

Appendix D: Ground Penetrating Radar Report (Prepared by Environmental Probing Investigations, Inc.)



ENVIRONMENTAL PROBING INVESTIGATIONS, INC.

833 MONMOUTH ROAD
CREAM RIDGE, NJ 08514
609.758.9000



SUBSURFACE SURVEY REPORT

DATE	October 22-24 and 28, 2019	CLIENT	Middlesex County Office of Arts and History
WEATHER	Sunny 50s - 60s	PROJECT NAME	Trinity Episcopal Church
EPI Geophysicist	Robert Wiencek & Paul McLeod	PROJECT ADDRESS	650 Rahway Avenue Woodbridge, New Jersey

EQUIPMENT USED

GPR: GSSI SIR-4000 RADAR SYSTEM with 350 HS antenna	X
RADIO FREQUENCY (RF) LINE TRACING: VIVAX/METROTECH – vLOCPro2	X
ELECTROMAGNETIC INDUCTION – GSSI EM-PROFILER	X
TRIMBLE Geo7X GPS	X

FIGURE 1

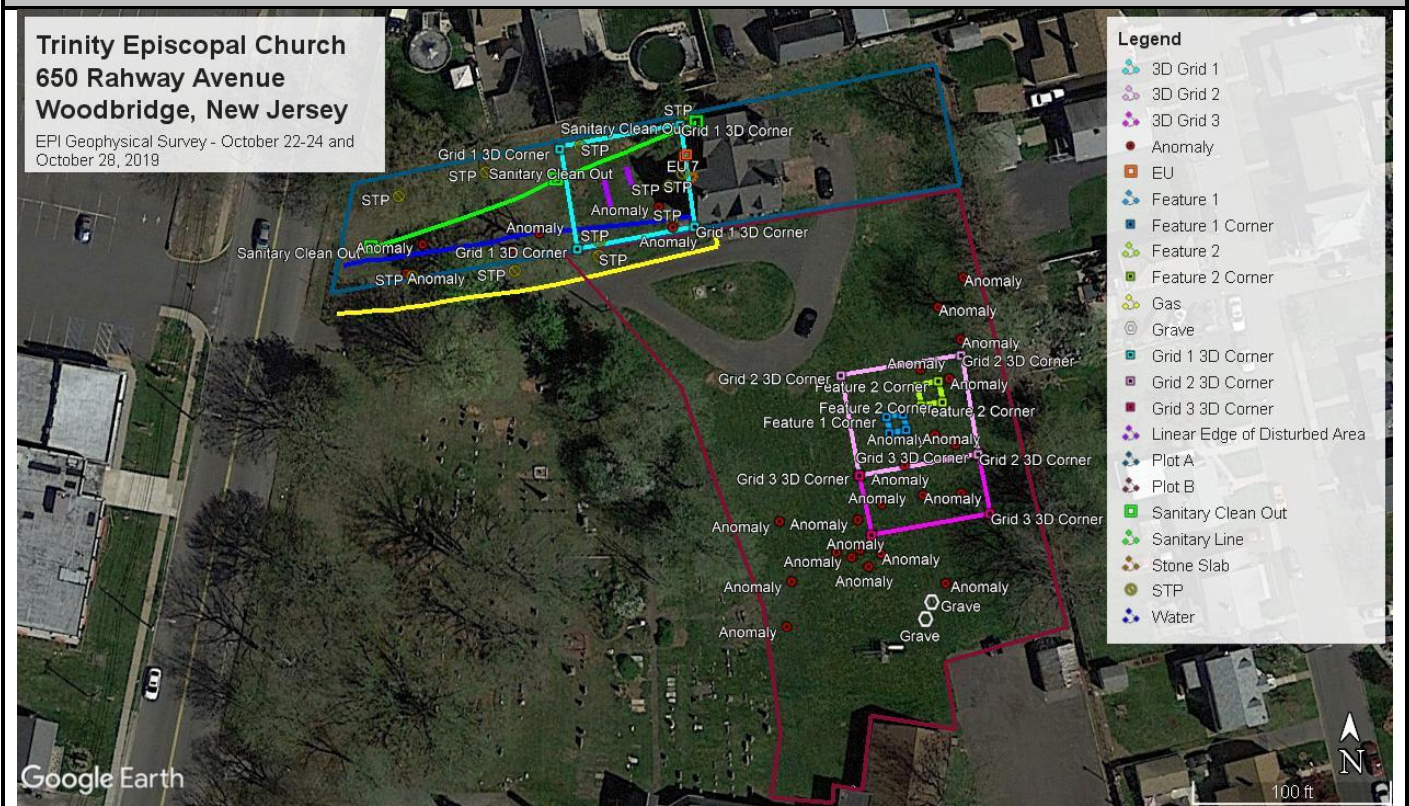


Figure showing the location of the geophysical survey (Plot A and Plot B) within the Trinity Episcopal Church property along with the geophysical findings.

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PROJECT SCOPE

Environmental Probing Investigations, Inc. (EPI) was contracted by Middlesex County Office of Arts and History to conduct a geophysical investigation in order to identify any cultural resources located within Plots A and B of the geophysical project area (see Figure 1).

Visual Site Inspection

The grounds of Trinity Episcopal Church date from the early 18th century. Plot A consists of a front and rear lawn area of the 18th century Dunham House property. Plot B is a large open field that is adjacent to the Trinity Church's cemetery.

Geophysical Survey Result

The ground penetrating radar (GPR) survey made use of a GSSI SIR-4000 together with a 350 HS antenna mounted on a cart. The method involves the transmission of microwave-like signals directly down into the ground and reception of those same signals as they reflect back up to the receiver. The method works best in dry, sandy, resistive soils with an approximate depth of penetration of around 8'. In damp, clayey, conductive soils the depth of penetration may be as little as 2'-3'. The soils within the project area allowed a signal penetration down to a depth of about 4'-5'.

An area of disturbance was located within the front lawn of the Plot A project area during the 2D GPR survey. Based on this finding, 3D GPR Grid 1, measuring 60' x 50', was set-up to encompass this area of disturbance. The post-processed 3D GPR data revealed that this area of disturbance is compact and may be a potential buried road or driveway. Future archaeological survey work is recommended within the 3D GPR Grid 1 area.

Two features were located within the Plot B project area during the 2D GPR survey. Feature 1 measures 8' x 8' and Feature 2 measures 11' x 10'. Based on these findings, 3D GPR Grid 2, measuring 60' x 50', was set-up to encompass each of these features. The post-processed 3D GPR data of these features indicate that these features may be potential outbuildings on the property. Future archaeological survey work is recommended within the 3D GPR Grid 2 area.

The 3D Grid 3 survey area was added as an extension of the 3D Grid 2 survey area. No features were located during the 2D GPR survey in this area. However, 3D Grid 3 was placed in order to determine if any other features would become visible in the 3D GPR data after processing. Two areas (see Photo 20) within the 3D GPR Grid 3 survey area would warrant future archaeological investigation.

Line Tracing was undertaken with a Vivax-Metrotech system, specifically the Loc-10Tx (10 Watt) transmitter and a VLocPro2 receiver. The system works on at least two modes including a passive mode where the receiver detects any lines carrying current as well as an induction/conduction mode. In the induction/conduction mode, a specific radio frequency is transmitted into a cable or pipe (either through direct connection or through inductive coupling) and that same frequency is then detected with the receiver to trace the location of the buried pipe or cable. A utility mark out for a gas line in Plot A was confirmed.

Upon completion of the geophysics fieldwork, all located anomalies and features, STPs and EUs, utilities, and the area and corners of the three 3D GPR survey grids and grid corners were surveyed using a Trimble Geo7X. The uncorrected location data from this instrument has an accuracy of approximately 2', but correction with Pathfinder software increases the accuracy to approximately 1'.

Limitations

EPI completes non-intrusive geophysical surveys using equipment and techniques consistent with the standards of the subsurface utility mapping industry. However, there can be no guarantee that every target will be detected at a particular site. Sub-surface conditions may prevent some or all geophysical methods from detecting a particular target. Targets that are non-metallic or deep, as well as areas that are paved or covered with reinforced concrete may difficult to locate.

Every reasonable effort was made to locate all systems of interest whether indicated on records available to us or not, but EPI does not guarantee that all existing utility systems can or will be detected. The results of this investigation should only be used as a tool and should not be considered a guarantee regarding the presence or absence of USTs or piping.

FIGURE 2

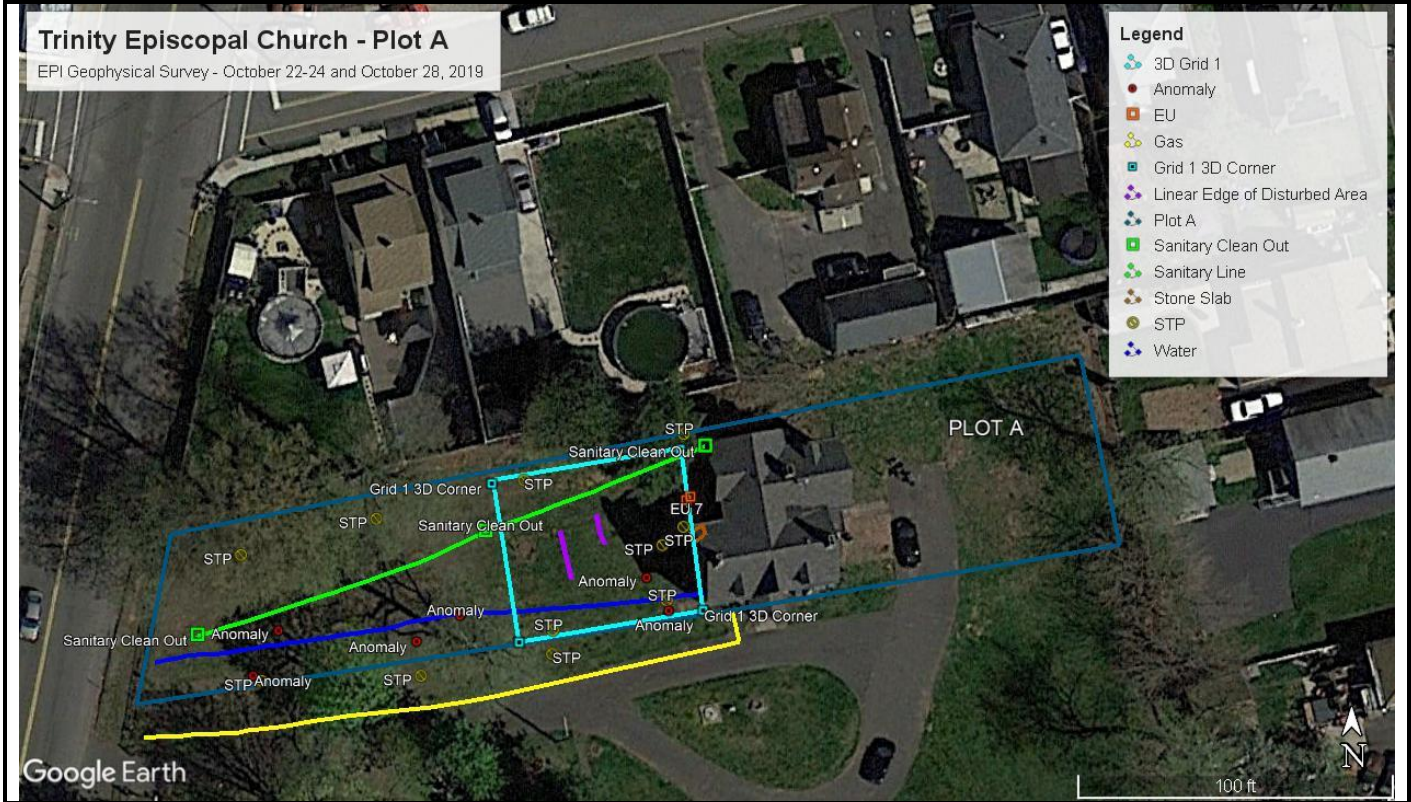


Figure showing the 3D Grid 1 GPR survey area, linear edges of disturbance, anomalies, STPs, EUs. and utilities within the Plot A geophysical survey area.

PHOTO 1



Photo showing the Plot A geophysical survey area. View east.

PHOTO 2



EM survey being conducted on Plot A of project area. View east.

PHOTO 3



An area of disturbance was found in Plot A during the 2D survey. This area of disturbance is shown above and is located between two linear (purple) edges (see also Figure 3 and Photos 7 - 10 for 3D radar findings of Plot A). View east.

PHOTO 4



Photo showing the Plot A location of the 3D GPR Grid 1 survey area (aqua) measuring 60' x 50'. The placement of the grid was based on an area of disturbance found during the 2D GPR survey. View east.

PHOTO 5

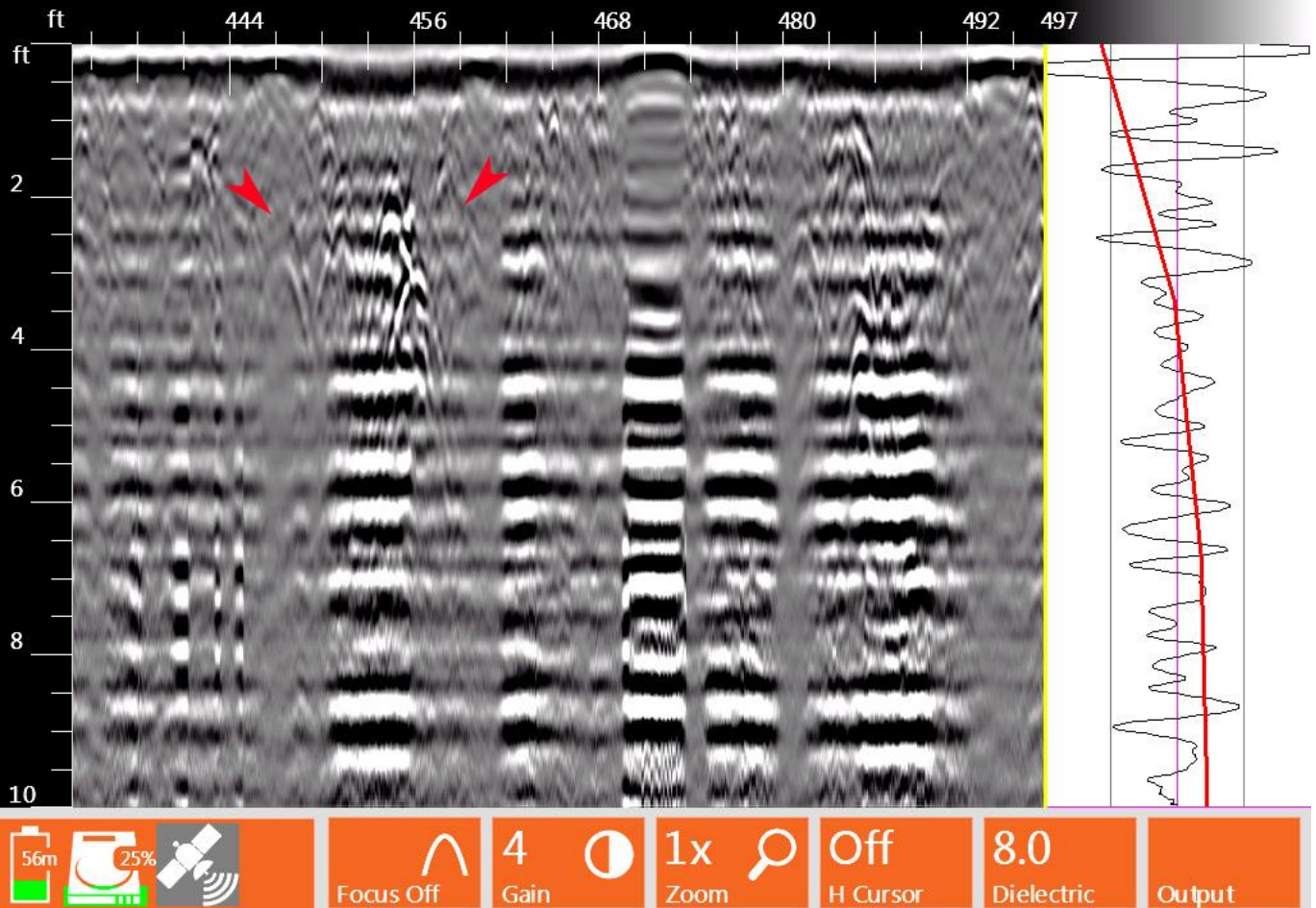


The 3D GPR Grid 1 survey being conducted within area of disturbance found during 2D survey. A portion of the 3D survey grid is outlined in aqua. View northwest.

PHOTO 6

Distance Mode - TRINITY..RIMAGES - ..._003

Distance: 497.08 ft



GPR data showing area of disturbance (between the two red arrows) within the 3D GPR Grid 1 survey area (see Photo 3).

FIGURE 3

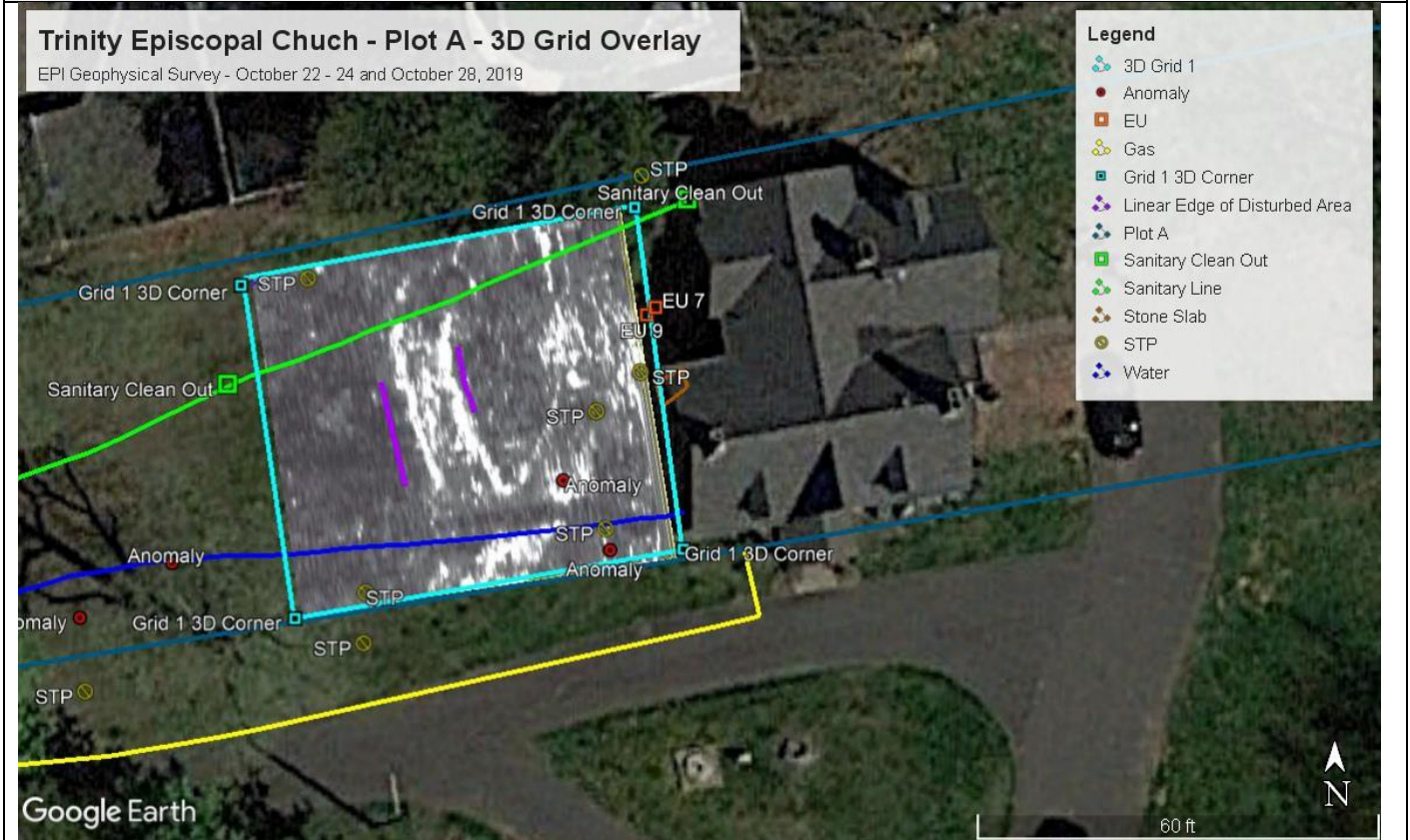
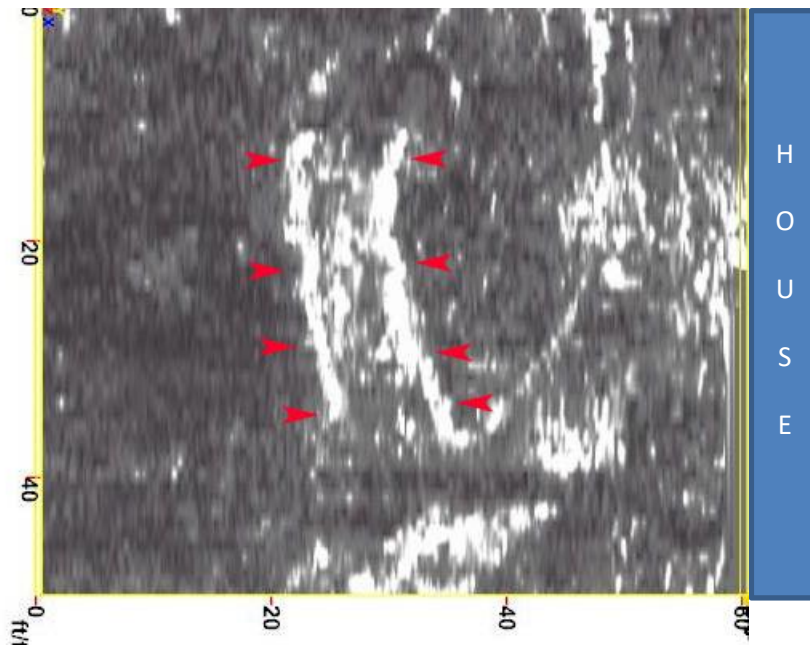


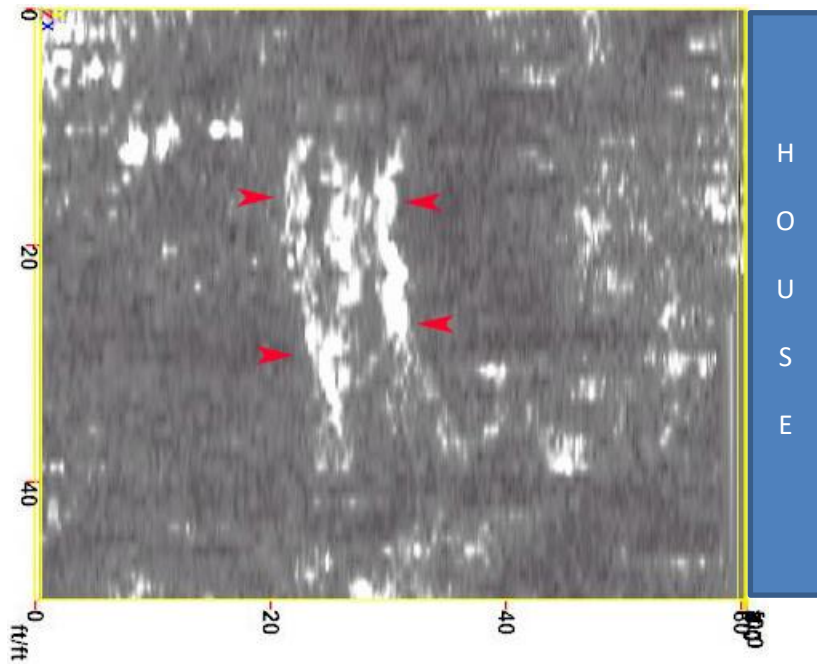
Figure showing the Plot A geophysical project area overlaid onto a Google Earth image. A post-processed 3D GPR image overlay shows a 1' depth slice of the disturbed area (bright white anomaly between two purple lines) within the 3D GPR Grid 1 survey area (aqua) measuring 60' x 50'. The disturbed area (see above) may be a potential buried road or driveway (see Photo 3).

PHOTO 7



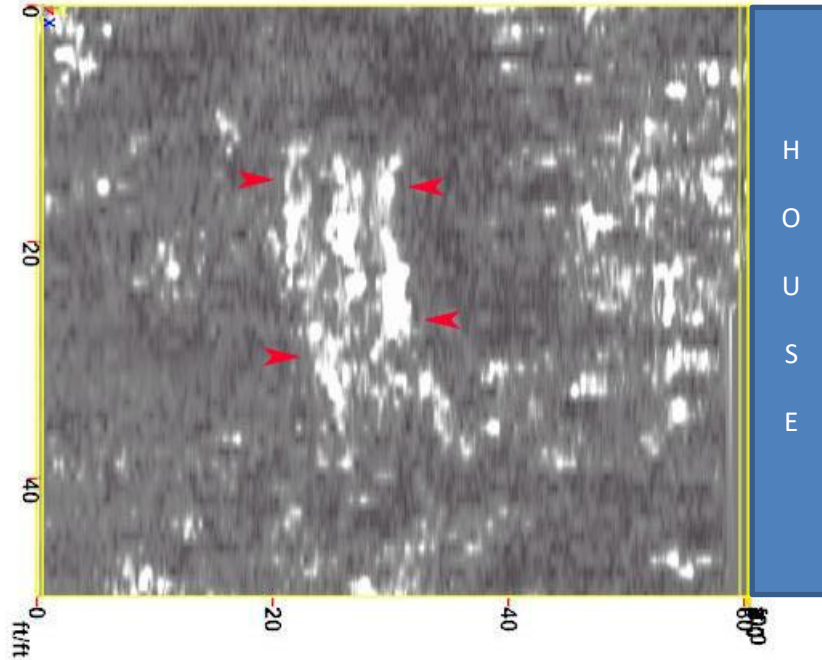
A 3D radar processed image showing the location of a disturbed area (bright white anomaly between red arrows) at a depth slice of 1' within the Plot A 3D survey area measuring 60' x 50' (see above). This disturbed area may be a potential driveway or buried road surface. Linear edges of this anomaly are highlighted by red arrows in the figure. See Figure 3 for placement of this 1' depth slice image within the 3D GPR Grid 1 survey area.

PHOTO 8



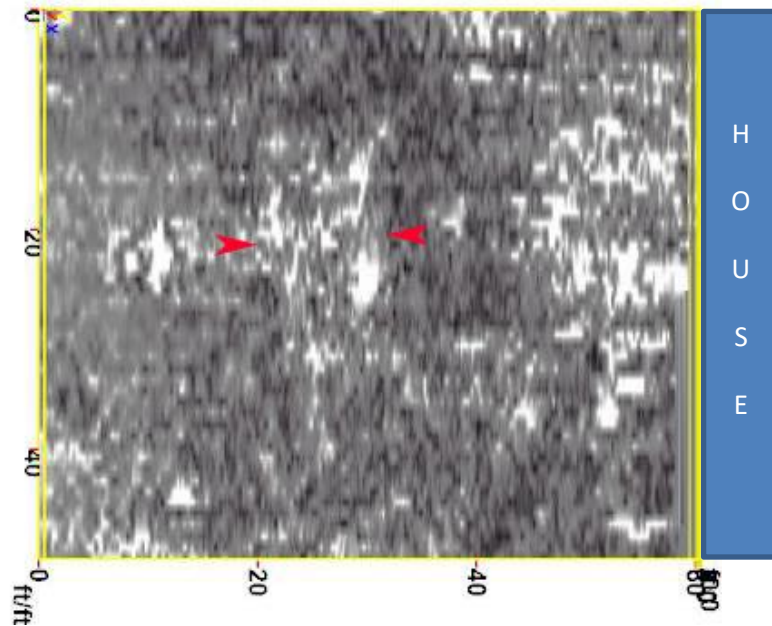
A 3D radar processed image showing the location of a disturbed area (bright white anomaly between red arrows) at a depth slice of 2' within the Plot A 3D survey area measuring 60' x 50' (see above). This disturbed area may be a potential driveway or buried road surface. Linear edges of this anomaly are highlighted by red arrows in the figure. See Figure 3 for placement of this 2' depth slice image within the 3D GPR Grid 1 survey area.

PHOTO 9



A 3D radar processed image showing the location of a disturbed area (bright white anomaly between red arrows) at a depth slice of 3' within the Plot A 3D survey area measuring 60' x 50' (see above). This disturbed area may be a potential driveway or buried road surface. Linear edges of this anomaly are highlighted by red arrows in the figure. See Figure 3 for placement of this 3' depth slice image within the 3D GPR Grid 1 survey area.

PHOTO 10



A 3D radar processed image showing the location of a disturbed area (bright white anomaly between red arrows) at a depth slice of 4.5' within the Plot A 3D survey area measuring 60' x 50' (see above). This disturbed area may be a potential driveway or buried road surface. At this depth, the anomaly and its linear edges are barely visible. See Figure 3 for placement of this 4.5' depth slice image within the 3D GPR Grid 1 survey area.

PHOTO 11

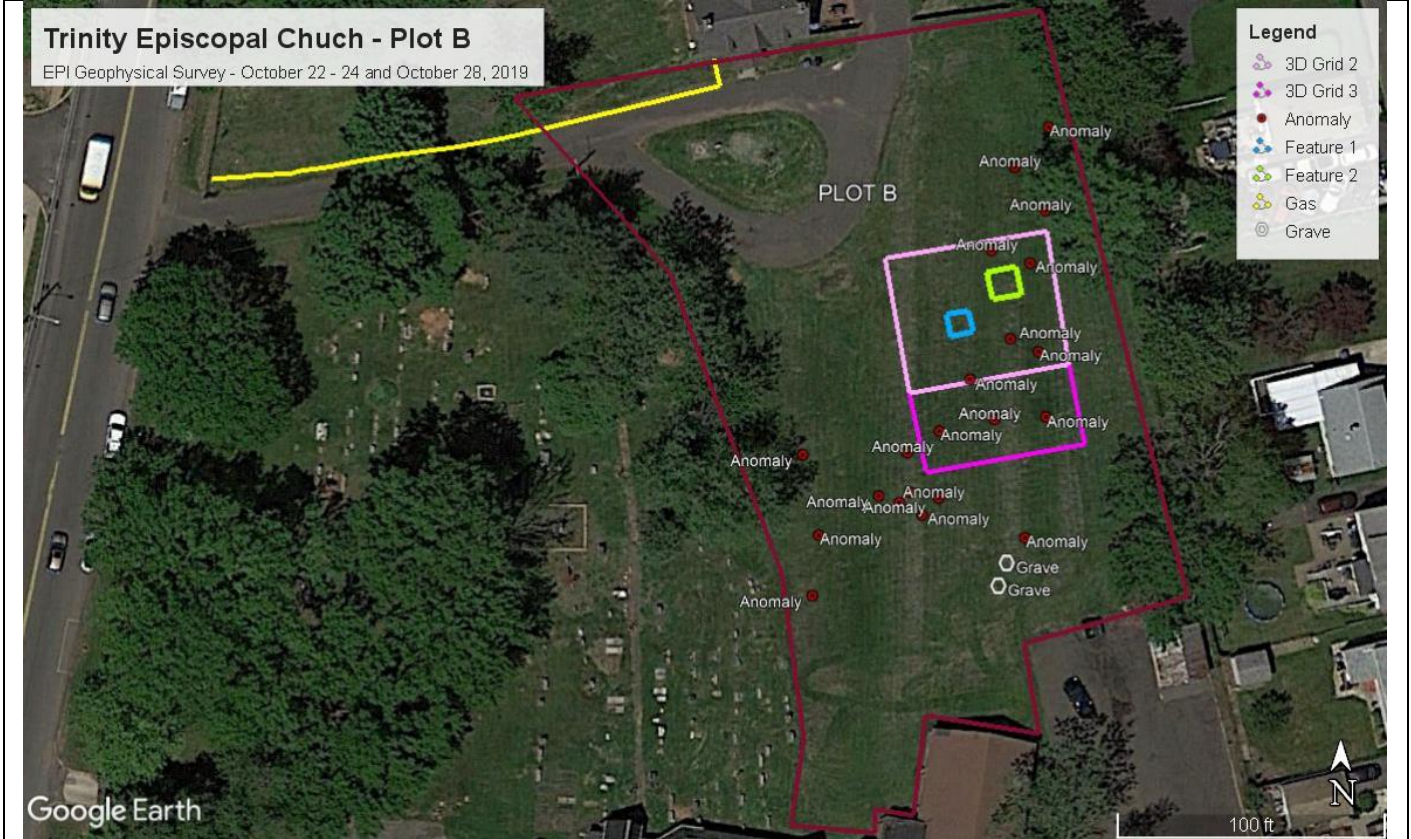


Figure showing the 3D Grid 2 and 3 GPR survey areas, Features 1 and 2, anomalies, graves, and a gas line within the Plot B geophysical survey area

PHOTO 12



Photo showing Plot B geophysical survey area. View north.

PHOTO 13



EM survey being conducted on Plot B of project area. View north.

PHOTO 14



Panoramic photo showing GPR survey being conducted in Plot B of the project area. View northwest.

PHOTO 15

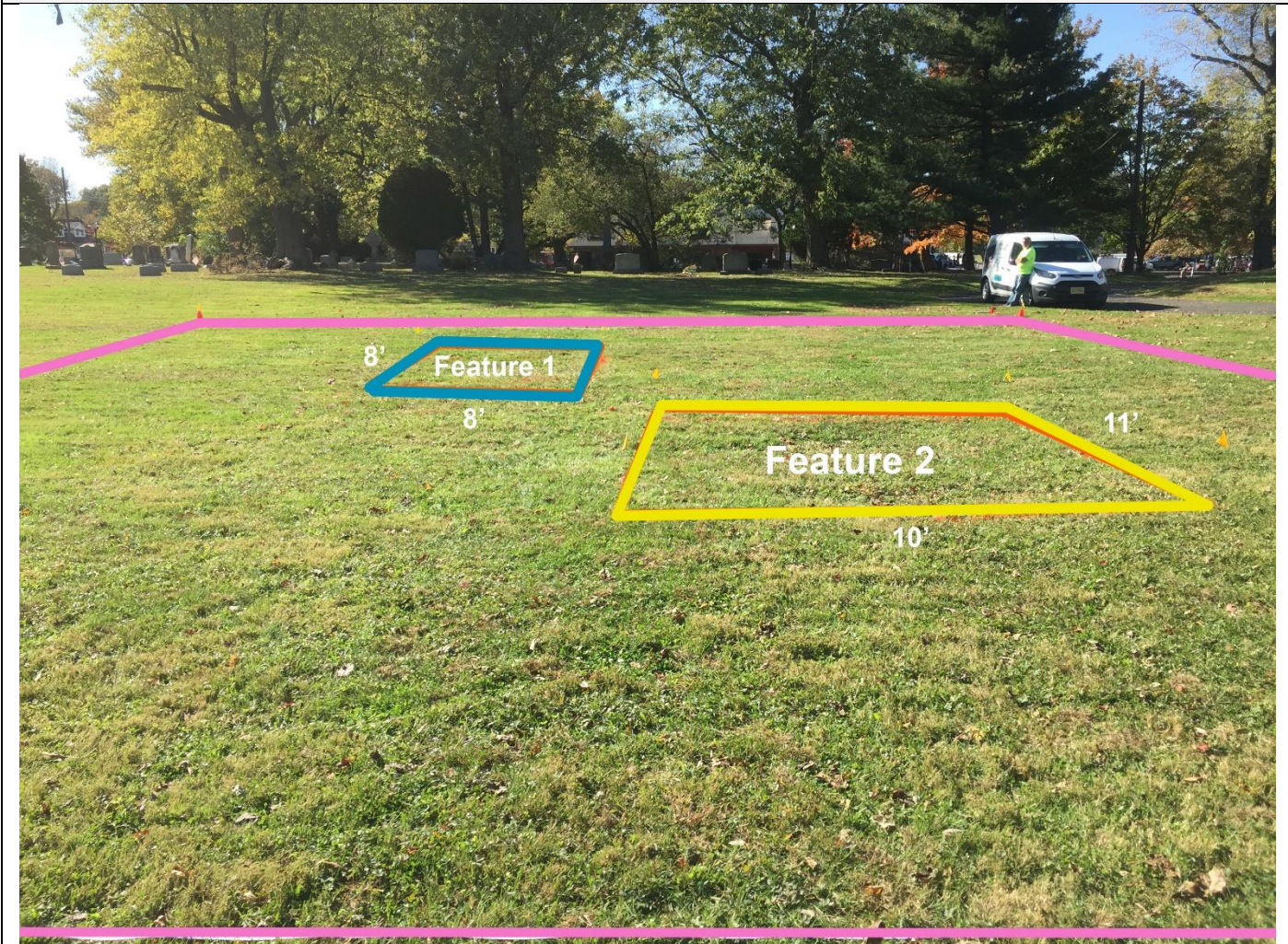


Figure showing the 3D GPR Grid 2 survey area (pink), measuring 60' x 50', along with two features located during the 2D GPR survey. Feature 1 (blue) measures approximately 8' x 8' and Feature 2 (yellow) measures approximately 11' x 10'. View west.

PHOTO 16

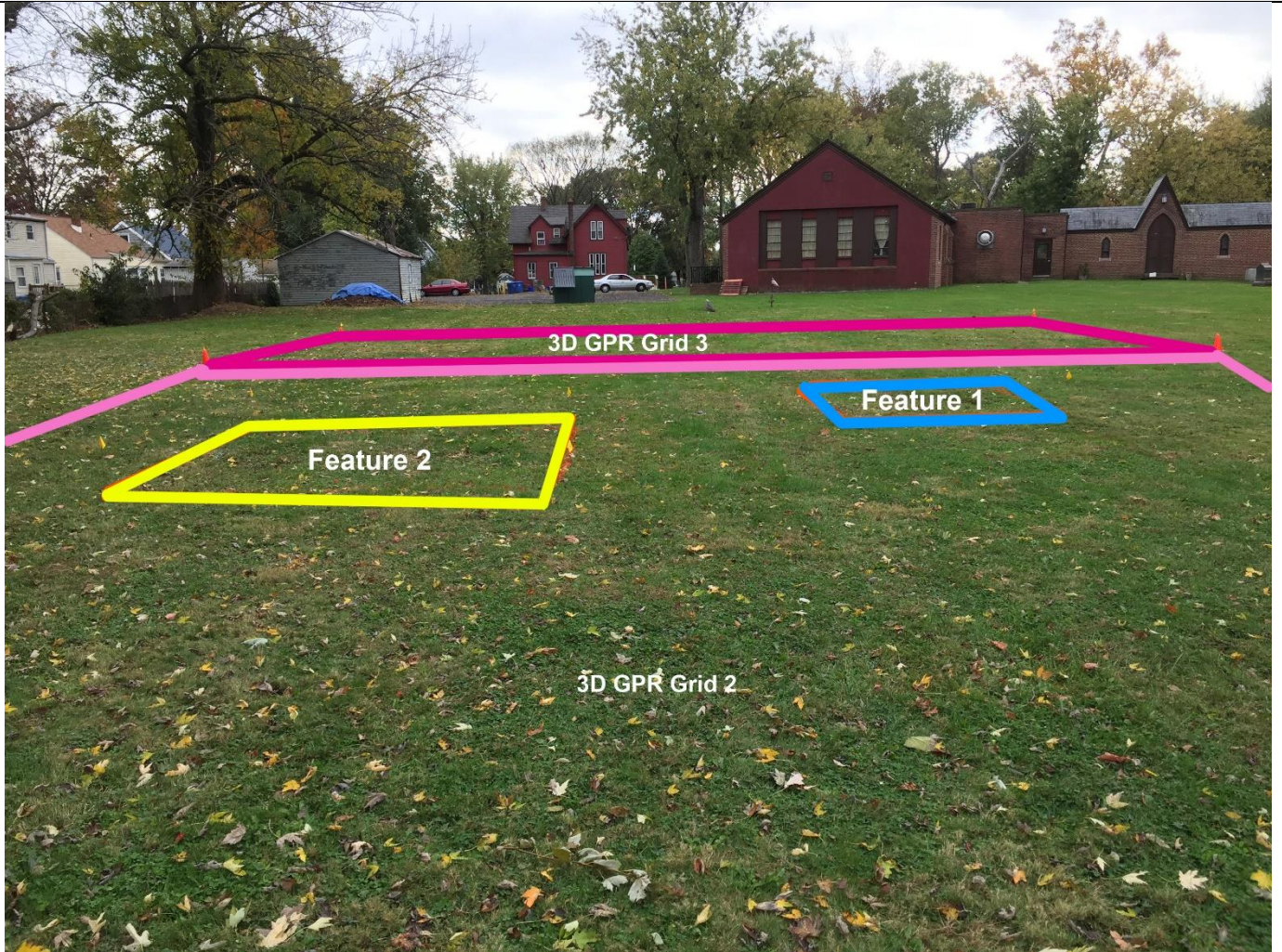
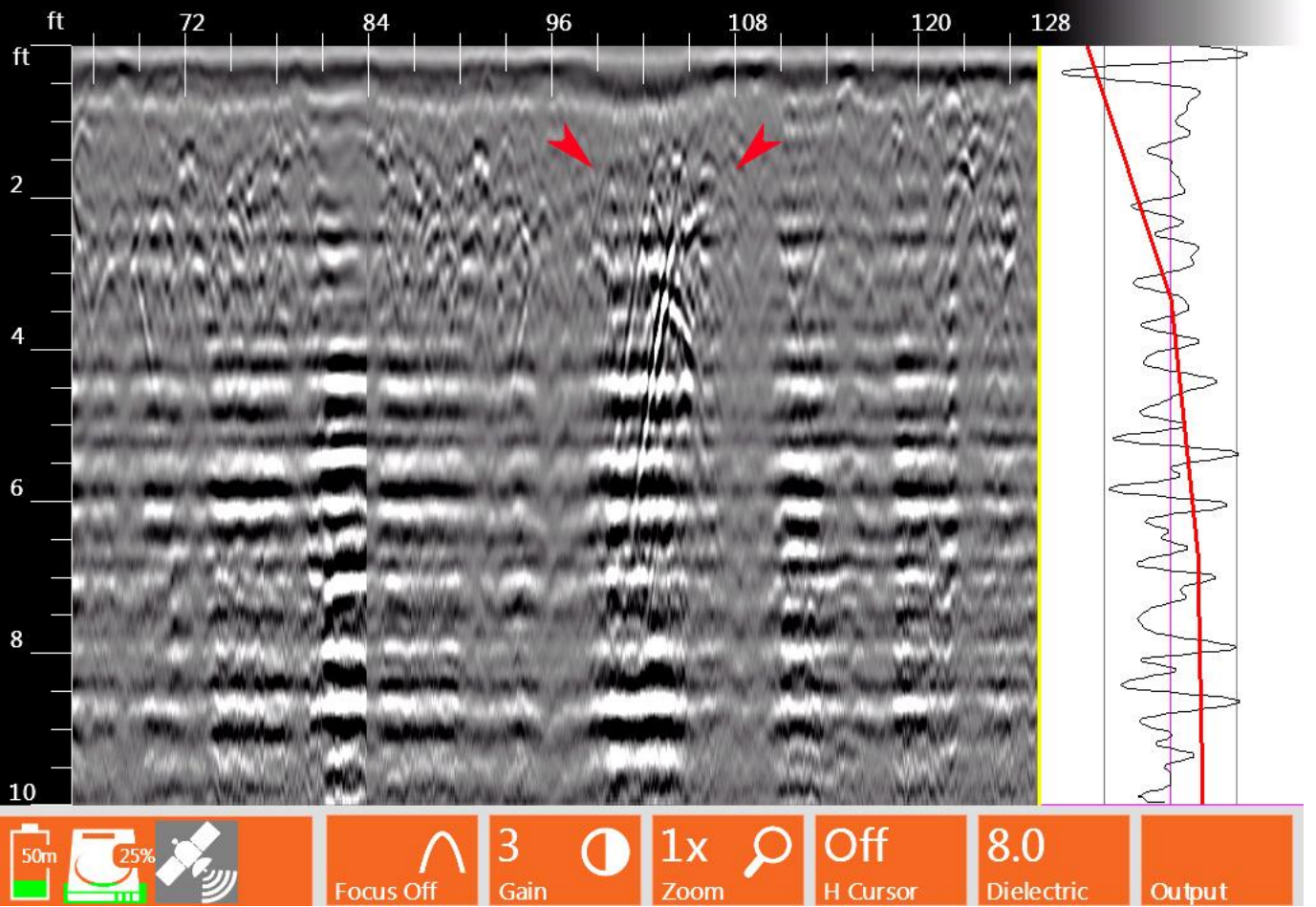
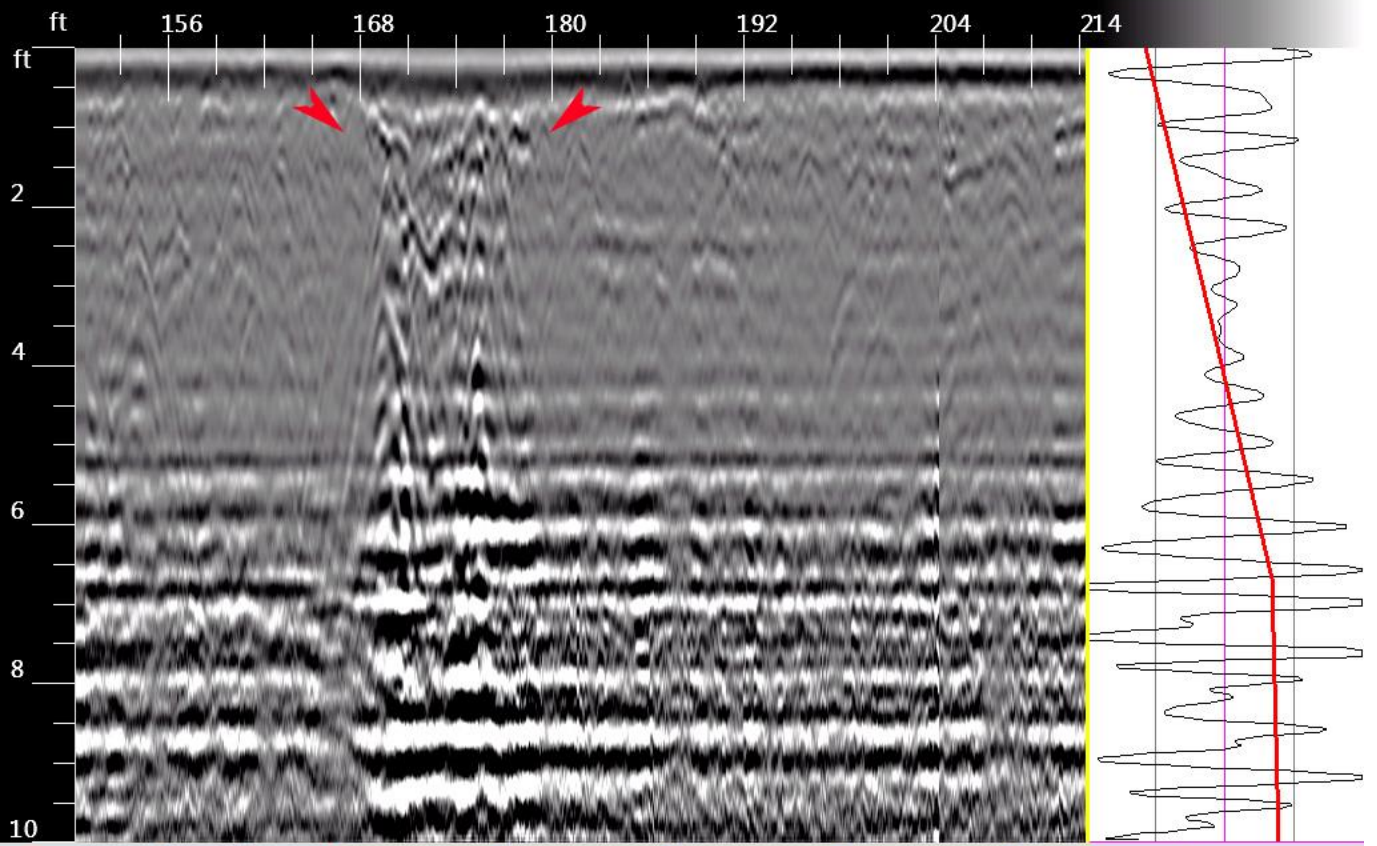


Figure showing the 3D GPR Grid 2 survey area (pink) measuring 60' x 50' and the 3D GPR Grid 3 survey area (magenta) measuring 60' x 50' and 3D GPR Grid 3 measures 60' x 30'. The two features located during the 2D GPR survey are also shown in Grid 2. The 3D Grid 3 survey area was added as an extension of the 3D Grid 2 survey area. No features were located during the 2D GPR survey in this area. However, 3D Grid 3 was placed to determine if any other features would become visible in the 3D GPR data after processing. View south.



GPR data showing a cross section of Feature 1 (between two red arrows) within the 3D Grid 2 survey area.



54m 25% Focus Off 0 Gain 1x Zoom Off H Cursor 8.0 Dielectric Output

GPR data showing a cross section of Feature 2 (between two red arrows) within the 3D Grid 2 survey area.

FIGURE 4

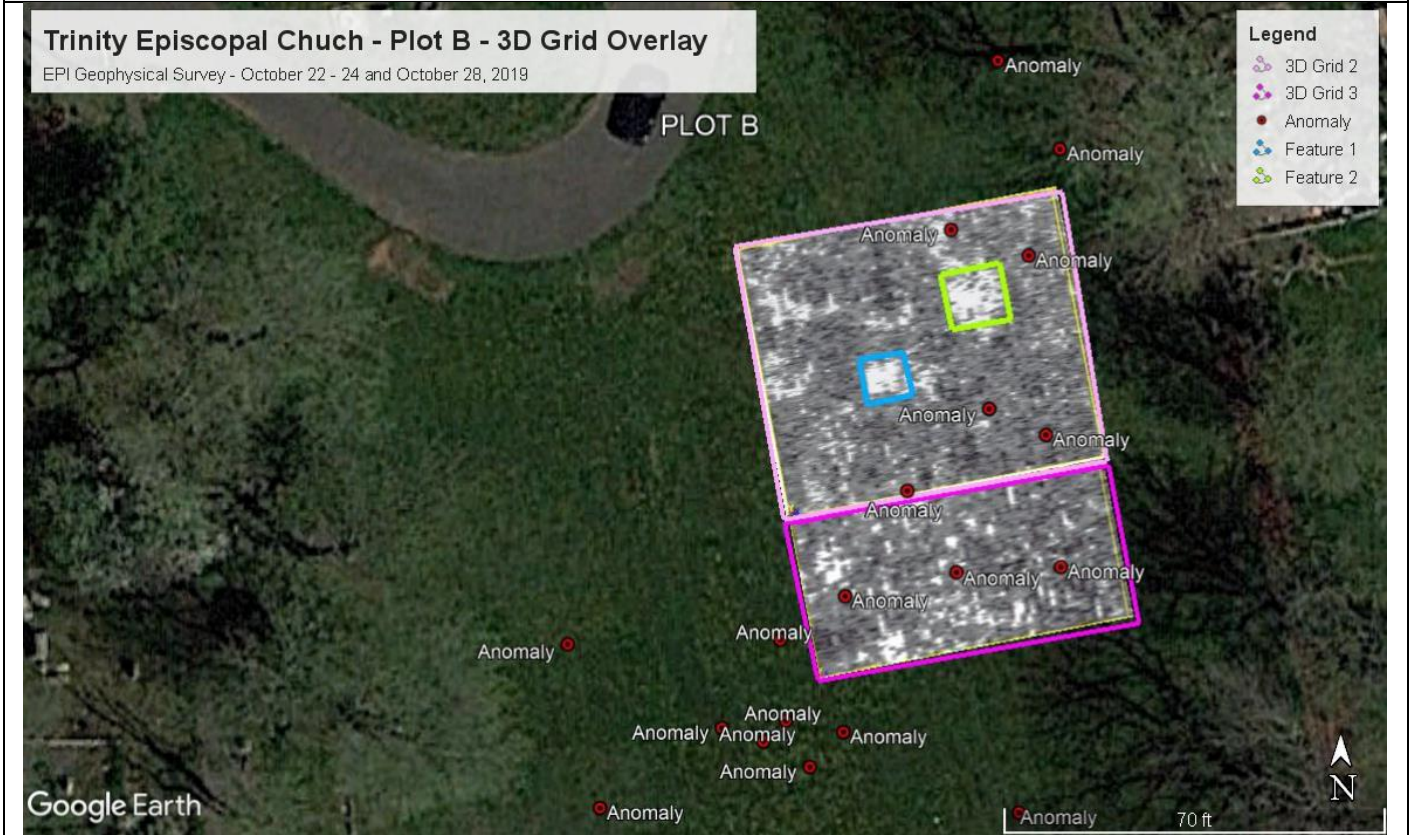
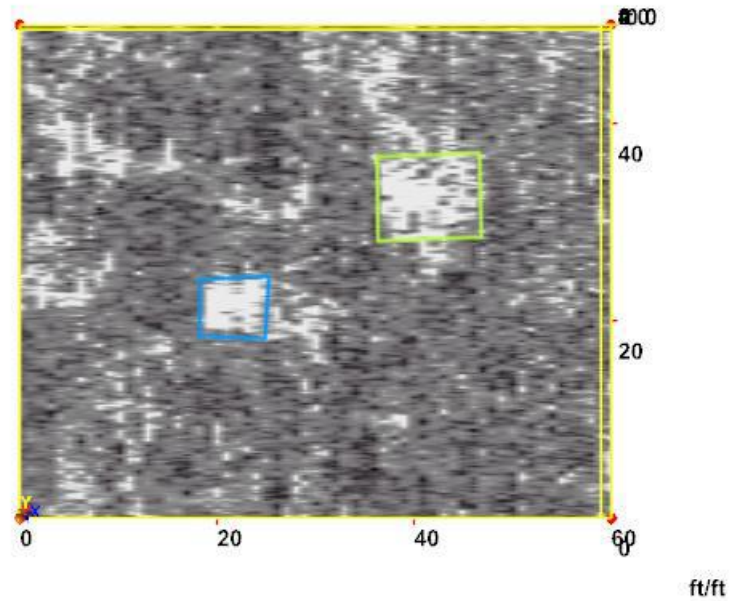


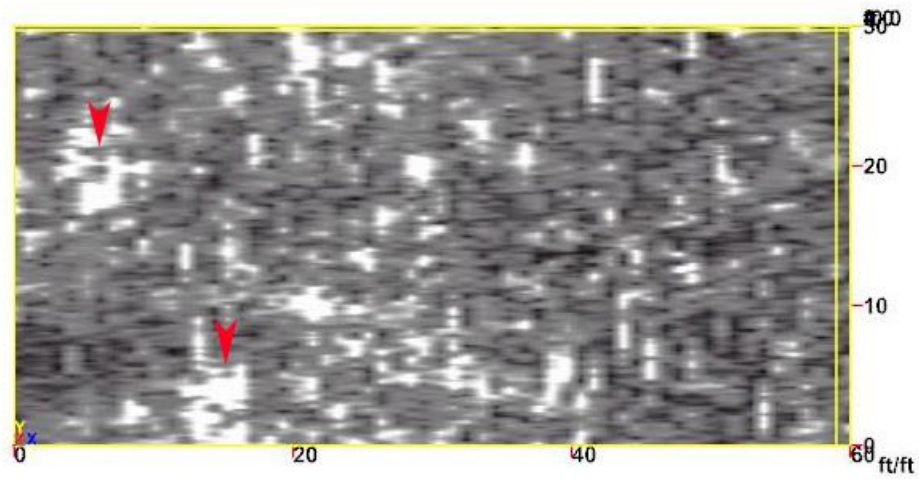
Figure showing the Plot B geophysical project area overlaid onto a Google Earth image. A post-processed 3D GPR image overlay shows a 3' depth slice of both Feature 1 (blue) and Feature 2 (yellowish-green) within the 3D GPR Grid 2 survey area (pink) measuring 60' x 50'. The 3D GPR Grid 3 survey area (magenta) is also shown measuring 60' x 30'. Single anomalies were located within both Grids 2 and 3.

PHOTO 19



A 3D radar processed image showing a 3.5' depth slice of both Feature 1 (blue) and Feature 2 (yellowish-green) within the Plot B 3D Grid 2 survey area (60' x 50'). Both Feature 1 and Feature 2 appear to be potential outbuildings. Feature 1 measures approximately 8' x 8' and Feature 2 measures approximately 11' x 10'. See Figure 4 for placement of this 3.5' depth slice image within the 3D GPR Grid 2 survey area.

PHOTO 20



A 3D processed radar image showing a 3' depth slice of the Plot B 3D Grid 3 survey area (60' x 30'). No features were located during the 2D radar survey of this area. However, two areas (bright white anomalies indicated by red arrows) warrant future archaeological investigation. See Figure 4 for placement of this 3.5' depth slice image within the 3D GPR Grid 2 survey area.

FIGURE 5

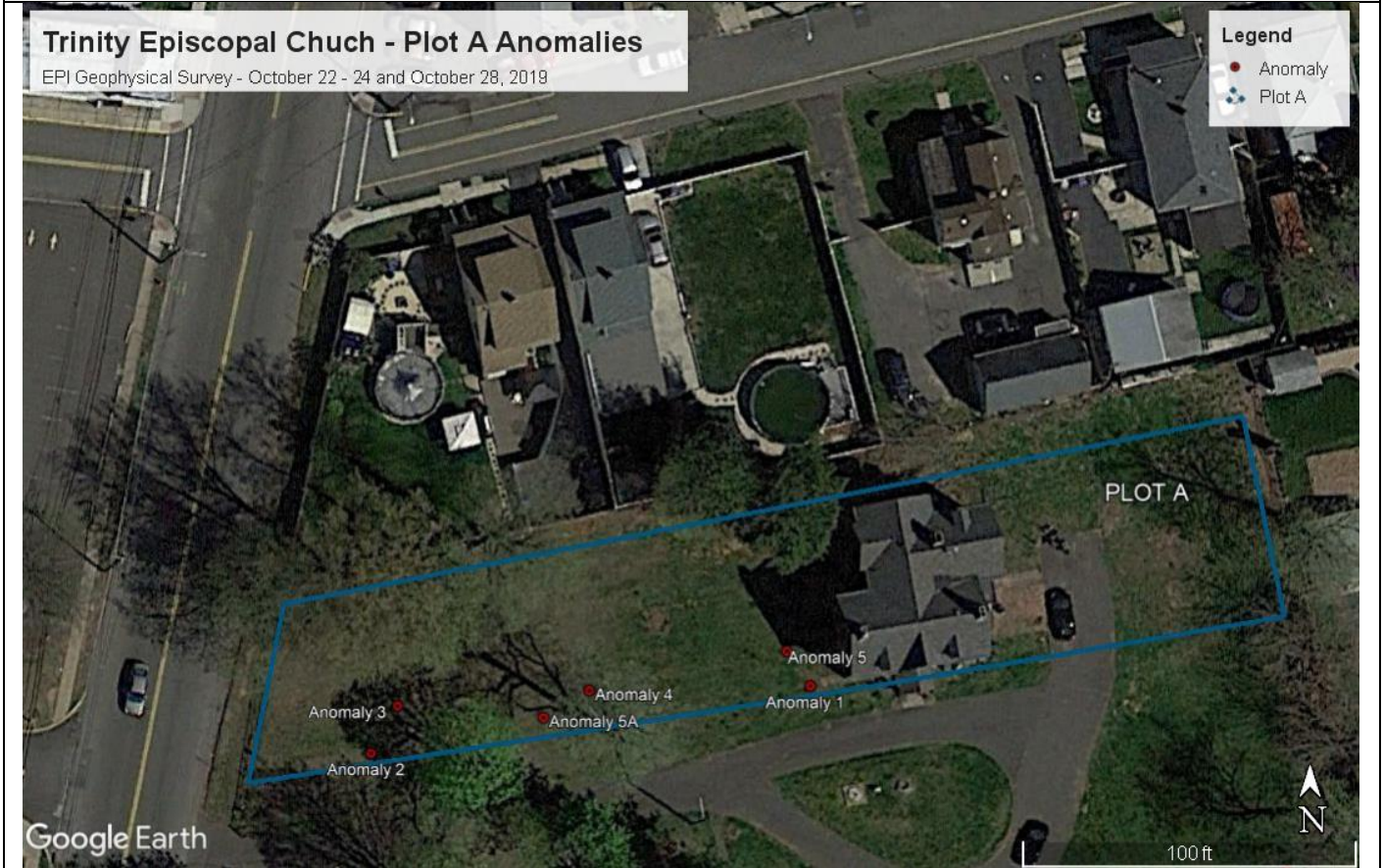


Figure showing anomalies located in Plot A.

FIGURE 6



Figure showing anomalies located in Plot B.

FIGURE 7

Point	West Latitude	North Latitude	State Plane Easting	State Plane Northing
Plot A - Grid 1 - 3D Survey Corner 1	-74.2727025	40.56436708	555272.823	630578.49
Plot A - Grid 1 - 3D Survey Corner 2	-74.27247836	40.56441226	555335.05	630595.109
Plot A - Grid 1 - 3D Survey Corner 3	-74.27247267	40.56425914	555336.774	630539.334
Plot A - Grid 1 - 3D Survey Corner 4	-74.27265987	40.56424455	555284.782	630533.886
Plot B - Grid 2 - 3D Survey Corner 1	-74.27216651	40.56392285	555422.149	630417.047
Plot B - Grid 2 - 3D Survey Corner 2	-74.27219913	40.56405758	555412.958	630466.106
Plot B - Grid 2 - 3D Survey Corner 3	-74.27198485	40.5640848	555472.462	630476.173
Plot B - Grid 2 - 3D Survey Corner 4	-74.27195466	40.56395102	555480.978	630427.46
Plot B - Grid 3 - 3D Survey Corner 1	-74.27214478	40.56384162	555428.261	630387.471
Plot B - Grid 3 - 3D Survey Corner 2	-74.27216615	40.56392223	555422.248	630416.822
Plot B - Grid 3 - 3D Survey Corner 3	-74.27193357	40.56387071	555486.912	630398.22
Plot B - Grid 3 - 3D Survey Corner 4	-74.2719539	40.56395096	555481.189	630427.442
EU 9	-74.27247961	40.56435312	555334.758	630573.563
EU 7	-74.27247486	40.56435607	555336.075	630574.641
STP 1	-74.27248254	40.56441003	555333.891	630594.293
STP 2	-74.27248284	40.56433009	555333.881	630565.173
STP 3	-74.2725068	40.56431417	555327.242	630559.355
STP 4	-74.27250169	40.56426664	555328.705	630542.044
STP 5	-74.27263172	40.56424003	555292.607	630532.257
STP 6	-74.27266601	40.56436949	555282.957	630579.393
STP 7	-74.27283754	40.56433532	555235.338	630566.822
STP 8	-74.2729955	40.56430317	555191.482	630554.997
STP 9	-74.27296979	40.56419312	555198.729	630514.928
Anomaly 1 at 2'	-74.2724987	40.5642583	555329.544	630539.01
Anomaly 2 at 2'	-74.27297895	40.56419832	555196.178	630516.814
Anomaly 3 at 3'	-74.27295006	40.56423759	555204.168	630531.143
Anomaly 4 at 4'	-74.27273845	40.56425193	555262.942	630536.515
Anomaly 5 at 2'	-74.27252391	40.56428649	555322.515	630549.26
Anomaly 5A at 2'	-74.272788550	40.564229356	555249.046	630528.258
Anomaly 6 at 2.5'	-74.27198098	40.56419056	555473.439	630514.706
Anomaly 7 at 2'	-74.27202614	40.5641504	555460.929	630500.043
Anomaly 8 at 2'	-74.27205682	40.56406635	555452.487	630469.4
Anomaly 8A at 4'	-74.27198534	40.56410648	555472.306	630484.072

Point	West Latitude	North Latitude	State Plane Easting	State Plane Northing
Anomaly 9 at 3'	-74.27200584	40.56405353	555466.661	630464.767
Anomaly 11 at 3'	-74.2720317	40.56397721	555459.55	630436.946
Anomaly 12 at 4'	-74.27199455	40.56396421	555469.882	630432.238
Anomaly 13 at 3.25'	-74.27208545	40.56393641	555444.656	630422.046
Anomaly 14 at 2'	-74.27205322	40.5638959	555453.648	630407.311
Anomaly 15 at 2'	-74.2719848	40.56389853	555472.652	630408.318
Anomaly 16 at 3'	-74.27216908	40.56386242	555421.491	630395.033
Anomaly 17 at 2'	-74.27216535	40.56382227	555422.564	630380.407
Anomaly 18 at 2.5'	-74.27212765	40.56381667	555433.043	630378.396
Anomaly 19 at 2.5'	-74.2721497	40.56379938	555426.934	630372.082
Anomaly 20 at 2.5'	-74.27218015	40.56381195	555418.462	630376.638
Anomaly 21 at 2'	-74.27230838	40.56386034	555382.793	630394.173
Anomaly 22 at 2'	-74.27220725	40.56381874	555410.928	630379.091
Anomaly 23 at 3'	-74.2722871	40.56377931	555388.78	630364.673
Anomaly 25 at 2'	-74.27229597	40.56371847	555386.375	630342.502
Anomaly 26 at 3'	-74.27201258	40.56377658	555465.05	630363.875
Feature 1 - 3D Corner SW	-74.27211249	40.5639794	555437.101	630437.686
Feature 1 - 3D Corner NW	-74.27211753	40.5640017	555435.681	630445.807
Feature 1 - 3D Corner SE	-74.27208262	40.56398412	555445.397	630439.428
Feature 1 - 3D Corner NE	-74.27208843	40.56400479	555443.764	630446.953
Feature 2 - 3D Corner SW	-74.27205624	40.56401701	555452.695	630451.428
Feature 2 - 3D Corner NW	-74.27206364	40.56404359	555450.614	630461.106
Feature 2 - 3D Corner SE	-74.27201791	40.56402139	555463.338	630453.052
Feature 2- 3D Corner NE	-74.27202555	40.56404991	555461.19	630463.434

GPS Coordinates of 3D grids, anomalies, features, EUs, and STPs.

EM SURVEY RESULTS

Electromagnetic Induction data was collected with the GSSI-EMP-400 multifrequency conductivity meter. The EM data is processed into two kinds of contour maps: In-Phase and Conductivity. These are both derived from the same frequency domain data, but the In-Phase data is given as a ratio of the transmitted signal to the received signal in parts per million (PPM), while the Conductivity data is given in milliSiemens per meter (mS/M). All contour maps were generated using Surfer software. The contour colors are intended to give an indication of signal intensity from low (blue) to high (red). In fact, the overall difference between the lowest and highest values on this project was relatively small; the variety of colors can give a false impression of big differences in electromagnetic response, but in this survey, the differences do not imply dramatic subsurface features. The color contours nevertheless give the ability to highlight subtle features in the surface which may be targets for follow-up study.

Any object in the subsurface that has different electromagnetic properties from the surrounding soil will cause a distortion in the received EM wave form. It is difficult to predict what kind of EM anomaly will result from a particular object or a particular condition, because the algorithms used are affected by so many variables including the conductivity of the object, the conductivity of the surrounding soil, the soil moisture, and the cultural interference. In general, EM contour data is more effective when viewed in a way that breaks out linear, rectilinear, or circular features from the background readings. In addition, EM is more effective at locating buried features that are at least several feet long as opposed to small-scale individual objects. Regardless of whether these anomalies represent higher or lower values than background, they should be viewed as warranting further investigation.

Two separate EM surveys were run, one on Plot A and the other on Plot B. The survey lines on Plot A were run in an east-west direction, while the survey lines on Plot B were run in a north-south direction. The EM survey featured a 3' line spacing in both plots. Tiny dots on the contour maps correspond to the places where data was collected, and these also give an indication of the linear paths in which data was collected. The data was projected into New Jersey State Plane coordinates, and grid lines spaced 5' apart are overlaid onto the contours.

The EM surveys on both plots were relatively quiet, meaning the range of readings was relatively narrow. Buried cultural remains commonly yield a wide range of readings, especially if there are metallic or magnetic materials included in those remains.

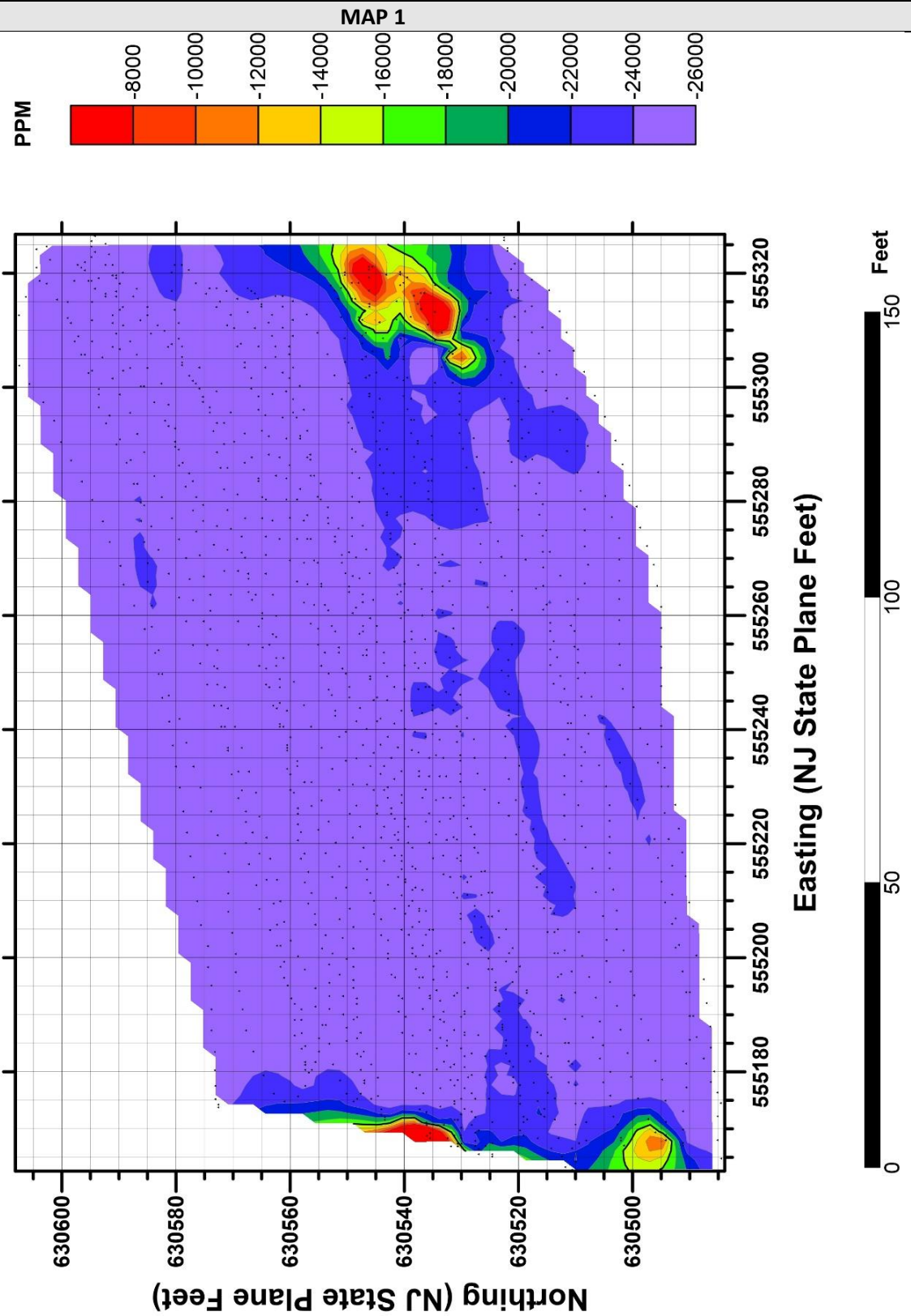
PLOT A

There are two areas in Plot A with high readings. One area is located at the far east end of the plot close to the parsonage. The second area is located at the far west end of the plot close to Rahway Ave. In both cases, it is likely that contemporary cultural features yield the high readings, namely the metal fence on the west end of the plot and a possible buried tank adjacent to the parsonage on the east end of the plot. Most of the grassy area shows very little EM activity.

PLOT B

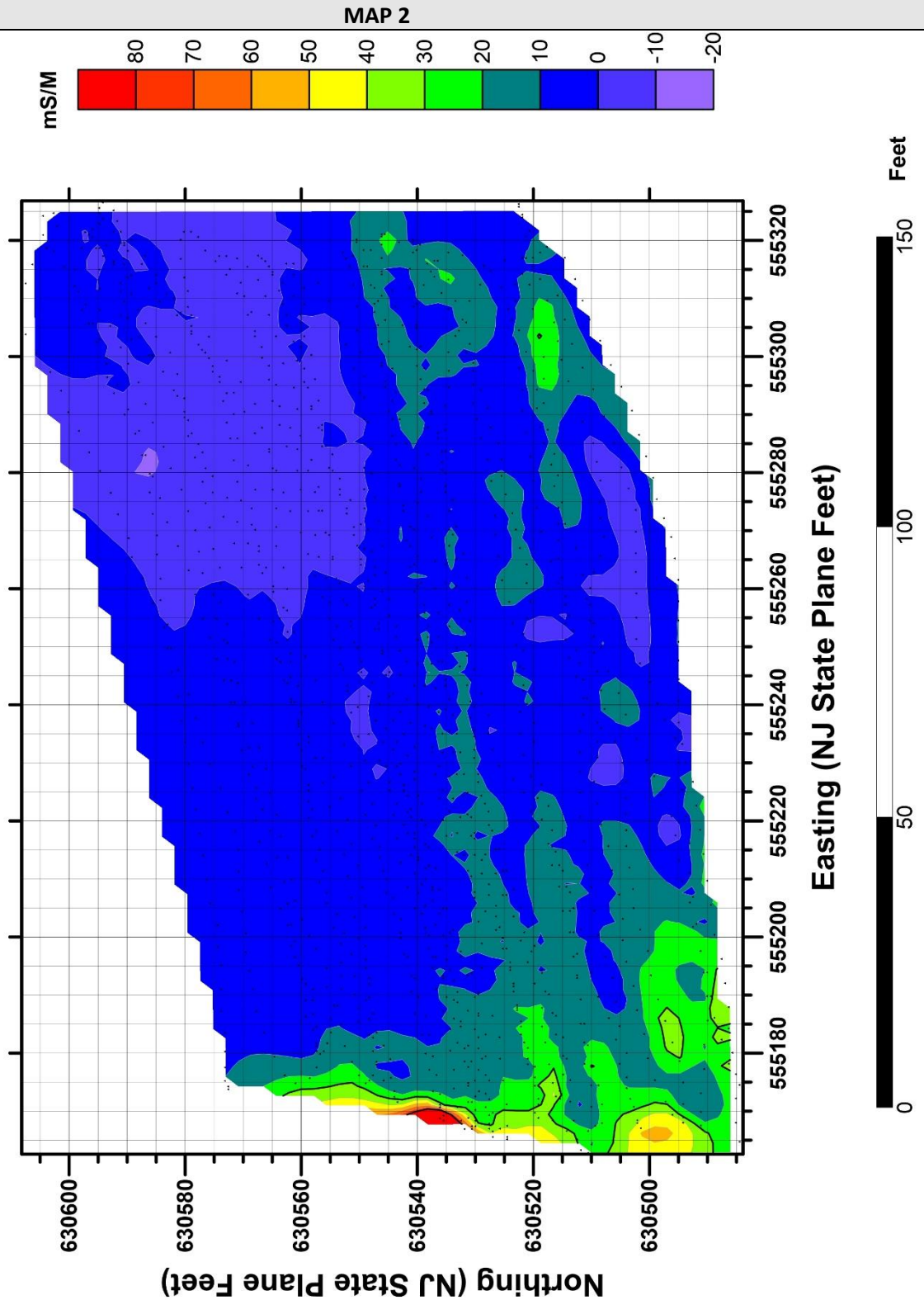
The north-south orientation of the lines in Plot B was chosen specifically to be able to cross any graves perpendicular to their long axes. The high readings at the south end of Plot B are clearly related to the interference of the church building, garage building, and trash dumpster. The curved greenish area at the north end of the plot is clearly reflecting the asphalt pavement of the driveway. The only significant EM anomaly in Plot B corresponds closely to a couple of burials which are marked by gravestones. These are in the southcentral part of the plot and labeled as "Graves" in Map 6. There are no other significant EM anomalies anywhere else in Plot B suggesting neither the presence of historic structures nor burials. There are two square areas (labeled Feature 1 and Feature 2 on Map 6) which yielded GPR anomalies near the center of Plot B, and it is significant that neither of these two features has any sort of EM signature. That shouldn't affect any decision to investigate these features in future archaeological field work.

**Trinity Church- Plot A- Woodbridge, NJ
EMI Survey, Freq: 15KHz, In Phase
EPI, 23 October 2019**



In-Phase electromagnetic induction data for the 15KHz frequency for Plot A. This is a horizontal slice corresponding to a depth of approximately 0-2'.

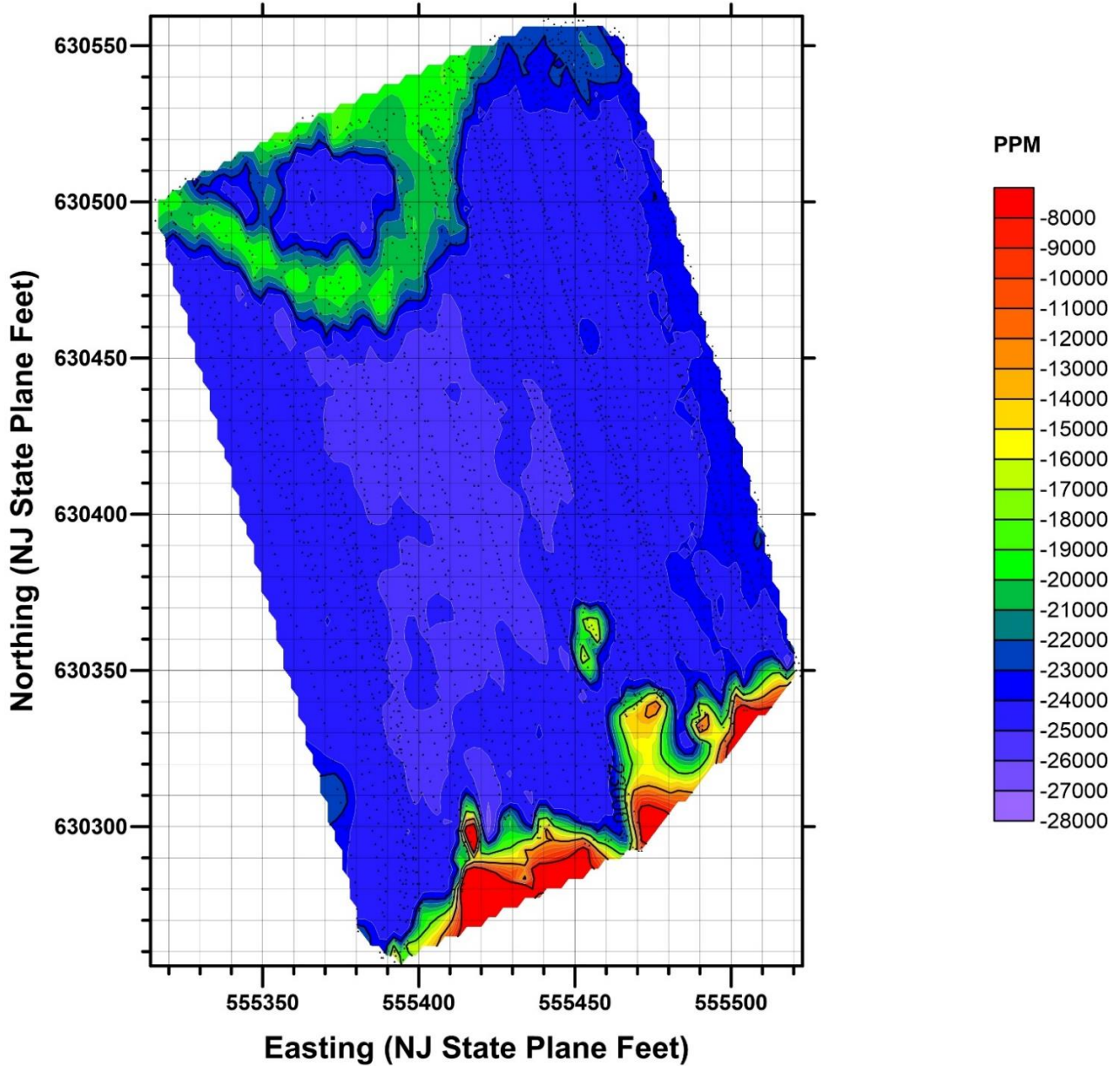
**Trinity Church- Plot A- Woodbridge, NJ
EMI Survey, Freq: 15KHz, Conductivity
EPI, 23 October 2019**



Electromagnetic induction data showing conductivity for the 15KHz frequency for Plot A. This is a horizontal slice corresponding to a depth of approximately 0-2'.

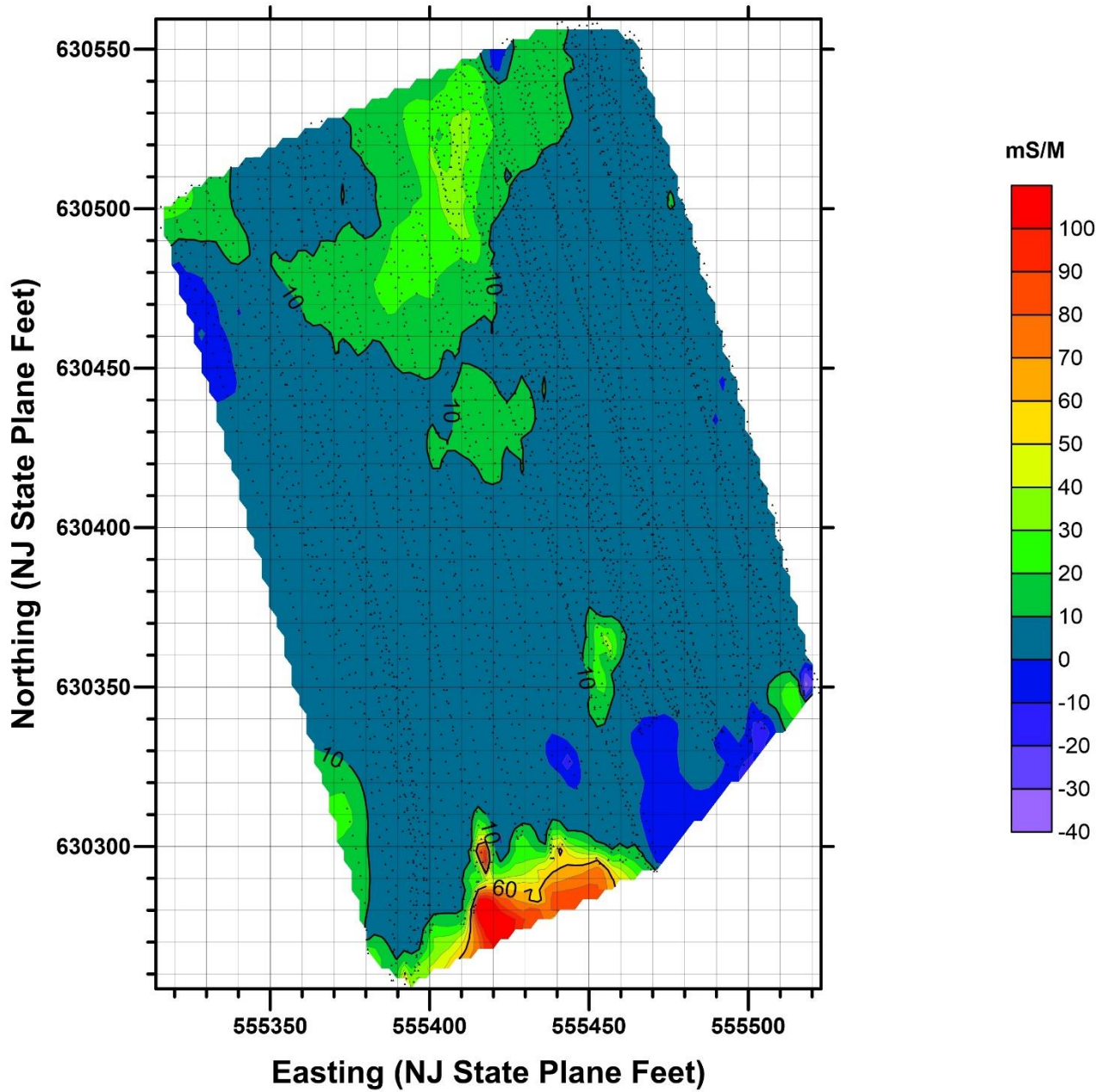
MAP 3

Trinity Church- Plot B- Woodbridge, NJ
EMI Survey, Freq: 15KHz, In Phase
EPI, 24 October 2019



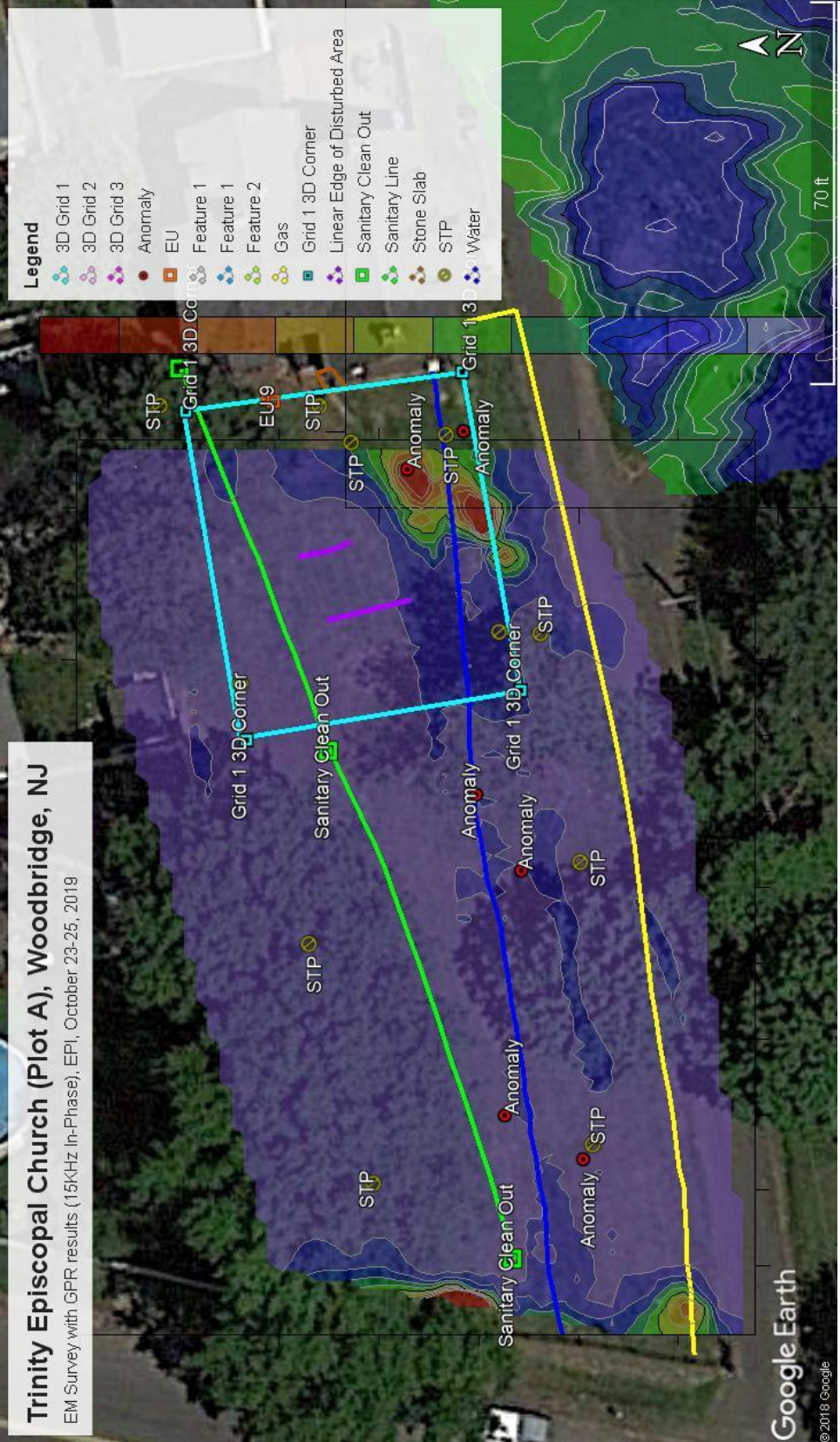
In-Phase electromagnetic induction data for the 15KHz frequency for Plot B. This is a horizontal slice corresponding to a depth of approximately 0-2'.

Trinity Church- Plot B- Woodbridge, NJ EMI Survey, Freq: 15KHz, Conductivity EPI, 24 October 2019



Electromagnetic induction data showing conductivity for the 15KHz frequency for Plot B. This is a horizontal slice corresponding to a depth of approximately 0-2'.

MAP 5



Trinity Episcopal Church (Plot A), Woodbridge, NJ

EM Survey with GPR results (15KHz In-Phase), EPI, October 23-25, 2019

EM data (In Phase, 15K frequency) overlaid on Google Earth imagery for Plot A. The GPR findings are included in this overlay as is the outline of the area where EPI conducted a 3D GPR survey.

