Ground Penetrating Radar (GPR) as an auxiliary tool in maintenance activities in hydrosanitary systems

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Abstract

This work presents the results of a geophysical survey performed with the GPR method, aiming to help in the maintenance of a part of the hydrosanitary system of the Federal University of Rio Grande do Norte (Universidade Federal do Rio Grande do Norte - UFRN). The main purpose was to avoid unnecessary excavation and damage to pre-existing pipelines. Data were collected using a 400MHz shielded antenna allowing the identification of water pipes, an old sewer pipe and also tree roots present in the survey area..

Introduction

This work brings a study about mapping subsurface interferences in an area located within the UFRN limits. Over the years, GPR has been characterized as an important tool for mapping subsurface objects, allowing the identification of electrical cables, pipes and buried foundations with great precision. For this reason, it has been widely used in the maintenance of hydrosanitary installations allowing a quick and accurate assessment of the presence of interference in the subsoil greatly contributing to assertive decision-making in maintenance activities of pipeline networks: Mota (2011), Taniyama (2019), Porsani et al. (2012), Ulriksen (1982), Prado (2003), Grote (2005), Souza (2006), Rauen (2014), Do Nascimento Dias (2017) and Caetano (2019).

Over the years, UFRN has undergone changes and today offers 115 undergraduate courses. Naturally, this expansion process implies expansion works and maintenance activities. In this context, the GPR method was used to assist the Infrastructure Superintendence (INFRA) in maintaining part of the UFRN's hydrosanitary system, avoiding unnecessary excavations and damage to pre-existing pipes. The work area consists of a segment of Rua das Sociais Aplicadas, located between the Communication Superintendence (COMUNICA) and the Djalma Marinho Community Center (Figure 01). The street is paved with cobblestones and the segment studied has the following dimensions: 56m x 11m. Below the paved surface, the area has a thin layer of landfills and is predominantly occupied by Quaternary sediments (sand from dunes), the result of sedimentary processes and the past action of the prevailing winds in the area. These layers have thicknesses ranging from a few centimeters to approximately one meter. In addition, the sediments have fine granulometry and white, yellow and gray colors.

Method

The methodology used in this research consists of a set of techniques and procedures suitable for mapping subsurface interference, particularly PVC pipes. Next, we briefly describe data acquisition and processing.

From a hydrosanitary map made available by the Infrastructure Superintendence of UFRN (INFRA), it was possible to plan the layout of the GPR sections. The acquisition grid consisted of 56 parallel sections (each one 11m long), spaced 1m apart.

The GPR used was the SIR 3000, made by the company Geophysical Survey Systems Incorporated(GSSI). This system comprises a 400 MHz shielded antenna, a digital control unit and an odometer. The equipment was configured to record reflections with double propagation times (range) of up to 60ns, at intervals of 0.02m.

After acquisition, the GPR data were processed following a flow composed of four steps: Offset correction, dewow, gains and filters.

Results

In this section, the results obtained from a geophysical survey conducted within the central campus of UFRN will be presented (Figure 1). After acquisition, all data were processed and interpreted from 2D sections and timeslices. The generated images allowed a precise identification of the positions and depths of six anomalies (D1, D2, D3, D4, D5 and D6), described below.

The D1 anomaly was observed in all GPR sections and also in the timeslice (Figures 02, 03 and 04). This anomaly was interpreted as a water pipe (56m long) running in the EW direction and presenting a smooth curvature to the SW. This duct is located at a depth of 0.5m and has an estimated diameter of 150mm.

The D2 anomaly is also present throughout the studied area (Figures 02, 03 and 04). It consists of a set of double diffractions, interpreted as two superimposed water ducts. These ducts occur at different depths (0.4m and 1.0m), are 56m long and have an estimated diameter of 150mm.

The D3 anomaly (Figures 03 and 04) is observed in a good part of the survey area, it is 34m long and is found at a depth of 0.4m. Its diameter is 200mm.

The D4 anomaly appears in the first GPR section and continues to the NW for 34m (Figures 02 and 03). Among the pipelines mapped in this research, this is the one with the greatest depth (1.5m). It has a diameter of 200mm and was interpreted as an old sewer pipe.

The D5 anomaly occurs at a depth of 0.2m. Also has a small lateral continuity (~7m) and is positioned between GPR sections number 17 and number 24. After the excavation work done by INFRA, it was verified that it was a 40mm thick deactivated PVC duct (Figures 02 and 04).

The GPR data also identified anomalies associated with tree roots (for example, the D6 marker in Figure 04). Unlike pipelines, which have good lateral continuity (generally greater than 3m), locating roots is not a simple task and requires integrated interpretation of 2D sections and 3D blocks.

Maintenance activities carried out at the survey site validated these interpretations.

Figure 01: Work area located on the UFRN Central Campus (red rectangle).

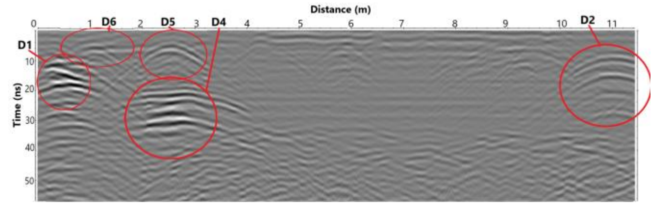

Figure 02: GPR section obtained with a 400 MHz antenna. Marks D1, D2 and D5 correspond to water pipes. While the D4 mark consists of an old sewer pipe, the D6 mark is associated with the roots of existing trees on the area.

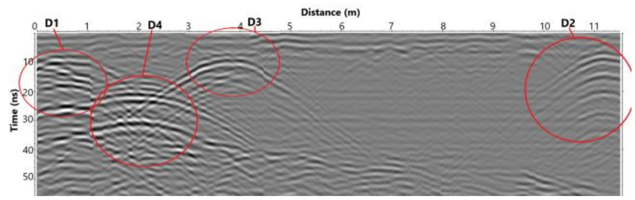

Figure 03: GPR section obtained with a 400 MHz antenna. Marks D1, D2 and D3 correspond to water pipes. The D4 brand consists of an old sewer pipe.

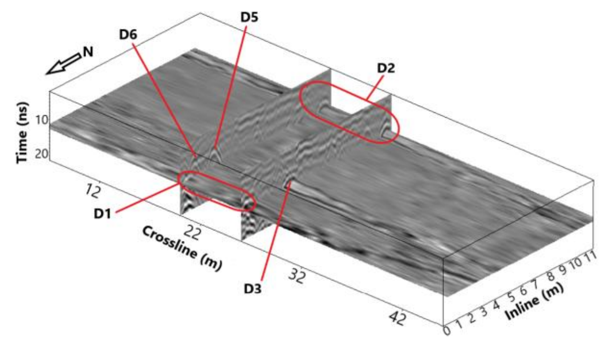

Figure 04: Fence diagram (composed of two GPR sections) over a timeslice at 10.5 ns. Marks D1, D2, D3 and D5 represent water pipes. The D6 mark represents tree roots.

Conclusions

This work addressed a problem related to the mapping of subsurface interferences through a geophysical survey with the GPR method. The survey took place within the limits of the UFRN Central Campus and the results achieved allowed the identification of some buried pipelines.

The pipelines were identified from the interpretation of six anomalies present in the GPR data.

The first anomaly consists of a 56m long duct located at a depth of 0.5m. This duct extends over the entire work area and has a diameter of 150mm. Until the middle portion of the work area it goes in the EW direction, when it smoothly turns to the SW..

The second anomaly crosses the lower portion of the work area (in the EW direction) and is 56m long. This anomaly indicates two overlapping water ducts, with a diameter of 150mm and depths of 0.4m and 1.0m, respectively.

The third anomaly is associated with a 200mm diameter water pipe that crosses the work area in the EW direction and is 34m long and 0.4m deep.

The fourth anomaly is an old sewage duct that appears at the beginning of the work area, continues to the NW for 34m and suffers a sharp curve to the SW, important information that is not included in the hydrosanitary map provided by INFRA.

The fifth anomaly is an old PVC duct with 40mm in diameter and approximately 7m in length. Its depth is 0.2m and is currently unused.

The GPR data also identified anomalies associated with tree roots, which have low lateral continuity.

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