Locating Leaks in Geomembrane Liners of Landfills Covered With a Protective Soil

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ABSTRACT

The electrical leak location method was used to locate leaks in the geomembrane liners of single-lined and double-lined landfills covered with a protective soil cover. The landfills ranged in size from 0.40 hectare (one-acre) to 3.2 hectares (eight-acre). Water in the leak detection system under the primary liner indicated the primary liners were leaking.

The principal of the electrical leak location method is to place a voltage across the geomembrane liner and then to detect areas where electrical current flows through leaks in the liner. The electrical leak location method proved to be a practical and efficient method to locate leaks under a protective soil cover. This method was very successful in locating leaks to solve the leak problems at the landfills.

INTRODUCTION

Geomembrane liners are covered often with sand or soil to protect the liner from mechanical damage and damage from solar ultraviolet radiation. Geomembrane liners covered with soil materials are also used to cap landfills. Because the geomembrane liner may be damaged while emplacing the protective soil, an electrical leak location survey of the soil-covered geomembrane is a highly effective method for ensuring that leaks will be located in the liner. The method is particularly valid because the liner is tested under load, and after the liner has been exposed to possible damage.

The development of the electrical leak location method began in 1980 and commercial surveys have been available for the past seven years. Electrical leak location surveys with soil cover have been conducted commercially for the past five years. The commercial surveys have been overwhelmingly successful in that many leaks were efficiently and accurately located in installations that had been previously tested with other methods.

Description of Method. The electrical leak location method has been described previously by the authors in several papers. The basic method is to connect an electrical power supply to electrodes above and below the liner and then detect areas of localized electrical current flow through leaks in the otherwise insulating liner. When no leaks are present, the voltage impressed across the liner produces a very low current flow and a relatively uniform voltage distribution in the material above the liner. If the liner has a leak, electrical current flows through the leak causing a localized anomaly in the potential gradient. Leaks are located by measuring potential gradients in the material above the liner to search for these localized areas of relatively high electrical potential gradients. The electrical leak location method is used in liquid impoundments, and for pre-service inspection of solid waste landfills with soil cover.

With the proper implementation of equipment and survey procedures the electrical leak location method is a very sensitive and accurate method. The measured amplitude of the leak signal is proportional to the amount of electrical current flowing through the leak. Therefore, leak location surveys should be conducted with the maximum practical safe impressed voltage. To increase the leak detection reliability the detector electronics must be optimized for maximum sensitivity. In addition, extraneous electrical conductors such as metal pipes and pump wiring that provide an electrical conduction path through or around the geomembrane liner should be eliminated or insulated.

SURVEYS OF WATER-FILLED LINERS

Surveys of water-filled liners are conducted while wading in the liquid or standing on the side slope using electrical search probes and associated instrumentation. This system is for inspection of non-hazardous liquid-filled impoundments and for pre-service inspection of water-filled impoundments and landfills. Figure 1 shows the operation of the equipment.

FIGURE 1. LEAK LOCATION SURVEY WITH WATER COVERING THE LINER

The authors have previously reported an average density of located leaks at 2.6 per 1,000 m^2 (2.4 per 10,000 sq. ft.) Darilek, et al (1989) and 3.4 leaks per 1,000 m^2 (3.1 per 10,000 sq. ft.) Laine and Miklas (1989) with several liners having more than 12.5 leaks per 1,000 m^2 (11.6 per 10,000 sq. ft.). To date the authors have surveyed over 850 thousand square meters (9 million sq. ft.) of liner material. The results of the most recent surveys are presented in Figure 2 and Table 1.

ELECTRICAL LEAK LOCATION METHOD WITH SOIL COVER

Systematic Surveys. The electrical leak location method for surveying surface impoundments was adapted to make surface soil potential measurements for locating leaks in geomembranes covered a protective or cap soil layer. The soil is dampened with water for electrical contact and to allow the water to percolate through leaks in the geomembrane liner. Water may be sprayed on the soil using a water truck or sprinkler hoses. In some cases, the natural moisture and rain may be sufficient for the survey. Surface potential measurements are made on the dampened soil in a systematic manner using specialized measurement electrodes and a portable digital data acquisition system.

Figure 3 shows the data collection operation for a leak location survey with soil cover. Surveys are conducted by making point-by-point potential measurements along predetermined survey lines with a fixed measurement electrode separation. The data in the portable digital data

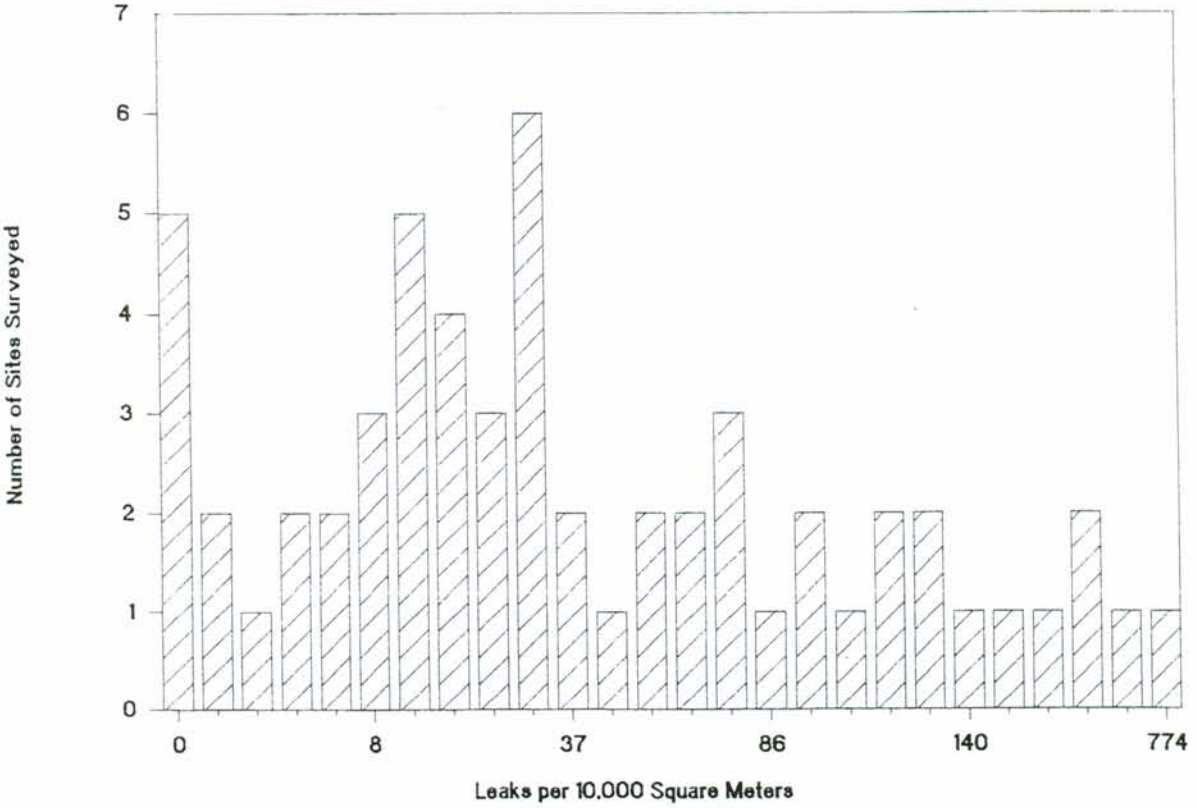

FIGURE 2. NUMBER OF SITES vs NUMBER OF LEAKS PER 10,000 M^2

TABLE 1. LEAK LOCATION SURVEY DATA FOR WATER-FILLED SURVEYS

SURVEY NO.	SIZE SQ. METERS	TOTAL LEAKS	LEAKS LOCATED SEAM	LEAKS LOCATED SHEET	10,000 SQ. METERS
1	195	0			0.0
2	223	6	2	4	269.1
3	232	2	1	1	86.1
4	281	0			0.0
5	290	1	1		34.4
6	302	7	6	1	231.8
7	302	2	1	1	66.2
8	330	4	3	1	121.3
9	358	0			0.0
10	372	1	1		26.9
11	393	9	9		229.3
12	393	1	1		25.5
13	393	1	1		25.5
14	530	8	8		151.1
15	530	4	2	2	75.5
16	530	41	41		774.2
17	530	1		1	18.9
18	530	4	4		75.5
19	697	4	2	2	57.4
20	798	15	10	5	188.0
21	1,347	3	3		22.3
22	1,457	18	18		123.6
23	1,457	0			0.0
24	1,457	11	7	4	75.5
25	1,457	14	12	2	96.1
26	1,906	4	4		21.0
27	1,906	22	22		115.4
28	2,007	24	24		119.6
29	2,007	4	4		19.9
30	3,066	43	43		140.3
31	3,066	9	9		29.4
32	3,530	34	29	5	96.3
33	4,047	3	1	2	7.4
34	4,181	19	19		45.4
35	4,645	18	18		38.8
36	4,645	3	3		6.5
37	4,645	31	30	1	66.7
38	6,000	10	10		16.7
39	6,039	65	62	3	107.6
40	6,039	32	29	3	53.0
41	6,039	7	5	2	11.6
42	6,039	5	3	2	8.3
43	6,070	2	2		3.3
44	6,070	0			0.0
45	7,432	6	4	2	8.1
46	7,479	13	6	7	17.4
47	8,094	6		6	7.4
48	8,919	19	17	2	21.3
49	8,919	25	25		28.0
50	8,919	12	9	3	13.5
51	12,141	4	3	1	3.3
52	14,864	6	5	1	4.0
53	22,297	61	61		27.4
54	28,328	37	37		13.1
55	28,328	40	40		14.1
56	28,328	34	34		12.0
57	33,751	21	12	9	6.2
58	48,562	41	31	10	8.4
TOTALS	363,684	817	734	83	22.5

FIGURE 3. LEAK LOCATION SURVEY WITH SOIL COVER

acquisition system is downloaded to a portable computer for storage, analysis, and plotting. The data is then analyzed in the field to identify leak signatures. When a suspect area is located, manual measurements are made to further isolate the leak.

Sensitivity and Accuracy. The sensitivity of electrical leak location method increases as the thickness of the soil decreases. Typically, leaks with a diameter greater than 0.30-centimeters (0.12-in.) can be located in a geomembrane covered with up to 60 centimeters (2 ft.) of soil. Typically surveys are conducted on the sand filtration layer or on the soil placed above the filtration layer. Surveys can be successfully conducted with geotextile separating the soil layers. To optimize leak detection sensitivity, testing for leaks with only a portion of the soil cover in place is recommended if the thickness of the soil cover will be greater than approximately 30 centimeters. Damage to the liner will most likely occur during the placement of this first layer of soil.

The leak location accuracy for surveys conducted with soil cover also depends upon the closeness of the spacing of the point-by-point measurements and the homogeneity of the soil cover. A practical accuracy guideline for leak location surveys with soil cover is approximately one-half of the soil thickness. When a leak signal is detected the soil is removed or the thickness of the soil decreased and follow-up measurements are made to exactly locate the leak.

The design of the surveys must be based on the physics of the electrical leak location method. The survey parameters must be designed for proper coverage and leak detection sensitivity. These include survey line spacing, spacing of measurements, and spacing of measurement electrodes.

LEAK LOCATION SURVEYS WITH SOIL COVER - CASE STUDIES

Isolated Leaks Under 60 Centimeters of Soil Cover. An electrical leak location survey was conducted on the floor area of a doubled-lined two-acre landfill. The primary liner and secondary liners were 1.5 millimeter (60-mil) high-density polyethylene material separated by a synthetic drainage net. The primary liner was covered with a sequence of approximately 30 centimeters (1 ft.) of gravel, a geotextile, and 30 centimeters (1 ft.) of sand. Water leakage after rainfalls indicated that the primary liner was leaking at a rate of approximately 1,150 liters (300 gal.) per day. Therefore, a small leak was suspected in the primary liner. Figure 4 shows a view of the survey site.

The floor area of the 8,100 square meter (87,000 sq. ft.) landfill was surveyed on a 60 centimeter (2 ft.) survey grid with the electrodes spaced 60 centimeters (2 ft.) apart. Three small leaks were located in the primary liner. Figure 5 shows a raster plot of the data collected near one of the leaks. The leak signature is clearly detectable on survey lines that are located 3 meters (10 ft.) from the leak. The detected leak was a 0.25-centimeter (0.1-in.) diameter hole through the liner.

FIGURE 4. VIEW OF DOUBLE-LINED LANDFILL CELL SURVEYED

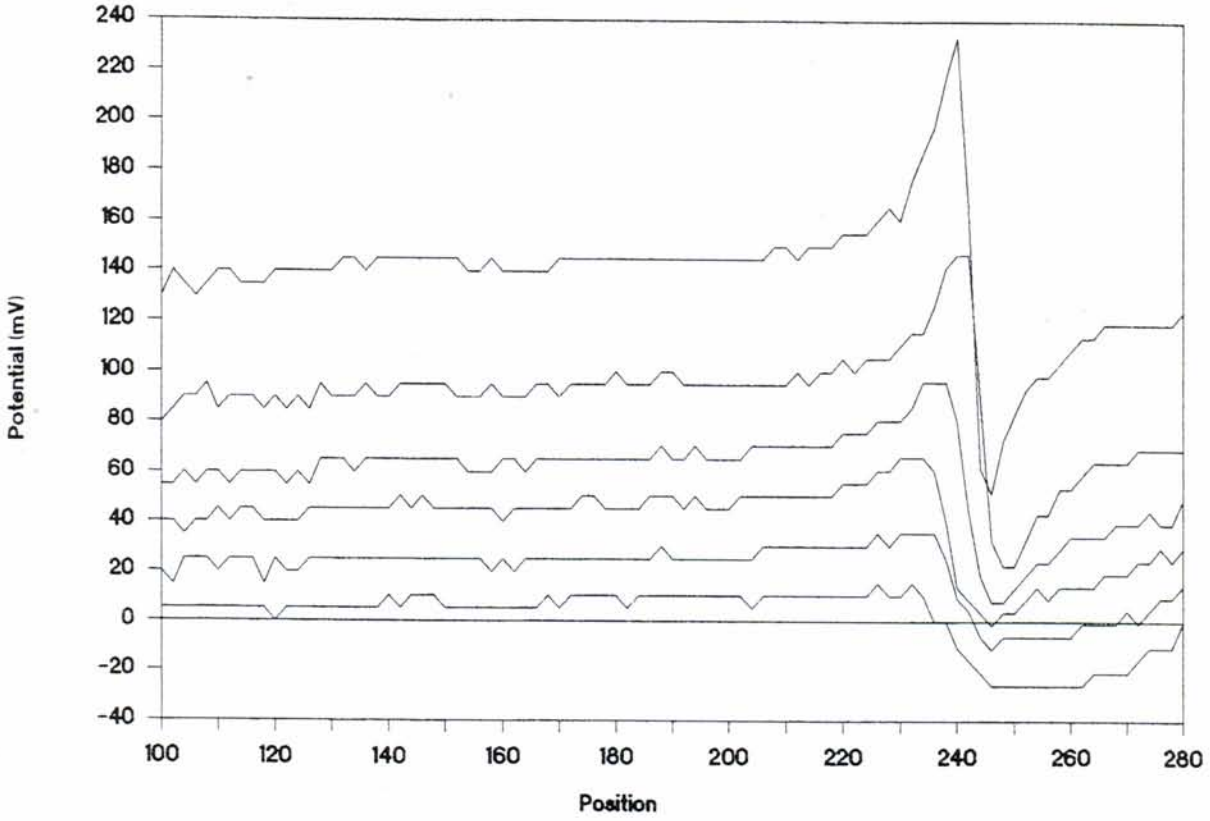

FIGURE 5. SURVEY DATA FOR 0.25 CENTIMETER DIAMETER LEAK LOCATED UNDER 60 CENTIMETERS OF SOIL COVER

Multiple Leaks. Isolating multiple closely-spaced leaks under soil cover requires a thorough, in-depth understanding of the physics of the electrical leak location method and extensive practical field experience. The superposition of the leak signatures results in a complex leak signature. The presence of multiple leaks must be recognized and subsequent measurements and excavations must be performed to isolate the leaks. Figure 6 shows a raster plot of some of the data taken on a single scrim-reinforced chlorosulfonated polyethylene (CSPER) liner with multiple leaks. The data is characterized by many leak signal excursions. The signals from several single leaks are evident on adjacent lines.

The liner was protected with large rock rip-rap placed on a 15-centimeter (6-in.) to 30-centimeter (12 in.) soil bed. The rock rip-rap was removed prior to the survey. The leak area shown between positions 60 and 190 on the survey lines was investigated further to isolate approximately 50 leaks. Figure 7 shows a 5-centimeter (2-in.) puncture leak that provided one of the larger leak signals previously shown in Figure 6. Figure 8 shows a 0.5-centimeter (0.2-in.) long puncture/abrasion.

Reconnaissance Surveys. A reconnaissance survey methodology for geomembranes with soil cover can be successful, particularly when an electrical leak location survey was previously conducted before the liner was covered with soil. Rather than performing a systematic survey on closely spaced survey lines to locate smaller leaks, the reconnaissance measurements are intended

to isolate a few large leaks. The reconnaissance methodology assumes that no smaller leaks are present in the geomembrane liner. The measurement sequence is to make measurements in the suspect areas to locate a leak, expose the leak, insulate the leak, and then measure the power supply output current. This sequence is repeated until the output current level is decreased to a level indicating that all of the major leaks have been found. Figure 9 shows a reconnaissance survey being performed on a 0.40-hectare (one-acre) landfill cell. The area in the lower left of Figure 9 was uncovered to expose a located leak.

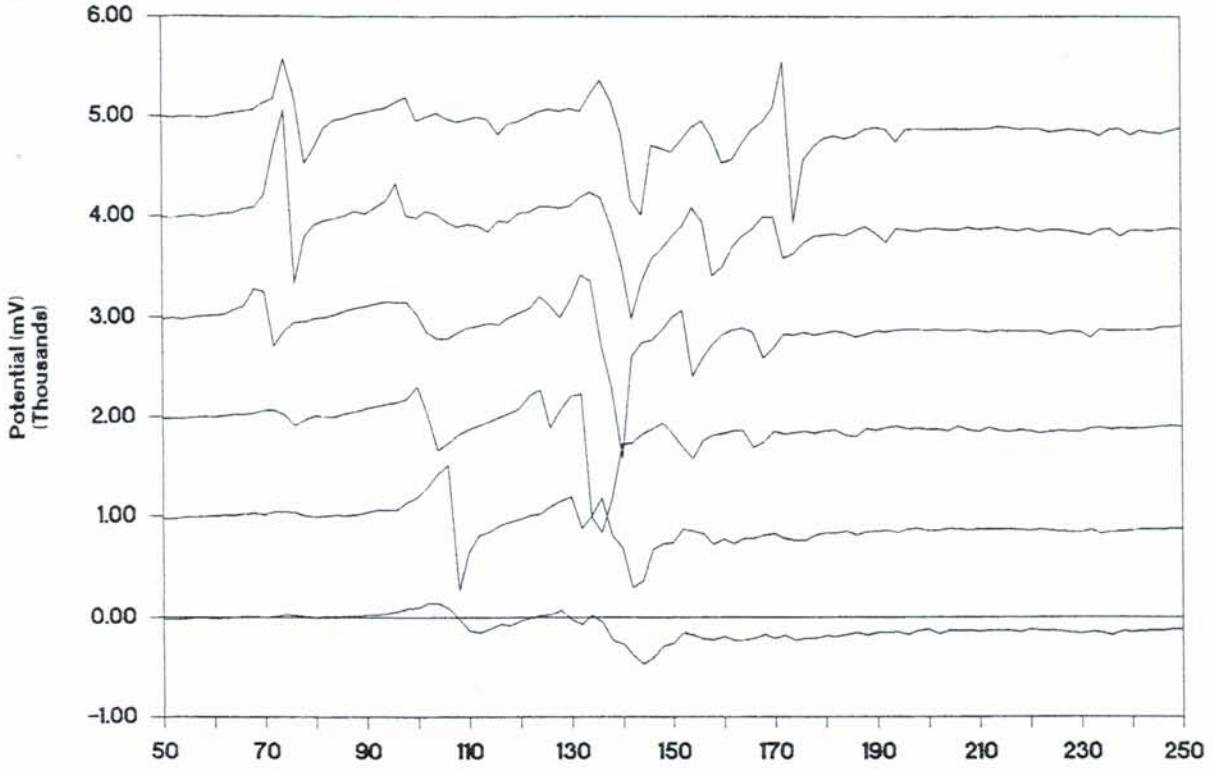

FIGURE 6. SURVEY DATA SHOWING MULTIPLE LEAK SIGNALS

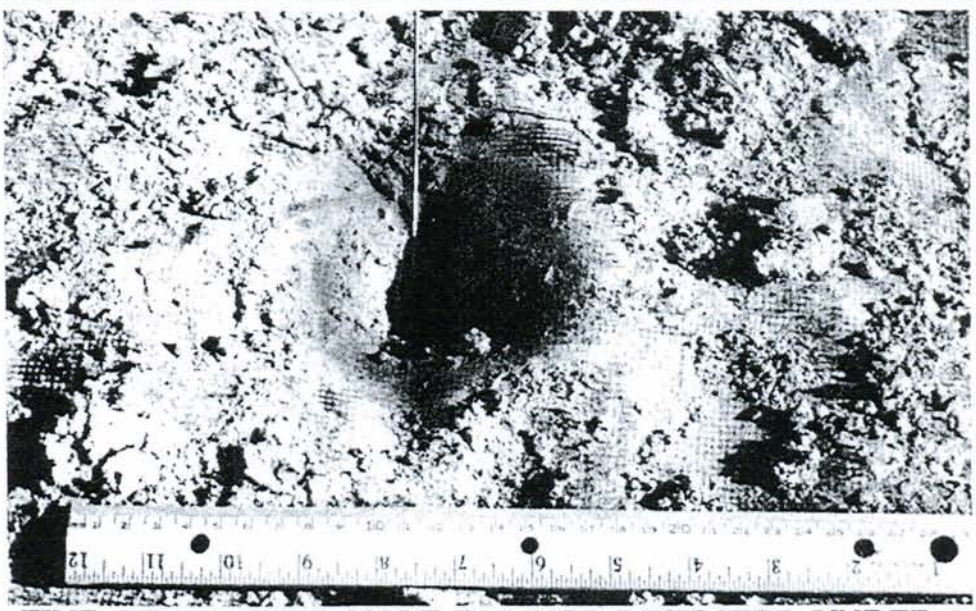

FIGURE 7. FIVE CENTIMETER HOLE IN LINER DETECTED UNDER SOIL COVER

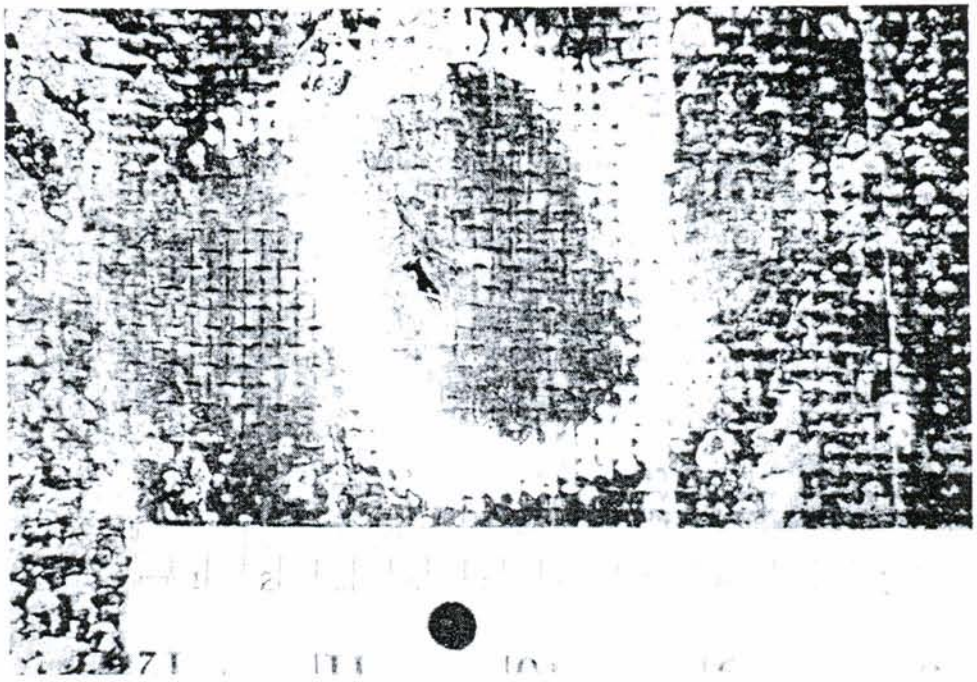

FIGURE 8. 0.5 CENTIMETER HOLE IN LINER DETECTED UNDER SOIL COVER

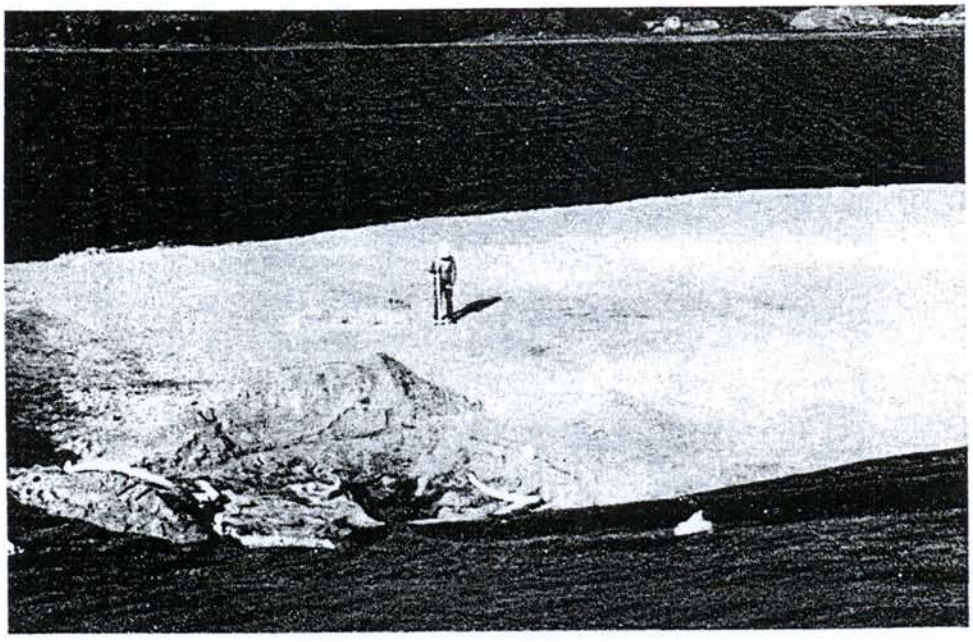

FIGURE 9. VIEW OF LANDFILL CELL WITH AN ELECTRICAL LEAK LOCATION RECONNAISSANCE SURVEY IN PROGRESS

CONCLUSIONS

An electrical method for locating leaks in geomembrane liners of waste impoundments and landfills has been developed and demonstrated successfully in a wide variety of applications. The validity and usefulness of the electrical leak location method has been demonstrated for testing the integrity of the geomembrane for single and double-liners with and without protective soil cover systems. The method will not damage the liner.

The technique is used for construction quality assurance and in-service performance monitoring. The electrical leak location method can be used in liquid impoundments, as a pre-service inspection of solid waste landfills, and to locate leaks in the final cover for landfills or impoundments. In addition, if leaks are suspected in the primary liner covered with up to two-feet of protective material, then they can be effectively located in a systematic manner using this method without removing the material covering the liner.

REFERENCES

1. Darilek, G.T., Laine, D.L., Parra, J.O., The Electrical Leak Location Method for Geomembrane Liners-Development and Applications, Industrial Fabrics Association International Geosynthetics '89 Conference, San Diego, CA, February 21-23, 1989.

2. Laine, Daren L., and Miklas, Michael P., Detection and Location of Leaks in Geomembrane Liners Using an Electrical Method: Case Histories, Superfund '89, 10th National Conference, Washington, DC, Nov. 27-29, 1989.

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