September 9th, 2024 Our File: T245720

Steven Iacucci
Manager, Senior Project (Redevelopment)
University Health Network

RE: Ground Penetrating Radar investigation at Toronto Western Hospital, 339 Bathurst St. in Toronto, Ontario

Dear Mr. Iacucci,

Geophysics GPR International Inc. (GPR) was requested to perform a ground penetrating radar (georadar) survey at the above address in Toronto. The purpose of the investigation was to identify any obstructions or facilities prior to drilling activities. It was also requested to relocate a potential borehole as this southernmost proposed borehole was inaccessible with construction activities occurring on the property. This is a follow-up to the investigation carried out for PCL by GPR in November of 2020.

The survey was performed on August 26, 2024. The approximate location of the survey is shown in Figure 1outlined in red.

The following paragraphs describe the survey design, the principles of the test method, the methodology for interpreting the data, and provide a culmination of the results in the form of an anomaly map/site drawing.

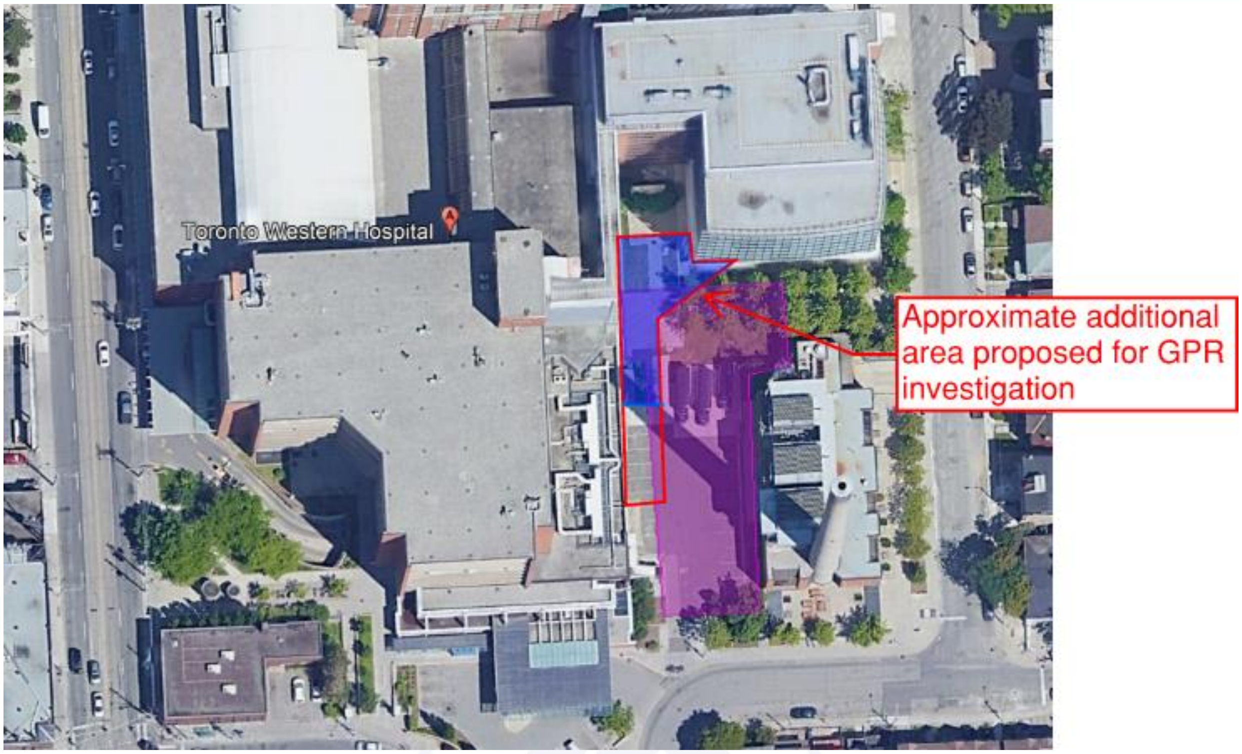

Figure 1: Proposed survey location outlined in red. Previous survey shaded in pink. Extent of area actually surveyed due to construction on-site shaded in blue.

Survey Design

Data collection took place on August 26, 2024.

A Geophysical Survey Systems, Inc. (GSSI) SIR-4000 ground-penetrating radar system with 350 MHz digital antenna was used to conduct the survey. The antenna was mounted on a GSSI 624 Survey Cart Assembly, which uses a digital counter wheel to collect measurements at regular distance intervals. The antenna used for this investigation is rated for a maximum depth of investigation of 12 meters, although the actual depth of penetration achieved is highly dependent on-site conditions. Conditions for penetration at this site were average (4-6 m).

Lines of data were collected in the N-S direction at approximately 1m intervals to initially identify anomalous areas. The boundaries of those identified anomalies were more thoroughly investigated with a series of profiles collected in multiple directions passing directly over top of each of them. If determined to be a significant anomaly, they were marked in survey paint on-site and their positions were recorded with a survey wheel. Sample profiles of each of the anomalies were also collected for the purposes of this report.

Due to proximity to the building, the accuracy of GPS data was too low to be useful. So, positioning of the radar system was determined through a survey wheel connected to the survey cart, allowing for measuring of distances along the survey lines. This, combined with notes of the position of each radar line relative to buildings and fences as well as measurements of anomaly locations relative to the same references were used to record positioning of radar profiles and the survey cart.

Finally, an RD7100 radio detection unit was used to follow-up the radar profiles and further clarify the nature of the anomalies (power, pipes, non-metal objects, etc.).

Basic Theory of Ground-Penetrating Radar

Ground-penetrating radar or georadar operates using the same principles as conventional radar, with a pair of antennae (in this case combined in a single unit) that transmit and receive electromagnetic (radio) waves. The receiving antenna emits a pulse of waves at a known time, and when these waves reach an interface between two materials, these waves can either be reflected back towards the receiving antenna or transmitted through the interface (or be diverted in such a way that they never return to the receiving antenna). These measurements can be repeated as the antenna is moved along the surface, generating a pseudo-cross section of the ground.

The ratio of reflected to transmitted energy depends on the relative dielectric permittivity (an electrical property of materials that are not perfect conductors or insulators) of the materials on either side of the interface, with greater contrasts in dielectric permittivity resulting in more of the energy being reflected. Examples of radar reflecting interfaces include the air-water boundary at the water table, and contacts between different sediments or sediments and bedrock.

The depth of investigation is limited by the strength of the radar signal, which is proportional to the power output of the antenna and limited by diffraction and attenuation of the signal by earth materials. More conductive materials (e.g., clays, groundwater with high dissolved salt content) attenuate the signal more strongly, and diffraction is the result of waves interacting with rough or irregular interfaces (e.g. boulders, heavily fractured rock, debris). Diffraction is more pronounced at higher frequencies, but higher frequency waves are capable of producing results with greater spatial resolution, and so there is a compromise between resolution and penetration that is governed by antenna frequency.

The results of a ground-penetrating radar survey are qualitative and subject to interpretation. This method does not provide direct information about the composition or competence of subsurface.

Interpretation Method

Interpretation was primarily conducted by the operator on-site such that the anomalous areas could be marked out.

The sample data were additionally post-processed and reviewed at a computer workstation to provide imagery, confirm the findings of the operator in the field and to more accurately determine the depths of the anomalies. Several processing steps were completed to interpret the data, including frequency filtering, gain adjustment, and deconvolution.

The vertical scale on all radar images is a two-way time scale representing the time taken for a radar pulse to travel to a reflector and be reflected back to the receiver following some number of transmissions through other interfaces. A time shift is applied during data processing to ensure that the time value of zero matches the point of contact between the radar antenna and the surface of the ground.

This travel-time axis can be converted to depth if the radar velocity of the subsurface is known. This velocity is a function of dielectric permittivity and can be estimated empirically in the field or by using an approximate value for the dielectric permittivity based on the expected material type. The dielectric value or velocity of a material varies over a range depending on moisture content and specific material makeup. An over-estimate of the velocity applied will cause an over-estimate of depths. For this investigation, an approximate radar velocity of 0.069 m/ns was estimated by fitting curves to diffraction hyperbolae in the data. This velocity corresponds to a dielectric constant of 18.88, and this is within the typical range of dielectric constants for concrete or wet soils.

The interpretation of the data is based primarily on the qualitative analysis of three characteristics of radar reflections: continuity, amplitude, and shape. The interpreter then identifies reflectors and textures within the radar records that represent subsurface contacts, objects, or zones.

Results and Conclusions

Geophysics GPR International Inc. (GPR) was requested to perform a ground penetrating radar (georadar) survey at Toronto Western Hospital, 339 Bathurst St. in Toronto. The purpose of the investigation was to identify any obstructions or facilities prior to drilling activities. It was also requested to relocate a potential borehole as this southernmost proposed borehole was inaccessible with construction activities occurring on the property.

Figure 2 presents a drawing with the locations of the results of this survey. This will also be provided as a separate PDF for a more detailed view.

The survey was performed on August 26th, 2024 and covered an area of approximately 30m x 12m.

For this investigation, buried infrastructure and obstructions were expected to appear as hyperbolic or flat reflectors depending on their size and extent. Additionally, they were expected to be strong or moderate reflectors if they were made of metal or non-metal objects, respectively, due to the high reflectivity of the radar signal from metal. Metal objects and power conduits may also cause “multiples” or “ringing” within the radar image which appears as a repeated image of the object extending deeper than the true depth. This is due to the high degree of reflection causing the radar signal to repeatedly bounce between the reflector and the antenna/surface.

Regions of interest were classified into three categories: areas with potential power conduits (red); areas with unidentified (metallic or non-metallic) buried objects (blue); and a suggested borehole location (magenta). These colours were identical between the attached drawing (Figure 2) and those used to mark these anomalies on-site except for the borehole location which was marked in yellow on-site. Pink paint on-site can be ignored and was used as a temporary reference only.

A radar image depicting typical, unobstructed soils is provided in Figure 3 for comparison with the following results.

The area contained eight (8) regions of interest (ROIs). Each one is numbered and displayed within the attached drawing as shown in Figure 2. Based upon the image provided by the client (Figure 11), it does not appear that the anomalies overlap with the proposed borehole locations.

The client requested that a new borehole location be proposed in place of the southernmost borehole location that cannot be accessed due to construction activities on the property. This location is **ROI 1** and has been marked in the attached drawing with a magenta X, surrounded by a circle and on-site with a yellow X, surrounded by a circle. Access to this location is limited due to a large transformer/power installation surrounded by a chain link fence acting as and obstruction. See Figure 10 for a reference photo. The next best location within the proposed survey area/addition footprint is very close to where a borehole has already been proposed, so it was not marked.

ROI 2 was found in the southwest of the survey area and was characterized by a flat, moderate strength reflector with hyperbolic ‘tails’ on each of its ends (Figure 4). It was found at a depth of ~0.52m This indicates a non-metallic, buried object but its nature could not be determined in more detail based upon the surrounding features so it has been marked in blue. It is recommended not to drill in this location.

ROI 3 was found to be a large power conduit under what appeared to be a removable concrete cover. This was confirmed to contain power with the RD7100. Sample images were not taken nor was this marked on-site due to is conspicuousness on-surface. However, it has been marked in the attached drawing in red for reference when on-site. It is recommended not to drill in this location.

ROI 4 was found northwest of ROI 3 and was characterized by a hyperbolic reflection, ‘ringing’ below the reflector and a linear track between the wall of the building and the nearby transformer/power installation at a depth of ~0.56m (Figure 5). This indicated a metal object, carrying power which was confirmed with the RD7100. It is recommended not to drill in this location nor in the immediately surrounding area.

ROI 5 was characterized by a moderate strength, hyperbolic reflection at a depth of ~0.61m (Figure 6). This indicates a non-metallic, buried object but its nature could not be determined in more detail based upon the surrounding features so it has been marked in blue. It is recommended not to drill in this location.

ROI 6 was characterized by a large, flat and strong reflector with hyperbolic tails on each side at a depth of ~0.92m (Figure 7). There also appeared to be an area of previous excavation above the reflector, characterized by a change in texture of the soils and dipping soil layers. This indicates a potential metal pipe or UST. It is strongly recommended not to drill in this location nor in the immediately surrounding area.

ROI 7 was characterized by a strong, hyperbolic reflection and continued linearly between two sections of grass at a depth of ~0.50m (Figure 8). This indicates a metal, buried linear object, pipe or potential power conduit. Results from the RD7100 were inconclusive. However, for the sake of caution, it has been marked in red. It was not possible to track this anomaly below the grass. This is likely due to inhomogeneity within the soil beneath the grass obscuring the visibility of the object within many hyperbolic reflections from rocks. Concrete is much more homogenous and provides a clearer image. It is recommended not to drill in this location, nor in surrounding locations where a pipe could exist if the anomalous area were extended in its apparent direction across the grass areas.

ROI 8 was characterized by a moderate strength, flat reflector at a depth of ~0.56m (Figure 9). This indicates a buried, non-metallic object. Its proximity to an air conditioning unit indicates in may be related infrastructure but further details of its nature could not be determined. So, it has been marked in blue. It is recommended not to drill in this location.

Due to the non-intrusive nature of ground-penetrating radar technology and the interpretive nature of the results, 100% detection or accuracy cannot be guaranteed. Accordingly, Geophysics GPR does not accept any responsibility or liability for losses or damages of any kind, resulting from undetected, misinterpreted, or misrepresented features or targets. Further we do not accept any responsibility or liability for losses or damages of any kind resulting from decisions or actions based on the information provided. The client bears the ultimate responsibility for confirming the precise nature and location of identified features or targets. By retaining Geophysics GPR to conduct this investigation and accepting/using the results you are agreeing to these terms.

This report has been prepared by Ethan Rudd, and reviewed by Carolyn Boone P.Geo.

Carolyn Boone, P.Geo

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TABLE OF FIGURES

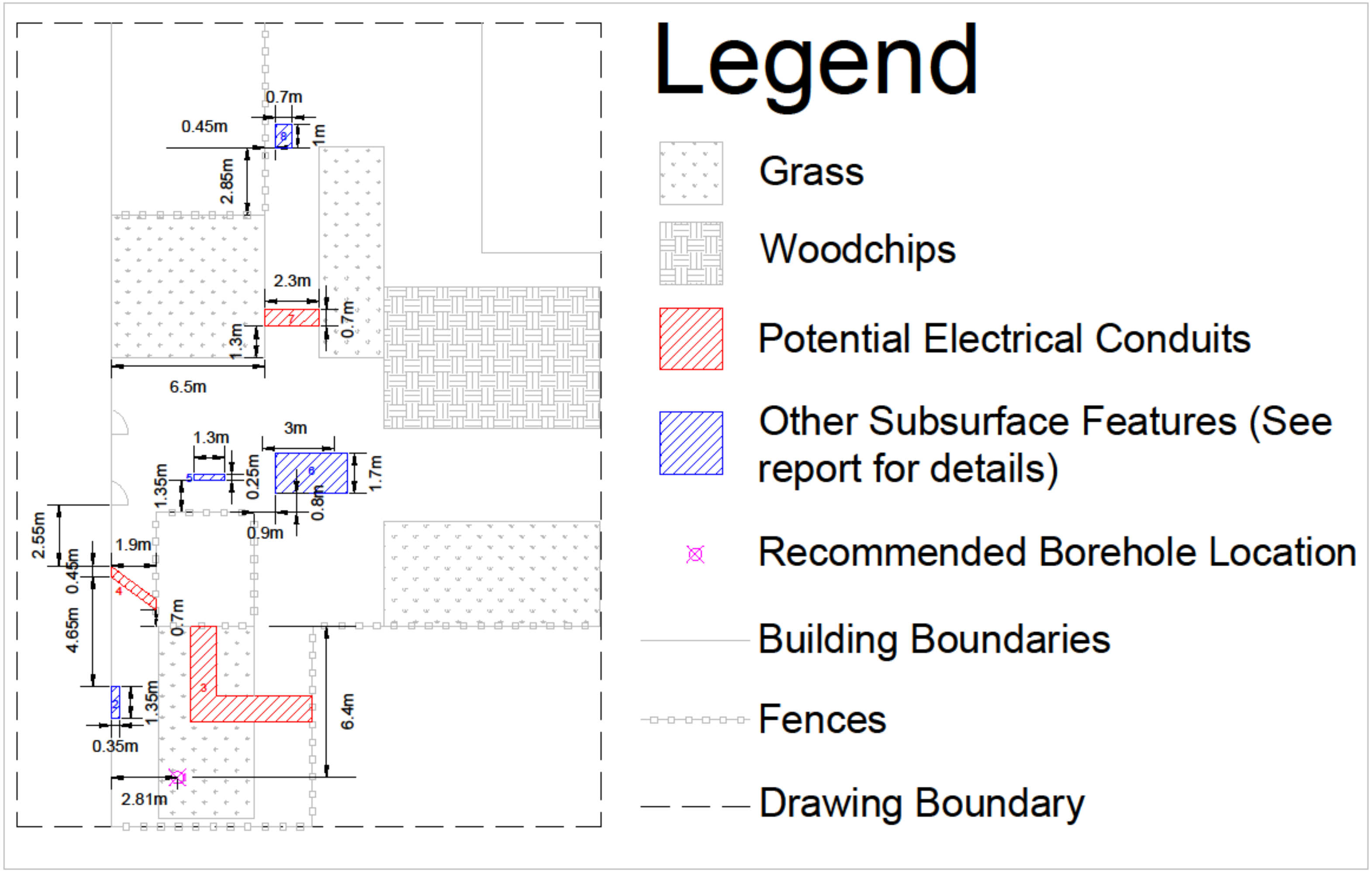

Figure 2: Drawing showing the locations of anomalies/ROIs relative to the surrounding buildings and fences

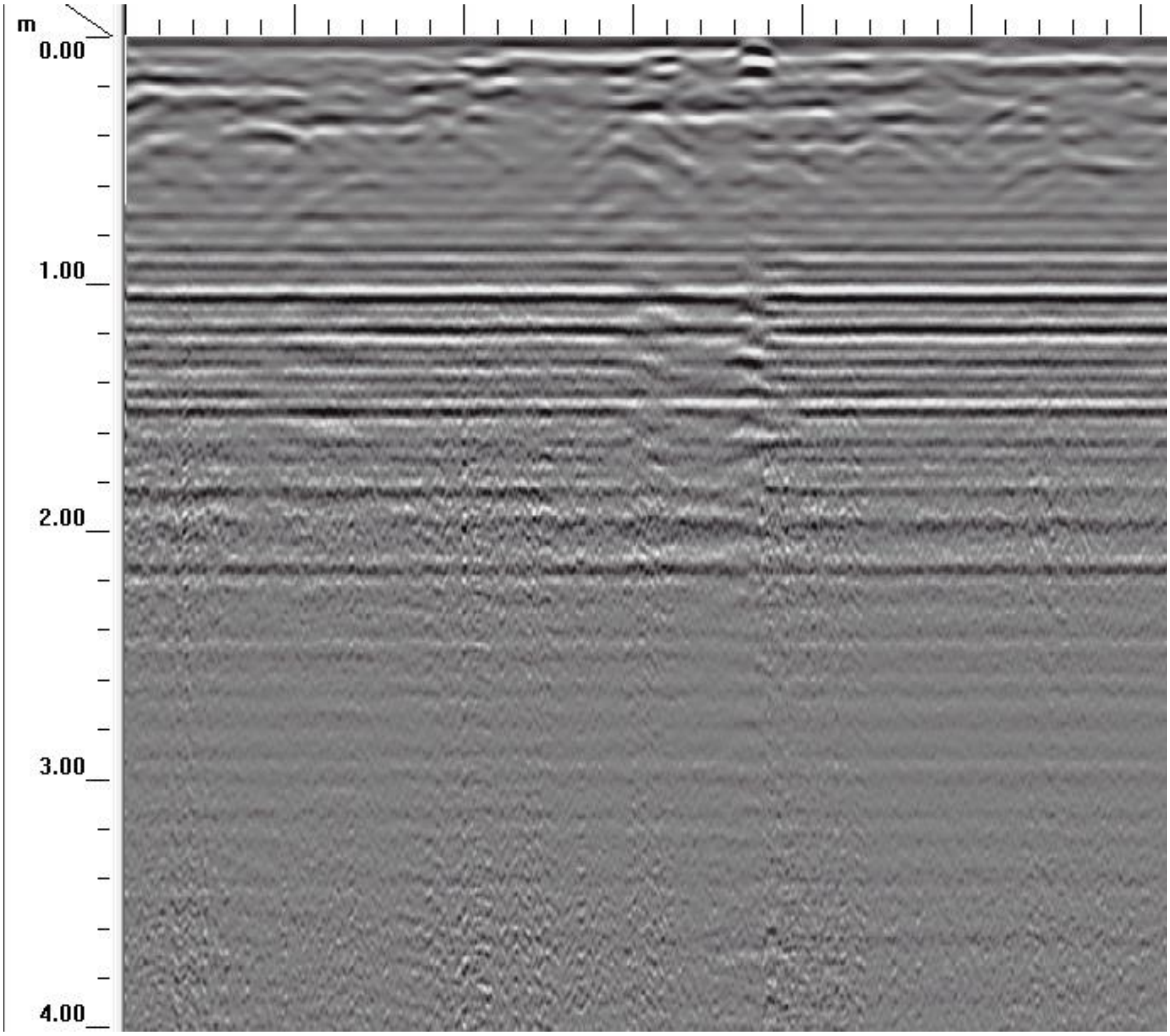

Figure 3: Example of typical data without anomalies. Horizontal lines are soil layers/stratification and weakly reflective hyperbolas are rocks and soil features

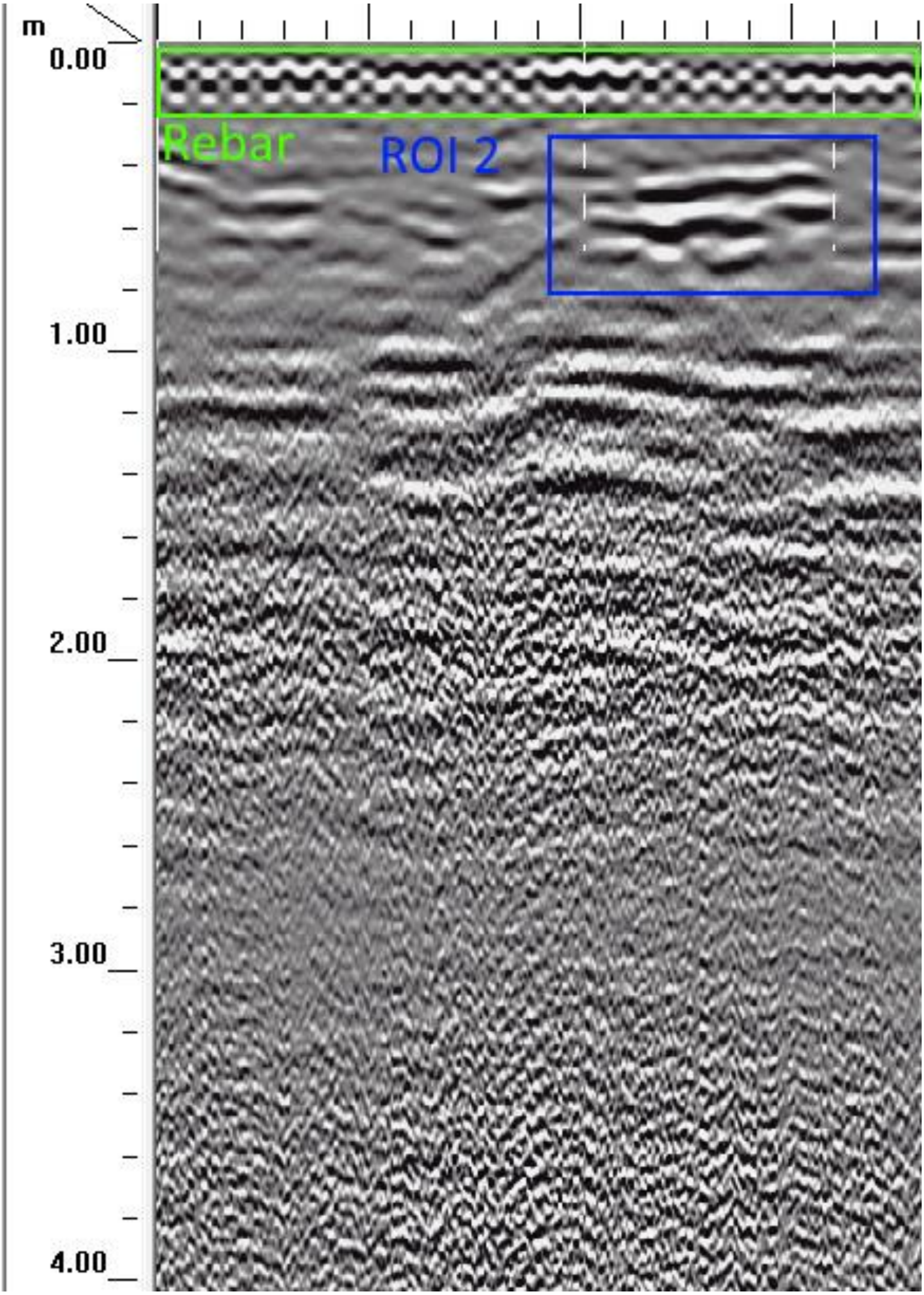

Figure 4: ROI 2(blue) beneath rebar near-surface (green)

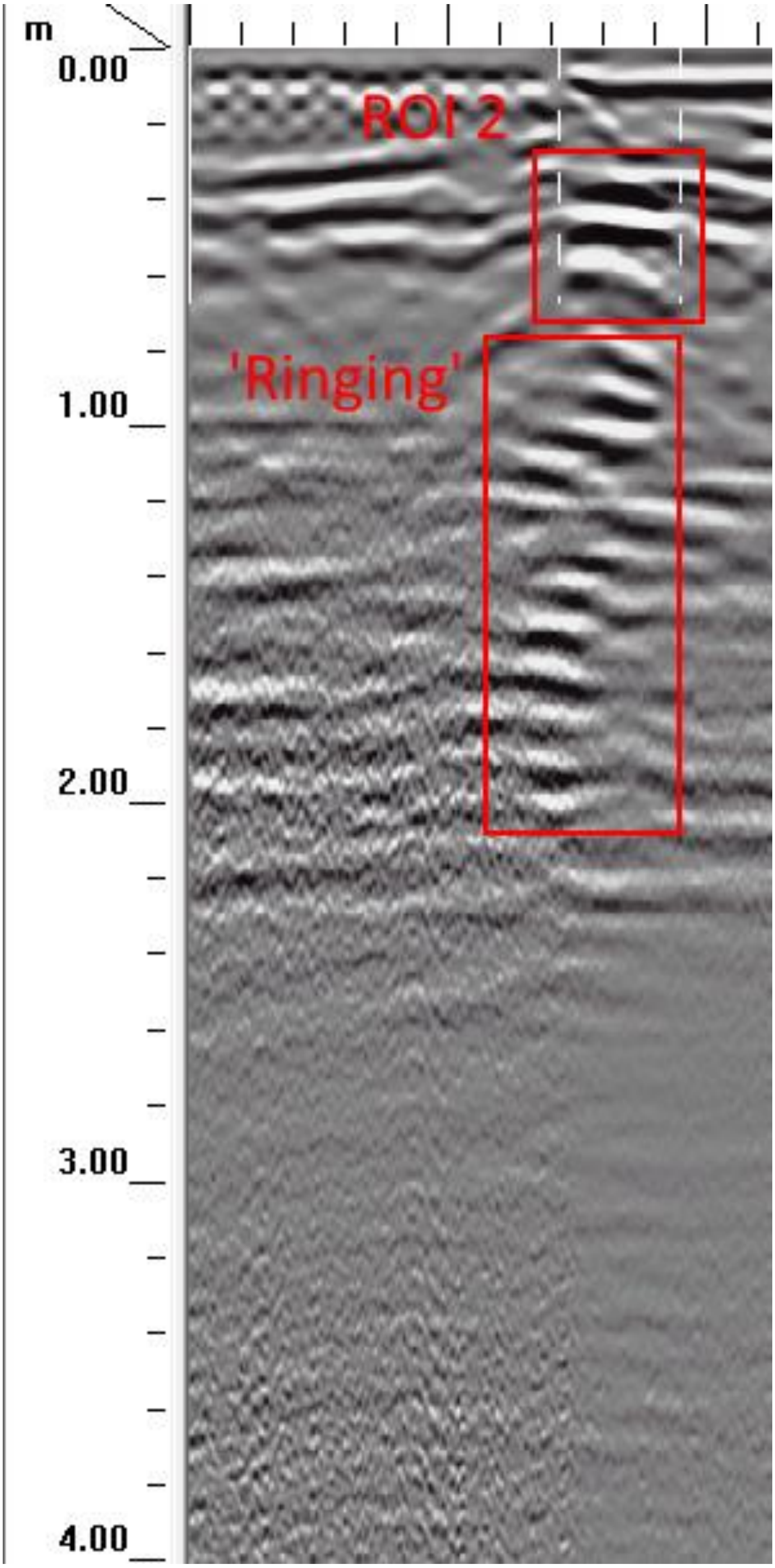

Figure 5: ROI 4 with ringing visible beneath the reflector

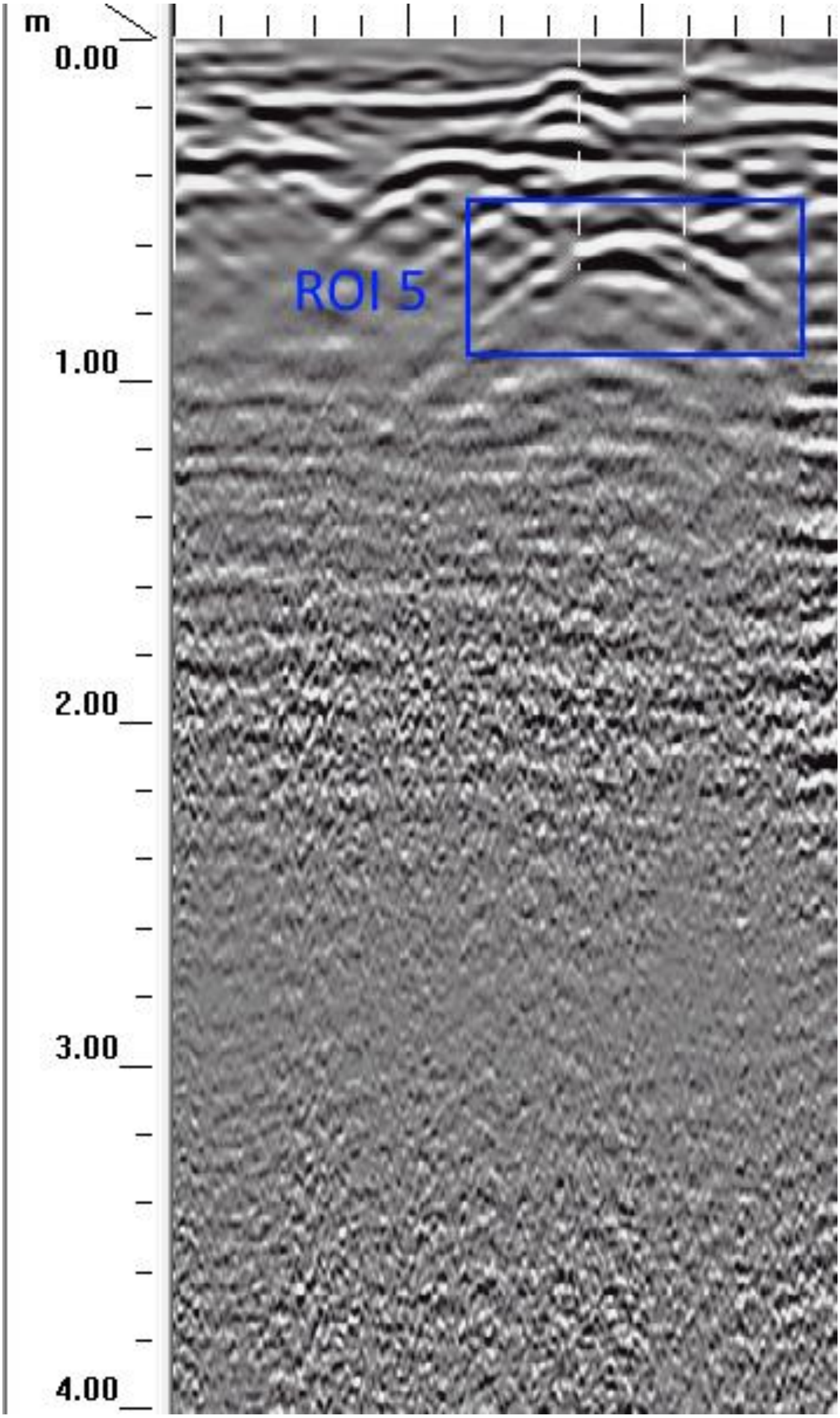

Figure 6: ROI 5 (blue)

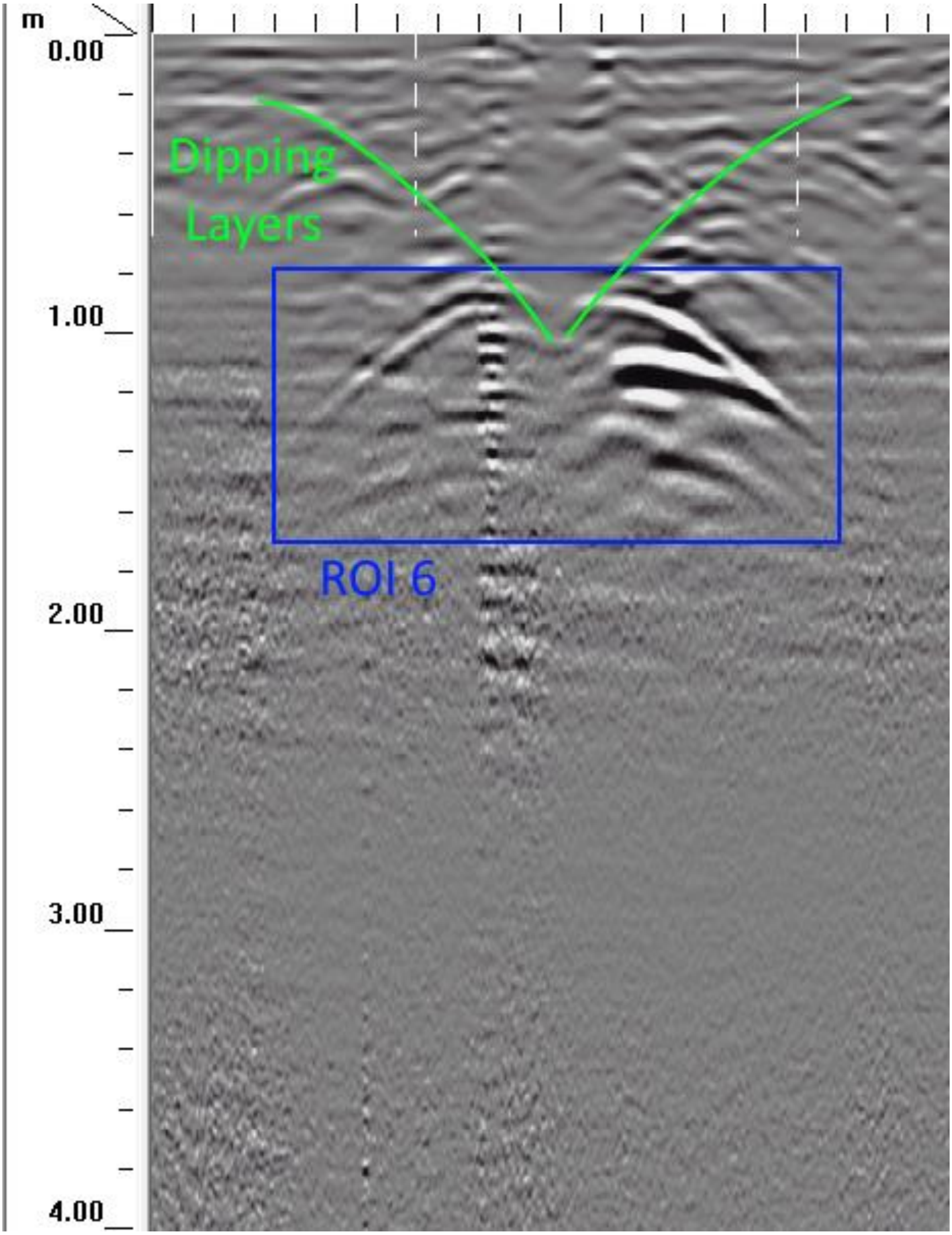

Figure 7: ROI 6 (blue) with dipping soil layers indicating previous excavation (green)

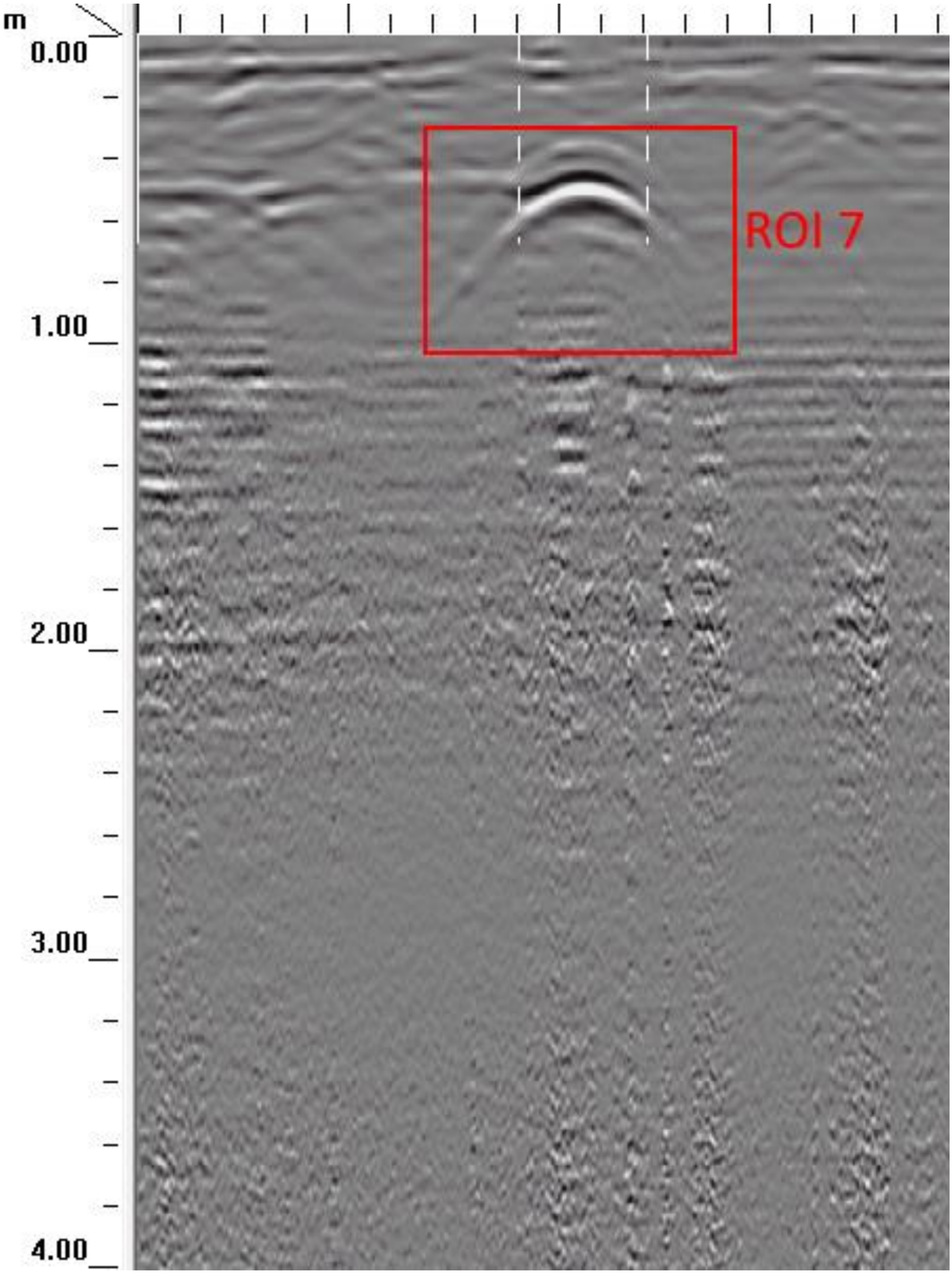

Figure 8: ROI 7

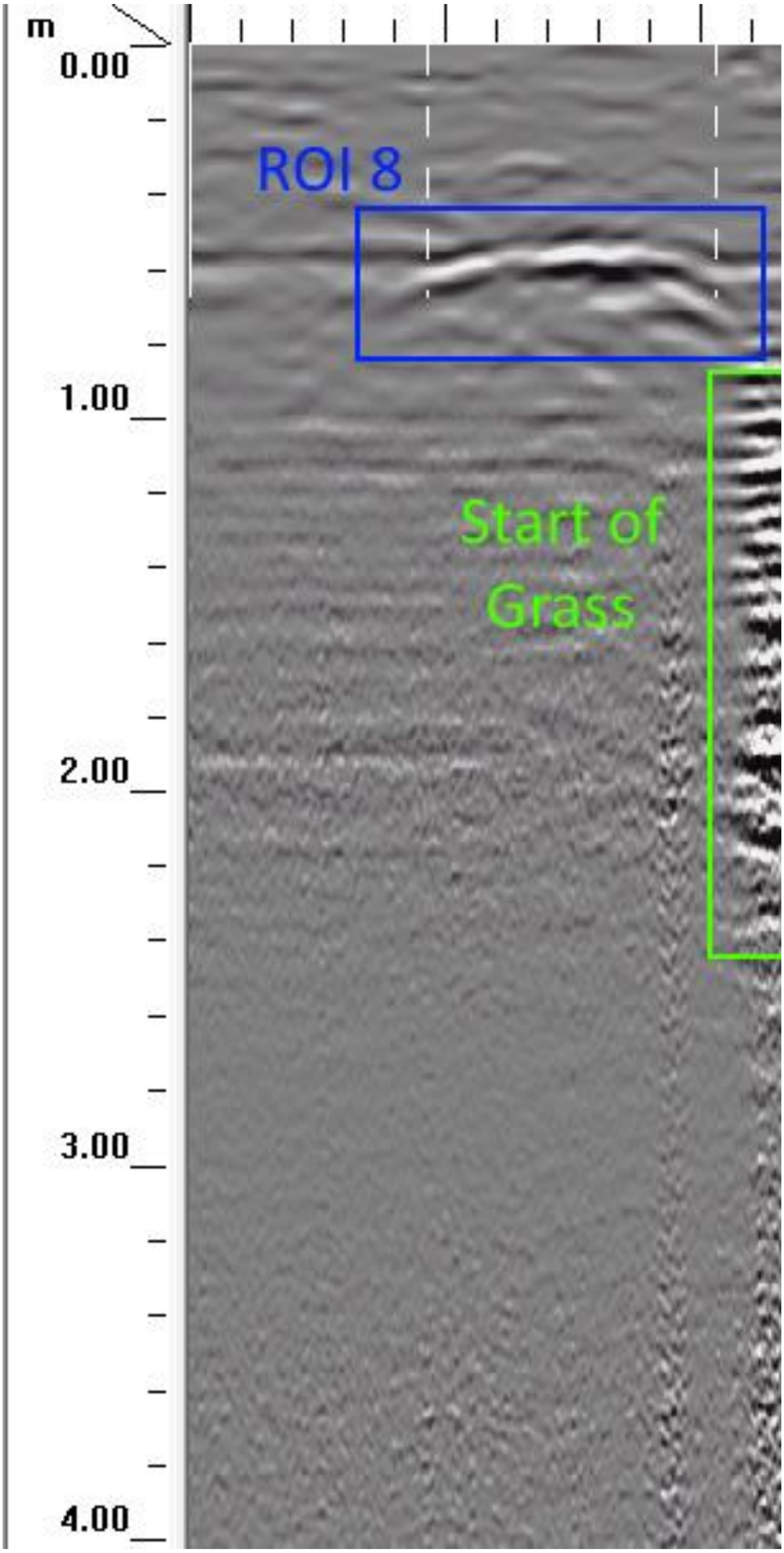

Figure 9: ROI 8 (blue) and high gains at grass/concrete boundary (green)

Figure 10: Photo showing restricted access to borehole location (next to nearest tree) with radar cart (left)

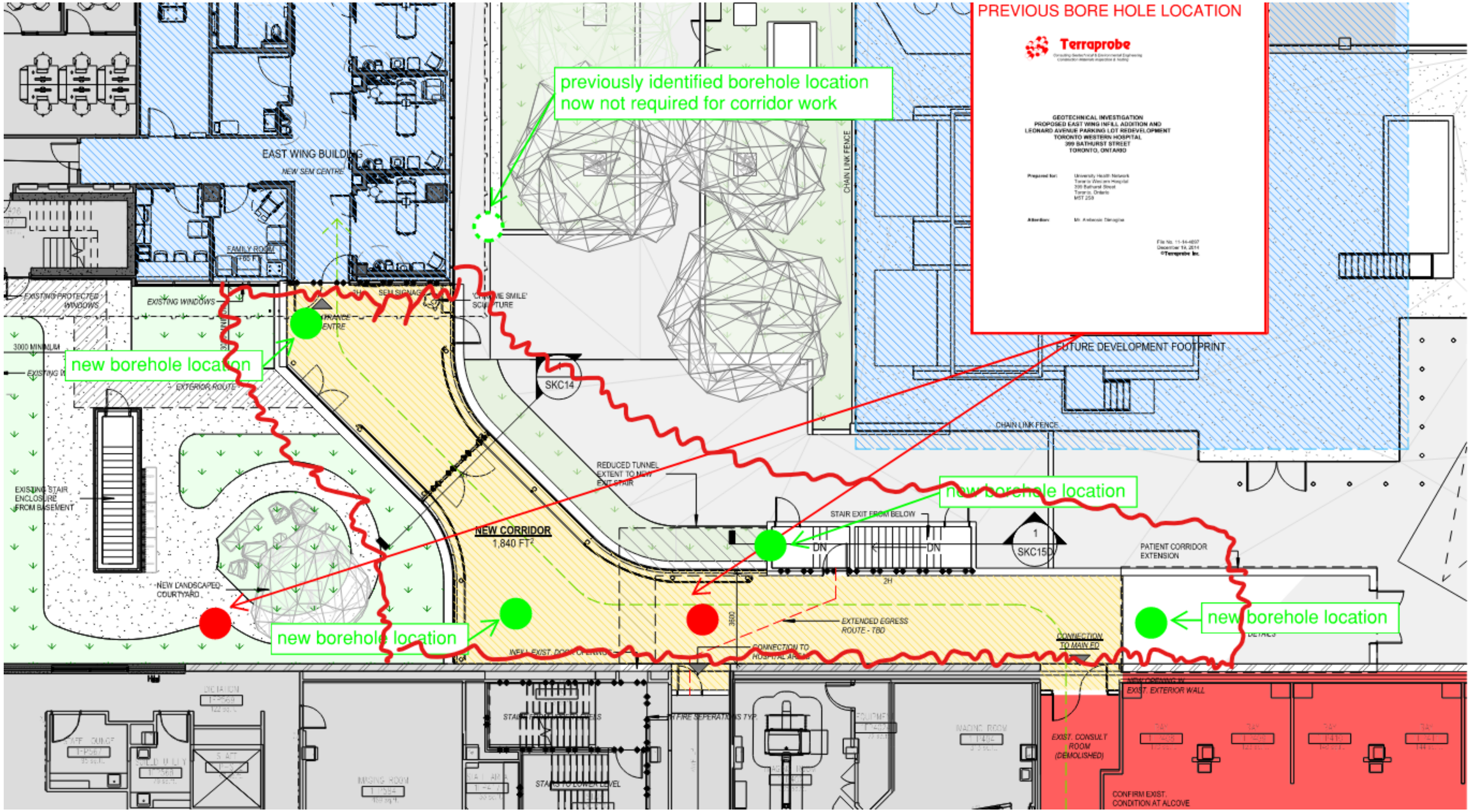

Figure 11: Client-provided borehole plan