CONTAMINATED SITE MAPPING USING GPR AND ELECTRICAL RESISTIVITY IN BRAZIL

Debora Silveira Carvalho, IDS Radar, Brazil
Roberto Okabe, IDS Radar, Brazil

Abstract

We will present our experience on a contaminated site mapping, using GPR and Electrical Resistivity geophysical methods at a Brazilian site. A multifrequency GPR equipment was used and all the geophysical, geological and borehole information were integrated to determine the next steps for investigations and site remediation.

The area presented hydrocarbon contamination with LNAPL (Light Non-Aqueous Phase Liquids) substances on a fuel supply and maintenance areas of train engines and vehicles, over operating railroads.

The geophysical results reach around 20 meters deep. Groundwater percolation might help to spread the contamination product through the depth.

Hydrocarbon contaminated sites usually give low resistivity anomalies and attenuation of electromagnetic signal and the integrated characterization by these methods allow us to delimitate contamination plume and suggest the best spots for future direct investigations.

Introduction

On fuel supply and maintenance areas for trains engines on operating railroads, contaminations by LNAPL substances – Light Non Aqueous Phase Liquids – are common. Those areas are usually undeveloped at Brazilian sites (Gallas et. al., 2005). Most of the companies are worried about the environment and many of these contaminated sites are being investigated for working on remediation plans.

At this stage we present one case where all the available information helped to integrate the geophysical mapping using GPR and Electrical Resistivity methods.

Some borehole information, aerial photographies, geological regional map and structures and a field description were given as previous information for planning the Geophysical investigation.

Acquisition data took place over a fuel supply and maintenance area for trains engines. Fuel activities could possibly be the source of contamination by hydrocarbon substances. Groundwater flow might have helped to spread these substances on a very porous layer mapped with Geophysical methods.

Background setting and regional characterization

Geological information allowed the technical crew to observe that regional faults and structures are present over the area on NE-SW direction. Some lineated trends are observed on the aerial photographies and geological maps. A latosoil red-yellowish is present over the investigated area (Teixeira, Toledo and Fairchild, org., 2001). This type of soil usually presents high porosity, where water can easily flow.

The borehole information shows underground conditions. Hydrocarbon presence was observed on drills over groundwater level. The area presents a granitic bedrock overlaid by clayey sands. The groundwater level (GWL) was between 3.6 to 8.0 meters. Two layers were identified: the topsoil layer, formed by some mixture of clay and sands, with bigger or smaller fragments of original bedrock, but in a very low stage of geological weathering. A second one, formed by clayey sand very porous with water and LNAPL substances, that might be contamination or not, depending on its concentrations and quantity on subsoil.

Boreholes PM – 05 and PM – 06 showed presence of LNAPL´s around 8.0 meters deep. This information could help to integrate all the geophysical and geological information, to delimitate the next step for site investigation and remediation.

These two layers presented variations on their thickness, depending on how close they were to the river. It is located around 40 meters from the end of the fuel supply ground pavement (made of a concrete layer) on S-W direction. Two Vertical Electrical Soundings (VES) were made to determine the presence and thickness of those layers and the presence of groundwater.

Geophysical investigations and results

As a cost-effective kind of investigation, a geophysical research was held using a multifrequency GPR, Electrical Resistivity and VES to detect the hydrocarbon impacted area.

The GPR equipment used was a RIS 2K from IDS Italy, with 200 and 600 MHz antennas. Results are shown in different levels, generated by average values in blocks of 0.6 meters, from ground level to 3.6 meters deep. Investigation lines were positioned every 2 meter. Some anomalies could be detected under the fuel supply soil pavement.

Electrical Resistivity was done using Dipole-Dipole field array, with 3 and 8 meters dipole size. Two VES were done to help understand the geological information given previously to the geophysical investigation (geological layers and water presence on soil pores).

The most important GPR anomaly was mapped from surface through 3.0 meters deep and it is an attenuation anomaly, presented in blue in Figure 1, an electromagnetic tomography.

Electrical Resistivity reached around 20 meters deep and interpretations allowed the delimitation of three different layers, divided by their apparent resistivity values. The first layer has very low apparent resistivity values (ranging from 5 to 40 ohm.m). Some parts might have water in their pores. As an LNAPL contamination this layer is a favorite target for directing the boreholes for confirming presence of theses substances. This is the most significant layer since this is an environmental research.

The second layer presents higher apparent resistivity values, ranging from 40 to 400 ohm.m and it is representative of a clayey sand material. These values are not significant for contamination substances.

The third layer is the bedrock or at least a less weathered bedrock or a clayey sand material, with apparent resistivity values in a range between 40 and 600 ohm.m. At the SE portion of the investigated area, weathered bedrock apparent resistivity values can be seen.

Integrating all geophysical, geological and borehole information it is possible to determine that bedrock is very deep and irregular at the site. Some blocks/boulders are present between the bedrock and topsoil.

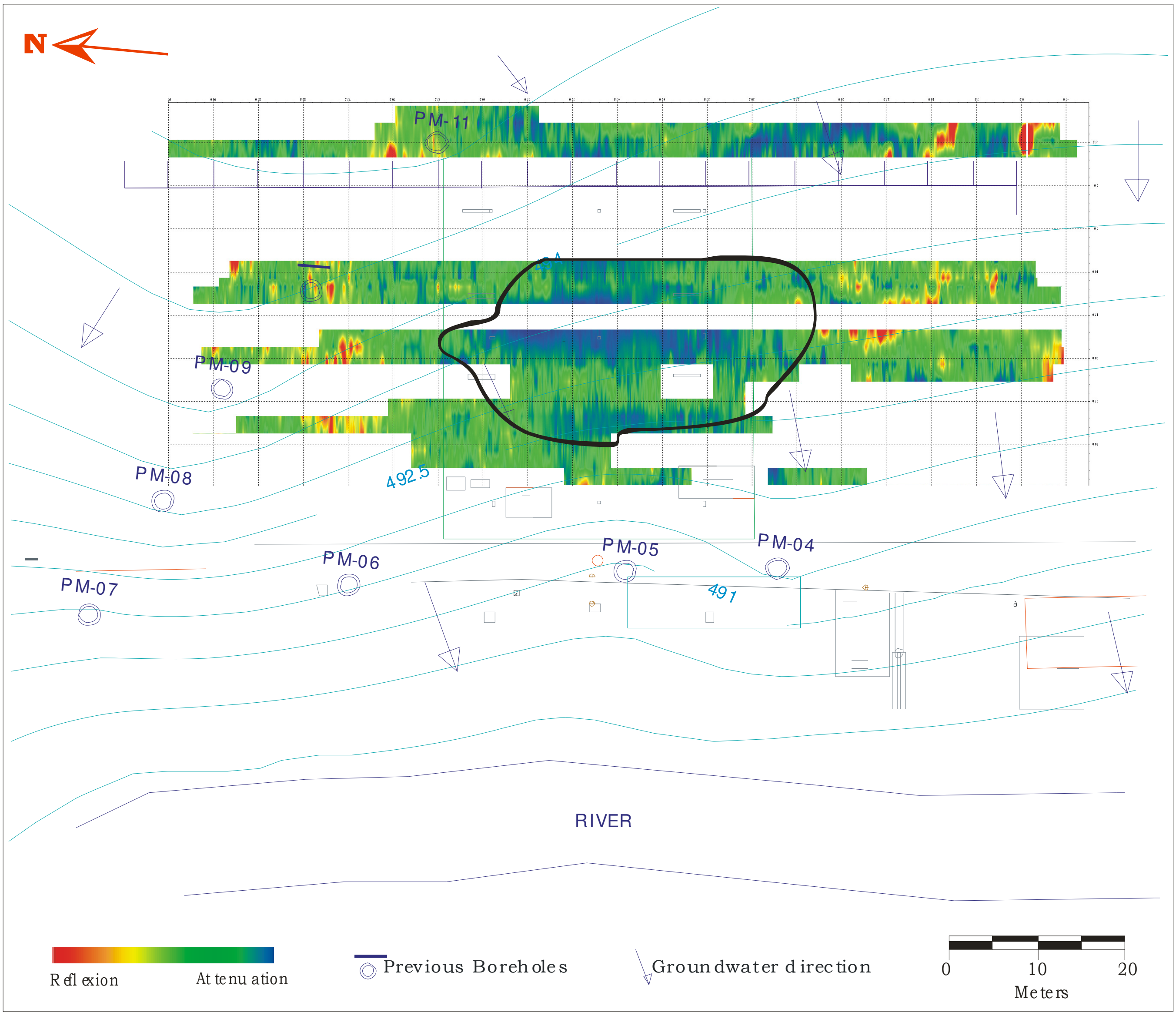

Figure 1: Electromagnetic tomography with a main anomaly under the fuel supply soil coverage.

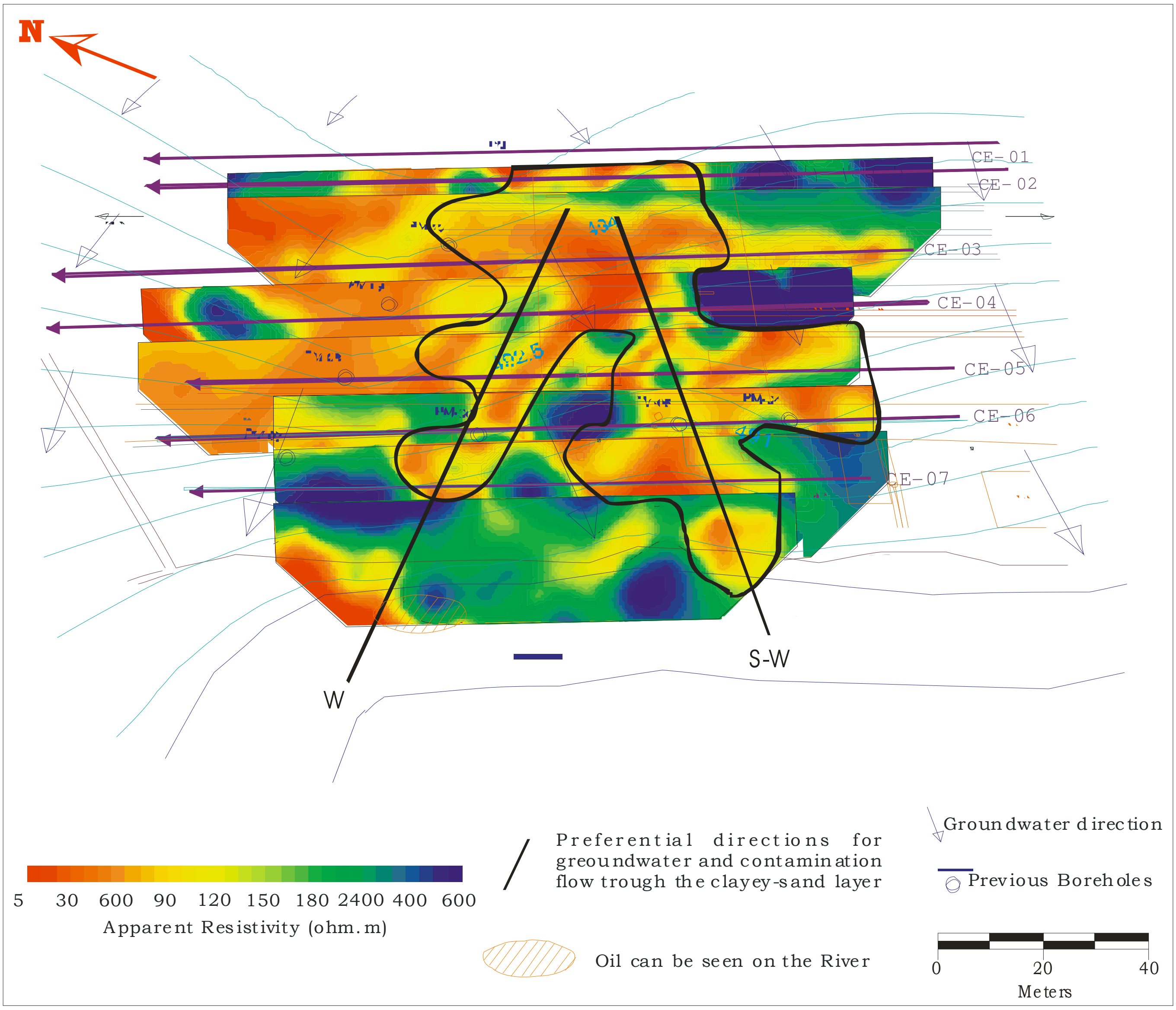

Figure 2: Electrical Resistivity tomographies with a main anomaly that determine the contamination flowing direction.

At N-W portion of investigated area, some low apparent resistivity values can de found. Previous to this investigation, some boreholes were located at this portion (PM – 07 to PM – 11). There are no evidences of contamination at this side at fuel supply area.

The groundwater level (GWL) was verified by two VES (Vertical Electrical Soundings) and it is about 3.6 meters deep at the E portion and around 8.0 meters at W side of the fuel supply pavement. Figure 3 shows two VES done at this investigation.

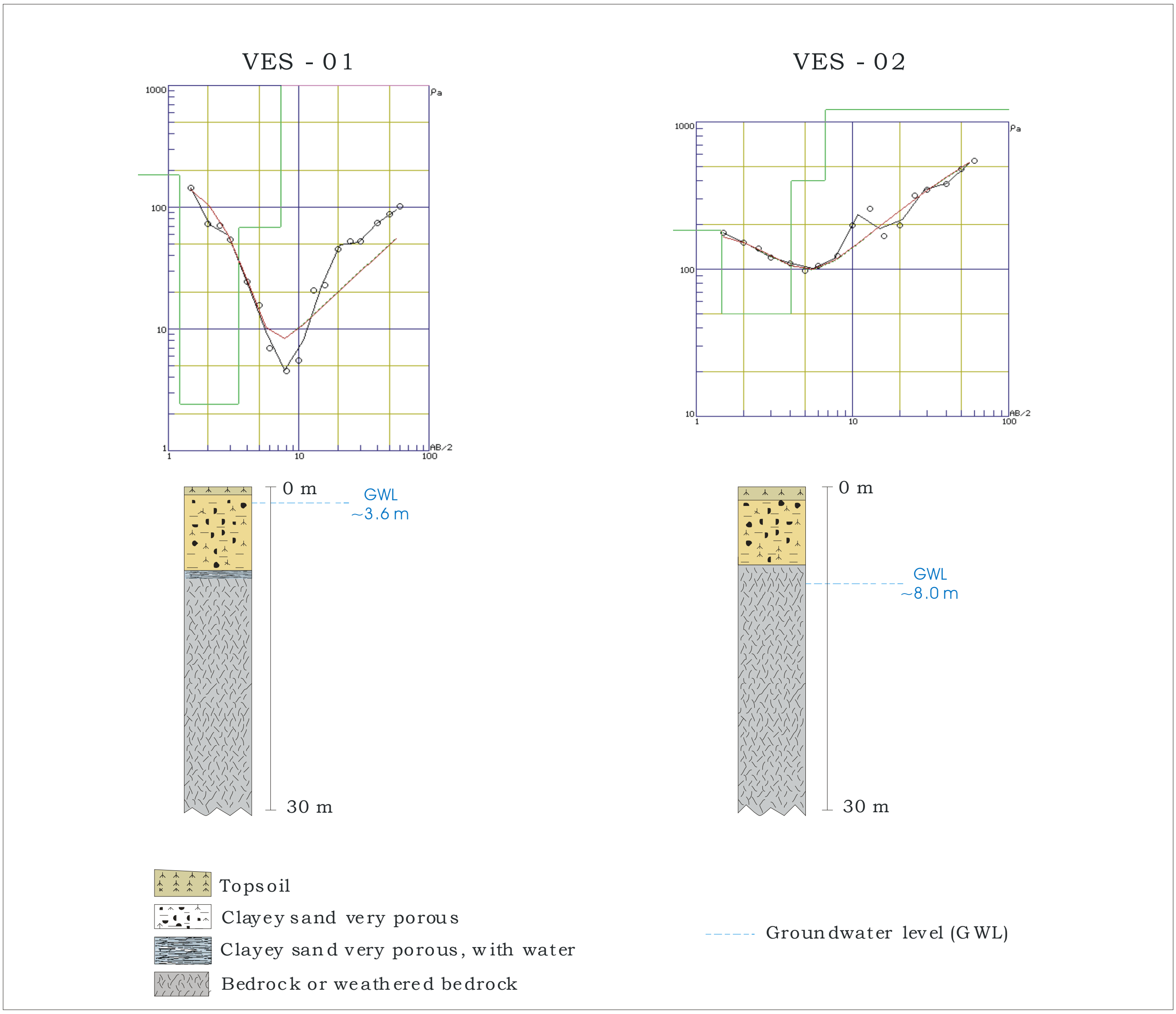

Figure 3: Geological layers inferred, for the VES results obtained.

The source of contamination was attributed to the main anomaly – where the electromagnetic attenuation is higher – mapped with GPR, just below the fuel supply concrete pavement.

For continuing the environmental problem solution, ten points of borehole investigation are suggested for confirming the presence of contamination by hydrocarbons, as shown in Figure 4. After having the borehole information a remediation plan can be done.

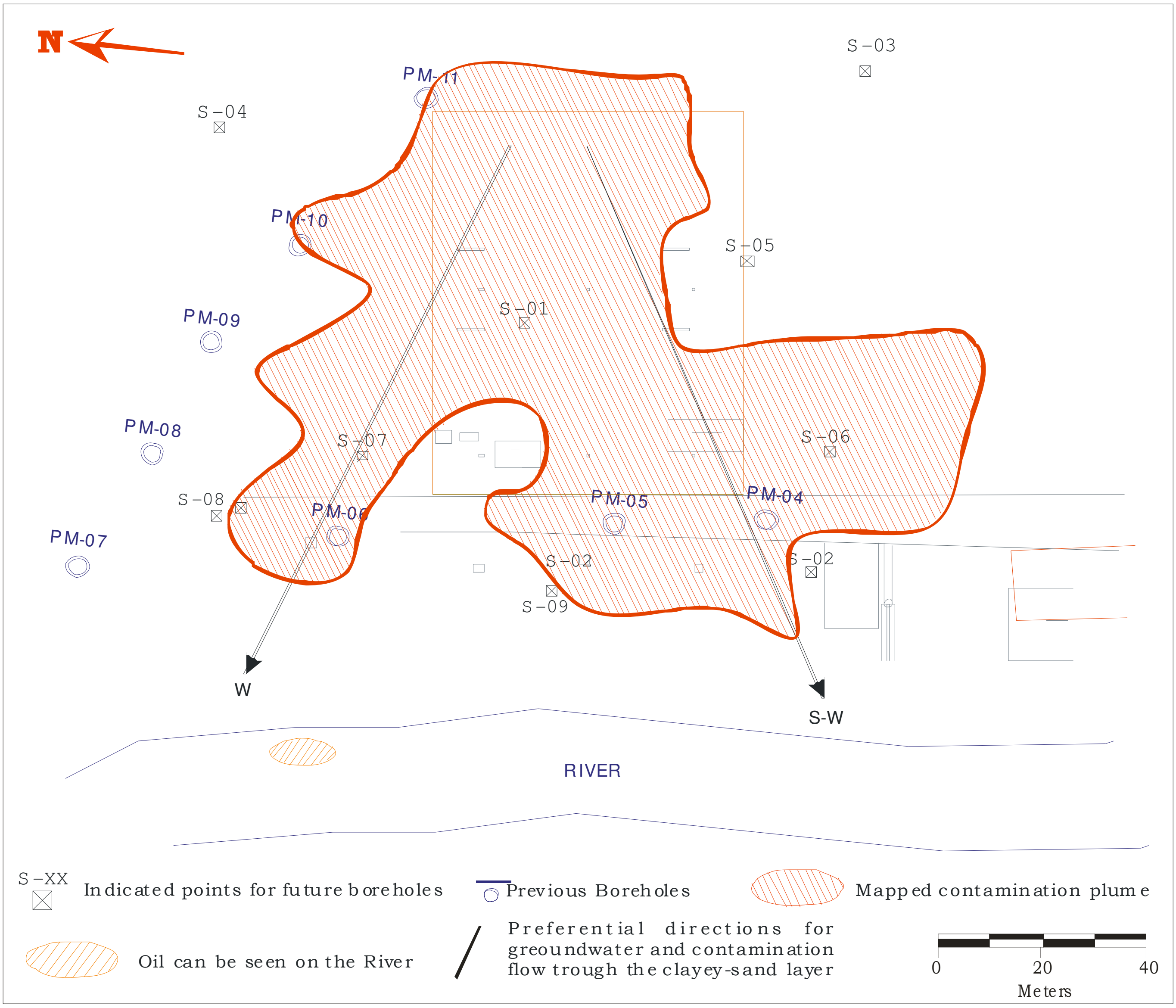

Figure 4: Contamination plume mapped over the fuel supply pavement area and the future boreholes indicated for contamination presence detection.

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