

# **Soil Survey: Methodology Improvement in Brazil Adopted by CTR-RIO for the Quality Control of Geomembrane Installations**

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## **ABSTRACT**

The soil survey methodology is used for the detection of leaks in geomembranes. Although little known in Brazil, it is well suited to minimize the risk of placing waste on a damaged liner system. A Canadian study indicates that the density of damages on installed geomembranes is on average between 4 and 22 leaks per hectare. Quality Control measures currently used in Brazilian landfills do not include this type of testing. As the existence of lined landfills is relatively new in Brazil, the impact caused by damage in the protective layers cannot be perceived. The landfill of CTR-RIO, in Rio de Janeiro, Brazil, adopted this methodology for quality control. The results after 4 years of operation indicated the amount of leaks found range between 0.5 and 8 leaks per hectare for an inspected area of approximately 310,000 m<sup>2</sup>. All identified damages could be repaired before the beginning of the waste disposal.

## **INTRODUCTION**

The establishment of National Politics of Solid Waste (Brazil Presidency of the Republic, 2010), in Brazil, in August 2010, defined a deadline for the closure of all dumps in the country. Despite this deadline (Brazil Presidency of the Republic, 2014) an impressive amount of dumps were closed, giving place to implantation of authorized landfills.

Although the environmental agency that established the standards for landfill installation permits does not require the use of geomembranes (ABNT, 1984 and ABNT, 1987), state agencies require them as a minimum standard.

Considering that geomembrane is used as the main liquid barrier to prevent soil and sub water contamination, the leak location testing after earth material is placed on and before waste disposal becomes essential.

Currently, the most common quality control method used to inspect geomembranes in Brazil is the weld seams test. However, this method tests only a very small percentage of total geomembrane area installed, without identifying potential damages not caused by seam welding.

In addition this method does not test the geomembrane after the earth materials placement stage when more significant amounts of damages have occurred due to use of heavy equipment to construct the liner and the effective load application over the geomembrane.

The statistics researched using monitoring data of geomembrane leaks developed in Canada (Forget et al, 2005), in 89 projects during a 10 years period (2,652,000 m<sup>2</sup> of area), show that the density of geomembrane damages varied, on average between 4 and 22 per hectare. This variation depends on the level of quality control used during the geomembrane installation. Seventy three percent of the damages occur during the application of overlying earth material on the geomembrane, twenty four percent occur during the installation of geomembrane and only two percent of the damages occur after the landfill construction. Contrary to the common perception, the majority of damages do not occur due to inadequate weld procedures so the testing regime should be expanded.

ASTM D7007 (Standard Practices for electrical methods for locating leaks in geomembranes covered with water or earthen materials) (ASTM, 2016), establish adequate methodology out of Brazil, to the quality control of geomembrane integrity after the placement of overlying material: The Soil Survey and Water Survey.

This particular methodology uses an electrical method to inspect geomembranes covered with soil or water, for example. The principle of this method is to apply a voltage across the plastic material to search for any electrical current leaks. Through this method it's possible to locate the damage and fix it before the deposition of waste (Laine et al, 1993).

The electrical methods to locate leaks in geomembranes have been practiced worldwide for many years (Laine and Darilek, 1993). Application of these methods has

been mandatory requirements for sanitary landfills in some states in the United States of America such as New Jersey, New York, and parts of California (Thiel et al, 2003).

In Brazil, the application of Soil Survey methodology was included in the geomembrane Construction Quality Control Program at CTR-RIO Landfill, in Seropedica City, in the State of Rio de Janeiro, Brazil. The adoption of this technology provides relevant security to the environmental agency, the company responsible for the sanitary landfill operation, and industries that dispose of waste.

## **METHODOLOGY**

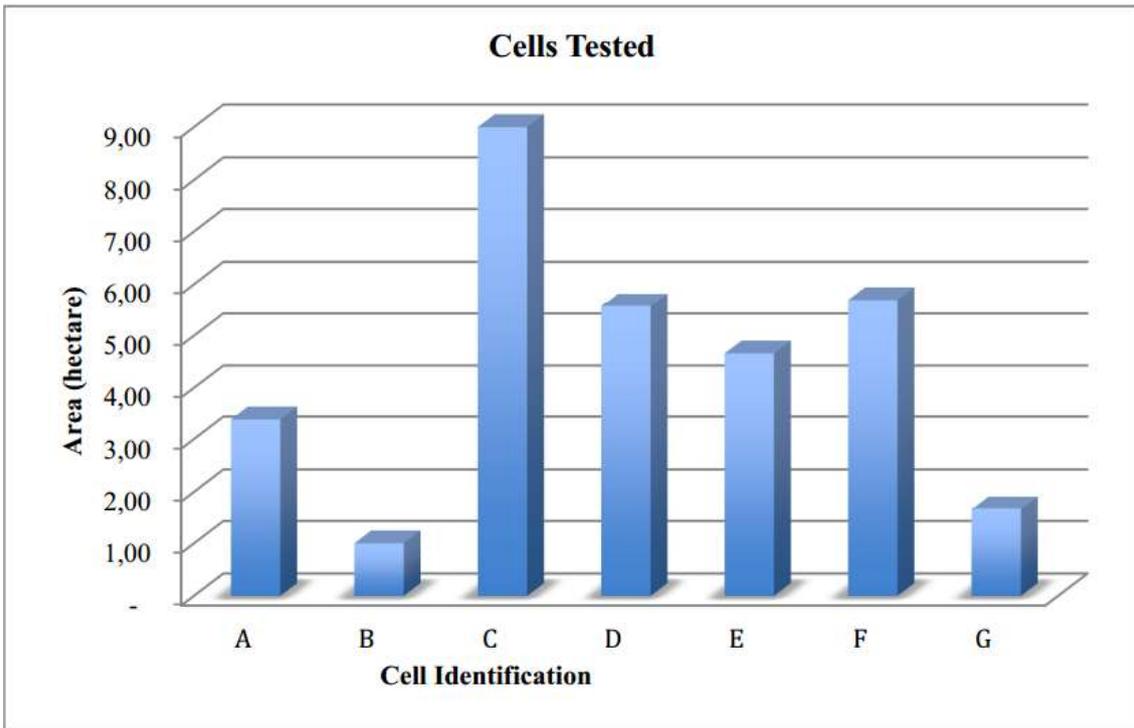
The landfill referenced in this paper has four leak resistant layers of thickness from the bottom up: 0.50m of compacted clay, a geosynthetic clay liner (GCL), 1.5mm thick of High Density Polyethylene (HDPE) geomembrane liner, and another layer of HDPE geomembrane liner 2 mm of thickness. Between the geomembranes is a drainage layer with 0.2 m thick layer of sand and perforated HDPE pipes (Drainage Tube Testimony) and a 0.15m thick clay layer just below the 2mm HDPE liner. The primary (top) 2.0 mm geomembrane layer is covered with 0.50 m thick layer of compacted soil, which is called the mechanical seal.

In the case of any leachate leakage through the primary geomembrane, the leachate will flow into the drainage layer, and will be collected by the Drainage Tube Testimony pipes.

Installed in the 0.15 m clay layer are electrodes for a separate geomembrane monitoring system to be used after waste is placed on the liner system.

This paper evaluated the Soil Survey results for the primary geomembrane layer, the 2 mm HDPE geomembrane located just below the mechanic seal, which is the first leak barrier layer that could have contact with the waste and leachate of the landfill cell.

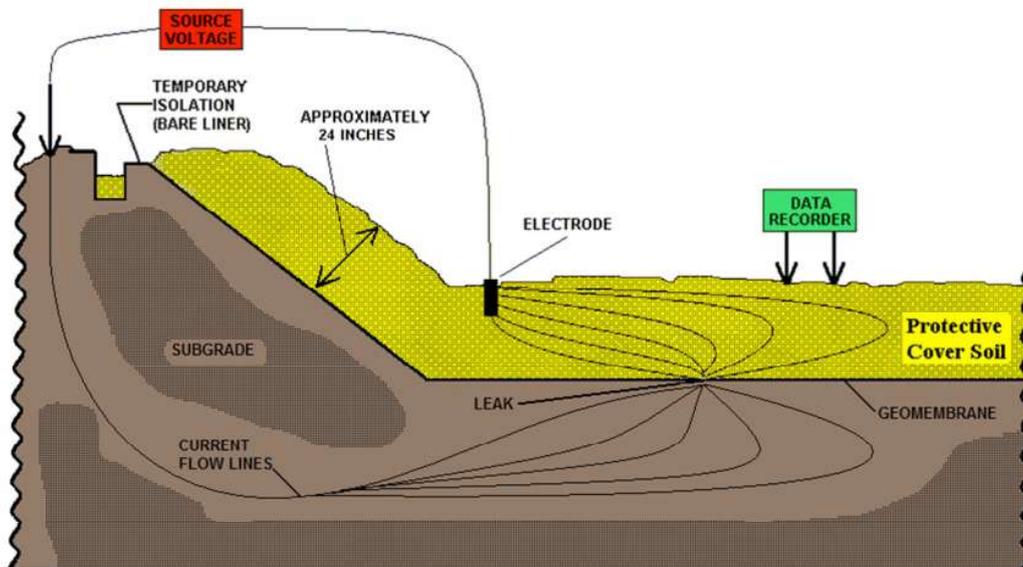
Considering the complexity associated with landfill operation and construction activities, the waste cells were designated as Cells A through Cell G. Figure 1 shows the areas of each cell. The total area surveyed was approximately 31 hectares.



**Figure 1: Areas of the cells tested with the electrical leak location survey**

The electrical leak location method consists of applying voltage across the geomembrane liner. This voltage produced a relatively uniform potential voltage distribution when no leaks are present. . If the geomembrane has a leak, current flowing through it produces an anomaly in the measured electrical field. Thereby the leaks can be detected and located. These anomalies in the electrical field are detected by making systematic measurements over the geomembrane area. Figure 2 is a diagram illustrating the method.

During the inspection, a power supply connected to two electrodes is used (Source and return electrodes). The source electrode is placed in the soil on the primary geomembrane and the return electrode is placed in the soil under the geomembrane in the leak location zone. The power source will generate an electrical field in the covering soil. If the liner has a leak, electrical current will flow through the leak to the return electrode, causing a localized abnormality in the potential gradient. That principle is shown on Figure 2.



**Figure 2: Diagram illustrating Soil Survey methodology (From LLSI)**

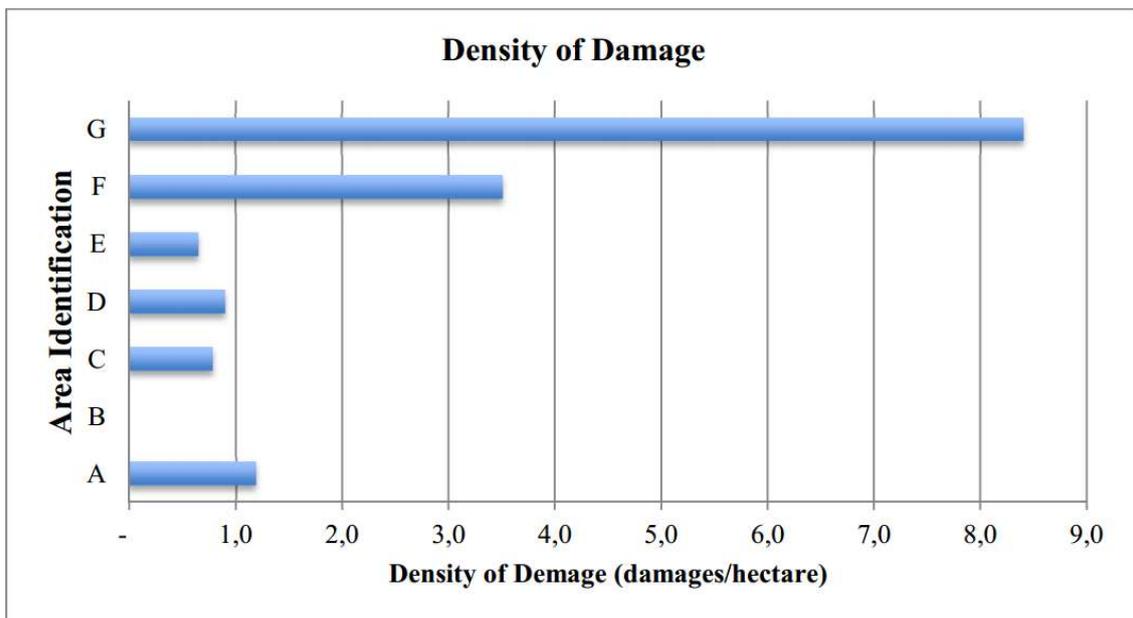
Soil Survey measurements marks are made using a pre-defined grid, which determines the measurements points on the landfill. The grid used was 3 by 3 meters and measurements were done every 1.5 meters. The data was collected using a portable data logger, like presented in Figure 3, and afterward downloaded using software responsible for processing the information enabling data analysis for the damage locations.



**Figure 3: A technician collecting field measurements**

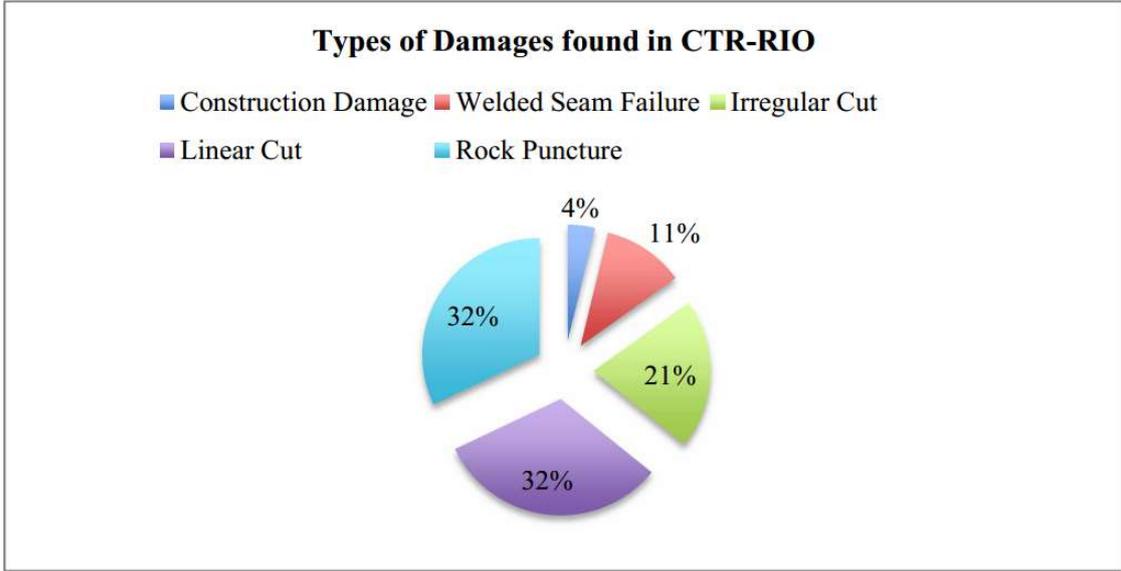
## DISCUSSION AND RESULTS

The Figure 4 shows the density of leaks in the various cells. The damages were also categorized and compared to data from technical literature. Figure 4 shows the damage density was smaller in areas A through E, which had a below average result compared to the technical literature (Forget et al. 2005). The results from areas F and G were comparable with data from the researched literature.



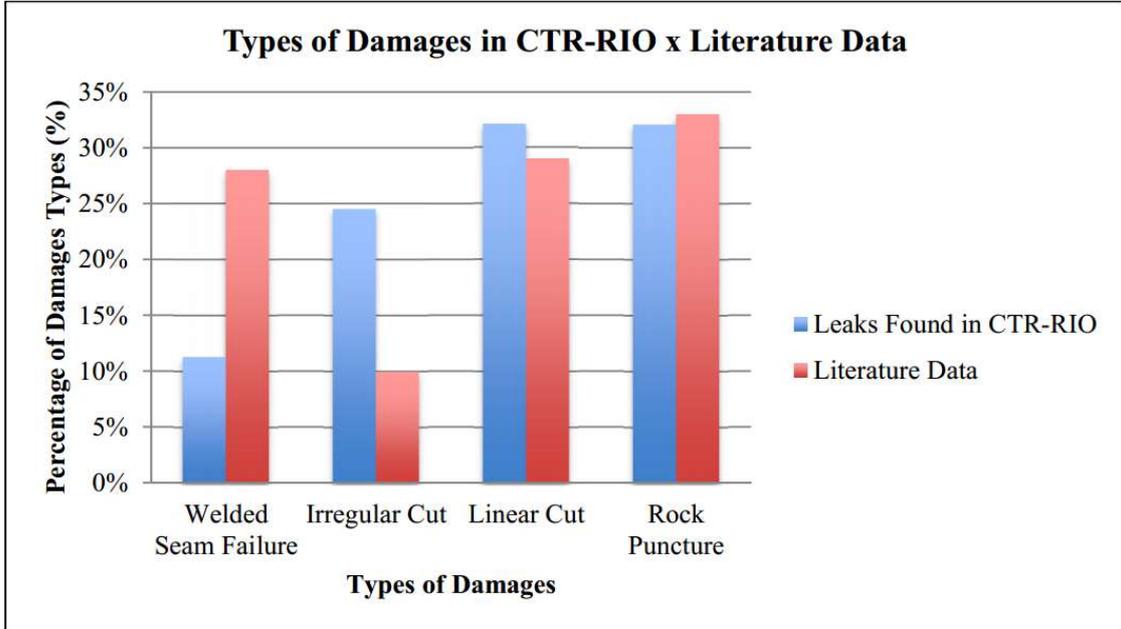
**Figure 4: Density of leaks located in each Cell tested with the Soil Survey in CTR**

Considering the types of damages located, cuts and punctures represent the majority of leaks discovered, as presented in figure 5, followed by irregular cuts, welded seam damage and damage caused by heavy equipment traffic.



**Figure 5: Types of damage and percentage of geomembrane damage located using the Soil Survey method**

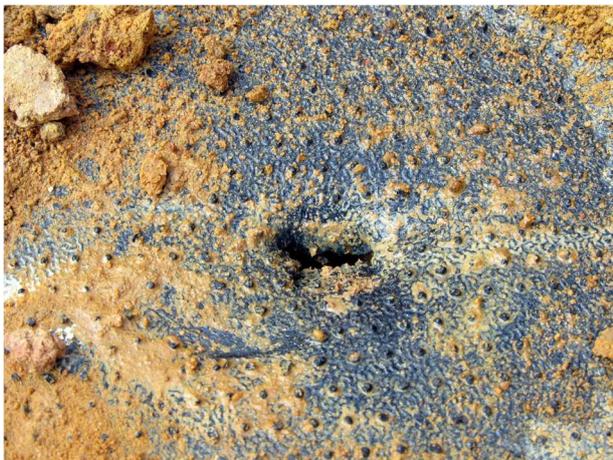
The comparison between damage types discovered in CTR-RIO and the reference from literature, (Forget et al, 2005) are shown in figure 6.



**Figure 6: Percentage of damage types found using Soil Survey in CTR-RIO compared with literature data (Forget et al, 2005).**

The percentages of linear cuts and rock punctures found in CTR Rio are very close to those cited in the literature (Forget et al. 2005). Irregular cut damages were more frequent in CTR Rio and welded seam damage were less frequent than the results mentioned in technical literature.

Figures 7 and 8, show pictures of damages discovered during the electrical Soil Survey, in CTR-RIO Cells. Figure 7 shows a rock puncture damage and Figure 8 shows a welded seam damage leak.



**Figure 7: Puncture damage.**



**Figure 8: welded seam damage**

## **CONCLUSION**

Geomembrane Construction Quality Control using Soil Survey demonstrates to be efficient in identifying geomembrane leaks and damages caused by geomembrane installation and covering. The types of damage to the primary geomembrane were similar to those attained in a comprehensive study in Canada. A lower density of leaks was found compared to the results in Canada. This might be associated with the geomembrane construction quality control that was used at this landfill.

As a result of the Soil Survey application on the primay geomembrane, CTR-RIO repaired a total of 53 leaks in 31 hectares. This avoided potential future leakage to the drainage layer and through the other impermeable layers. The results of the electrical Soil Survey show that geomembrane leaks are a real threat to liner installation in landfills. For this reason this testing technique should be adopted for Brazilian landfills, as CTR Rio has done, as an additional tool in the quality control program for geomembrane installations.

This technique, already practiced worldwide, represents an improvement in this country for geomembrane installation quality control and consequently the environmental risk reduction that is inherent with waste disposal activities.

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