UXO Standardized Test Site: APG Soils Description

Data Summary
May 2002

Janet E. Simms and Robert Larson
Geosciences and Structures Division
Geotechnical and Structures Laboratory
U.S. Army Engineer Research and Development Center
Vicksburg, Mississippi

Thomas E. Backes
German Military Geologist
Pionierschule Muenchen, Germany

SOIL SAMPLING and TESTING PROCEDURES

Soil Collection

Both continuous core and surface soil samples were acquired over the site. Sixteen surface samples (GB-1 to 16) were interspersed amongst the 13 core locations (GP-1 to 13) (Figure 1). The sample locations were initially placed within the boundaries of the Open Field. However, modifications to the boundary after the soil samples were obtained leave some samples outside the present boundary of the test site.

The surface samples comprise the first 5cm of soil. They were acquired by first removing the surface vegetation and then using a clean shovel to collect the soil. Enough soil was acquired to fill a quart-size plastic bag. The soil was immediately double-bagged in resealable plastic freezer bags and labeled.

The soil cores were acquired using a Geoprobe system. At each core location a 5cm diameter continuous soil core 3m in length was acquired in three 1m sections. The soil core was placed in a plastic tube during the drilling process and the ends of each section capped upon extrusion. Each core tube was labeled identifying the core location and depth.

Laboratory Tests

Several laboratory tests were performed on the surface soil samples and soil cores. The water content was determined for all surface samples and each surface sample was subjected to a sieve analysis and magnetic susceptibility measurements. Magnetic susceptibility measurements were also acquired along the length of each core section. Individual soil samples were then extracted from the cores at depths of 5, 10, 25, 50, 100, 150, 200, 250, and 300cm. Water content, sieve/hydrometer, and magnetic susceptibility tests were conducted on all but the 10cm core samples. Of these samples, dielectric permittivity measurements were performed on the 10, 25, 100, and 200cm samples. Three samples representative of the clay, silt, and sand were selected for X-ray diffraction analysis. Table 1 summarizes the laboratory tests performed on each soil sample.

Table 1. Laboratory Tests Performed on Soil Samples					
Sample	Water Content	Sieve/Hydrometer	Magnetic Susceptibility	Dielectric Permittivity	X-Ray Diffraction
GB-1 to GB-16	X	X	X		
GP-1 to GP-13 cores			X		
GP-1 to GP-13 0.05m	X	X	X		
0.10m				X	
0.25m	X	X	X	X	
0.50m	X	X	X		
1.00m	X	X	X	X	
1.50m	X	X	X		
2.00m	X	X	X	X	
2.50m	X	X	X		
3.00m	X	X	X		
GP-2 0.05m					X
GP-7 0.05m					X
GP-11 3.00m					X

The water content and sieve and hydrometer analysis were performed following standard laboratory practices (U.S. Army Corps of Engineers 1970). The dielectric permittivity test procedure is described in Curtis (2002). The magnetic susceptibility data were acquired following the procedure described by Dearing (1999). Interpretation of X-ray patterns was accomplished using JADE (Materials Data, Inc. X-ray pattern processing software) and the International Center for Diffraction Data (ICDD) PDF database. Test procedures and analysis of data were based on Brindley and Brown (1980), Klug and Alexander (1974), and those recommended by the Concrete and Materials Branch, Geotechnical and Structures Laboratory, ERDC.

SOIL ANALYSIS

Sieve, Hydrometer, and Water Content

Results of the water content and sieve/hydrometer tests are summarized in Tables 2 and 3 for the surface and core samples, respectively. The majority of soil to a depth of 3m consists of at least 90% fines. Those having less than 90% fines have a greater concentration of sand present in the 1.5m to 3m samples. Plasticity tests were not performed on the samples so the soil description is based on a visual classification. Tables 4 and 5 give the soil type based on the USDA soil classification. Using this system, 70% of the samples are classified as a silt loam (Table 6). Addition of clay in the soil generally occurs shallower than 1m whereas any sand present in the samples is present at depths at or greater than 2m.

The majority (77%) of soil samples have a measured water content between 15 and 30% with most samples between 20-25%. The water content tends to decrease slightly with depth. The surface samples (5cm depth) collected in the wooded area (GP-3, GP-4, GB-3) have a significantly greater water content (> 40%) than those in the open field.

Dielectric Permittivity

Dielectric permittivity is a fundamental parameter for electromagnetic instruments that operate in and above the megahertz range, such as ground penetrating radar (GPR). A complete description of all dielectric permittivity measurements, graphs, and tables is found in Curtis

(2002). Presented here is a summary of that data. Figure 2(GP7) is an example of the data acquired and illustrates the frequency dependency of the soils. The soil conductivity, power attenuation, and phase velocity all increase with increasing frequency. A comparison of the soil samples and how they vary with moisture content for frequencies of 10 MHz, 100 MHz, 300 MHz, and 1000 MHz is shown in Figures 3-6, respectively. Only plots of power attenuation and normalized phase velocity are presented. Those of the real and imaginary component of the relative dielectric permittivity, conductivity, and loss tangent are in Curtis (2002). The greatest variation in power attenuation is seen at low moisture contents, < 10%. At the water content levels (15 to 30%) typically encountered within the APG Standardized UXO Test Site, the power attenuation can vary by an order of magnitude. The range of variation tends to decrease as frequency increases, however the absolute value of attenuation is greater at higher frequencies; 1 to 10 dB/m at lower frequencies versus 10 to 50 dB/m at higher frequencies.

The normalized phase velocity is indirectly related to the real component of the dielectric constant. Therefore, as the moisture content increases, the normalized phase velocity decreases (Figure 7). There is an obvious difference in the 10 MHz and 100 MHz curves but little

Table 2. Summary of Sieve and Hydrometer Analysis, Surface Samples

Sample	Depth (m)	Visual Classification	Color	% Gravel	% Sand	% Fines	Specific Gravity of Solids (est.)	Water Content
GB-1	surface	Clay	Gray	0	1.4	98.6	2.62	28.6
GB-2	surface	Clay	Gray	0	1.4	98.6	2.65	29.1
GB-3	surface	Clay	Gray	0	1.9	98.1	2.61	42.0
GB-4	surface	Clay	Gray	0	1.8	98.2	2.67	17.6
GB-5	surface	Clay	Gray	0	2.3	97.7	2.63	25.6
GB-6	surface	Clay	Gray	0	2.0	98.0	2.64	22.1
GB-7	surface	Clay, trace of sand	Gray	0	3.3	96.7	2.66	24.5
GB-8	surface	Clay, trace of sand	Gray	0	4.3	95.7	2.66	22.2
GB-9	surface	Clay	Gray	0	2.5	97.5	2.65	16.6
GB-10	surface	Clay with sand	Gray	0	6.7	93.3	2.62	20.7
GB-11	surface	Clay, trace of sand	Gray	0	3.9	96.1	2.66	25.6
GB-12	surface	Clay	Gray	0	2.0	98.0	2.66	27.2
GB-13	surface	Clay with sand	Gray	0	5.0	95.0	2.63	11.2
GB-14	surface	Clay	Gray	0	2.9	97.1	2.68	17.8
GB-15	surface	Clay, trace of sand	Gray	0	3.8	96.2	2.66	15.8
GB-16	surface	Clay, trace of sand	Gray	0	3.1	96.9	2.66	23.9

Table 3. Summary of Sieve and Hydrometer Analysis, Core Samples

Sample	Depth (m)	Visual Classification	Color	% Gravel	% Sand	% Fines	Specific Gravity of Solids (est.)	Water Content
GP-1	0.05	Silt, trace of sand	Brown	0	3.1	96.9	2.68	19.3
	0.25	Silt	Gray	0	1.0	99.0	2.68	18.9
	0.5	Silt	Gray	0	0.6	99.4	2.68	21.8
	1.0	Silt	Gray	0	0.6	99.4	2.68	21.5
	1.5	Silt	Gray	0	0.5	99.5	2.68	23.5
	2.0	Silt, trace of sand	Brown	0	3.2	96.8	2.68	25.0
	2.5	Silt with sand	Gray	0	5.1	94.9	2.68	51.9
	3.0	Sandy silt	Gray	0	16.9	83.1	2.68	16.3
GP-2	0.1	Silt	Gray	0	2.6	97.4	2.68	28.2
	0.25	Silt	Gray	0	1.1	98.9	2.68	22.2
	0.5	Silt	Gray	0	0.8	99.2	2.68	18.6
	1.0	Silt	Brown	0	0.7	99.3	2.68	19.9
	1.5	Silt	Gray	0	1.4	98.6	2.68	21.4
	2.0	Silt	Gray	0	1.1	98.9	2.68	84.4
	2.5	Silt with sand	Gray	0	10.6	89.4	2.68	21.0
	3.0	Sandy silt	Gray	0	28.3	71.7	2.68	17.2
GP-3	0.05	Silt, trace of sand	Brown	0	3.1	96.9	2.68	52.1
	0.25	Silt	Gray	0	1.4	98.6	2.68	25.2
	0.5	Silt	Gray	0	1.3	98.7	2.68	24.5
	1.0	Silt	Gray	0	1.0	99.0	2.68	22.7
	1.5	Silt	Brown	0	2.7	97.3	2.68	25.2
	2.0	Silt	Gray	0	2.0	98.0	2.68	?101
	2.5	Silt with sand	Gray	0	5.4	94.6	2.68	30.6
	3.0	Silt with sand	Gray	0	10.1	89.9	2.68	25.9
GP-4	0.05	Silt with sand	Gray	0	5.6	94.4	2.68	57.9
	0.25	Silt	Gray	0	1.9	98.1	2.68	27.5
	0.5	Silt	Gray	0	2.6	97.4	2.68	27.6

Table 3. Summary of Sieve and Hydrometer Analysis, Core Samples

Sample	Depth (m)	Visual Classification	Color	% Gravel	% Sand	% Fines	Specific Gravity of Solids (est.)	Water Content
GP-4	1.0	Silt	Gray	0	1.5	98.5	2.68	19.4
	1.5	Silt, trace of sand	Gray	0	3.7	96.3	2.68	92.6?
	2.0	Silt, trace of sand	Gray	0	3.8	96.2	2.68	25.2
	2.5	Sandy silt	Brown	0	16.2	83.8	2.68	17.1
	3.0	Sandy silt	Brown	0	46.0	54.0	2.68	17.7
GP-5	0.05	Silt	Gray	0	1.8	98.2	2.68	31.0
	0.25	Silt	Gray	0	1.0	99.0	2.68	197
	0.5	Silt	Gray	0	0.8	99.2	2.68	31.9
	1.0	Silt	Gray	0	0.6	99.4	2.68	21.5
	1.5	Silt	Gray	0	1.6	98.4	2.68	20.5
	2.0	Sandy silt	Gray	0	12.6	87.4	2.68	?113
	2.5	Sandy silt	Gray	0	16.7	83.3	2.68	16.7
	3.0	Silt with sand	Gray	0	6.1	93.9	2.68	20.6
GP-6	0.05	Silt	Gray	0	2.7	97.3	2.68	27.5
	0.25	Silt	Gray	0	1.2	98.8	2.68	21.7
	0.5	Silt	Gray	0	0.9	99.1	2.68	20.0
	1.0	Clay	Brown	0	0.6	99.4	2.70	31.8
	1.5	Clay	Brown	0	0.7	99.3	2.70	32.6
	2.0	Clay	Brown	0	1.1	98.9	2.70	58.0
	2.5	Clay with sand	Gray	0	9.0	91.0	2.70	22.8
	3.0	Sandy silt	Gray	0	16.0	84.0	2.68	15.4
GP-7	0.05	Clay	Gray	0	1.9	98.1	2.70	32.7
	0.25	Clay	Brown	0	1.4	98.6	2.70	21.1
	0.5	Clay	Brown	0	1.4	98.6	2.70	22.0
	1.0	Clay	Brown	0	1.9	98.1	2.70	18.0
	1.5	Sandy clay	Brown	0	13.9	86.1	2.70	18.7
	2.0	Clay with sand	Brown	0	5.6	94.4	2.70	20.7

Table 3. Summary of Sieve and Hydrometer Analysis, Core Samples

Sample	Depth (m)	Visual Classification	Color	% Gravel	% Sand	% Fines	Specific Gravity of Solids (est.)	Water Content
GP-7	2.5	Clay, trace of sand	Brown	0	3.1	96.9	2.70	16.8
	3.0	Clay with sand	Brown	0	8.5	91.5	2.70	17.8
GP-8	0.05	Clay	Gray	0	1.5	98.5	2.70	56.1
	0.25	Clay	Brown	0	0.7	99.3	2.70	30.2
	0.5	Clay	Brown	0	1.8	98.2	2.70	23.8
	1.0	Clay	Brown	0	2.9	97.1	2.70	22.9
	1.5	Sandy clay	Brown	0	28.7	71.3	2.70	18.1
	2.0	Sandy clay	Brown	0	20.8	79.2	2.70	21.7
	2.5	Clay with sand	Gray	0	7.9	92.1	2.70	54.8
	3.0	Clay	Gray	0	2.3	97.7	2.70	20.4
GP-9	0.05	Clay, trace of sand	Brown	0	3.0	97.0	2.70	18.1
	0.25	Clay	Brown	0	2.1	97.9	2.70	18.6
	0.5	Clay	Brown	0	1.0	99.0	2.70	20.5
	1.0	Clay with sand	Brown	0	6.5	93.5	2.70	20.6
	1.5	Clay with sand	Gray	0	10.7	89.3	2.70	53.4
	2.0	Sandy clay	Gray	0	21.5	78.5	2.70	15.7
	2.5	Sandy clay	Brown	0	41.3	58.7	2.70	20.5
	3.0	Sandy clay	Brown	0	37.2	62.8	2.70	21.4
GP-10	0.05	Clay	Gray	0	2.5	97.5	2.70	26.5
	0.25	Clay	Brown	0	1.2	98.8	2.70	22.9
	0.5	Clay	Brown	0	1.4	98.6	2.70	25.8
	1.0	Clay	Brown	0	2.9	97.1	2.70	5.5
	1.5	Clay, trace of sand	Brown	0	3.9	96.1	2.70	25.1
	2.0	Sandy clay	Brown	0	34.9	65.1	2.70	18.4
	2.5	Sandy clay	Brown	0	16.1	83.9	2.70	22.9
	3.0	Sandy silt	Brown	0	16.7	83.3	2.70	20.8

Table 3. Summary of Sieve and Hydrometer Analysis, Core Samples

Sample	Depth (m)	Visual Classification	Color	% Gravel	% Sand	% Fines	Specific Gravity of Solids (est.)	Water Content
GP-11	0.05	Clay	Gray	0	2.8	97.2	2.70	24.6
	0.25	Clay	Brown	0	1.1	98.9	2.70	21.2
	0.5	Clay	Brown	0	1.2	98.8	2.70	22.3
	1.0	Clay	Brown	0	2.7	97.3	2.70	19.6
	1.5	Sandy clay	Brown	0	24.2	75.8	2.70	15.7
	2.0	Sandy silt	Brown	0	46.9	83.1	2.68	15.5
	2.5	Sandy silt	Brown	0	33.1	66.9	2.68	19.1
	3.0	Sand	Brown	0	96.6	3.4	2.65	1.7
GP-12	0.05	Clay with sand	Gray	0	7.8	92.2	2.70	35.8
	0.25	Clay	Brown	0	1.6	98.4	2.70	22.9
	0.5	Clay	Brown	0	1.3	98.7	2.70	24.9
	1.0	Clay	Brown	0	1.0	99.0	2.70	5.4
	1.5	Clay with sand	Brown	0	10.8	89.2	2.70	20.4
	2.0	Sandy clay	Brown	0	20.4	79.6	2.70	20.7
	2.5	Sandy clay	Brown	0	19.0	81.0	2.70	19.7
	3.0	Sandy silt	Brown	0	43.1	56.9	2.68	16.5
GP-13	0.05	Clay	Gray	0	2.8	97.2	2.70	25.1
	0.25	Clay	Brown	0	1.5	98.5	2.70	21.7
	0.5	Clay	Brown	0	1.2	98.8	2.70	23.3
	1.0	Clay, trace of sand	Brown	0	4.8	95.2	2.70	18.9
	1.5	Sandy clay	Brown	0	31.2	68.8	2.70	14.9
	2.0	Silty sand	Brown	0	51.5	48.5	2.68	18.0
	2.5	Sandy clay	Brown	0	18.5	81.5	2.70	18.5
	3.0	Silty sand	Brown	0	52.9	47.1	2.68	14.1

Table 4. USDA Soil Type Based on Sieve and Hydrometer Analysis, Surface Samples

Sample	Depth (m)	% > 2mm	% > 0.05mm	% > 0.002mm	% Sand	% Silt	% Clay	USDA Soil Type
GB-1	surface	0	13	89.5	1.4	98.6	2.62	Silt loam
GB-2	surface	0	18	82.5	1.4	98.6	2.65	Silt loam
GB-3	surface	0	13	89	1.9	98.1	2.61	Silt loam
GB-4	surface	0	12	91	1.8	98.2	2.67	Silt loam
GB-5	surface	0	13	93	2.3	97.7	2.63	Silt loam
GB-6	surface	0	13	93	2.0	98.0	2.64	Silt loam
GB-7	surface	0	16	89	3.3	96.7	2.66	Silt loam
GB-8	surface	0	14	91	4.3	95.7	2.66	Silt loam
GB-9	surface	0	12	91	2.5	97.5	2.65	Silt loam
GB-10	surface	0	16	92	6.7	93.3	2.62	Silt loam
GB-11	surface	0	14	92	3.9	96.1	2.66	Silt loam
GB-12	surface	0	12	87.5	2.0	98.0	2.66	Silt loam
GB-13	surface	0	14	92	5.0	95.0	2.63	Silt loam
GB-14	surface	0	13	91	2.9	97.1	2.68	Silt loam
GB-15	surface	0	16	92	3.8	96.2	2.66	Silt loam
GB-16	surface	0	12.5	91	3.1	96.9	2.66	Silt loam

Table 5. USDA Soil Type Based on Sieve and Hydrometer Analysis, Core Samples

Sample	Depth (m)	% > 2mm	% > 0.05mm	% > 0.002mm	% Sand	% Silt	% Clay	USDA Soil Type
GP-1	0.05	0	14	86	14	72	14	Silt loam
	0.25	0	10	82	10	72	18	Silt loam
	0.5	0	8	71	8	63	29	Silty clay loam
	1.0	0	11	82	11	71	18	Silt loam
	1.5	0	20	86	20	66	14	Silt loam
	2.0	0	28	88	28	60	12	Silt loam
	2.5	0	49	86	49	37	14	Loam
	3.0	0	24	82	24	58	18	Silt loam
GP-2	0.1	0	17	94	17	77	6	Silt loam
	0.25	0	13	90	13	77	10	Silt loam
	0.5	0	14	76	14	62	24	Silt loam
	1.0	0	7	84	7	77	16	Silt loam
	1.5	0	16	84	16	68	16	Silt loam
	2.0	0	29.5	97	29.5	67.5	3	Silt loam
	2.5	0	31	82	31	51	18	Silt loam
	3.0	0	48	87.5	48	39.5	12.5	Loam
GP-3	0.05	0	17	92	17	75	8	Silt loam
	0.25	0	14	79.5	14	65.5	20.5	Silt loam
	0.5	0	14	74	14	60	26	Silty clay loam
	1.0	0	12.5	85.5	12.5	73	14.5	Silt loam
	1.5	0	18	82	18	64	18	Silt loam
	2.0	0	57	93	57	36	7	Sandy loam
	2.5	0	14	79	14	65	21	Silt loam
	3.0	0	25	82	25	57	18	Silt loam
GP-4	0.05	0	24	92	24	68	8	Silt loam
	0.25	0	17	79.5	17	62.5	20.5	Silt loam
	0.5	0	12	81	12	69	19	Silt loam
	1.0	0	17	84	17	67	16	Silt loam

Table 5. USDA Soil Type Based on Sieve and Hydrometer Analysis, Core Samples

Sample	Depth (m)	% > 2mm	% > 0.05mm	% > 0.002mm	% Sand	% Silt	% Clay	USDA Soil Type
	1.5	0	46	92.5	46	46.5	7.5	Loam
	2.0	0	19	77.5	19	58.5	22.5	Silt loam
	2.5	0	34.5	84.5	34.5	50	15.5	Silt loam
	3.0	0	62	91	62	29	9	Sandy loam
GP-5	0.05	0	20	94	20	74	6	Silt loam
	0.25	0	11	77	11	66	23	Silt loam
	0.5	0	15	71	15	56	29	Silty clay loam
	1.0	0	11	86	11	75	14	Silt loam
	1.5	0	21	88	21	67	12	Silt loam
	2.0	0	57	92	57	35	8	Sandy loam
	2.5	0	41	83	41	42	17	Loam
	3.0	0	17.5	79.5	17.5	62	20.5	Silt loam
GP-6	0.05	0	22	92	22	70	8	Silt loam
	0.25	0	12	88	12	76	12	Silt loam
	0.5	0	13	80	13	67	20	Silt loam
	1.0	0	9	66	9	57	34	Silty clay loam
	1.5	0	12	79.5	12	67.5	20.5	Silt loam
	2.0	0	12	79	12	67	21	Silt loam
	2.5	0	24	78	24	54	22	Silt loam
	3.0	0	29	80	29	51	20	Silt loam
GP-7	0.05	0	17	93	17	76	7	Silt loam
	0.25	0	10.5	81	10.5	70.5	19	Silt loam
	0.5	0	16	79.5	16	63.5	20.5	Silt loam
	1.0	0	22	86	22	64	14	Silt loam
	1.5	0	27	77	27	50	23	Silt loam
	2.0	0	21	82.5	21	61.5	17.5	Silt loam
	2.5	0	16	77.5	16	61.5	22.5	Silt loam
	3.0	0	30	81	30	51	19	Silt loam

Table 5. USDA Soil Type Based on Sieve and Hydrometer Analysis, Core Samples

Sample	Depth (m)	% > 2mm	% > 0.05mm	% > 0.002mm	% Sand	% Silt	% Clay	USDA Soil Type
GP-8	0.05	0	17	90	17	73	10	Silt loam
	0.25	0	12	71	12	59	29	Silty clay loam
	0.5	0	15	81	15	66	19	Silt loam
	1.0	0	26	89	26	63	11	Silt loam
	1.5	0	48	84	48	36	16	Loam
	2.0	0	35	83	35	48	17	Loam
	2.5	0	28	86	28	58	14	Silt loam
	3.0	0	12	78	12	66	22	Silt loam
GP-9	0.05	0	20	88	20	68	12	Silt loam
	0.25	0	39	86	39	47	14	Loam
	0.5	0	20	84	20	64	16	Silt loam
	1.0	0	29	84	29	55	16	Silt loam
	1.5	0	22	84	22	62	16	Silt loam
	2.0	0	32.5	82	32.5	49.5	18	Loam
	2.5	0	56	88	56	32	12	Sandy loam
	3.0	0	55	89	55	34	11	Sandy loam
GP-10	0.05	0	13	92.5	13	79.5	7.5	Silt loam
	0.25	0	13	77	13	64	23	Silt loam
	0.5	0	12	78	12	66	22	Silt loam
	1.0	0	17	89	17	72	11	Silt loam
	1.5	0	27	84	27	57	16	Silt loam
	2.0	0	49	87	49	38	13	Loam
	2.5	0	27	82.5	27	55.5	17.5	Silt loam
	3.0	0	36	85	36	49	15	Loam
GP-11	0.05	0	20	92.5	20	72.5	7.5	Silt loam
	0.25	0	17.5	80	17.5	62.5	20	Silt loam
	0.5	0	15	82	15	67	18	Silt loam
	1.0	0	16	84	16	68	16	Silt loam

Table 5. USDA Soil Type Based on Sieve and Hydrometer Analysis, Core Samples

Sample	Depth (m)	% > 2mm	% > 0.05mm	% > 0.002mm	% Sand	% Silt	% Clay	USDA Soil Type
	1.5	0	42.5	84.5	42.5	42	15.5	Loam
	2.0	0	61	89.5	61	28.5	10.5	Sandy loam
	2.5	0	48	87.5	48	39.5	12.5	Loam
	3.0	0	9	97.5	9	88.5	2.5	Silt
GP-12	0.05	0	24	93	24	69	7	Silt loam
	0.25	0	16	78	16	62	22	Silt loam
	0.5	0	12	87	12	75	13	Silt loam
	1.0	0	16	85	16	69	15	Silt loam
	1.5	0	26	85	26	59	15	Silt loam
	2.0	0	39	82.5	39	43.5	17.5	Loam
	2.5	0	36	83	36	47	17	Loam
	3.0	0	57.5	89	57.5	31.5	11	Sandy loam
GP-13	0.05	0	15	91	15	76	9	Silt loam
	0.25	0	13	79	13	66	21	Silt loam
	0.5	0	15.5	78	15.5	62.5	22	Silt loam
	1.0	0	17	82	17	65	18	Silt loam
	1.5	0	41	88	41	47	12	Loam
	2.0	0	62	83	62	21	17	Sandy loam
	2.5	0	38	84	38	46	16	Loam
	3.0	0	64	92	64	28	8	Sandy loam

Table 6. Summary of Soil Types, Core Samples

	Number of Samples at Depth (m)										
Soil Type	**0.05**	**0.10**	**0.25**	**0.50**	**1.00**	**1.50**	**2.00**	**2.50**	**3.00**	**Total**	**% of Total**
Silt	0	--	0	0	0	0	0	0	1	1	1.0
Silt loam	12	1	11	10	12	9	5	7	6	73	70.2
Silty clay loam	0	--	1	3	1	0	0	0	0	5	4.8
Sandy loam	0	--	0	0	0	0	4	1	4	9	8.7
Loam	0	--	1	0	0	4	4	5	2	16	15.3

difference is observed between the higher frequency plots. This is a reflection in behavior of the real component of the dielectric constant (Figure 2).

Magnetic Susceptibility

The magnetic susceptibility of a material represents the degree to which the material can be magnetized. For a soil or rock, it is dependent on the amount of magnetic minerals present. The soils present within the first 3m of the surface of this site are considered to have a very weak magnetic susceptibility. Measured mass susceptibility values for the surface samples and individual core samples are listed in Tables 7 and 8, respectively. The surface soil samples on the eastern section of the site (GB-10, GB-12 to GB-16, GP-9 to GP-13) exhibit susceptibility values as much as ten times greater than the rest of the site. The magnetic susceptibility is also higher at depth within cores GP-10 to GP-13. Although these values are much higher, they still are classified as having a weak magnetic susceptibility.

X-Ray Diffraction

Identification of the mineral constituents in three soil samples visually classified as clay, silt, and sand was accomplished through X-ray diffraction. Under the USDA classification the clay and silt samples are described as silt loam whereas the sand sample is silt. Results of the analysis are plotted in Figure 8. The clay and silt sample have nearly identical mineralogical makeup with the silt sample lacking the potassium feldspar (Table 9). Clay minerals that may be present in these two samples are kaolinite and vermiculite. The sand sample contains primarily quartz and plagioclase feldspar, with some clay (illite, general term for mica-like clay minerals).

References

Curtis, J.O. 2002. "Dielectric properties of soils from Aberdeen Proving Ground, MD," Unpublished Data Report, 27 March 2002, US Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, Mississippi.

Dearing, J. 1999. Environmental magnetic susceptibility. Using the Bartington MS2 system. Chi Publishing, England.

U.S. Army Corps of Engineers 1970. Laboratory soils testing, Engineering Manual EM 1110-2-1906, 30 November 1970 with Change 2 dated 20 August 1986, U.S. Army Corps of Engineers, Washington, DC.

Table 7. Mass Magnetic Susceptibility, Surface Samples

Location	Depth (m)	Mass Magnetic Susceptibility ($x10^{-5}$) SI
GB-1	surface	3.0
GB-2	surface	4.2
GB-3	surface	2.8
GB-4	surface	3.9
GB-5	surface	5.1
GB-6	surface	7.5
GB-7	surface	9.1
GB-8	surface	4.0
GB-9	surface	3.6
GB-10	surface	17.8
GB-11	surface	6.6
GB-12	surface	12.8
GB-13	surface	27.2
GB-14	surface	26.0
GB-15	surface	42.5
GB-16	surface	34.0

Table 8. Mass Magnetic Susceptibility, Core Samples

Location	Depth (m)	Mass Magnetic Susceptibility ($x10^{-5}$) SI
GP-1	0.05	4.5
	0.25	3.2
	0.5	3.3
	1.0	5.9
	1.5	5.8
	2.0	4.7
	2.5	3.6
	3.0	3.7
GP-2	0.1	--
	0.25	2.9
	0.5	5.6
	1.0	6.8
	1.5	5.1
	2.0	2.6
	2.5	2.9
	3.0	4.2
GP-3	0.05	2.9
	0.25	4.5
	0.5	5.5
	1.0	5.8
	1.5	6.4
	2.0	1.3
	2.5	4.5
	3.0	4.5
GP-4	0.05	4.4
	0.25	4.8
	0.5	3.7
	1.0	3.8
	1.5	2.9
	2.0	3.6
	2.5	4.3
	3.0	3.4
GP-5	0.05	4.2
	0.25	5.0
	0.5	4.7
	1.0	5.0
	1.5	4.4
	2.0	2.7
	2.5	4.3
	3.0	6.0
GP-6	0.05	11.1
	0.25	8.1
	0.5	2.8

Table 8. Mass Magnetic Susceptibility, Core Samples

Location	Depth (m)	Mass Magnetic Susceptibility ($x10^{-5}$) SI
	1.0	7.3
	1.5	5.0
	2.0	5.9
	2.5	3.2
	3.0	4.7
GP-7	0.05	5.9
	0.25	5.7
	0.5	5.8
	1.0	5.8
	1.5	3.2
	2.0	6.6
	2.5	4.8
	3.0	6.0
GP-8	0.05	3.8
	0.25	6.1
	0.5	6.2
	1.0	5.0
	1.5	18.5
	2.0	13.3
	2.5	3.1
	3.0	5.5
GP-9	0.05	40.1
	0.25	22.9
	0.5	6.4
	1.0	9.3
	1.5	2.9
	2.0	3.4
	2.5	13.6
	3.0	8.2
GP-10	0.05	35.2
	0.25	43.3
	0.5	24.8
	1.0	10.9
	1.5	16.1
	2.0	19.6
	2.5	21.0
	3.0	14.3
GP-11	0.05	20.8
	0.25	18.5
	0.5	6.3
	1.0	22.8
	1.5	14.4
	2.0	8.4
	2.5	10.4

Table 8. Mass Magnetic Susceptibility, Core Samples

Location	Depth (m)	Mass Magnetic Susceptibility ($x10^{-5}$) SI
	3.0	2.2
GP-12	0.05	25.0
	0.25	33.9
	0.5	14.7
	1.0	8.1
	1.5	9.2
	2.0	21.4
	2.5	26.8
	3.0	12.2
GP-13	0.05	34.8
	0.25	37.5
	0.5	10.8
	1.0	7.1
	1.5	15.7
	2.0	11.5
	2.5	13.0
	3.0	13.4

Table 9. Mineralogy by X-ray Diffraction			
Mineral Constituents	**Sample**		
	GP-2	**GP-7**	**GP-11**
Quartz	X	X	X
Illite (mica)	X	X	X
Plagioclase feldspar	X	X	X
Potassium feldspar	X	-	-
Kaolinite	X*	X	-
14 Å (Angstrom) clay	X**	X	-
* Tentative identification ** This indicates the presence of vermiculite, or chlorite or combination of the above			