United States Department of Agriculture

Natural Resources Conservation Service

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Subject: ARCH-Geophysical Field Assistance **Date:** 7 May 2008

To: Margo L. Wallace
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Purpose:
At the request of the Connecticut State Archaeologist and local historians, ground-penetrating radar (GPR) surveys were conducted at archaeological and forensic sites located in Enfield, Shelton, Redding, Mashantucket, Newington, and Norwich, Connecticut.

Principal Participants:
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Dan Civson, President Archaeological Society of Connecticut, Newtown, CT
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Tony Secondo, Historian, Town of Enfield, Enfield, CT
John Spalding, Archaeologist, FOSA/ABAS, Glastonbury, CT
Debbie Surabian, Soil Scientist, USDA-NRCS, Tolland, CT

Activities:
All activities were completed during the period of 21 thru 25 April 2008.

Summary:

1. At the Enfield site, an approximate $10m^2$ square area that contains high levels of "*cultural noise*" was identified with GPR. This area contains high amplitude subsurface reflections between depths of 60 and 90 cm, which are presumed to represent buried rubble and remnants of a former house. The lack of subsurface reflectors below these relatively shallow depths suggests that the former structure lacked a basement.

2. At the Shelton forensic site, there were no noticeable subsurface reflection patterns evident on radar records collected over a small grid site that suggest the presence of either a buried 55 gallon drum or a refilled trench.

3. At the Redding site, extremely rocky, steeply sloping, forested terrains proved too inhospitable for the proper use of GPR. The large number of rock fragments in the soils produced high levels of unwanted background noise and made difficult the discrimination of natural rock concentrations from rock rubble associated with collapsed Revolutionary War era chimneys.

4. At the Preston Plain site, several bowl-like depressions were identified on radar records. Archeologists believe these mysterious features were formed by human hands. Based on radar information, bowl-like depressions are more common the western portion of the study site. A 3D pseudo-image of a small grid site provided further evidence supporting the presence of bowl-like depressions and clues as to the internal geometry of these features.

5. At the Newington Site, a GPR grid survey identified the buried stone foundation of an outbuilding associated with the Colonial Era Well's house. *Wild cat* GPR surveys across remaining portions of the backyard disclosed the location of a feature suspected to be a former well.

6. At the Pine Island Cemetery in Norwalk, anomalous GPR responses were associated with areas of disturbed soils. These areas may represent unmarked gravesites and are worthy of further investigations to confirm GPR interpretations. These excavations should precede any widening of the adjoining Crescent Street.

It was my pleasure to work in Connecticut and to be of assistance to you and your staff.

With kind regards,

James A. Doolittle
Research Soil Scientist
National Soil Survey Center

cc:
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Study Sites:

Enfield Green Site:

The purpose of this investigation was to identify the location of a former house owned by Dr. Henry A. Grant. Dr Grant was a prominent citizen who served as the Surgeon-General of Connecticut. Remnants of the house are believed to underlie a small mound areas located on the town's green. This site is situated in an area of Rainbow silt loam on 0 to 3 % slopes. The moderately well drained Rainbow soils formed in a thin silt mantle that overlies lodgment till. The Rainbow soils are very deep to bedrock and moderately deep to a densic contact. The Rainbow series is a member of the coarse-loamy, mixed, active, mesic Aquic Dystrudepts family.

Shelton Site:

Sheldon Police suspect that a missing person may be buried in the driveway of a house on Fort Hill Road in Shelton. There is reason to believe that the missing person was murdered and buried on this property in a 55 gallon metal drum. The area was previously surveyed with electromagnetic induction, but results were inconclusive (Surabian, 2007b). A recommendation of Deborah Surabian was to conduct a GPR survey of the driveway. The property is located in an area of Paxton-Urban Land Complex, 3 to 8 % slopes. The well drained Paxton soils formed in lodgment till. Paxton is very deep to bedrock and moderately deep to a densic contact. The Paxton series is a member of the coarse-loamy, mixed, active, mesic Oxyaquic Dystrudepts family.

Redding Site:

The investigated site served as an encampment area for colonial troops during the American Revolution. As many as 1000 troops were camped at this site during the winter of 1778 and 1779. These troops were housed in 12 by 16 ft log cabins. The purpose of this investigation was to locate the fire backs of collapse chimneys. The site (41.3273 ^{o} N. Latitude and 73.4069 ^{o} W. Longitude) is located off of Whortleberry Hill Road in Redding in an area of Charlton-Chatfield complex, 15 to 45 % slopes, very rocky. The very deep, well drained Charlton and the moderately deep, well drained and somewhat excessively drained Chatfield soils formed in till. Charlton and Chatfield series are members of the coarse-loamy, mixed, mesic Typic Dystrudepts family.

Preston Plain (Mashantucket) Site:

The site is located in cultivated fields (41.4888 ^{o} N. Latitude, 71.9795 ^{o} W. Longitude) just off of State Highway 2 near Mashantucket. In one of these fields, several, puzzling, subsurface bowl-like features have been exposed in trenches. These features are 1 to 1.5 m deep, have no surface expression, and contain low density stone tools, flakes and points, which have been dated to 4000 to 5000 Before Present (BP). These earthen, bowl-like features are believed to be the work of human hands, but display no recognizable spatial arrangement or patterns. The fields are mapped as Agawan fine sandy loam, 3 to 8 % slopes, and Haven and Enfield soils, 0 to 3 % slopes. The very deep, well drained Agawam soils formed in sandy, water deposited materials. The Agawan series is a member of the coarse-loamy over sandy or sandy-skeletal, mixed, active, mesic Typic Dystrudepts family. The very deep, well drained Haven and Enfield soils formed in loamy over sandy and gravelly outwash. The Haven series is a member of the coarse-loamy over sandy or sandy-skeletal, mixed, active, mesic Typic Dystrudepts family. The Enfield series is a member of the coarse-silty over sandy or sandy-skeletal, mixed, active, mesic Typic Dystrudepts family.

To unravel the geometry of these subsurface features, the use of 3-D GPR was recommended. This site is expected to be one of the stops on the NE Cooperative Soil Survey Conference Tour schedule for June 2008.

Lisbon:

This site, known as the "Roger Site", is located on a wooded terrace that overlooks the Quinbaug River near Lisbon. This site contains the campsite(s) of Pre-Contact Native Americans. Artifacts, including an extremely rare human face effigy made from soapstone, have been discovered on this site by the owner of the property, Richard Roger. The site is presently being excavated by the Office of the State Archaeologists. Excavations have exposed a stone lined cremation area. Though mapped as Hinckley gravelly sand loam, 15 to 45 % slopes, soils at the site best represent the concepts of the Enfield-Hinckley Complex, 3 to 15 % slopes (Surabian, 2007a). A silt loam mantle, as great as 210 cm thick, overlies alluvial sands and gravels. The very deep, well drained Enfield soils formed in a silty mantle overlying glacial outwash. The very deep, excessively drained Hinckley soils formed in sandy, water-sorted materials. Hinckley is a member of the sandy-skeletal, mixed, mesic Typic Udorthents family.

A random, “*wild cat*” GPR survey was conducted across this site in an attempt to located additional stone lined cremation areas.

<u>Newington:</u>
As winter snows melted, the owner of the historic Elijah Wells house (circa 1774) in Newington frequently noticed faint, linear patterns across his backyard. Excavations along several of these lines have revealed brick and stone works. The purpose of this investigation was to confirm the present of former outbuildings and to locate the historic well for the house. The site is located in an area of Elmridge-Urban land complex, 0 to 8 % slopes. The very deep, moderately well drained Elmridge soils formed in loamy over clayey sediments. The Elmridge series is a member of the coarse-loamy over clayey, mixed, semiactive, mesic Aquic Dystric Eutrudepts family.

<u>Norwalk Site:</u>
Plans are being made to widen a portion of Crescent Street near the I-95 overpass. This project will expand the road into a portion of the Pine Island Cemetery near the intersection of Crescent Road and Science Street. The purpose of this survey was to identify the presence of graves in the proposed impact area (41.1071^{o} N. latitude, 73.4153^{o} W. longitude) of the Pine Island Cemetery. The impact area is located in an area of Udorthents-Urban land complex. Soil materials in this unit are presumed to be mostly disturbed.

Equipment:
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) discusses the use and operation of GPR. The antenna used in these studies had a center frequency of 400 MHz.

The SIR-3000 system provides a setup for the simultaneous use of a GPS receiver and serial data recorder (SDR). This setup allows the automatic integration of GPR and GPS data. With this setup, each scan on radar records is geo-referenced. Geo-referenced radar records are imaged using the *3D QuickDraw Module* of RADAN (version 6.6). In addition, using the *Interactive 3D Module* of the RADAN processing software, depths to soil horizons and features can be quickly, automatically, and accurately picked and outputted to worksheets (X, Y, Z format; containing latitude, longitude, and depths to a soil, stratigraphic, or cultural features). Using this module, data can be easily exported into GIS for plotting and visualization

Radar records contained in this report were processed with the *RADAN* for Windows (version 6.6) software developed by GSSI.[1] Processing included: header editing, time zero adjustment, distance normalization, and range gain adjustments. The Super 3D QuickDraw program developed by GSSI was used to construct three-dimensional (3D) pseudo-images of the radar records that were collected over grids established at several of the sites.

Ground-penetrating radar:
Ground-penetrating radar is an impulse radar system designed for shallow, subsurface investigations. This 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), 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., bedrock, 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

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

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 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. At the Enfield Site, based on a reflector buried at a depth of 49 cm, the estimated E_r and v through the upper part of the soil profile were 11.23 and 0.0889 m/ns, respectively. At the Preston Plain Site, based on a reflector buried at a depth of 55 cm, the estimated E_r and v through the upper part of the soil profile were 7.01 and 0.1125 m/ns, respectively. At the Newington Site, based on the depth to a buried cultural feature (40 cm), the estimated E_r and v through the upper part of the soil profile are 17.14 and 0.0720 m/ns, respectively.

Survey Procedures:

Survey grids were established at the Enfield, Shelton, Mashantucket, Newington, and Norwich sites. Dense vegetation and sloping terrains precluded the creation of grids at the Redding and Lisbon sites. Survey grids are necessary to collect the data required for construction of 3D GPR pseudo-images. At each grid site, two parallel survey lines were laid out and served as grid axis lines. Along these two parallel axis lines, survey flags were inserted into the ground at a spacing of 50 cm (Shelton, Mashantucket, Newington, and Norwich sites) or 100 cm (Enfield site). A distance-graduated rope was stretched between matching survey flags on these two axis lines, which were located on opposing sides of the grid. GPR traverses were conducted along this line. The 400 MHz antenna was towed along the graduated rope on the soil surface and, as it passed each 100-cm graduation, a mark was impressed on the radar record. Following data collection along the line, the distance-graduated rope was sequentially displaced either 100- or 50-cm to the next pair of survey flags to repeat the process.

At the Redding and Lisbon sites, random or *wild-cat* surveys were conducted across accessible areas. At the Preston Plain Site, a Trimble AG114 global positioning system (GPS) receiver was used to collect the coordinates of each radar scan along a long GPR traverse line.

Enfield Site:

A 25 by 20 m grid was established over a slightly raised, level, rectangular mound. This noticeable mound, which is located within the Enfield Town Green, is the suspected site of the house owned by Dr. Grant. On an 1860's map of Enfield, the house appears to be located in the general vicinity of the level, platform mound.

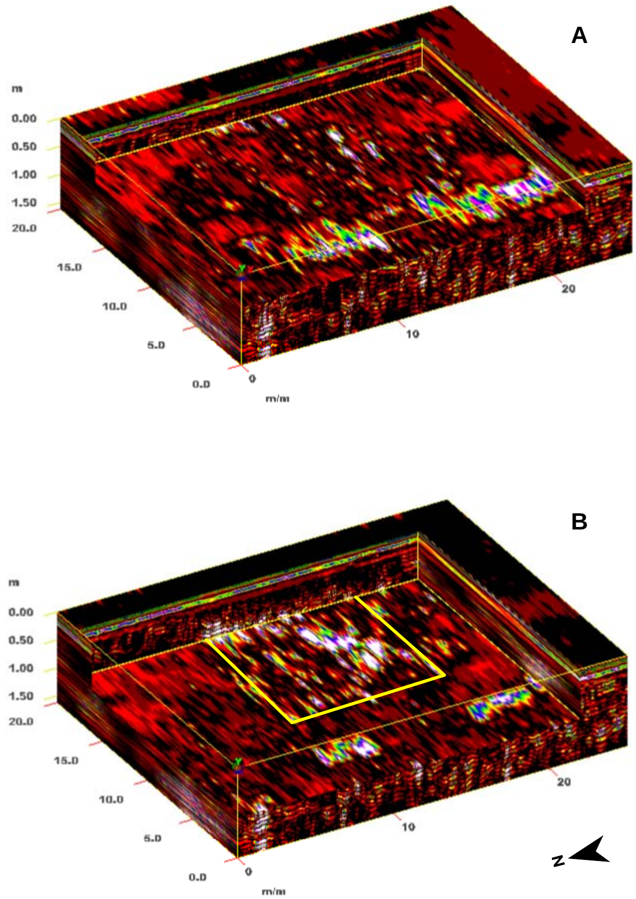

Figure 1. Anomalous pattern of high-amplitude reflections are apparent in these two, 3D-pseudo images from the Enfield Town Green.

Two, 3D pseudo images of the Enfield grid site are shown in Figure 1. In each image a 22 by 18 m inset cube has been removed from the 3D pseudo image. The base of the cutout cubes are at depths of 60 and 90 cm, in the upper and lower images, respectively. In both 3D pseudo images, a linear, north-south trending pattern is evident near the western (lower) boundary of the grid area. This corresponds with the more sloping apron of the mound. The extent of this feature suggests a continuous stratigraphic or soil layer, or possibly, shallowly buried brickwork relating to the house. In the lower 3D pseudo image (B), an approximate 10 m^2 square area, which contains a multitude of high amplitude reflections, has been outline along the base (90 cm depth) of the cutout cube. While these patterns vary with depth (suggesting a large amount of small-sized reflectors), they persist between depths of 70 to 100 cm. Based on location, spatial pattern and depth, these reflectors are believed to represent rubble and the remnants of Dr. Green's house. It is inferred from the lack of subsurface reflectors below these relatively shallow depths that the former structure lacked a basement.

Shelton Site:
An 8 by 11.5 meter grid was established on a portion of the driveway in the area immediately adjacent to the house. Parallel radar traverses were conducted across the grid area in a back and forth patterns (lines orientated in a general north to south direction). These traverses were spaced 50 cm apart. Random GPR surveys were also conducted over the cement floor of the garage, which was located under the house. However, the cement is composed of materials that proved highly attenuating to the radar. As a consequence, no subsurface information could be obtained with the 400 MHz antenna beneath the cement floor.

Buried, metallic objects often produce “ringing” or multiple “reverberations” of reflected signals on radar records. Within the grid area, no subsurface feature produced this phenomenon. Consequently, the present of a suspected, buried, 55 gallon metal drum is considered to be unlikely beneath the grid area.

Figure 2 is a relatively non-descript solid block pseudo-image of the grid site. All radar traverses were conducted parallel to the X axis (right foreground). As a result, traces were more continuously sampled and reflectors are strongly represented with little distortion to the data in this direction (essentially, north-south). Along the Y axis, however, data were not continuously recorded but interpolated over a 50-cm interval (the distance between radar traverses). As a result, some subsurface information was lost during interpolation and data along the Y-axis appear slightly smudged, less resolved, and more generalized. This 3D pseudo image was examined in a number of different color palettes and transforms as the use of different colors and amplitude can sometimes help to visualize and interpret the radar data.

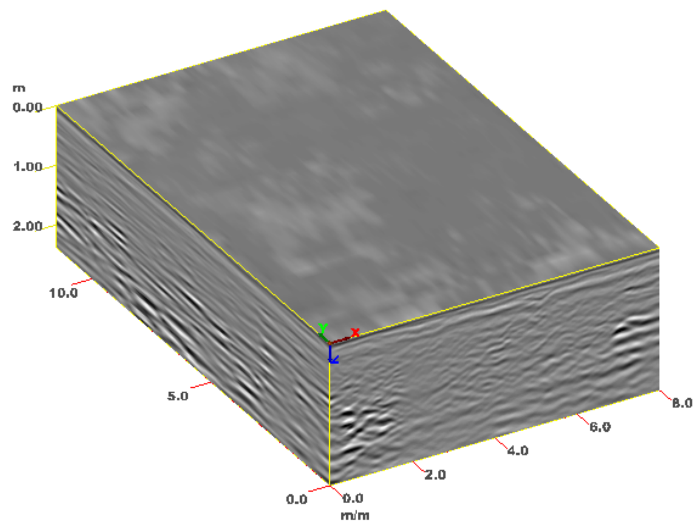

Figure 2. The Shelton grid area is displayed in this 3D cube image.

The use of digital signals and sophisticated signal-processing software, have enabled signal enhancement and improved pattern-recognition on radar records in some soils. Processing algorithms used to improve the interpretability of subsurface archaeological features appearing on radar records are discussed by Sciotti et al. (2003) and Conyers and Goodman (1997). In recent years, an advanced type of GPR data manipulation, known as *amplitude slice-map analysis*, has been used in archaeological investigations (Conyers and Goodman, 1997). For this analysis, a 3D pseudo image of a survey site is constructed from the computer analysis and synthesis of a series of closely-spaced, two-dimensional radar records. Amplitude differences within the 3-D pseudo image are analyzed in "*time-slices*" that examine changes within specific depth intervals in the ground (Conyers and Goodman, 1997). In this process, the reflected radar energy is averaged horizontally between adjacent, parallel radar records and in specified time (or depth) windows to create a time-slice (or depth-slice) image. Each amplitude time-slice shows the spatial distribution of reflected wave amplitudes, which may indicate changes in soil properties or the presence of subsurface features. In many instances, 3D GPR imaging techniques have been used to distinguish and identify potential targets and to reduce interpretation uncertainties.

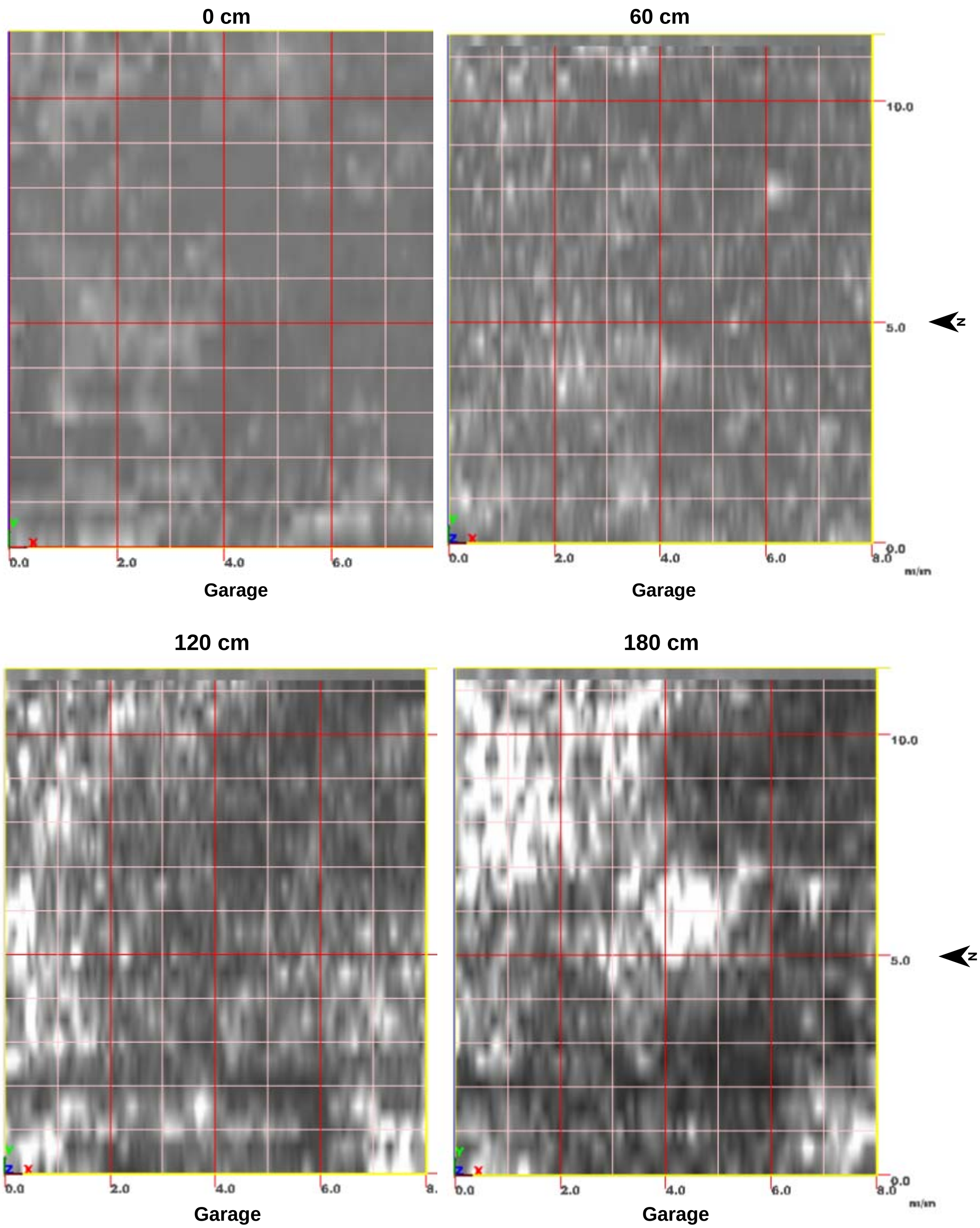

Figure 3. In these 3D pseudo images of the Shelton Grid Site, horizontal slices have been made at depths of 0, 60, 120, and 180 cm. The grid area is viewed from directly above, with the house and garage located immediately below (lower on page) each image. Each slice has a width of 25 cm.

Figure 3 contains four time or *depth slice* images from the Shelton site. In these images, the 3D block diagram shown in Figure 2 is viewed from directly overhead as sequential layers of materials are *sliced-away* and removed to display spatial patterns at the four specified depths. A 1 m^2 mesh has been overlaid on each of the time slices to provide a better indication of scale and location. The four horizontal time-slices shown in Figure 3 represent soil depths of about 0, 60, 120, and 180 cm. These depths were based on an estimated propagation velocity of 0.0889 m/ns through the soil.

In the time-sliced images shown in Figure 3, no persistent rectangular pattern, with dimensions suggesting a refilled former trench, is identifiable. A trench would be refilled with mixed materials and cut through different soil layers. These properties should produce noticeably different tonal patterns that show the outline of a refilled trench on time slices of the 3D pseudo-image. No such patterns are discernable in these time-sliced images. With increasing depth, higher-amplitude reflections (colored white) become increasingly more noticeable in the northeastern and northern portions of the grid site. These patterns are irregularly shaped suggesting that they represent natural features. Typically, artificial (human) subsurface features appear as linear patterns on radar records. High amplitude reflections are produced by abrupt interfaces (boundaries) that separate highly contrasting materials. Paxton soil is very deep (> 150 cm) to bedrock, but is moderately depth (50 to 100 cm) to denser soil materials. In these images, the high amplitude reflection form irregular spatial patterns that suggest natural features such as the irregular contact with denser soil materials or the soil/bedrock interface and features within the bedrock.

At the Shelton site, there were no noticeable subsurface reflection patterns evident beneath the grid site that suggest the presence of a refilled trench or a buried 55 gallon metal drum within depths of 2 m.

Redding Site:
Rocky, steeply sloping, forested terrains made the Redding site extremely inhospitable to GPR. The large number of rock fragments in the soils produced high levels of unwanted background noise and made it difficult to discriminate natural rock concentrations from rock rubble associated with collapsed chimneys. Figure 4 is a representative radar record from the Redding Site. This radar record was collected on a steeply-sloping side slope. As elevation data were not collected, the radar record has not been corrected for changes in elevation and the surface is shown as horizontal. On this radar record, the interpreted soil/bedrock interface has been highlighted with a white line. The overlying soil is characterized by numerous reflectors, which represent rock fragments and larger tree roots. These reflectors represent unwanted background noise. This background noise effectively masked the presence of rubble associated with chimneys and made interpretations ambiguous.

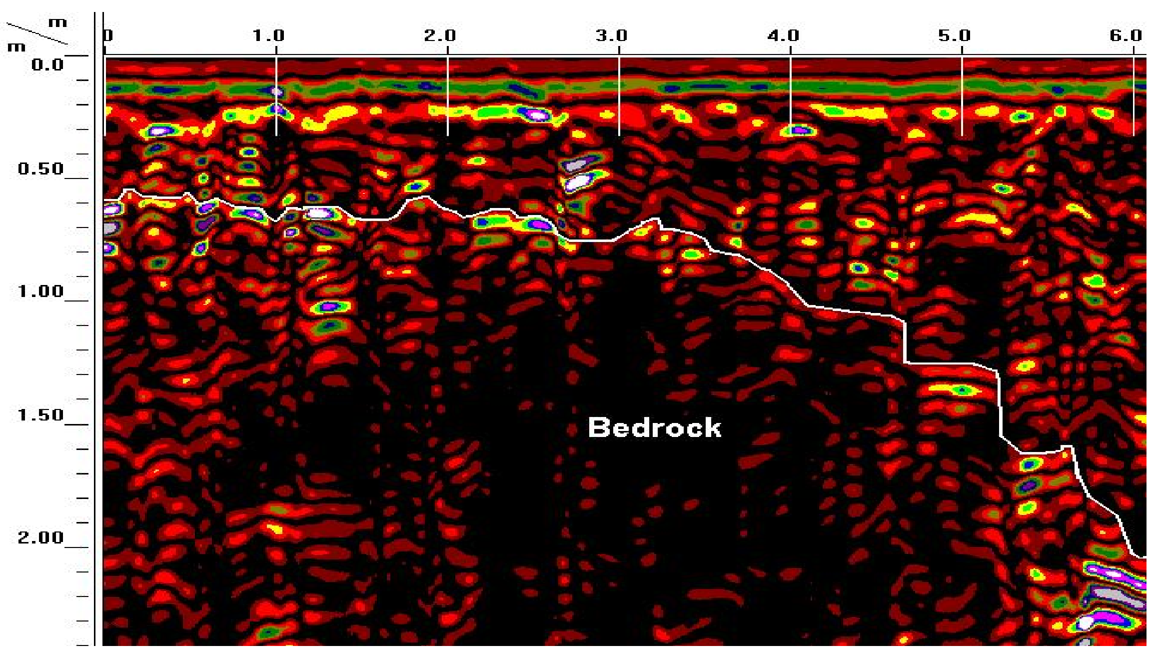

Figure 4. The soil/bedrock interface has been highlighted with a white line on this radar record collected with the 400 MHz antenna at the Redding Site. Numerous rock fragments are evident in the soil profile.

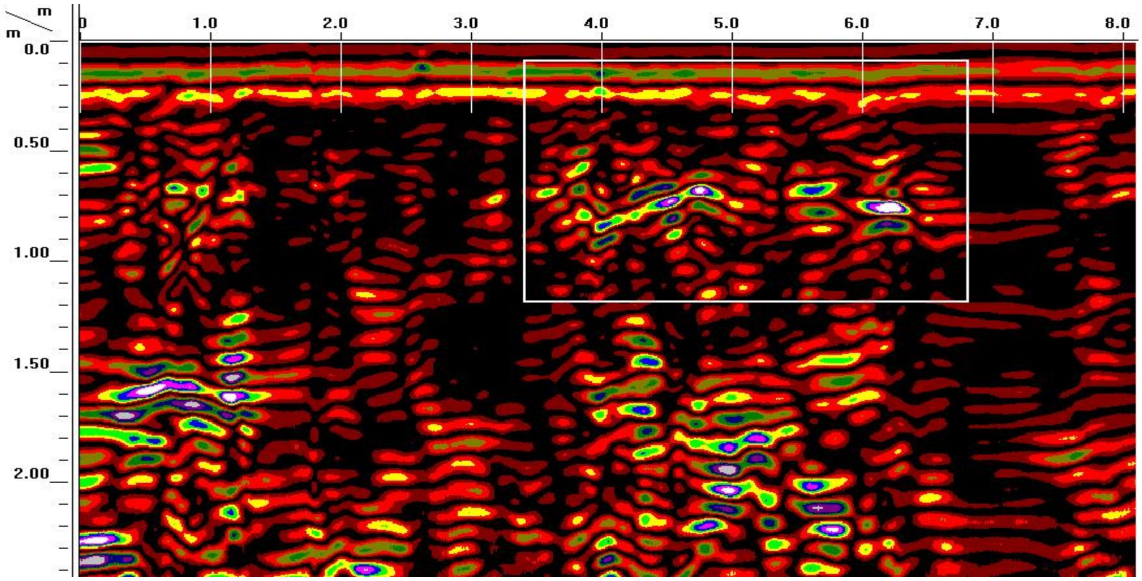

Figure 5. The cube identifies remnants of a former structure on a lower-lying terrace at the Redding Site.

Within the Redding Site, soils located on an isolated, lower-lying terrace, have lower rock contents. Because of lower contents of rock fragments, interpretations were less ambiguous on this surface. Here, a partially buried archaeological structure was recognized with GPR. In Figure 5, the features enclosed in the rectangular area represent remnants of a former structure. The location and dimensions of this structure were distinguishable from the concentration of rock debris exposed on the surface. The nearly continuous, higher-amplitude, planar reflector between depths of 65 to 85 cm, is believed to represent a buried cultural layer or floor to this former structure.

Preston Plain (Mashantucket) Site:

Archaeologists have unearthed several puzzling, subsurface bowl-like features in exploratory trenches. These features are 1 to 1.5 m deep, have no surface expression, and contain a low density of stone tools, flakes and points. These artifacts have been dated to 4000 to 5000 Before Present (BP). The bowl-like, earthen features are believed to be the work of human hands, but display no recognizable spatial arrangement or patterns.

The radar record shown in Figure 6 contains a conspicuous bowl-like feature. This portion of the radar record was collected in an area of Agawam soil. The Haven soils formed in coarse-loamy over sandy and gravelly outwash. In Figure 6, the contact between the coarse-loamy mantle and the underlying sands and gravels is apparent as a planar reflector at a depth of about 70 cm on either end of the radar record. This contact dives to a depth of about 150 cm in the central portion of the radar record where it has been highlighted by a white-colored line. The depression or *bowl-like feature* is principally filled with similar coarse-loamy sediments, which lack contrast and produce low amplitude (colored red and black) reflections. Within this filled-depression, in places, the boundary between the mostly infilled sediments (there are noticeable inclusions with different signal amplitudes) and the underlying sand and gravel outwash is irregular and difficult to trace laterally. High amplitude (colored white and grey) planar reflectors represent contrasting layers of sands and gravels in the underlying outwash. The irregular surface and discontinuous strata, which are arranged in different orientations, suggest highly turbulent depositional environment or rather extreme post-depositional modifications of these outwash sediments.

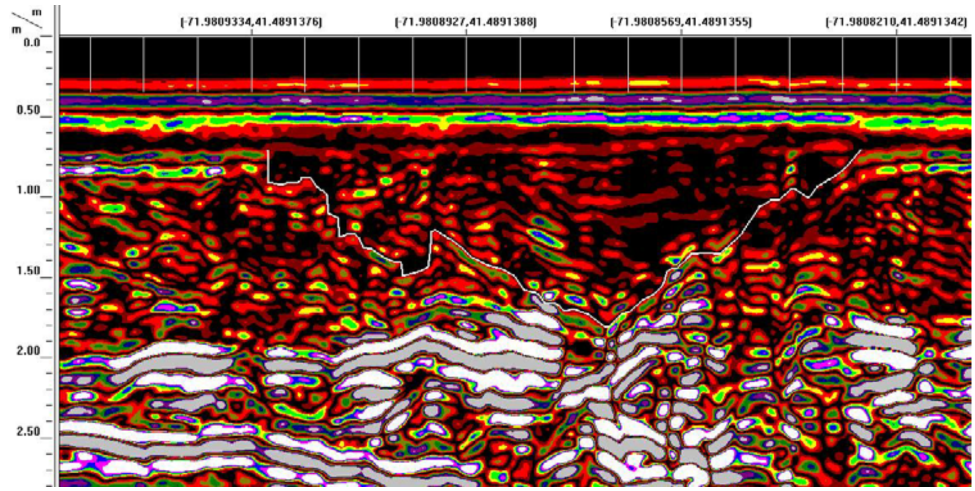

Figure 6. The interpreted boundary of a deep, broad, bowl-like feature has been outlined with a white line on this radar record that was obtained at the Preston Plain site.

Figure 7 is a Goggle Earth image of the Preston Plain site. In this image, the location of the GPR traverse line is shown. Areas that are colored blue along this traverse lines have been interpreted to contain bowl-like features. For this interpretation, the moderately deep, horizontal contact between the loamy mantle and the underlying sands and gravel is absent and a bowl-like depression is imaged. The bowl-like depression must be filled with mostly similar sediments, which provide low-amplitude, planar reflections. Based on soil information, bowl-like depressions are more common in the western portion of the site and in areas of Agawam fine sandy loam, 3 to 8 % slopes, and less common in the eastern portion of the site and in areas of Haven and Enfield soils, 0 to 3 % slopes. While conducting the radar traverse, rock fragments were more noticeable on the soil surface in areas of Haven and Enfield soils suggesting a thinner mantle overlying sands and gravels.

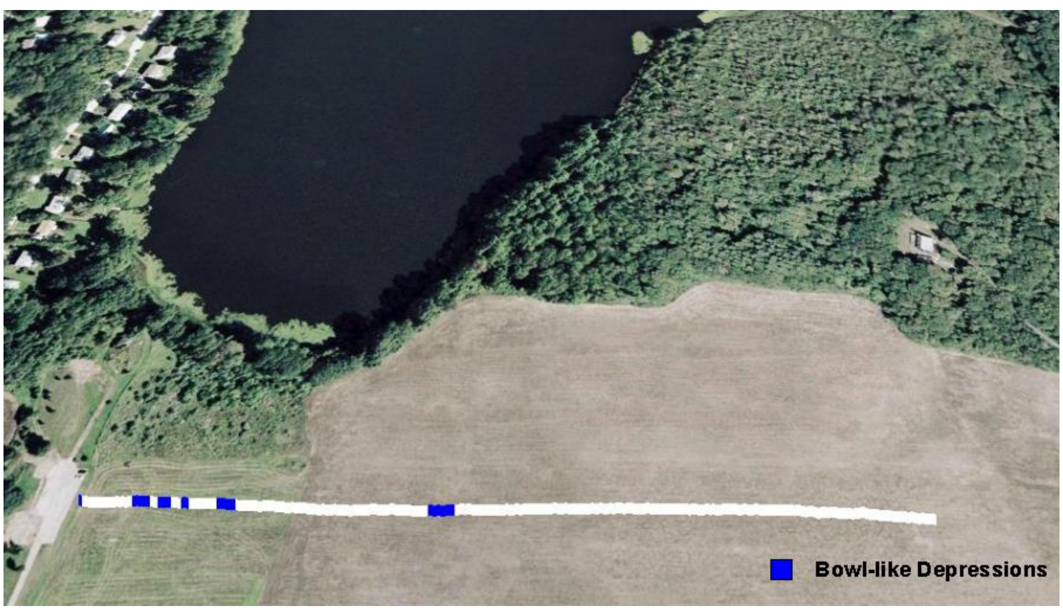

Figure 7. The location of a GPR traverse that was conducted in an area of Agawam fine sandy loam, 3 to 8 % slopes, and Haven and Enfield soils, 0 to 3 % slopes at the Preston Plain site is shown on this Goggle Earth image. A blue color is used to indicate the locations of interpreted bowl-like depressions.

A 24 by 20 meter grid was established across a portion of the study site, in which a bowl-like depression was interpreted from the radar records. Parallel radar traverses were conducted with a 400 MHz antenna across the grid area in a back and forth patterns (lines orientated in a general north south direction). These traverses were spaced 50 cm apart.

Figure 8 is 3D GPR pseudo-image of the grid site. Signal stacking (a signal averaging technique) has been used to reduce high frequency noise and increased display gains have been used to enhance subsurface reflections. In this pseudo-image, a 20.0 by 18.0 by 70 cm cube has been removed. A sequence of stratigraphic layers is evident in this image. The surface mantle of loamy sediments is characterized by mostly low-amplitude reflections; the substratum is composed of stratified sands and gravels that are characterized by high-amplitude reflections. Both point and planar reflections are evident in the underlying sands and gravels. However, the planar reflectors are inclined at different angles and slope in different directions suggesting a turbulent depositional or post-depositional environment.

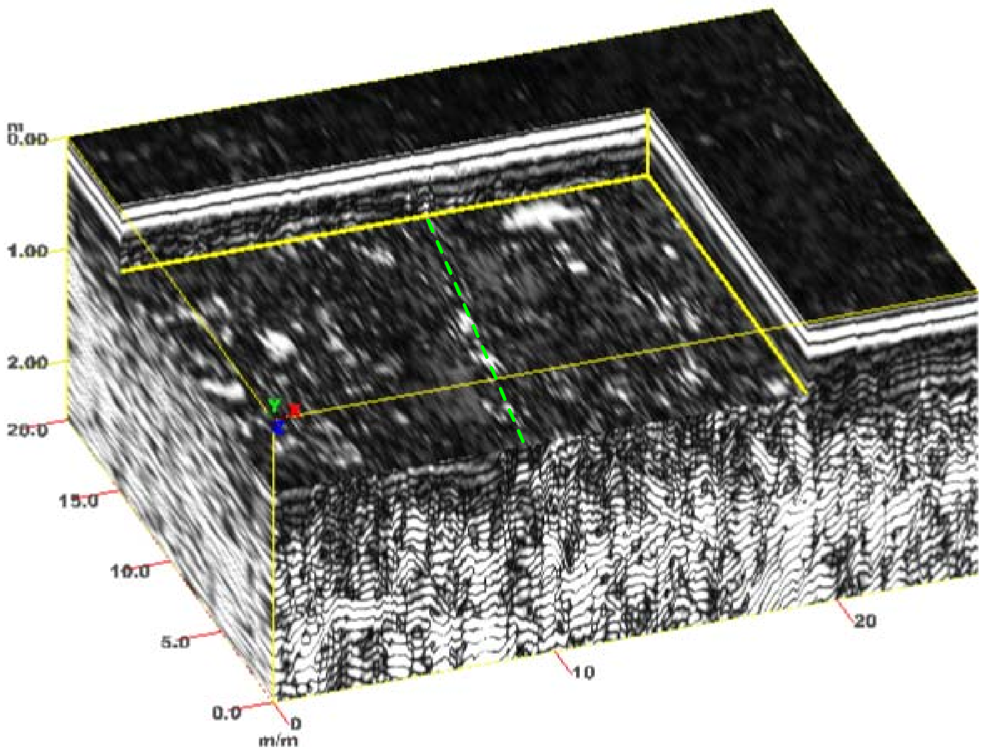

Figure 8. A 3D pseudo-image of a grid site located within the Preston Plain site.

In the 3D pseudo-image shown in Figure 8, a segmented green line is used to identify the location of a refilled trench. The trench had been excavated by archaeologist during a site investigation. This trench bisects a large oval area of homogenous materials characterized by low signal amplitudes. Because of the lack of reflectors, this oval area is interpreted to be composed of loamy mantle materials. Though faintly expressed, the geometry of this area suggests a potential bowl-like feature. This interpretation is confirmed by the observations made in the trench by archaeologists.

Lisbon:

The Lisbon site contains the campsite(s) of Pre-Contact Native Americans. Numerous artifacts have been discovered on this site. The site is presently being excavated by the Office of the State Archaeologists. Excavations have exposed a stone lined cremation area.

A grid survey was impracticable at this site because of the large number of tree. As a consequence, random or "*wild cat*" GPR surveys were conduct across the more "*open areas*" among the trees. Tree roots provided unwanted background noise, which made it difficult to distinguish artifacts and to identify buried cremations. Cores were extracted with a soil auger over eight "promising" reflectors. All but one reflector were confirmed to be larger tree roots. However, the GPR did detect one buried cremation. This buried cremation is evident on the radar record shown in Figure 9. The buried cremation is located at depths of 25 to 60 cm beneath the 2.5 to 3.5 m distant marks. This radar record was obtained in a relatively open area that lacked large tree roots. In this radar record, the contact between the coarse-silty mantle and the underlying sandy or sandy-skeletal glacial outwash is evident at depths of about 1 m.

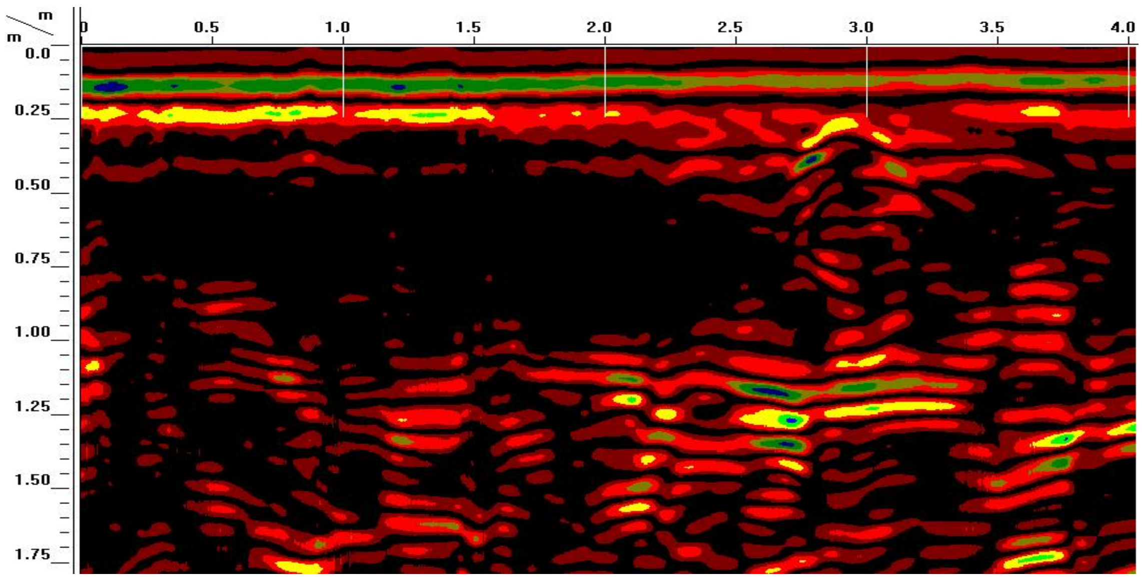

Figure 9. On this radar record from the Lisbon site, reflections from a buried cremation are evident beneath the 3.0 m distant mark at depths of 25 to 50 cm.

Newington:

The purpose of this investigation was to confirm the present of outbuildings and to locate a former well of a house (circa 1774). A 23 by 14 m grid was established across the backyard. Parallel radar traverses were conducted across the grid area in a back and forth patterns (lines orientated in a general east-west direction). These traverses were spaced 50 cm apart. Random GPR surveys were also conducted over the remaining portions of the backyard.

Figure 10 is a 3D cube pseudo-image of the grid site. All measurements are expressed in meters. In Figure 11, the 3D cube shown in Figure 10 has been rotated so the view is from directly overhead. Figure 11 contains three *time or depth slice* images of the grid area. These time-slices images represents a cross-sectional view of the grid area with the soil removed to depths of about 0, 50, and 100 cm. These depths were based on an averaged propagation velocity of 0.0720 m/ns through the soil.

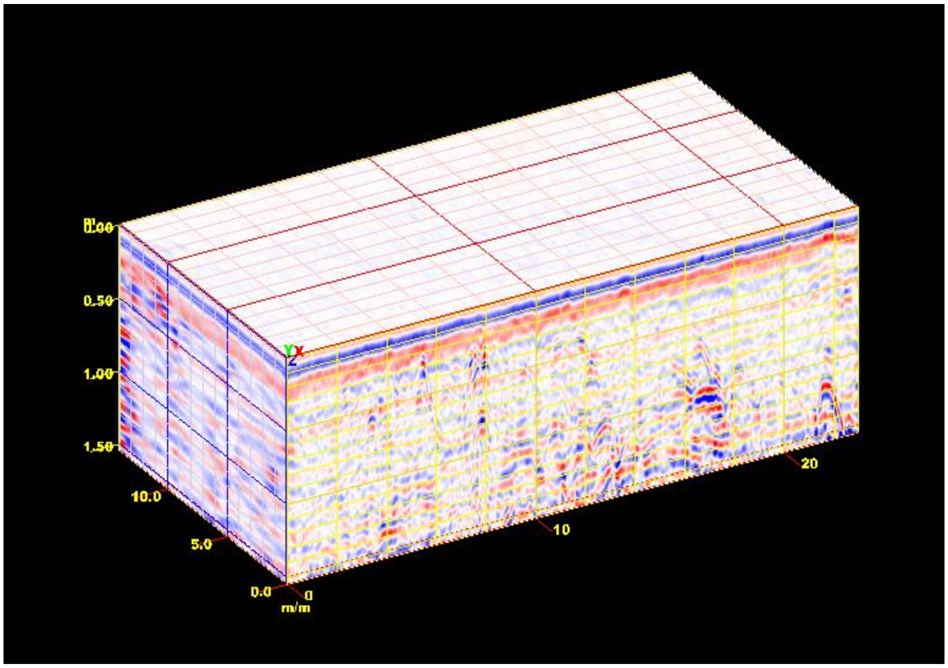

Figure 10. A 3D solid pseudo-image of a grid site located in the backyard of the Well's House in Newington.

In Figure 11, the 0 cm slice, contains two thin, parallel, faintly expressed, linear reflectors on either side of "A". These linear reflectors are spaced about 1 m apart and trend in a north-south direction towards the northern boundary of the grid site. The shallow depth and appearance of these reflectors suggest a former walkway. In the 50 cm slice, a known subsurface structure is evident at "B". Portions of this brick and stonework structure are exposed in a nearby excavation. Also shown in the 50 cm slice, is the outline of a former outbuilding's foundation at "C". This foundation is assumed to be composed of brick and stonework. In the 100 cm slice, linear reflection patterns associated with buried drainage or utility lines are identified at "D" and "E". With succeeding (deeper) depth-slices, the utility line at "D" continues to extend in a west-northwesterly direction towards the Well's house, which is located to the west (left-hand side) of the grid site.

A random "*wild cat*" survey of the remaining portions of the backyard revealed a conspicuous subsurface reflector on several radar records. This reflector is located near the house and was interpreted to represent the well. Limited excavations disclosed another subsurface brickwork feature.

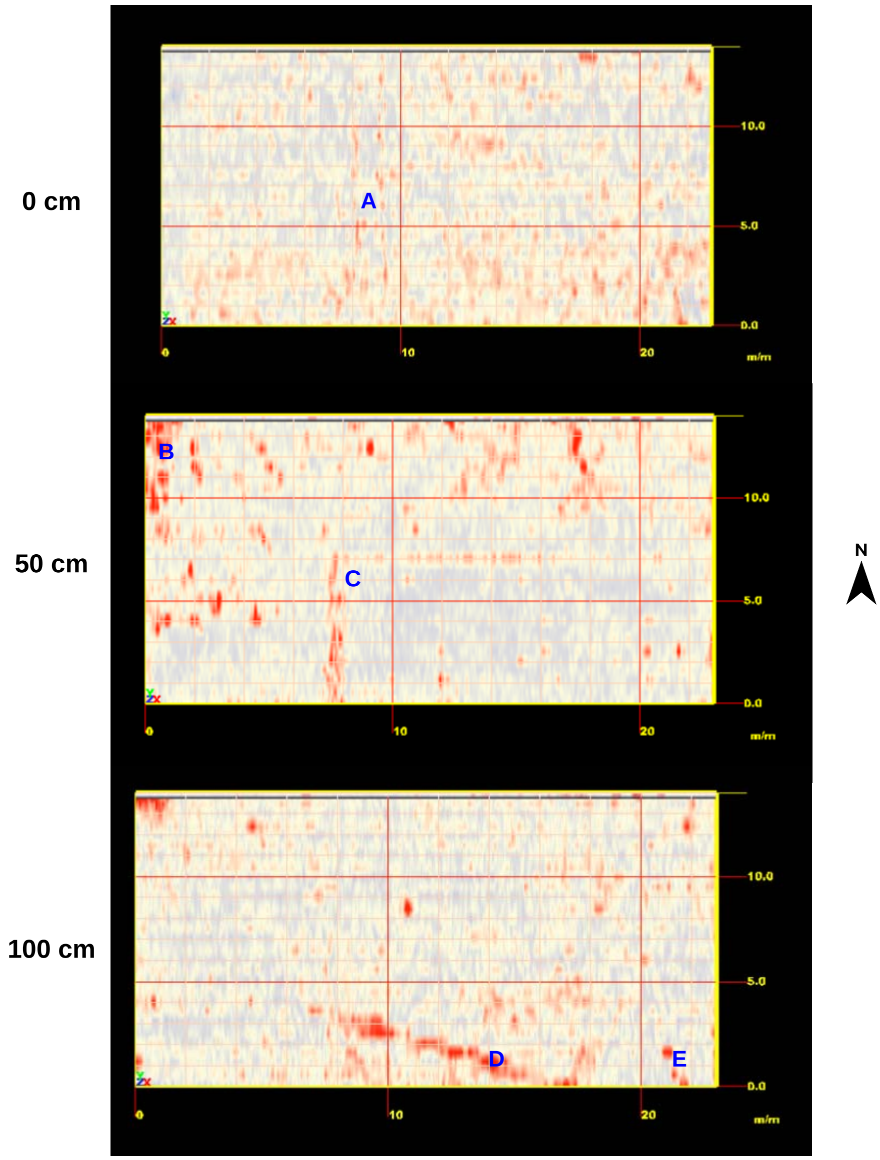

Figure 11. In these 3D pseudo images of the Newington Site, horizontal slices have been made at depths of 0, 50, and 100 cm. The grid area is viewed from directly above. Each slice has a width of 25 cm.

Norwalk:

Plans are being made to widen a portion of Crescent Street near the I-95 overpass. This project will expand the road into a portion of the Pine Island Cemetery near the intersection of Crescent Road and Science Street. The purpose of this survey was to identify the presence of graves in the proposed impact area (41.1071^{o} N. latitude, 73.4153^{o} W. longitude) of the Pine Island Cemetery. The impact area is located in an area of Udorthents-Urban land complex. Soil materials in this unit are presumed to be disturbed.

Three small survey grids were established across the small, irregularly shaped portion of the Pine Island Cemetery, which bordered Crescent Street. Each grid was surveyed with the 400 MHz antenna. Several subsurface anomalies suspected to represent burial grave shafts were interpreted on the radar records. The locations of these anomalies depicted the anticipated distribution of unmarked burials. These anomalies were flagged and some were investigated with limited coring by the State Archaeologists. The extract cores revealed highly disturbed soil materials that were linked to refilled grave shafts.

Figure 12. Conducting a GPR Grid survey at the Pine Island Cemetery in Norwalk.

Unfortunately the radar records from this site were lost due to a computer malfunction.

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