line.

The taxonomic composition along the GPR transect lines were:

	Line 1	Line 2
Martinsville	77	82
Ormas	23	18

In the area transected with the radar, the average depth to the argillic horizon was 17 inches with a range of 9 to 37 inches. In areas of Martinsville soils, the average depth to the argillic horizon was 15 inches with a range of 9 to 19 inches. Other included soils observed in the study area but not traversed by the transect lines were Metea and Coloma soils.

Site 13 was located in the northwest quarter of Section 36, T. 37 N., R. 5 E. This site was on a terrace of the Elkart River. A 2050 foot transect line was established across areas of map units OsA, Oshtemo loamy sand, 0 to 2 percent slopes; and OsB, Oshtemo loamy sand, 2 to 6 percent slopes. Observation flags were inserted in the ground at 50 foot intervals along this transect line.

Soils observed along this transect line included Billet, Guilford (coarse-loamy, mixed, mesic Typic Haplaquolls), and Shipshe (loamy-skeletal, mixed, mesic Typic Argiudolls). As in other outwash areas which had been mapped as Oshtemo soils, interpretations of the radar profiles were exceedingly difficult and "highly interpretative" because of the occurrence of the numerous, short, segmented soil horizons and strata. In addition, the GPR was not able to differentiate calcareous from noncalcareous soils. No interpretation of the radar profile from Site 13 was attempted.

The Goshen News
AGRICULTURE

Soil Scientists Test Space Technology To Update Survey

By JULIA MAST

What does Elkhart County have in common with Vietnam and the moon? Ground penetrating radar.

Soil scientists from Elkhart County, Indianapolis and other states have been trying out a radar system in Elkhart County which helps them to identify soils.

The system was developed for use during the Vietnam war and it has been used on the moon.

"It was developed by the Army for tunnel detection in Vietnam," Jim Doolittle, ground penetrating radar (GPR) specialist from the Chester, Pa., Soil Conservation Service (SCS), explained. "Then NASA used it in the lunar landing to explore the subsurface."

Doolittle, along with Jerry Larson, Indianapolis SCS soil specialist, and Elkhart County SCS soil scientists, Rex Brock, Franklin Furr and Tom Sigler, recently completed a week-long study using GPR to see how well it works and to determine if it can be used in conducting soil surveys.

Elkhart County was chosen because of its northern sandy soils. The county is also completing the first year of a five-year soil survey update.

What does something which has been used on the moon look like? Unassuming at first glance.

An antenna which sends out high frequency signals is housed in a wooden box. The box is dragged behind the soil scientist's truck through the fields.

Inside the truck things get a little more interesting. Mounted behind the front seat is a shelf full of electronic equipment including frequency controls, an electronic simulation of the radar readings and a graphic recorder.

Doolittle said the equipment is worth about $55,000.

As the box is dragged over the land, a fast-acting control switch in the truck sends a burst of energy down the cable connecting the box, and on to the antenna, Doolittle explained. The energy is radiated out into the soil and continues down until it hits an interface, which is a place in the soil that is different than nearby soils.

"Then reflection occurs," Doolittle said. "The amount of reflection depends upon the amount of contrast."

The signal then comes back to the cable and goes through the control unit to be printed out on the graphic recorder.

When operating, there is a whirling noise inside the truck as the equipment operates. As the findings are printed out the printer creates a slight burning smell.

The truck moves at about 2 or 3 mph. Still the pace is faster than soil scientists on foot can work.

On foot, soil scientists must base their interpretations from point to point where they think the soil is uniform. Holes are dug at points of change to verify their findings. "But they can't dig a hole everywhere," Doolittle said. "With this we have a continuous profile of the subsurface. It gives a soil scientist a little bit better understanding and confidence in his interpretations."

In 17 minutes, the GPR sled made a 3,000 foot transection.

Soil scientists hope to use GPR as a quality control tool. "We're testing it out here to see how suitable it is for soil survey investigation for the state and to see if these soil scientists can use it for their work," Doolittle said. "With radar we can increase the quality control and reduce field time by 210 percent."

The equipment whirled as Doolittle demonstrated the GPR in a field belonging to Charles Phillips north of Middlebury recently. "As I move, the paper is coming out with a picture of the subsurface," he said. "There are 120 megahertz of electromagnetic energy being sent down into the soil."

"Here we're looking at the underlying topography of the soil. As I'm going, the radar is recording the subsurface, in this instance going down 20 feet," Doolittle said as he looked at the printout. "There is lots of sand and gravel here. As we go lower here we'll pick up the water table."

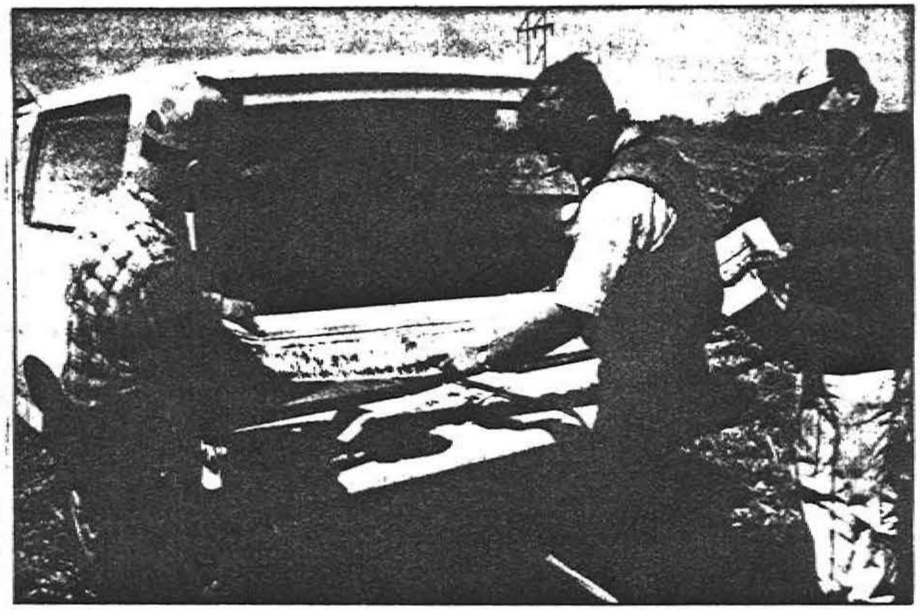
Sitting in back on the gate of the truck, Jerry Larson clicked a button to make marks on the printout. These points are areas where the scientists can go back to dig holes for confirmation.

The printout looked like a series of wavy lines on top of each other. "The first day I was confused," Doolittle confessed. "Basically this picture doesn't tell you anything unless we can put soil names on it. It was hard to get oriented to the soils in this county. Some of the soils are highly complex and variable over short distances."

"There's a lot of give and take this week," he continued. "Right now this is definitely a learning experience. Each and every one of these soil scientists is making a judgment on whether this can be used in their line of work. It appears that it can."

The GPR is already used in Florida and Massachusettes. Doolittle said in Indiana the use will be fairly restricted because of the amount of course-textured soils.

Doolittle travels nationwide to demonstrate and try out the technology.



Elkhart County soil scientist, Rex Brock, left, looks at the soil profile printout with Jim Doolittle, a ground penetrating radar specialist from the Chester, Pa., Soil Conservation Service. The radar was tested in Elkhart County recently. Also shown is Jerry Larson, soil specialist from the Indianapolis Soil Conservation Service office.

(News Photos by Julia Mast)

Larson rides on tailgate as the radar antenna is dragged through the field. The wooden box, or sled, protects the device.

Pesticide Safety Is A Must At Planting

Ag Line

By DALE REDDING
LaGrange Co. Ag Agent

With the increasing number of pesticides becoming classified as "restricted use" pesticides because of their toxicity or long residual effectiveness, most farmers have spent six hours in special private applicator training meetings to be licensed to purchase and use them.

Safe use of pesticides begins with knowing which pest you are controlling or preventing and reading the label to be sure that it is the correct product for that use.

Generally the chemical dealer or crop care consultant will assist in product appropriateness, but the operator needs to read the label nonetheless.

The label should be read thoroughly to be aware of the use and storage guidelines, needed personal safety protection equipment and first aid procedures, the use rates and application procedures before the day of application.

Personal safety equipment and a first aid kit should also be readied before the time they are needed.

Storage areas for pesticides should be separated from feed or other storage areas, secured with a lock, well-marked and with a leak-proof floor and freeze-proof if liquid formulations are kept.

The spraying system should be calibrated before and regularly during the spraying season, and filling should take place at least 100 feet from the well and any rinseade should be included in the spray solution left around the farm.

The pesticide safety plan should include:

- Reading the pesticide label thoroughly.
- Having well-informed family members; account for children.
- A list of pesticides being used.
- A properly stocked first aid kit, which includes a quarter and a phone number of the EMS and poison control center.
- A container of clean water and soap in the field, appropriate safety gear for handling that product.
- Smoking, restroom and eating safety habits.
- Pesticide transportation proce...