# GROUND PENETRATING RADAR SURVEYS AT THE SPURLING CEMETERY GREAT CRANBERRY ISLAND, MAINE

## INTRODUCTION

At the request of Anne Grulich of the Great Cranberry Island Historical Society, ground penetrating radar (GPR) surveys were conducted at the Spurling cemetery site on Great Cranberry Island, Maine. The purpose of the survey was to help locate unmarked grave sites and buried fallen headstones or footstones. The survey was conducted on June 15th, 2016 by Mike Scully and Michael McCormick of Northeast Geophysical Services (NGS).

## SITE LOCATION AND CONDITIONS

The project site is located at the north end of Great Cranberry Island approximately 475 feet northwest of the town dock and 50 feet from the shore. The area surveyed was approximately 60 feet by 70 feet in size. The surface of the survey area was mostly mowed field grass and the tops of several large rocks were also exposed on the ground surface. The Spurling Cemetery is a Revolutionary War era cemetery that had apparently been abandoned and completely unmaintained for many years. It was believed to have had 25 burials in 33 plots. Anne Grulich had previously mapped and recorded 10 headstones and 4 possible footstones in the cemetery. Several of the headstones are fallen and/or broken and the inscriptions on many are illegible. There are too few headstones for the number of burials believed to be at the site and the locations of the visible headstones don't match the recorded layout of the cemetery.
Weather conditions on the day of the survey were good.

## METHODS AND INSTRUMENTATION

**Ground Penetrating Radar (GPR)** utilizes high frequency radio waves to probe the subsurface. Radar waves are transmitted into the ground from an antenna that is pushed or pulled across the ground surface. In the subsurface, radar waves are reflected at interfaces of materials with contrasting dielectric properties. The returning signal is intercepted by a receiver and converted to a digital graphic image. The horizontal axis of the image is distance along the traverse. The vertical axis is two-way travel time of the radar pulses in nanoseconds (ns) which can be converted to depth.

Tanks, pipelines and other objects with rounded tops (boulders, tree roots, or segments of old foundations for example) may show up on the profiles as hyperbola-shaped reflections. Tanks and pipelines usually appear on more than one survey line as hyperbolic reflectors on lines perpendicular to the tank or pipe axis and as horizontal reflectors on lines along the axis. The GPR instrument used was a GSSI, SIR-3000. A 400-MHz antenna was used with a time range set for 60 nanoseconds. At this setting the depth potentially surveyed is approximately 10 feet. The effectiveness of GPR to identify human burial sites will vary greatly from place to place and will depend upon several factors including: soil conditions, the contents of the burial, and the age of the burial. Moist, silt or clay-rich soils will generally inhibit penetration of the GPR signal and prevent identification of subsurface features.

**Field Survey Procedures:** The general layout of the Spurling Cemetery site is shown on Figure 1 including the locations of headstones, surface depressions and exposed boulders. The figure also shows the locations of numbered flags placed by Anne during the survey which are referenced in her field notes. First a 5 foot by 5 foot orthogonal field survey grid was marked on the ground using tape measures and spray paint. The southeast corner of the mowed area was arbitrarily established as 0 feet north, 0 feet east on the survey grid. GPR profiles were then recorded along lines spaced 2.5 feet apart in two perpendicular grid directions. Twenty six profiles were recorded in the north-south grid direction and twenty eight profiles were recorded in the east-west direction. Interesting features observed on the GPR during the survey were pointed out to Anne and she placed a numbered flag at the spot as mentioned above.

**Data Processing:** Following the field survey the raw GPR data profiles were processed using GSSI's RADAN software to enhance interpretation of the records. Processing included: zero time adjustment, application of horizontal background and vertical FIR filters to remove noise, and gain adjustments. Migration of the data to remove hyperbolic diffractions and the Hilbert transform were also used for the three dimensional model of the data. The 54 individual GPR profiles were compiled into a three-dimensional model using the 3-D module of the software. Figures 2 through 4 show horizontal slices at three depths up through the model (4', 3', & 1' respectively).

**Survey Limitations:** The Ground Penetrating Radar survey produces reflectors at interfaces of materials with contrasting dielectric properties. The instrument provides indirect measurements of subsurface conditions. The actual cause of the features depicted on the figures can only be conclusively determined by direct observation.

## SURVEY RESULTS

Figure 1 shows site layout and the limits of the area surveyed as well as the locations of headstones, surface depressions and exposed boulders. The effective depth of penetration of the GPR signal at this site was approximately 8 feet below the ground surface in most areas. The presence of a lot of large rocks and boulders in the soil at the site had a detrimental effect on our ability to confidently identify unmarked burials at the site. The main problem is that the abundance of large rocks in the subsurface creates so many GPR reflections that is difficult to distinguish the rocks from the possible burials. In addition, the fact that the burials are so old and likely don't have much solid material left for the GPR signal to reflect off of made for a very difficult interpretation of the data. Some of the apparent burial plots marked by headstones had no GPR reflectors associated with them at all.

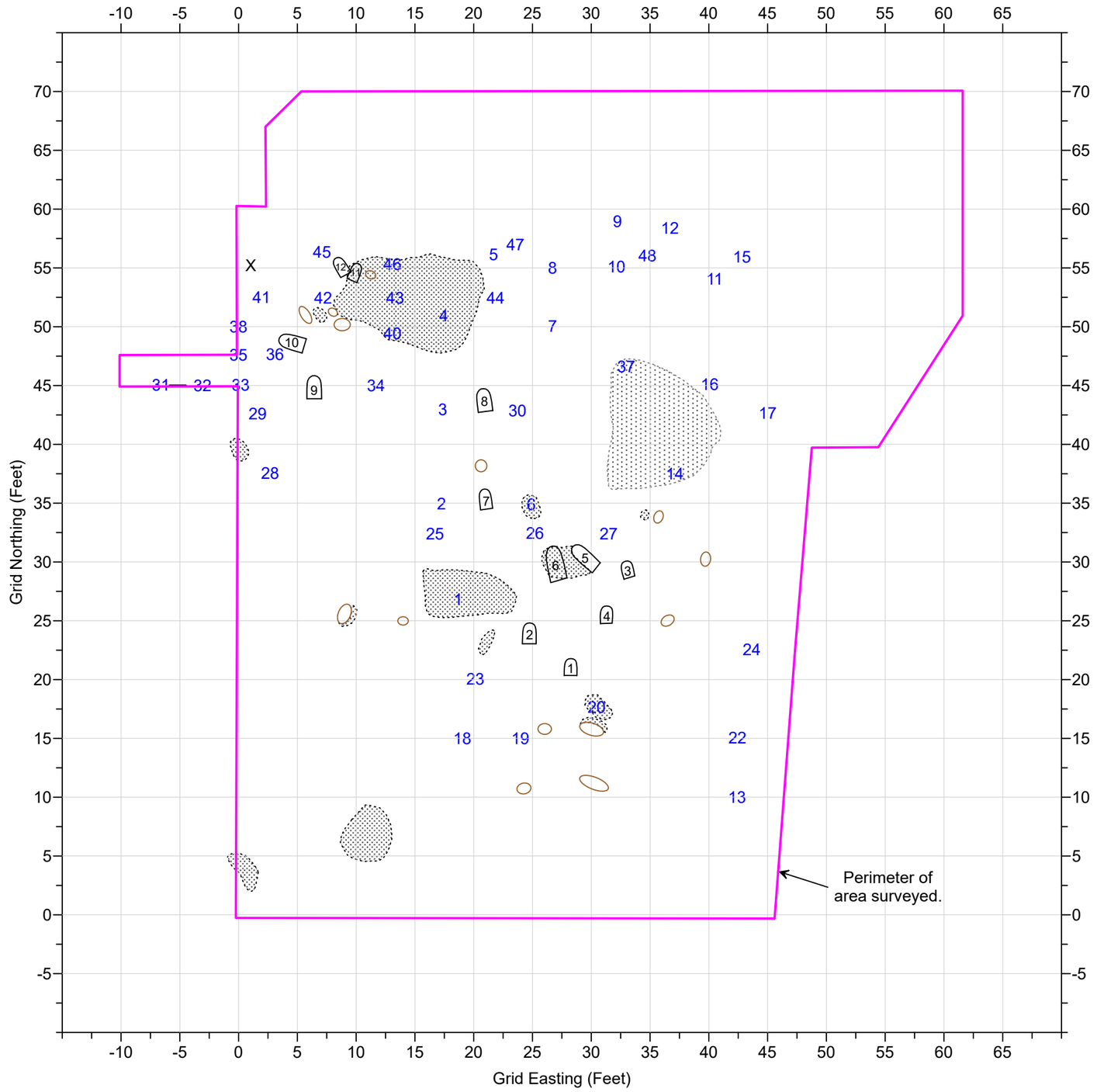
We were able to distinguish some significant reflectors associated with known burials associated with existing headstones at the site. Most of the interpreted possible burial reflectors tended to occur at between 3 and 5 feet deep. Note that GPR reflectors generally occur at the top of the object causing the reflection. So even though a grave may have been dug to 6 feet deep, it would be the top of the coffin for instance that would cause the reflection. Figure 2 shows a horizontal slice through the 3D GPR model at 4 feet deep and shows interpreted anomalies that are 4 feet deep or deeper. Figure 3 shows a horizontal slice through the 3D GPR model at 3 feet deep and shows interpreted anomalies that are in the range of 3 to 4 feet deep. We attempted to prioritize

the anomalies that were most likely burials but undoubtedly some of those marked are caused by large rocks. The anomalies marked with heavy solid lines are interpreted as the most likely to be burials, whereas those marked with dashed lines are somewhat less likely to be burials.

The most significant GPR reflectors are concentrated in the northwest corner of the survey area. One strong possible burial reflector was actually detected just to the west of the main survey area as shown on the figures. Based on these results and the somewhat odd placement and orientation of the visible headstones, it seems possible that some burials occur northwest of the area surveyed. Future efforts to locate covered fallen headstones should include at least a cursory search of that area with a probe in my opinion.

Figure 4 shows a horizontal slice through the 3D GPR model at 1 foot deep and shows interpreted anomalies that are in the range of 0 to 1 foot deep. These anomalies are those that could be caused by fallen headstones that have become covered with soil and vegetation. Again, some of these are also likely caused by rocks.

In summary, the interpretation of the GPR data collected at the Spurling Cemetery site was made difficult by the presence of abundant large rocks and boulders in the ground there. Figures 2 and 3 show the interpreted GPR anomalies that most likely represent human burials in the range of 3 to 5 feet deep. These anomalies are concentrated in the northwest portion of the survey area and it is possible that burials occur beyond the area surveyed in that direction. Figure 4 shows GPR anomalies in the range of 0 to 1 foot deep that could be caused by fallen headstones that have become covered by soil and vegetation.




**Headstone Markings**

1 B.S.
2 Benjamin Spurling
3 B.S. ?
4 F.S. ?
5 Illegible
6 Illegible
7 Joseph L'Grow
8 Sarah L'Grow
9 Edward Spurling
10 Illegible
11 Footstone?
12 Illegible

# FIGURE 1

## GPR SURVEY SITE LOCATION MAP

SPURLING CEMETERY
GREAT CRANBERRY ISLAND, ME

For:

GREAT CRANBERRY ISLAND
HISTORICAL SOCIETY

8 Headstone or Footstone

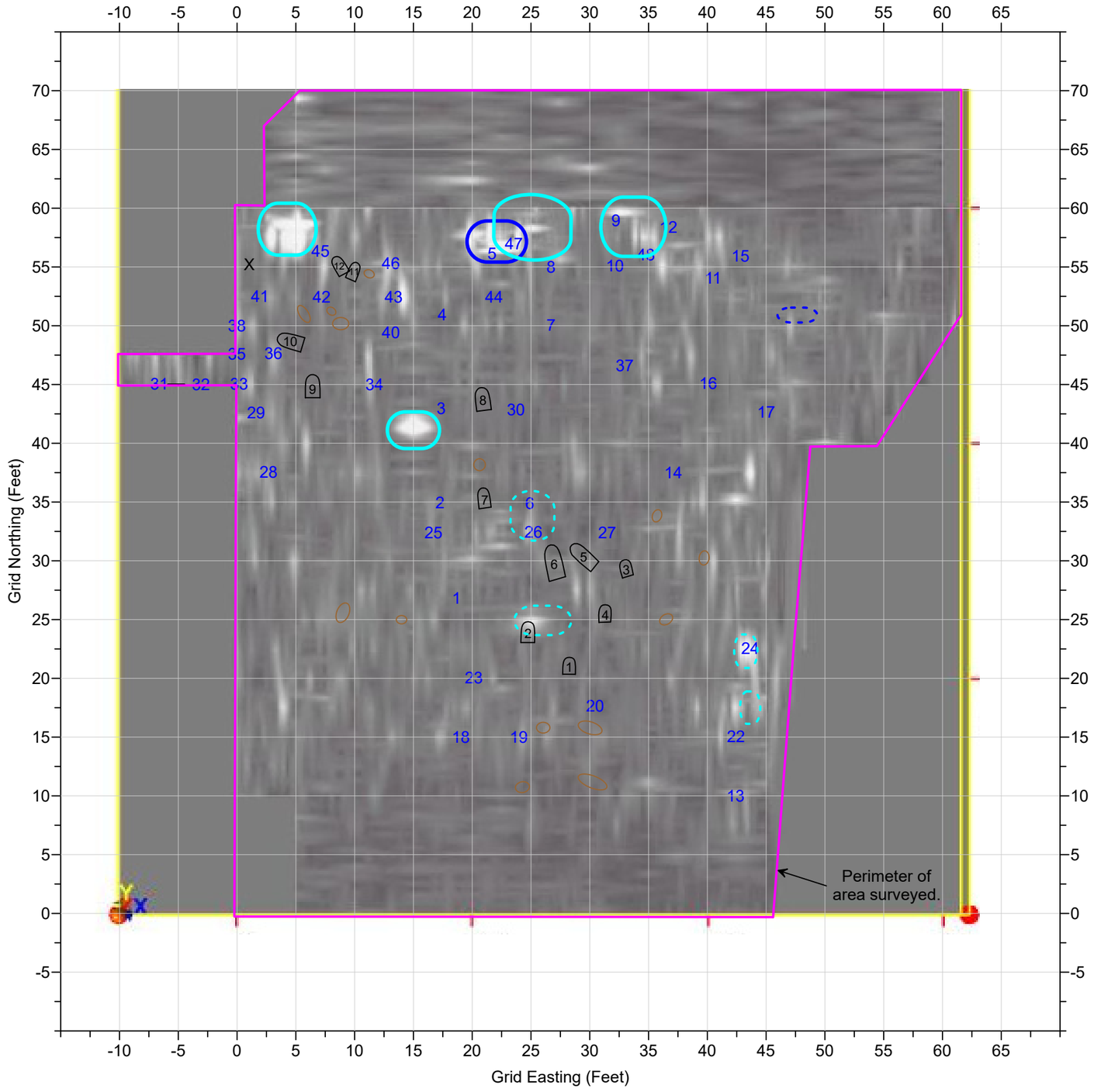
Surface Depression

Exposed Rock

10 Numbered Flags

Surveyed: 6/15/2016 by:

***Northeast Geophysical Services***




**Headstone Markings**

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3 B.S. ?
4 F.S. ?
5 Illegible
6 Illegible
7 Joseph L'Grow
8 Sarah L'Grow
9 Edward Spurling
10 Illegible
11 Footstone?
12 Illegible

FIGURE 2

GPR SURVEY RESULTS MAP
SHOWING 3D MODEL
ANOMALIES > 4 FEET DEEP

SPURLING CEMETERY
GREAT CRANBERRY ISLAND, ME

For:

GREAT CRANBERRY ISLAND
HISTORICAL SOCIETY

8 Headstone or Footstone

Surface Depression

Exposed Rock

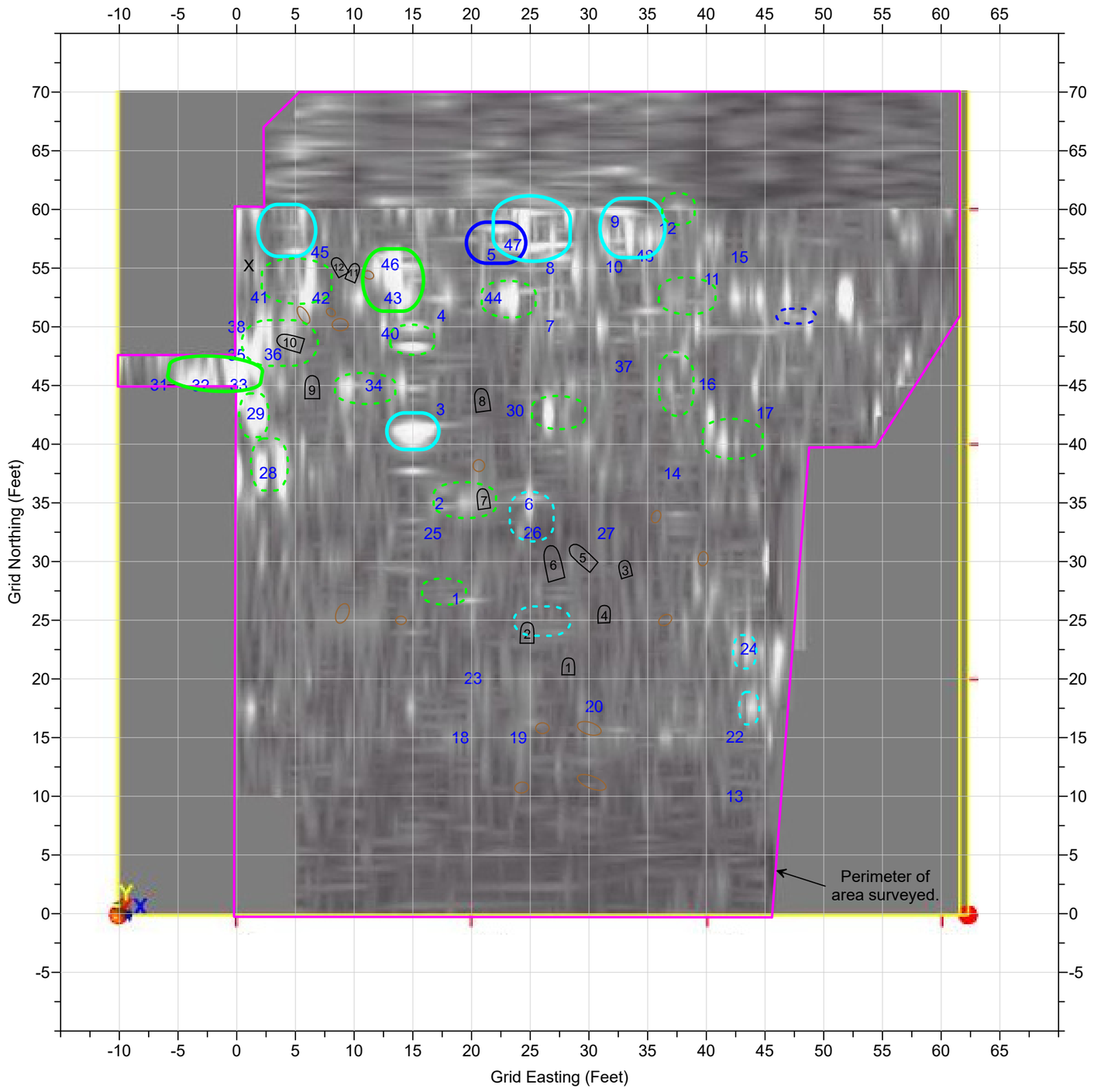
10 Numbered Flags

GPR Anomaly >5 Feet Deep

GPR Anomaly 4 to 5 Feet Deep

GPR Anomaly 3 to 4 Feet Deep

Surveyed: 6/15/2016 by:
***Northeast Geophysical Services***

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7 Joseph L'Grow
8 Sarah L'Grow
9 Edward Spurling
10 Illegible
11 Footstone?
12 Illegible

FIGURE 3

GPR SURVEY RESULTS MAP
SHOWING 3D MODEL
ANOMALIES > 3 FEET DEEP

SPURLING CEMETERY
GREAT CRANBERRY ISLAND, ME

For:

GREAT CRANBERRY ISLAND
HISTORICAL SOCIETY

8 Headstone or Footstone

Surface Depression

Exposed Rock

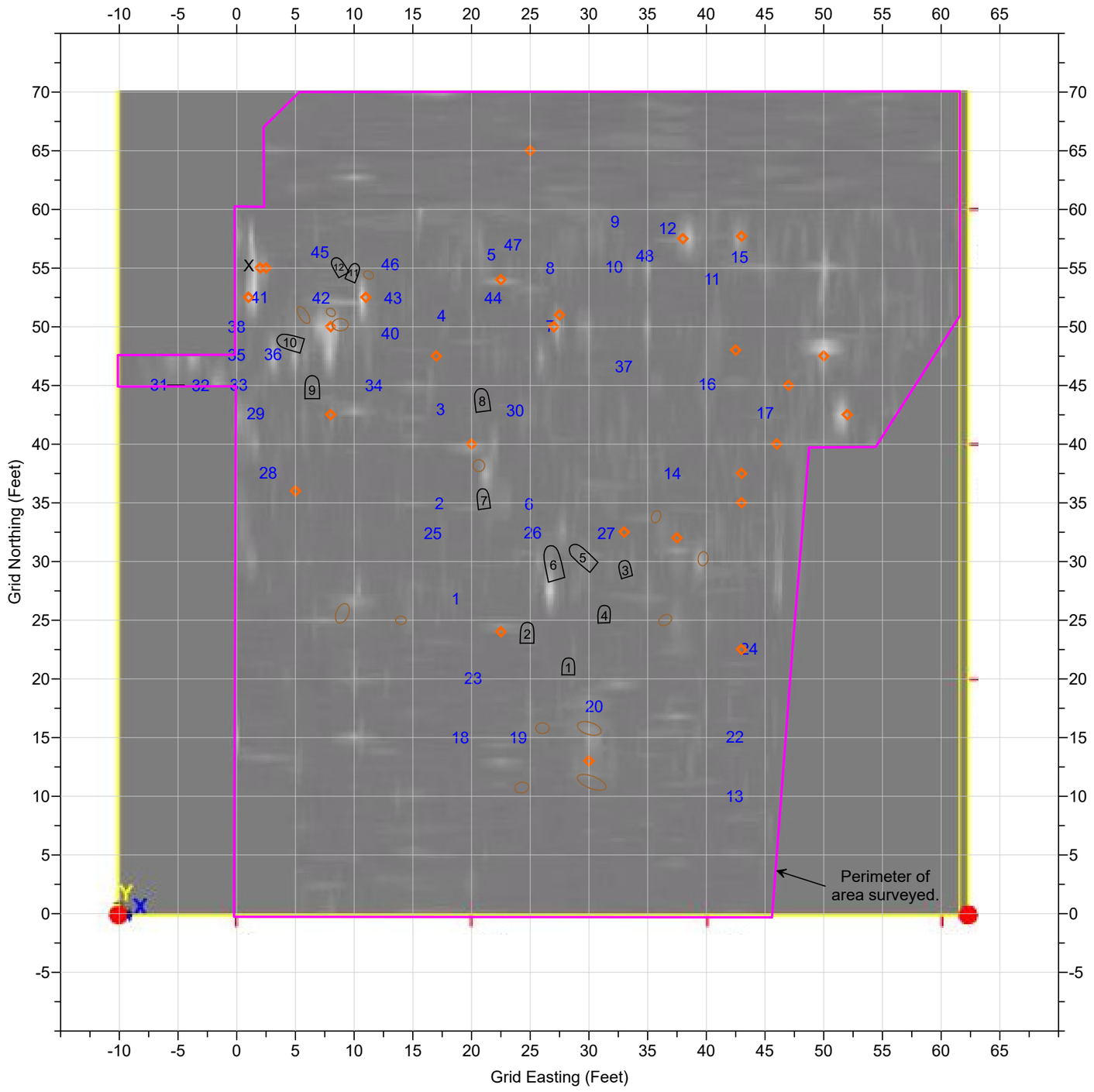
10 Numbered Flags

GPR Anomaly >5 Feet Deep

GPR Anomaly 4 to 5 Feet Deep

GPR Anomaly 3 to 4 Feet Deep

Surveyed: 6/15/2016 by:
***Northeast Geophysical Services***




**Headstone Markings**

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3 B.S. ?
4 F.S. ?
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6 Illegible
7 Joseph L'Grow
8 Sarah L'Grow
9 Edward Spurling
10 Illegible
11 Footstone?
12 Illegible

FIGURE 4

GPR SURVEY RESULTS MAP
SHOWING 3D MODEL
ANOMALIES < 1 FEET DEEP

SPURLING CEMETERY
GREAT CRANBERRY ISLAND, ME

For:

GREAT CRANBERRY ISLAND
HISTORICAL SOCIETY

8 Headstone or Footstone

Surface Depression

Exposed Rock

10 Numbered Flags

GPR Anomaly >5 Feet Deep

GPR Anomaly 4 to 5 Feet Deep

GPR Anomaly 3 to 4 Feet Deep

Buried rock or possible headstone < 1 foot deep

Surveyed: 6/15/2016 by:

***Northeast Geophysical Services***