

CE311S Lab 2

Conditional Relationships within a Waste Containment Facility

Purpose

The purpose of this laboratory is to explore the relationship between two components of a landfill system (the lining system and a monitoring well, as shown in Figure 1) and how these components affect the system performance.

Introduction

The United States generates more than 7 billion tons of waste annually. There are over 6,000 waste containment facilities, or landfills, to store this waste. Landfills are usually constructed by excavating into the soil, constructing a lining system, placing waste on top of the lining system, and constructing a cover system over the waste. The purpose of both the lining system and the cover system is to minimize the release of contamination to the environment. This release could be in the form of leaks into the groundwater below. Samples of groundwater collected from groundwater monitoring wells installed down gradient, or downstream, of the landfill help to determine whether or not the groundwater is being contaminated by the landfill.

A groundwater monitoring well is a vertical well drilled to a depth below the groundwater table. Samples of groundwater are collected from the well and sent to a laboratory for analysis. If the samples contain contaminants known to be present in the landfill waste, it suggests that the landfill may be leaking and contaminating the groundwater. However, the lab results may falsely indicate leakage because of other contamination sources nearby, or because of laboratory error.

The overall performance of the system is described by whether or not the liner system actually leaks and whether or not the monitoring well detects leakage. The following events describe the performance of the landfill system:

L = Event {landfill liner leaks}

M = Event {monitoring well detects leakage}

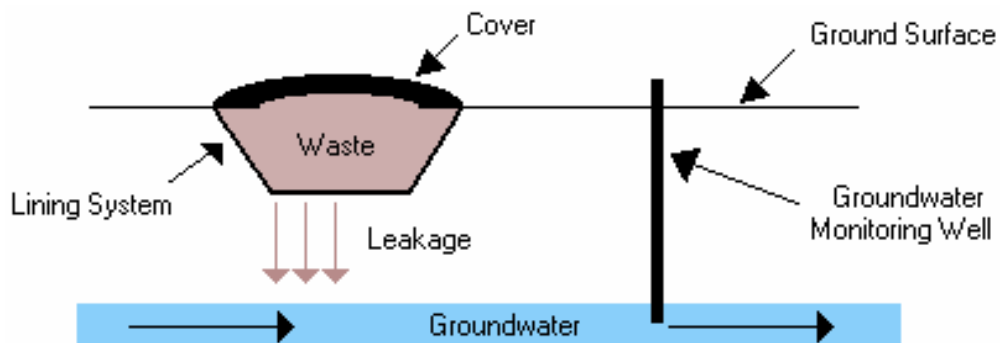


Figure 1: Waste containment system.

Procedure

You will use a computer program to simulate the performance of 50 waste containment facilities.

1. Answer Questions 1 through 3.
2. Download the zip file “landfill.zip” . Save the unzipped program “landfill.vi” to your desktop.
3. Click on the run button. Record how your landfill performed and the expected cleanup cost of your facility in Table 1. The cleanup cost includes costs associated with cleaning the groundwater and any loss of life costs.
4. Run 100 more simulations and record the results. To make this easier, split the task in half with your lab partner and each record the 50 distinct results in Tables 1 and 2.

Table 2. Summary of 100 Landfill System Simulations (5 pts)

Event	Frequency
Landfill liner leaked	
Landfill liner <i>did not</i> leak	
Monitoring well detected leakage	
Monitoring well <i>did not</i> detect leakage	
Monitoring well detected leakage <i>and</i> the liner leaked	
Monitoring well detected leakage <i>and</i> the liner <i>did not</i> leak	
Monitoring well <i>did not</i> detect leakage <i>and</i> there was a leak	
Monitoring well <i>did not</i> detect leakage <i>and</i> the liner <i>did not</i> leak	

Questions:

- 1) a) Draw the Venn diagram that describes the performance of the landfill system, which includes both the lining system and the monitoring wells. Use the events M and L as described in the Introduction. (10 pts)

b) List the four combinations of events M and L – both symbolically and in words - that describe the landfill system performance. Describe each of these four events in words (Hint: see Table 2.) Are these four events mutually exclusive and collectively exhaustive? Why or why not? (5 pts)

2) Draw a new Venn diagram to show how the sample space changes if you know for certain that the landfill liner has leaked (that is, you know for sure the lab tests will give a true positive). (5 pts)

3) There are serious consequences associated with *not* detecting leakage when it is actually occurring. On the other hand, there are also serious consequences associated with incorrectly detecting leakage (called a “false positive”). Therefore, system failure is defined as:

- lining system leaked and the monitoring well did *not* detect leakage; or
- lining system did *not* leak and the monitoring well detected leakage.

a) What are the consequences of each of these types of failure? (5 pts)

b) What are the costs associated with each of these types of failures? (Hint: look at your results in Table 1). Why are they different? (10 pts)

c) As an engineer, which are you most concerned about? Why? (5 pts)

4) When monitoring a landfill's performance, usually the only information the engineer has is whether or not the monitoring well has detected leakage. The engineer does not know for certain if the landfill liner has leaked or not. Use the frequencies you found in your simulation as the probabilities of these events occurring in a new landfill.

a) If the monitoring well detects leakage, what is the probability that the landfill has leaked? Considering costs, will you clean up the groundwater? (10 pts)

- b) If the monitoring well does *not* detect leakage, what is the probability that the landfill has leaked? Considering costs, will you clean up the groundwater? (10pts)
- c) What is the probability that the monitoring well detects leakage? Given this and the probabilities found in questions 4a and 4b, what is the probability of failure? Show all work. (10 pts)
- d) Are the probabilities you calculated above (in questions 4a and 4b) acceptable to you as an engineer? Are you confident that your monitoring well will help you determine when the landfill liner has leaked and when you need to clean up the groundwater? What could you do as an engineer to improve these probabilities? (Use back if you wish) (10 pts)

Table 1 (15 pts)

Simulation Number	Did the monitoring wells detect leakage?	Did the landfill liner leak?	Expected Clean-Up Cost X \$10 ⁷	Simulation Number	Did the monitoring wells detect leakage?	Did the landfill liner leak?	Expected Clean-Up Cost X \$10 ⁷
1	Yes No	Yes No		26	Yes No	Yes No	
2	Yes No	Yes No		27	Yes No	Yes No	
3	Yes No	Yes No		28	Yes No	Yes No	
4	Yes No	Yes No		29	Yes No	Yes No	
5	Yes No	Yes No		30	Yes No	Yes No	
6	Yes No	Yes No		31	Yes No	Yes No	
7	Yes No	Yes No		32	Yes No	Yes No	
8	Yes No	Yes No		33	Yes No	Yes No	
9	Yes No	Yes No		34	Yes No	Yes No	
10	Yes No	Yes No		35	Yes No	Yes No	
11	Yes No	Yes No		36	Yes No	Yes No	
12	Yes No	Yes No		37	Yes No	Yes No	
13	Yes No	Yes No		38	Yes No	Yes No	
14	Yes No	Yes No		39	Yes No	Yes No	
15	Yes No	Yes No		40	Yes No	Yes No	
16	Yes No	Yes No		41	Yes No	Yes No	
17	Yes No	Yes No		42	Yes No	Yes No	
18	Yes No	Yes No		43	Yes No	Yes No	
19	Yes No	Yes No		44	Yes No	Yes No	
20	Yes No	Yes No		45	Yes No	Yes No	
21	Yes No	Yes No		46	Yes No	Yes No	
22	Yes No	Yes No		47	Yes No	Yes No	
23	Yes No	Yes No		48	Yes No	Yes No	
24	Yes No	Yes No		49	Yes No	Yes No	
25	Yes No	Yes No		50	Yes No	Yes No	

Simulation Number	Did the monitoring wells detect leakage?	Did the landfill liner leak?	Expected Clean-Up Cost X \$10 ⁷	Simulation Number	Did the monitoring wells detect leakage?	Did the landfill liner leak?	Expected Clean-Up Cost X \$10 ⁷
51	Yes No	Yes No		76	Yes No	Yes No	
52	Yes No	Yes No		77	Yes No	Yes No	
53	Yes No	Yes No		78	Yes No	Yes No	
54	Yes No	Yes No		79	Yes No	Yes No	
55	Yes No	Yes No		80	Yes No	Yes No	
56	Yes No	Yes No		81	Yes No	Yes No	
57	Yes No	Yes No		82	Yes No	Yes No	
58	Yes No	Yes No		83	Yes No	Yes No	
59	Yes No	Yes No		84	Yes No	Yes No	
60	Yes No	Yes No		85	Yes No	Yes No	
61	Yes No	Yes No		86	Yes No	Yes No	
62	Yes No	Yes No		87	Yes No	Yes No	
63	Yes No	Yes No		88	Yes No	Yes No	
64	Yes No	Yes No		89	Yes No	Yes No	
65	Yes No	Yes No		90	Yes No	Yes No	
66	Yes No	Yes No		91	Yes No	Yes No	
67	Yes No	Yes No		92	Yes No	Yes No	
68	Yes No	Yes No		93	Yes No	Yes No	
69	Yes No	Yes No		94	Yes No	Yes No	
70	Yes No	Yes No		95	Yes No	Yes No	
71	Yes No	Yes No		96	Yes No	Yes No	
72	Yes No	Yes No		97	Yes No	Yes No	
73	Yes No	Yes No		98	Yes No	Yes No	
74	Yes No	Yes No		99	Yes No	Yes No	
75	Yes No	Yes No		100	Yes No	Yes No	