Ground Penetrating Radar survey of Erf 7540, Erf 7541 & Erf 7538

Corner of Quinn and Naude Streets

Kimberley

Undertaken on behalf of P&V Pillay Family Trust

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By

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1. Objective and Terms or Reference (ToR):

Terra Scan was appointed by Mr Tom Pillay to undertake a non-intrusive Ground Penetrating Radar (GPR) survey of Erf 7540, Erf 7541 and Erf 7538 (The Site) in order to establish the presence or absence of an old (1870's / 1879) cemetery or any other buried manmade structures on the site. Terms of Reference (ToR) for the identification of graves included:

i. A consistent high-density pattern of subsurface disturbance that would reflect rows or row-like patterns of graves situated between 15-20cm (6-8 inches) apart reflective of the study site forming part of the inferred cemetery 'site proper'.
ii. A lower density pattern of subsurface disturbance that would reflect rows or row-like patters of graves situated in excess of roughly 20cm (8 inches) apart or a random scatter of subsurface disturbance reflective of the study site forming part of the inferred cemetery but closer associated with 'perimeter' burials.
iii. Individual or low density scattered subsurface disturbance that may reflect on Later Iron Age (LIA) burial practice of burial within a homestead yard.
iv. Stratigraphy of the site, based on archaeological excavation data from the immediate vicinity included a top Hutton sand level underlain by a '*consolidated calcified sand / calcrete*' member, situated at approximately 60-65cm below the contemporary surface. The said member may be lense like, not continuing across the sub-surface extent of the study site or may be characteristic of the sub-surface geology of the study site.
v. Previously identified graves in the vicinity of the study site were dug between 10-40+cm into the '*consolidated calcified sand / calcrete*' member.

The results of the GPR survey will be used by ArchaeoMaps in the preparation of an Archaeological and Cultural Heritage Impact Assessment (AIA).

2. What is Ground Penetrating Radar?

A GPR system is made up of a control unit, antenna, a power source and a trolley cart.

GPR is described by Geophysical Survey Systems, Inc as:

"The control unit contains the electronics which triggers the pulse of radar energy that the antenna sends into the ground. It also has a built-in computer and hard disk/solid state memory to store data for examination after fieldwork. Some systems, such as the GSSI DF, are controlled by an attached Windows computer with pre-loaded control software. This system allows data processing and interpretation without having to download radar files into another computer.

The antenna receives the electrical pulse produced by the control unit, amplifies it and transmits it into the ground or other medium at a particular frequency while the antenna moves across the ground surface. Antenna frequency is one major factor in depth penetration. The higher the frequency of the antenna, the shallower into the ground it will penetrate. A higher frequency antenna will also 'see' smaller targets.

GPR works by sending a tiny pulse of energy into a material and recording the strength and the time required for the return of any reflected signal. A series of pulses over a single area make up what is called a scan. Reflections are produced whenever the energy pulse enters into a material with different electrical conduction properties or dielectric permittivity from the material it left. The strength, or amplitude, of the reflection is determined by the contrast in the *dielectric constants and conductivities of the two materials. This means that a pulse which moves from dry sand (dielectric of 5) to wet sand (dielectric of 30) will produce a very strong reflection, while moving from dry sand (5) to limestone (7) will produce a relatively weak reflection.*

While some of the GPR energy pulse is reflected back to the antenna, energy also keeps traveling through the material until it either dissipates (attenuates) or the GPR control unit has closed its time window. The rate of signal attenuation varies widely and is dependent on the properties of the material through which the pulse is passing.

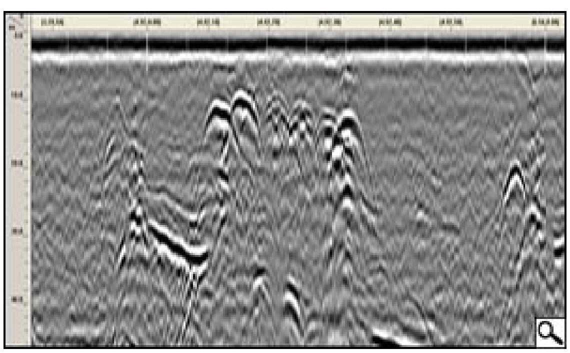
Materials with a high dielectric will slow the radar wave and it will not be able to penetrate as far. Materials with high conductivity will attenuate the signal rapidly. Water saturation dramatically raises the dielectric of a material, so a survey area should be carefully inspected for signs of water penetration.

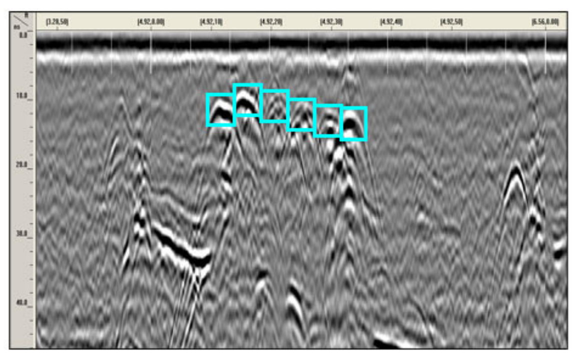
Metals are considered to be a complete reflector and do not allow any amount of signal to pass through. Materials beneath a metal sheet, fine metal mesh, or pan decking will not be visible.

Radar energy is not emitted from the antenna in a straight line. It is emitted in a cone shape. The two-way travel time for energy at the leading edge of the cone is longer than for energy directly beneath the antenna. This is because the leading edge of the cone represents the hypotenuse of a right triangle.

*Because it takes longer for that energy to be received, it is recorded farther down in the profile. As the antenna is moved over a target, the distance between them decreases until the antenna is over the target and increases as the antenna is moved away. It is for this reason that a single target will appear in a data as a hyperbola, or inverted "U." The target is actually at the peak amplitude of the positive wavelet." (*http://www.geophysical.com/whatisgpr.htm - accessed on 26 January 2015.)

The example linescan radar images below identify several soil anomalies that equate the locations of remains during an archaeology survey. (http://www.geophysical.com/archaeology.htm - accessed on 26 January 2015.)





Grave locations

3. Equipment used to scan the site:

An UtilityScan DF system with cart serial number # 204, antenna serial number # 217 manufactured by Geophysical Survey Systems, Inc. (GSSI) was used for the survey. The DF system incorporates a digital dual-frequency antenna (300 MHz and 800 MHz) and a touchscreen interface that allowed shallow and deep targets to be viewed simultaneously in a single scan. The DF system has a maximum depth range of 5m depending on the soil conditions. The system has a signal floor tracking feature whereby the calculated penetration depth based on the site specific conditions was displayed.

4. Survey methodology and data acquisition on the site:

The extent of the survey site is indicated by datum points 1, V and W, as indicated on the site map below.

A heap of gravel and rocks was present on the Western side of the survey site and the area underneath the heap could therefore not be surveyed.

A total of 155 scans were performed in three different grid formations around the obstruction mentioned above.

5. Site Map. (GPS data recorded and map produced by ArchaeoMaps)

6. Site conditions and GPR penetration at the site:

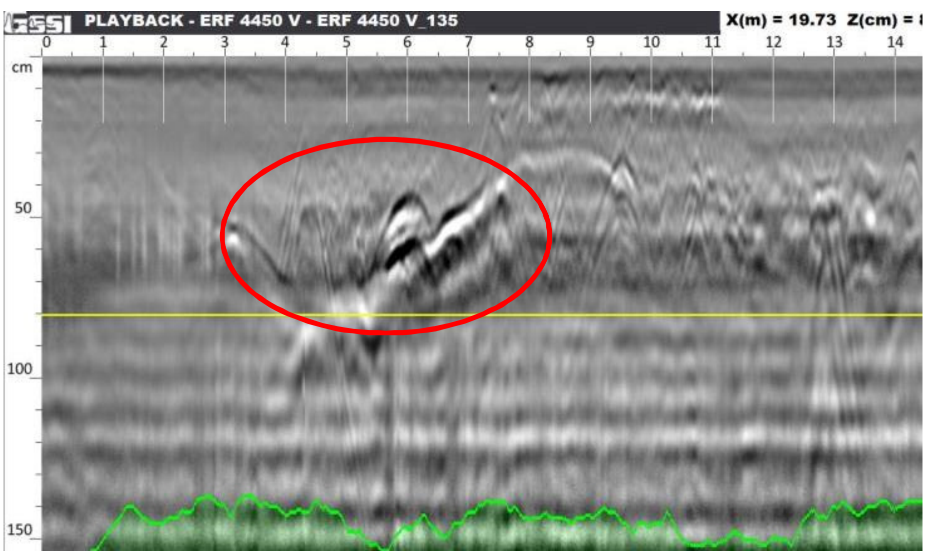
The surface layer of the area in question was undisturbed with a grass cover at the time of the survey.

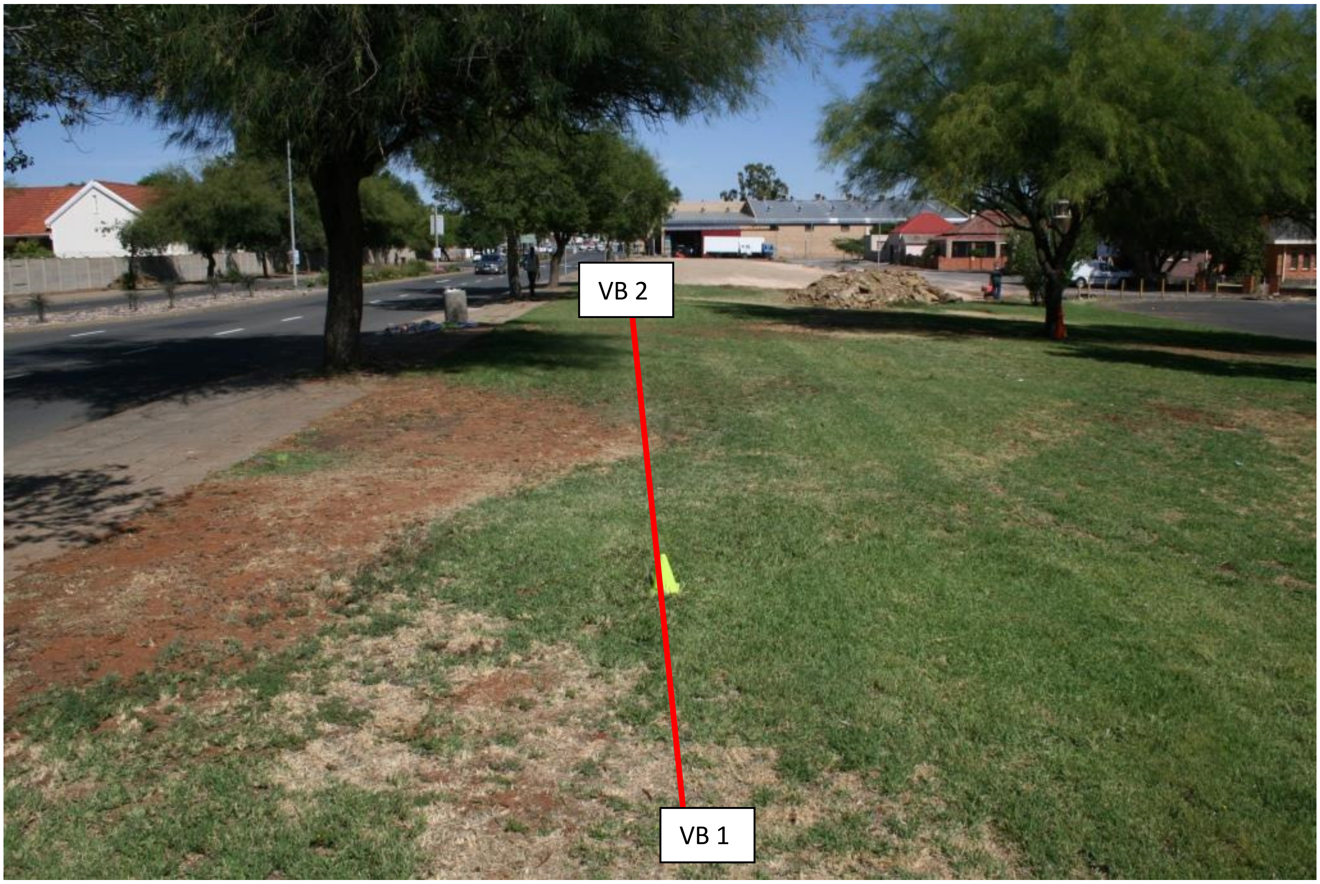
Penetration with the 800Mhz channel was relatively good up to 500mm as indicated by the signal floor tracking indicator, a change in geology across the entire area is evident at a depth of ± 6o cm. The calculated signal tracker indicated that a penetration depth of ± 1300mm was achieved with the 300Mhz antenna as per the two examples below. The geology change at a 60cm below surface had an adverse effect on the visible image quality between 700mm and 1300mm. It is believed that the dielectric constant and conductivity of the soil changes dramatically at the point of change in geology as described above.

7. On-site observations and findings at the site:

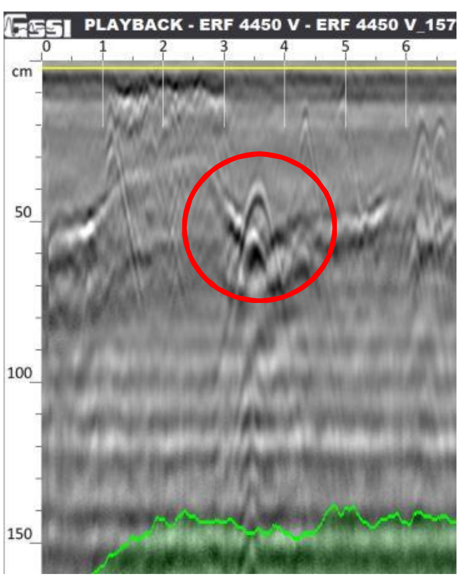
During the on-site survey, three objects were detected at depths varying between 350mm to 700mm below ground surface. The location of these detected objects was recorded and is indicated on the Google earth image, the GPS coordinates of the indicated positions was recorded by ArchaeoMaps. The positioning and shape of two of the detected objects suggest that the detected objects are of a linear nature and represent the remains of old infrastructure.

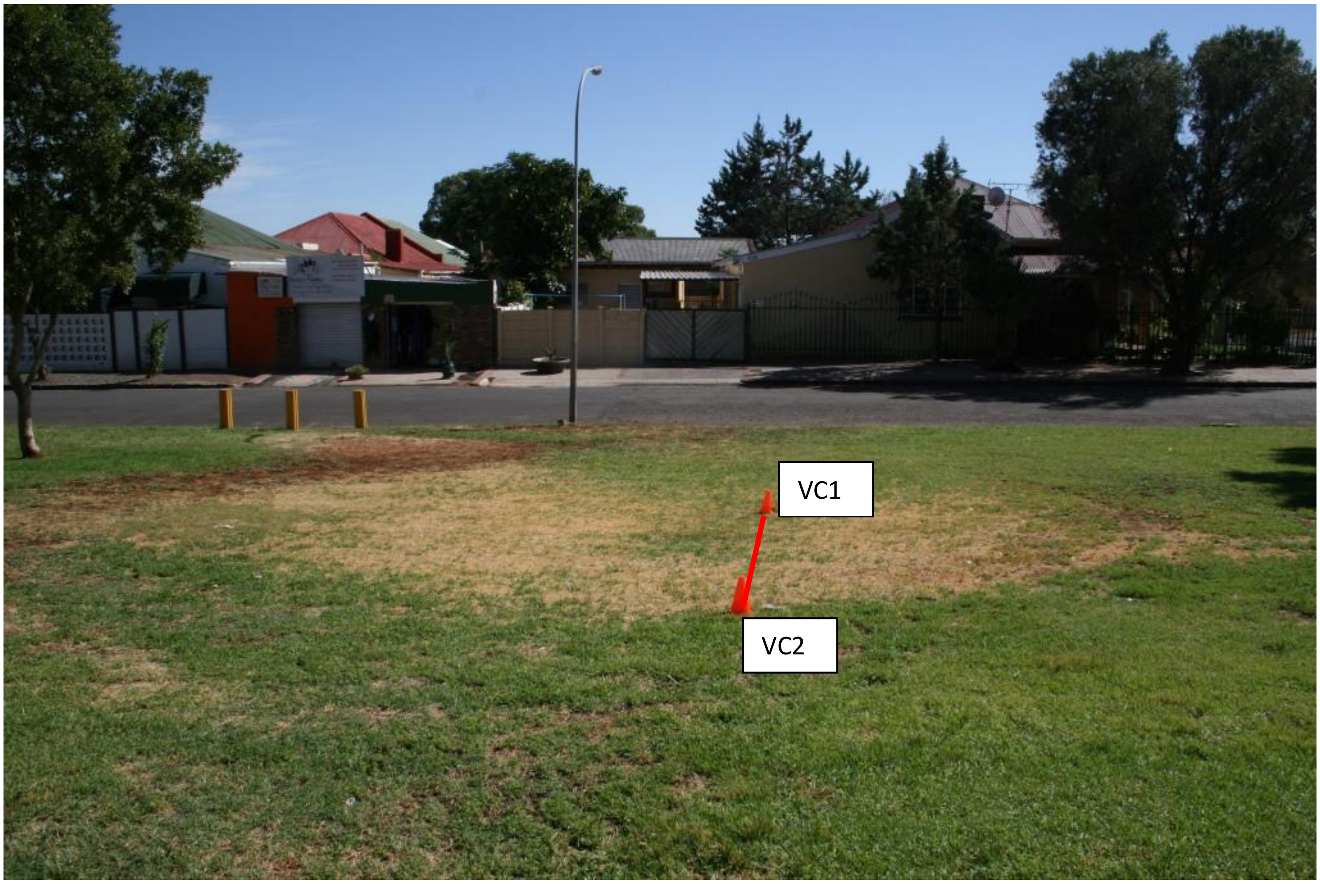
Extent of the marked positions: VB1 and VC2. During the on-site survey the line between VB1 and VB1, as shown below was identified as remains of previous infrastructure, possibly the remains of a railroad. This object extends onto the adjacent Erf 44500.



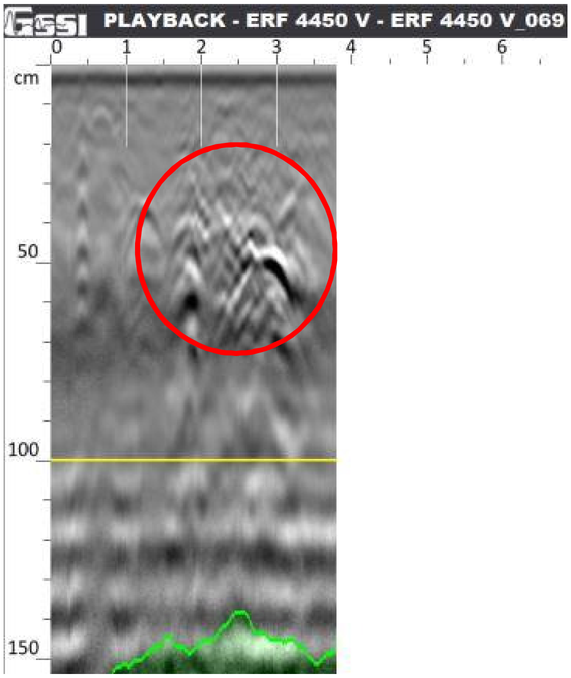


Extent of the marked positions: VC1 and VC2.





Marked position VA1. The GPR image suggests buried objects are present in this area; it can well be an old rubbish dump or building rubble.


PLAYBACK - ERF 4450 V - ERF 4450 V_069
cm
50
100
150


VA1

8. Limitations of results:

It should be noted that GPR and geophysical investigations and the interpretation of data from these investigations are inherently ambiguous. More than one source may have similar variations in the measured property, making it difficult to correctly interpret the results. In other words, the measured geophysical anomaly may have more than one interpretation and different physical sources may produce similar geophysical anomalies.

The depth to anomalies is determined by the velocity of the electromagnetic energy in the soil. In the case of Erf 7540, Erf 7541 & Erf 7538 a dielectric constant of 9 was used for limestone and clay. Variations in the constant as a result of moisture or changes in the medium itself may produce incorrect depths because of an "incorrect" dielectric constant. In this case a change in the dielectric constant of the soil is expected at a depth of approximately 56cm below surface at the point where there is a drastic change in the geology on site. These variations are typically small and should typically not produce errors larger than 10% in depth estimation.

9. Conclusion:

The objects detected and marked out during the onsite survey (VB1 to VB2 and VC1 to VC2) represents linear objects that represents the remains of what is believed to be manmade infrastructure such as the remains of an old railway route and possibly a water pipe. The position marked as VA1 needs to be further investigated as the data suggest multiple small objects are present, typical of a rubbish dump or building rubble.

During the onsite survey, no consistent high or lower density patterns of subsurface disturbance were detected that could reflect rows or row-like patterns, or infrequent random scatters of graves as described in the ToR (i, ii, iii & v), with grave-like disturbance inferred to be variable in size, primarily rectangular in shape, but which may approach 'square shaped' disturbances (double or multiple graves) and which may approach 'oval' shapes. No disturbance other than the three objects described above, penetrated the geological member situated at 60 - 65cm below ground surface as described in ToR (iv & v).

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