Subject: Arch: - Geophysical Assistance **Date:** 4 December 2009

To: Jon F. Hall
State Conservationist
USDA-NRCS
John Hanson Business Center
339 Busch's Frontage Road #301
Annapolis, MD 21401-5534

Purpose:
At the request of Ron Anderson (OCIO, NHQ, Washington DC) and Amanda Moore, electromagnetic induction (EMI) and ground-penetrating radar (GPR) assistance was provided for the purpose of assessing two sites and identify promising areas for future archaeological excavations within the Fort Circle Park (owned by National Park Service) in northwest Washington D.C. The sites are located on a crown of hills on either side of the old Washington Road (Bladensburg Road). Here Commodore Barney's flotilla-men were positioned during the War of 1812's Battle of Bladensburg (August 1814). This project is being directed by the Benjamin Harrison Society, which is a 4-H Club affiliated group dedicated to teaching students about history, historical preservation, and conservation. Also participating in this investigations are research staff members from the Smithsonian Institute in Washington, D.C.

NRCS Participants:
Jim Doolittle, Research Soil Scientist, USDA-NRCS-NSSC, Newtown Square, PA
Amanda C. Moore, State Soil Scientist, USDA-NRCS, Annapolis, MD

Activities:
All field activities were completed on 21 November 2009.

Summary:

1. High school and charter school students were introduced to two geophysical methods. These students later operated an electromagnetic induction meter and completed reconnaissance surveys of two archaeological sites. Plots of both electromagnetic induction (EMI) and ground-penetrating radar (GPR) data were used to identify areas within each site for future archaeological investigations by students and archaeologists assigned to the Smithsonian Institute.

2. Within the two investigated sites, both EMI and GPR surveys revealed the presence of what is believed to be extensive areas having buried cultural features. Undoubtedly, the two sites have witness varying degrees of cultural disturbances over the years. As large areas of these sites have been disturbed and presumably cleaned of earlier artifacts, the possibility of unearthing relics from the Battle of Bladensburg may prove difficult. The use of geophysical methods, however, has identified several potential areas of interest and avoidance within each site. Plots contained in the attached technical report may be used by Dr Noel Broadbent and other archaeologists to plan future test-trenching in the two sites.

3. It was the pleasure of the National Soil Survey Center to participate and assist your staff in this project, and to demonstrate the potential of using geophysical methods in archaeological investigations to local high school and charter school students associated with the Benjamin Harrison Society. We feel that this brief encounter with high school students has fostered increased awareness to USDA-NRCS and positive relationships with our urban neighbors.

4. Results reported in the technical report are interpretive. Interpretations should be verified by ground-truth observations made by archaeologists to confirm their validity.

/s/ Jonathan W. Hempel

JONATHAN W. HEMPEL
Director
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cc:
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Technical Report on Geophysical Investigations conducted in Northeast Washington D.C. on 21 November 2009

James A. Doolittle

Background:
The Battle of Bladensburg (24 August 1814) was fought during the War of 1812. The battle was fought mostly near the Bladensburg Bridge and on the west side of the Eastern Branch of the Potomac in Maryland. Prior to the battle, Commodore Joshua Barney and about 400 American sailors and marines were posted on a ridge line about one mile west of the Bladensburg Bridge (spans the Eastern Branch of the Potomac River) in what is now Washington D.C. Barney reportedly had two 18-pounder guns and three 12-pounder guns. During the latter stages of the battle, Barney's force was overwhelmed and driven from the ridge line by the British. The defeat at Bladensburg allowed the British to capture and burn Washington.

The site of Barney's stand is believed to be located in Fort Circle Park (owned by National Park Service) in northwest Washington D.C. (about latitude 38.93057 N, longitude 76.96065 W). The park is located on a prominent ridge. The ridge is orthogonally crossed by the Bladensburg Road (see Figure 1). The Bladensburg Road is the old-post road that connected Baltimore and Washington, and along which the British advanced on the American positions during the Battle of Bladensburg.

Study Site:

Figure 1. This blurred image from the Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm) identifies the soils and shows the locations of the two Bladensburg study areas.

The two study areas are located at the intersection of Bladensburg and Eastern Avenue in northeast Washington DC. Study Areas 1 and 2 are located directly across Bladensburg Road from one another and are bounded on the northeast by Eastern Ave and its extension (Figure 1). Both areas are grassed covered. Area 1 has been mapped as Christiana-Urban land complex on 0 to 8 % slopes (CfB) and Urban land (Ur). Area 2 has been mapped as Christiana silt loam on 0 to 8 % slopes (CeB) and Christiana-Urban land complex on 0 to 8 % slopes. The very deep, moderately well drained Christiana soils form in clayey fluviomarine deposits on uplands. Christiana is a member of the fine, kaolinitic, mesic Aquic Hapludults taxonomic family. Because of its relatively high clay content (28 to 75 %), Christiana soils are considered to have low potential for deep GPR soil investigations (http://soils.usda.gov/survey/geography/maps/GPR/methodology.html).

Equipment:
An EM38-MK2-2 meter (Geonics Limited; Mississauga, Ontario), was used in this investigation.[1] The EM38-MK2-2 meter requires no ground contact and only one person to operate. This meter operates at a frequency of 14,500 Hz and weighs about 5.4 kg (11.9 lbs). The meter has one transmitter coil and two receiver coils. The receiver coils are separated from the transmitter coil by distances of either 100 or 50 cm (40 or 20 inches). This configuration provides nominal depth of penetration ranges of about 150 and 75 cm (60 and 30 inches) in the vertical dipole orientation and about 75 and 37 cm (about 30 and 15 inches) in the horizontal dipole orientation. In either dipole orientation, the EM38-MK2-2 meter provides measurements of both the quadrature-phase (apparent conductivity) and the inphase (susceptibility) components for the two depth ranges. The quadrature phase component is linearly related to the ground conductivity or apparent conductivity (EC_a), which is typically expressed in milliSiemens/meter (mS/m). The inphase (IP) component of the induced magnetic field is often used to detect metallic objects. The Inphase component is often referred to as the *metal detection phase.* Ferrous materials provide a stronger response and, therefore, are more detectable in the inphase component. The quadrature behaves similarly for both ferrous and nonferrous materials. Inphase measurements are expressed in parts per thousand (ppt). Operating procedures for the EM38-MK2-2 meter are described by Geonics Limited (2008).

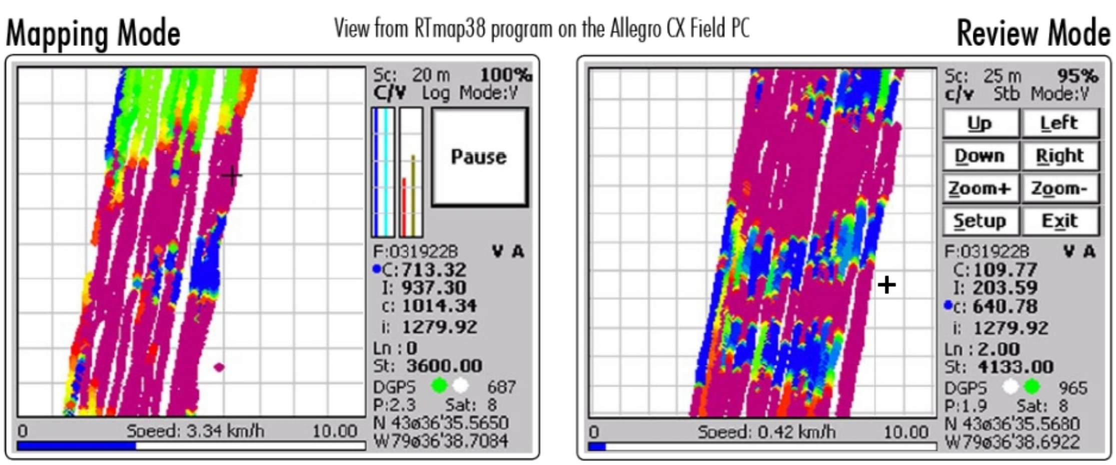

Figure 2. The RTmap38 program provides an instantaneous track of each traverse with EC_a or IP measurements displayed as a colored image on the Allegro CX field computer (courtesy of Geomar Software, Inc.). The cross hair on these images marks current position.

A Trimble AG114 L-band DGPS (differential GPS) antenna (Trimble, Sunnyvale, CA) was used to georeferenced the EMI data.[1] Using the RTmap38 program (Geomar Software, Inc., Mississauga,

[1] Manufacturer's names are provided for specific information; use does not constitute endorsement.

Ontario), both GPS and EC_a data were simultaneously recorded and displayed on an Allegro CX field computer (Juniper Systems, North Logan, UT).[1] The color display for the RTmap38 program (see Figure 2) allows the operator to immediately track, observe, and interpret the results of EMI surveys. With this software program, operators can visually correlate EMI data with soil and landscape patterns, and move directly to sites with different EMI responses for locating, sampling, and verifying the factors or features influencing the different measurements. In Figure 2, the left-hand plot shows the display as data are being recorded; the right-hand plot shows the screen when data collection is paused and the *hidden menu* appears.

The radar unit is the TerraSIRch Subsurface Interface Radar (SIR) System-3000 (SIR-3000), manufactured by Geophysical Survey Systems, Inc. (GSSI; Salem, NH).[1] The SIR-3000 consists of a digital control unit (DC-3000) with keypad, SVGA video screen, and connector panel. A 10.8-volt lithium-ion rechargeable battery powers the system. The SIR-3000 weighs about 9 lbs (4.1 kg) and is backpack portable. With an antenna, the SIR-3000 requires two people to operate. Daniels (2004) and Jol (2008) discuss the use and operation of GPR. A 200 MHz antenna was used in this study.

The RADAN for Windows (version 6.6) software program (GSSI) was used to process the radar records.[2] Basic processing steps, which were applied to all radar records, included: header editing, setting the initial pulse to time zero, color table and transformation selection, display range gain adjustments. Radar records were also subjected to more sophisticated processing to improve visualizations and interpretations. The added processing procedures included: signal stacking, horizontal high-pass filtration, migration, and range gain adjustments (see Daniels, 2004; and Jol, 2008 for discussions of these processing techniques).

Recent technical developments allow the automatic integration of GPR and GPS data. This integration effectively geo-references each scan on a radar record. TheTrimble AG114 L-band DGPS (differential GPS) antenna was used to georeferenced the GPR data. Using this setup, GPR data were quickly compiled and exported for visualization into *Goggle Earth*.[1]

Survey Procedures:
Electromagnetic induction surveys were conducted with the EM38-MK2-2 meter operated in the deeper-sensing vertical dipole orientation (VDO). Apparent conductivity and inphase data were recorded for both the 50 and 100 cm intercoil spacings. The EM38-MK2-2 meter was operated in the continuous (measurements recorded at a rate of 1/sec) mode. Using the TrackmakerEM38MK2 software program, both GPS and EMI data were simultaneously recorded in an Allegro CX field computer. While surveying, the EM38-MK2-2 meter was held about 5 cm (about 2 inch) above the ground surface. The meter was orientated with its long axis parallel to the direction of traverse. Surveys were completed by walking at a fairly uniform pace, in a back and forth pattern across each site. The EMI data discussed in this report were not temperature corrected.

Three random GPR traverses were conducted across Area 1 by pulling a 200 MHz antenna along the ground surface.

Results:
Electromagnetic Induction:
<u>Area 1</u>
Table 1 provides the basic statistics for the EMI survey that was completed across Area 1. In Area 1, EC_a averaged about 40 mS/m and ranged from about -63 to 78 mS/m for measurements obtained with the deeper-sensing (0 to 150 cm), 100-cm intercoil spacing. One-half the EC_a measurements acquired with the 100-cm intercoil spacing were between about 33 and 45 mS/m. For the shallower-sensing (0 to 75 cm), 50-cm intercoil spacing, EC_a averaged about 24 mS/m and ranged from about -236 to 74 mS/m.

One-half the EC_a measurements acquired with the 50-cm intercoil spacing were between about 18 and 30 mS/m. Negative EC_a measurements are attributed to the presence of metallic artifacts scattered across the site.

Within Area 1, for measurements obtained with the deeper-sensing, 100-cm intercoil spacing, inphase (IP) measurements averaged about 19 ppt and ranged from about -90 to 130 ppt. One-half the IP measurements acquired with the 100-cm intercoil spacing were between about 12 and 23 ppt. For the shallower-sensing, 50-cm intercoil spacing, inphase (IP) measurements averaged about 20 ppt and ranged from about -165 to 287 ppt. One-half the IP measurements acquired with the 50-cm intercoil spacing were between about 8 and 27 ppt. Negative and anomalously high IP measurements are attributed to the presence of metallic artifacts scattered or buried across the site.

Table 1. Basic statistics for EMI survey conducted with an EM38-MK2-2 meter operated in the VDO within Area 1. Other than the number of observations, EC_a and inphase data are expressed in mS/m and ppt, respectively.

	EC_a 0 to 150 cm	**IP 0 to 150 cm**	**EC_a 0 to 75 cm**	**IP 0 to 75 cm**
Observations	1347	1347	1347	1347
Minimum	-63.44	-89.61	-236.41	-164.73
25 %-tile	33.09	12.50	18.20	7.62
75 %-tile	44.84	23.20	29.92	27.27
Maximum	78.05	130.43	74.06	286.80
Average	39.92	19.24	23.78	20.19
Standard Deviation	11.77	13.40	15.21	25.29

In general, in Area 1, EC_a increased with increasing soil depth. This trend is assumed to reflect the increase in clay and moisture contents with increasing soil depths in Christiana soils. The wide range and negative responses (both EC_a and IP) are believed to reflect the presence of metallic artifacts across Area 1. These results suggest that Area 1 has been disturbed and is a site of former structures or occupational histories.

Figure 3 contains plots of the EC_a data collected with EM38-MK2-2 meter at Area 1. In Figure 3, the left-hand plot shows spatial EC_a patterns for the shallower-sensing, 50 cm intercoil spacing; the right-hand plot shows spatial EC_a patterns for the deeper-sensing, 100 cm intercoil spacing. In both plots, similar color scales and ramps have been used for comparative purposes. Comparing the two plots shown in Figure 3, the increase in EC_a with increasing soil depth soil depth is apparent. While this trend is attributed to an increase in clay and moisture contents with depth in Christiana soils, significant departures in this trend are presently associated with the presence of artifacts or aberrant soil properties. In the plot of the deeper-sensing, 100-cm intercoil spacing (right-hand plot), the conspicuous region of high EC_a (see "*A*", and area colored in shades of red) along the southwestern border of the study area is believed to represent the locations of buried utility or pipes lines. This subsurface feature(s) is perhaps associated with a nearby gas station or a utility line, which is offset along an adjoining street. In the northeast corner of Area 1, inverse (see "*B*" in Figure 3, right-hand plot) or uniform EC_a trends (see "*C*" in Figure 3, right-hand plot) with increasing soil depths suggest the presence of unnatural or disturbed subsurface properties or features. In these plots, the widely-scattered, high (<60 mS/m) and low (<0 mS/m) spatial patterns are considered anomalous and believed to indicate the locations of buried cultural features.

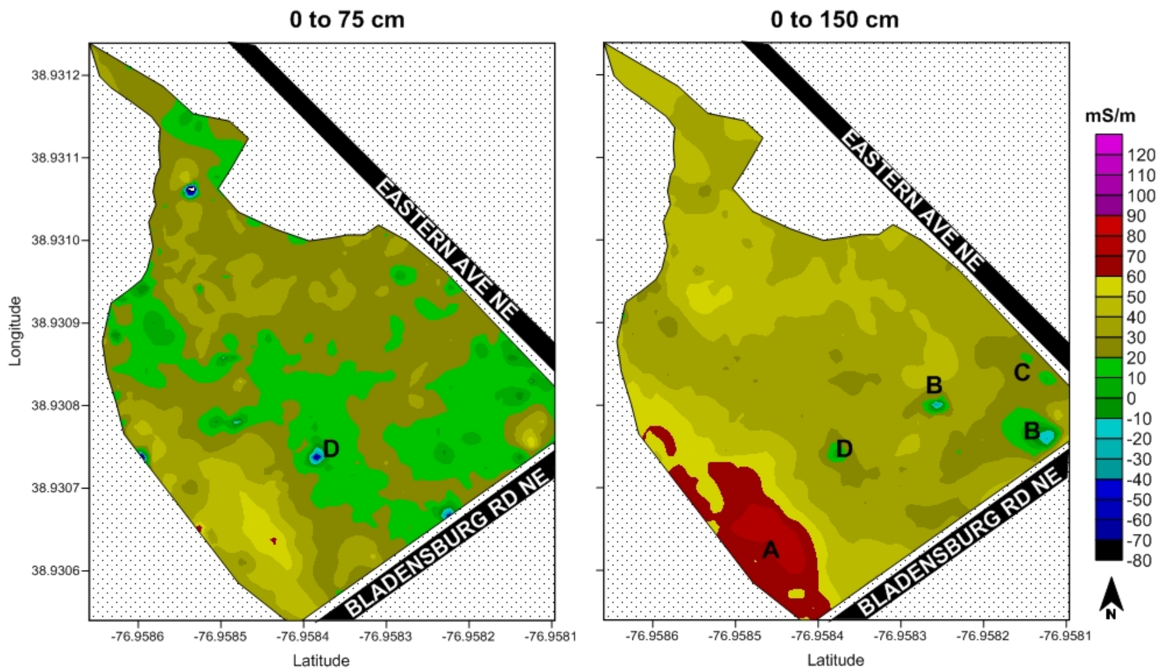

Figure 3. Plots of spatial EC_a *data collected with the EM38-MK2-2 meter at Area 1. Plots display data collected with the shallower-sensing 50 (left plot) and deeper-sensing 100 (right plot) cm intercoil spacings. Apparent conductivity is expressed in milliSiemens per meter.*

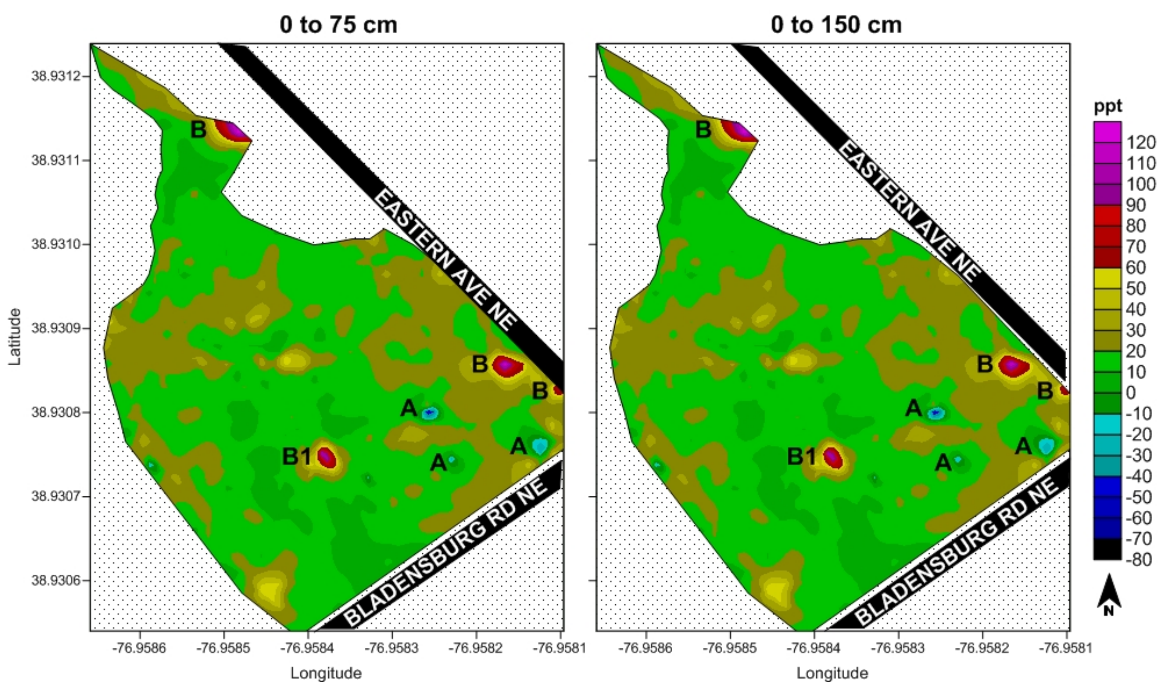

Figure 4. Plots of spatial inphase data collected with the EM38-MK2-2 meter at Area 2. Plots display data collected with the shallower-sensing, 50 (left plot) and deeper-sensing, 100 (right plot) cm intercoil spacings. Inphase data are expressed in parts per thousand.

Figure 4 contains plots of the inphase data collected with EM38-MK2-2 meter in Area 1. In Figure 4, the left-hand plot shows spatial IP patterns for the shallower-sensing, 50 cm intercoil spacing; the right-hand plot shows spatial IP patterns for the deeper-sensing, 100 cm intercoil spacing. In both plots, similar color scales and ramps have been used. Remarkably similar spatial IP patterns were obtained from measurements obtained with the two intercoil spacings. In both plots, small, widely-scattered areas with noticeably higher (<40 ppt; see "*B*" in Figure 4) and lower (<-10 ppt; see "*A*" in Figure 4) values are considered anomalous and believed to indicate the locations of larger, buried artifacts. The previously noted area of conspicuously higher EC_a measurements that was identified along the southwestern border of Area 1 (see "*A*" in right-hand plot of Figure 3) is not apparent on either of the two plots shown in Figure 4. The lack of expression of this subsurface anomalous pattern in the IP data suggests that the buried feature(s) may be non-metallic or perhaps represents contaminants emanating from an adjoining gas station. Noteworthy anomalous areas (Figure 4, "*A*" and "*B*") are apparent in both plots of IP data. These areas may represent features of interest, to be excavated in the future by archeologists involved in this study. During this field investigation, a very shallow hole was made over the feature identified by "*B1*" in Figure 4. A small cluster of old nails were uncovered at this site. However, these features alone are not believed to be totally responsible for the anomalous response observed at location *B1*.

<u>Area 2:</u>
Table 2 provides the basic statistics for the EMI survey that was completed across Area 2. Apparent conductivity averaged about 39 mS/m and ranged from about -473 to 638 mS/m for measurements obtained with the deeper-sensing, 100-cm intercoil spacing. However, one-half the EC_a measurements acquired with the 100-cm intercoil spacing were between the relatively narrow range of 20 and 46 mS/m. This range is believed to be more characteristic of the EC_a for undisturbed areas of Christiana soils. For the shallower-sensing, 50-cm intercoil spacing, EC_a averaged about 54 mS/m and ranged from about -456 to 831 mS/m. One-half the EC_a measurements acquired with the 50-cm intercoil spacing were between about 18 and 47 mS/m. Once again, this relatively narrow inter-quartile range is considered more or less characteristic for undisturbed areas of Christiana soils. Negative EC_a measurements are attributed to the presence of metallic artifacts.

Table 2. Basic statistics for EMI survey conducted with an EM38-MK2-2 meter operated in the VDO within Area 2. Other than the number of observations, EC_a and inphase data are expressed in mS/m and ppt, respectively.

	EC_a – 100 cm	IP – 100 cm	EC_a – 50 cm	IP – 50 cm
Observations	2107	2107	2107	2107
Minimum	-473.40	-1280.00	-455.55	-995.40
25 %-tile	20.12	15.31	18.20	13.13
75 %-tile	46.45	48.95	47.30	71.80
Maximum	638.16	1280.00	831.45	1280.00
Average	38.97	51.32	54.31	106.09
Standard Deviation	61.98	221.20	96.49	265.96

Within Area 2, inphase (IP) measurements averaged about 51 ppt and ranged from about ±1280 ppt for measurements obtained with the deeper-sensing, 100-cm intercoil spacing. A measurement of ±1280 is the most extreme (maximum or minimum) IP value that can be recorded on the EM38-MK2-2 meter. One-half the IP measurements acquired with the 100-cm intercoil spacing were between about 15 and 49 ppt. For the shallower-sensing, 50-cm intercoil spacing, inphase (IP) measurements averaged about 106 ppt and ranged from about -995 to 1280 ppt. One-half the IP measurements acquired with the 50-cm intercoil spacing were between about 13 and 72 ppt. Once again, negative EC_a and IP measurements are attributed to the presence of metallic artifacts. Compared with Area 1, inphase data from Area 2 were more extreme and variable. This is interpreted to reflect the presence of more numerous and widespread, larger and/or shallowly buried metallic artifacts within Area 2 than Area 1.

Figure 5 contains plots of EC_a and IP data collected with EM38-MK2-2 meter in Area 2. In Figure 5, the left-hand plots show spatial EC_a patterns for the shallower-sensing, 50 cm intercoil spacing (upper plot) and the deeper-sensing 100 cm intercoil spacing (lower plot). The left-hand plots show spatial IP patterns for the shallower-sensing, 50 cm intercoil spacing (upper plot) and the deeper-sensing, 100 cm intercoil spacing (lower plot). In all plots, similar color scales and ramps have been used for comparative purposes. In these plots, areas shown in white exceed the range listed in the colored scale.

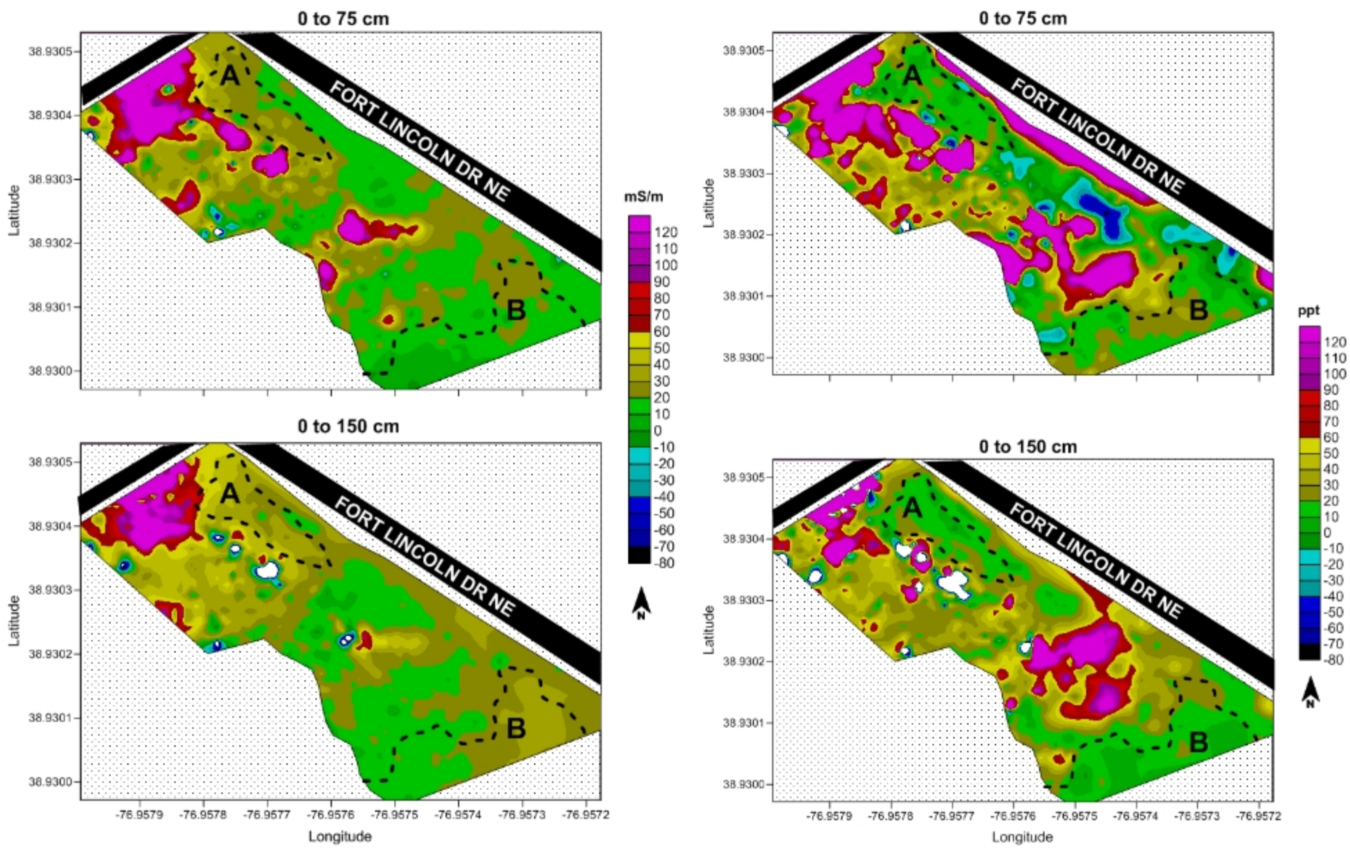

Figure 5. *Plots of spatial EC_a (left-hand plots) and inphase (right-hand plots) data collected with the EM38-MK2-2 meter in Area 2. The upper plots are of data collected with the shallower-sensing, 50 cm intercoil spacing; the lower plots are of data collected with the deeper-sensing, 100 cm intercoil spacing*

In the plots shown in Figure 5, a majority of the spatial patterns are highly complex with wide ranges in values occurring over short distances. Typically, natural variations in soils and soil properties are more gradual, occur over larger distances, and display less complex patterns than those depicted in Figure 5. These spatial patterns are considered unnatural and are believed to indicate soil disturbances and the presence of buried artifacts. Compared with Area 1, spatial EMI patterns in Area 2 suggest that the distribution of artifacts is more widespread and occur at shallower depths. Anomalous EMI response and spatial pattern occupy a far larger portion of Area 2 than Area 1. It is inferred from these patterns that Area 2 contains more disturbed soil materials, with a larger number of artifacts than Area 1. In the plots shown in Figure 5, two areas, Areas *A* and *B*, have been identified and enclosed with segmented lines.

Based on spatial EMI patterns, these areas are interpreted to contain less disturbed soil materials and fewer artifacts.

Ground-penetrating radar:
Ground-penetrating radar is an impulse radar system designed for shallow, subsurface investigations. The system operates by transmitting short pulses of electromagnetic energy into the ground from an antenna. Each pulse consists of a spectrum of frequencies distributed around the center frequency of the transmitting antenna. Whenever a pulse contacts an interface separating layers of differing dielectric permittivity (E_r), a portion of the energy is reflected back to the receiving antenna. The receiving unit amplifies and samples the reflected energy, and converts it into a similarly shaped waveform in a lower frequency range. The processed reflected waveforms are displayed on a video screen and can be stored on a hard disk for future playback, processing, and/or display.

Ground-penetrating radar is a time scaled system. This system measures the time that it takes electromagnetic energy to travel from the antenna to an interface (e.g., soil horizon, buried archaeological feature) and back. To convert the travel time into a depth scale, the velocity of pulse propagation or the depth to a reflector must be known. The relationships among depth (D), two-way pulse travel time (T), and velocity of propagation (*v*) are described in the following equation (Daniels, 2004):

$$v = 2D/T \qquad [1]$$

The velocity of propagation is principally affected by the relative dielectric permittivity (E_r) of the profiled material(s) according to the equation (Daniels, 2004):

$$E_r = (C/\ v)^2 \qquad [2]$$

Where C is the velocity of propagation in a vacuum (0.298 m/ns). Velocity is typically expressed in meters per nanosecond (ns). In soils, the amount and physical state (temperature dependent) of water have the greatest effect on the E_r and *v*. Based on hyperbola matching techniques (Jol, 2008), the *v* and E_r at this site were estimated to be 0.0878 m/ns and 11.5, respectively. These values were used to depth scale the radar records.

Results:
As a demonstration of GPR and to evaluate its effectiveness in areas of Christiana soils, three random radar traverses were conducted across the eastern-most portion of Area 1. Figure 6 is a three-dimensional rendition of the radar record from a traverse that was conducted orthogonal to the Bladensburg Road in Area 1. On this radar record all scales are expressed in meters. The Universal Transverse Mercator (UTM) coordinate system is used in this three dimensional image.

The radar signal is weaker and more highly attenuated on either end of the radar record shown in Figure 6. In these areas, the depth of penetration is restricted; probably do to high rates of signal attenuation cause by clayey soil materials. In the central portion of this record, high-amplitude (colored white and grey) point and planar reflectors identify contrasting materials and objects. As the depth of penetration appears greater in this portion of the radar record, these materials are assumed to be less attenuating and more electrically resistive. These point and planar reflectors are considered anomalous for Christiana soils and are inferred to represent buried cultural features. In Figure 6, a rectangular box has been used to identify this area of *high cultural noise*. The section of high cultural noise contains numerous, high-amplitude point and planar reflectors. These features are tentatively interpreted as remnants of a former structure and possibly an infilled, former cellar. In Figure 6, to the left (east) of this area of high cultural noise, near-surface, planar reflection patterns and reverberated signals are identified at *C*. These layers are suspected to be cultural in origin also. In Figure 6, and to the right (west) of the area of high cultural noise, a more weakly expressed (lower signal amplitudes; colored in shades of red) subsurface interface has been identified by a segmented line. This interface occurs between depth of 50 and 100 cm. It is believed to represent either an interface between soil horizons or the contact of a fill overburden with the original soil surface.

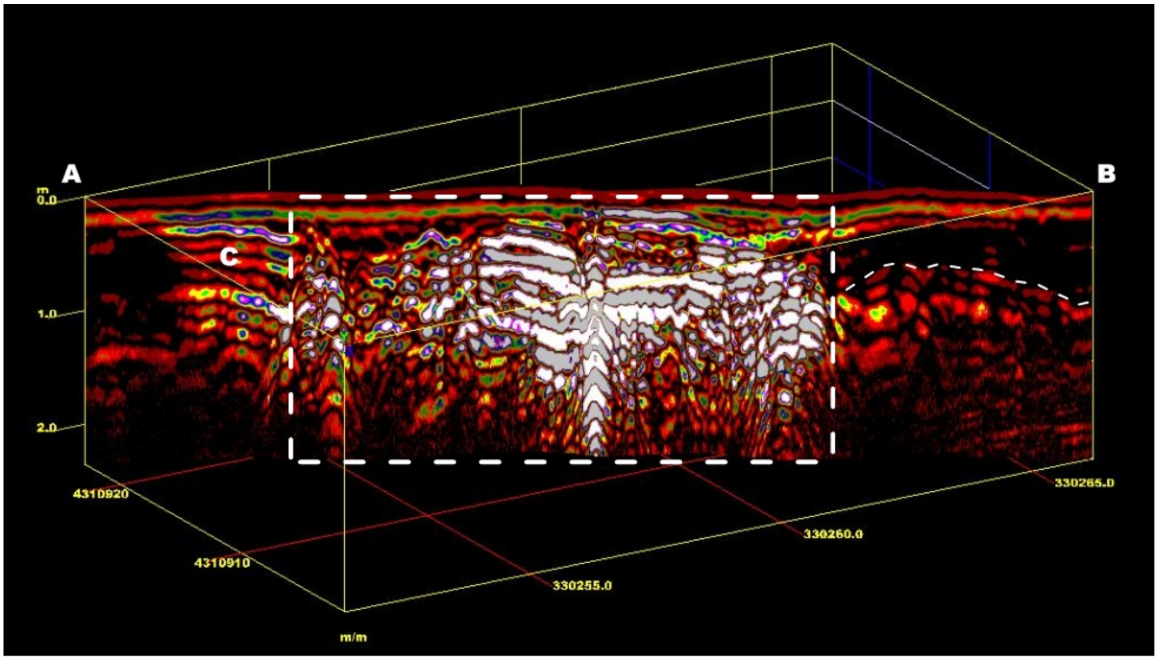

Figure 6. This representative radar record was collected in Area 1 with the 200 MHz antenna. The high-amplitude reflectors in the central portion of this record are believed to represent disturbed soil materials and an area of cultural debris.

Figure 7 is a Google Earth image of Area 1 showing the three GPR traverse lines. In this image, different colors have been used to indicate the inferred presence (red) or absence (green) of buried cultural features. The line identified by the letters A and *B* corresponds to the radar record shown in Figure 6. This brief radar survey of Area 1 has outlined an area having “high cultural noise”, which is presently interpreted as remnants of former structures. These interpretations, however, are tentative and can only be verified through ground-truth corings and excavations.

Figure 7. In this Google Earth image of the Bladensburg study site, the locations of the three georeferenced GPR traverse lines conducted in Area 1 are shown. Colors indicate the inferred presence or absence of buried cultural features. Letters identify the ends of the GPR traverse shown in Figure 6.

References:

Daniels, D. J., 2004. Ground Penetrating Radar; 2nd Edition. The Institute of Electrical Engineers, London, United Kingdom.

Geonics Limited, 2008. EM38-MK2 ground conductivity meter operating manual. Geonics Limited, Mississauga, Ontario.

Jol, H., 2008. Ground Penetrating Radar: Theory and Applications. Elsevier Science, Amsterdam, The Netherlands.