A RELIABLE
LANDFILL MONITORING SYSTEM, LEAKAGE BARRIER, plus REMEDIATION METHOD, IN ONE DESIGN

presented by

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topics to be covered:

- definition of reliable
- method of reliability calculation
- typical reliabilities
- a better monitoring design
- the design function
- the design cost

Reliability is the common measure by which candidate monitoring designs are judged. Right???

- Reliability is: **The probability of detection of a significant leak in the lifetime of the hazard monitored.** Its a number (0-100%)
- significant is? - X curies, or Y gallons, in Z days
- lifetime of the hazard is? 10, 100, 1000 years?

A reliable system is not necessarily:

- The best that we can afford
- That required by the law
- Traditional practice
- That which meets the concerns of the regulators
- That which has been tried before
- That which meets the concerns of the public

What is “Reliable”?

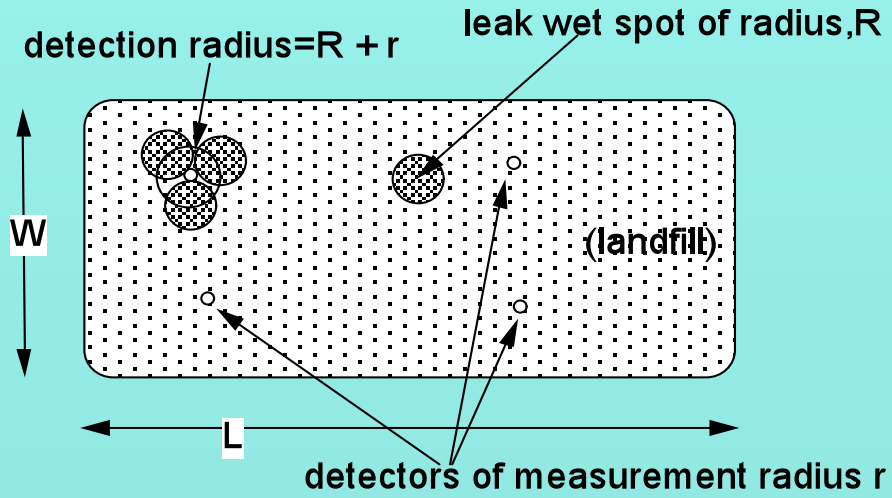
- 99% probability of :
  - detection of a dangerous leak
    - » in one year,5 years ,30 years, 100years, ?1000years?
- 50% probability of:
  - detecting a leak under the leachate sump
    - » in the first five years
- 10% probability of:
  - detecting a leak, if it is large and wide spread
    - » in the first year

The last is more typical of traditional practice

How does one determine reliability of an earth flow system?

- calculate the probability, PI, of intercepting the leak with the detector (a porous flow calc., coupled with the geometry of the system)
- calculate the probability the detector is working, PG, (based upon experience)
- calculate the probability the detector is monitored, PP, (the procedure, time dependent)
- calculate the probability, PA, that the data is correctly evalulated (an experience judgement)
- The total probability of detection is the product of the four probabilities : P = PI*PG*PP*PA

The intercept probability for a point detector (e.g., suction lysimeter)



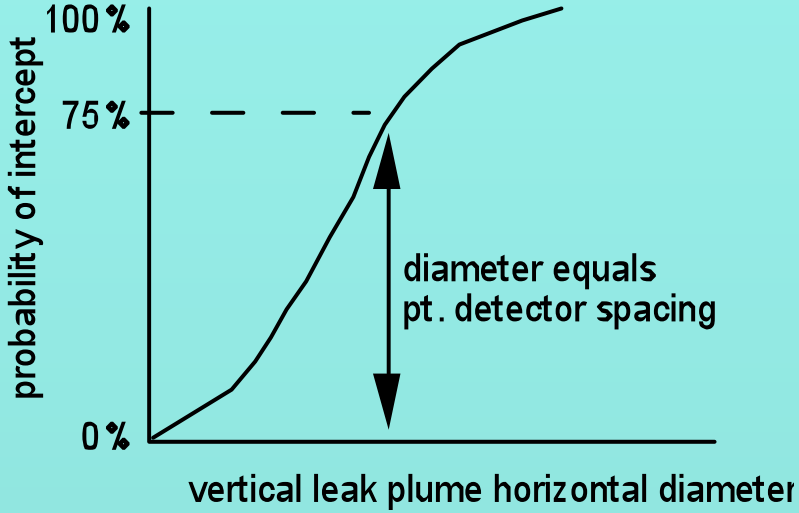
Probability of detection of a leak with four detectors is

$$P = 4\ (R + r)^2 / (L \times W)$$

If, r = 1/2 m, R = 5 m, L = 100 m, W = 200 m,

Then, P = 2 %. Not a very high reliability

The probability of detection is likely to depend upon the size of the leak

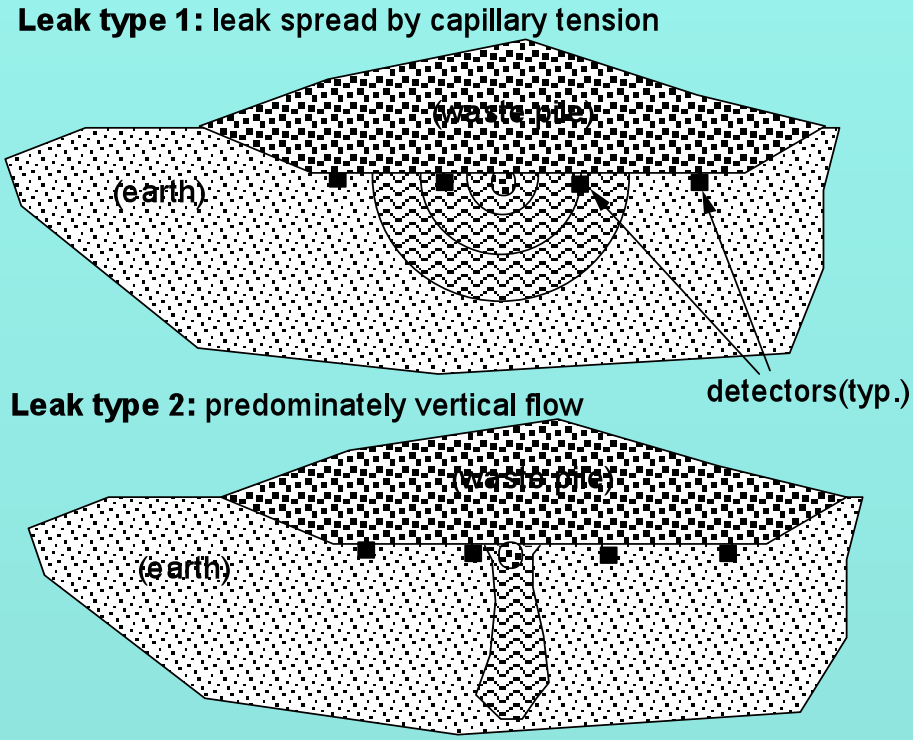


The best sensors measure over a plane;

the next best measure along a line;

the worst are point sensors.

The vertical plume geometry is important



- **How will we know the horiz. leak radius?**

Application of the above rationale to a neutron moisture gauge in a single diagonal hole gives:

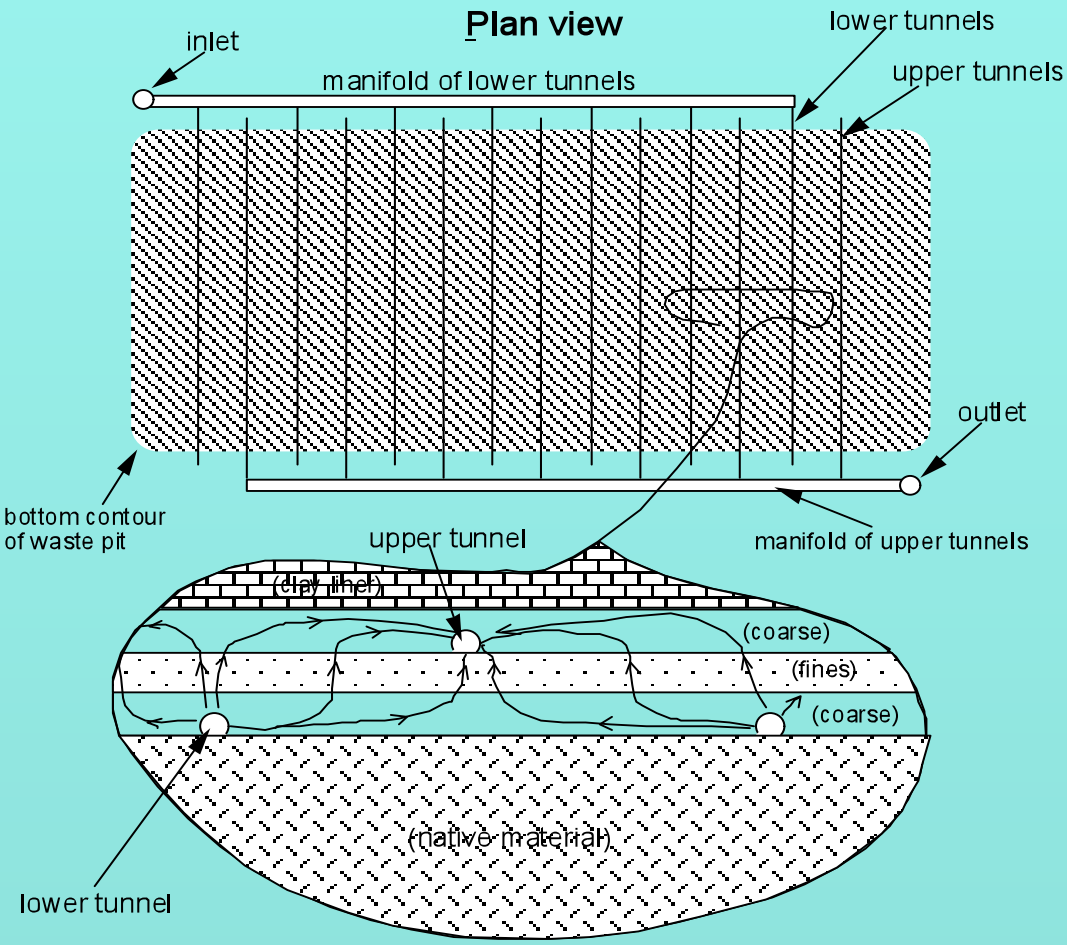
- Probability of intercept of a 10m diameter, vertical,cylindrical wet spot beneath a 50m x 100m trench is 10%
- Unfortunately, the detection of moisture tells one nothing of the leak composition, or leak rate. What should be done when a wet volume is detected?
- And, the leak may not be a nice vertical cylindrical plume.

Would it not be better to use a monitoring system that has a high probability of:

- leak detection,
- leak location,
- leak composition measurement,
- leak rate measurement,
- a barrier to leakage, and
- several leak remedy options inherent in the monitoring system?

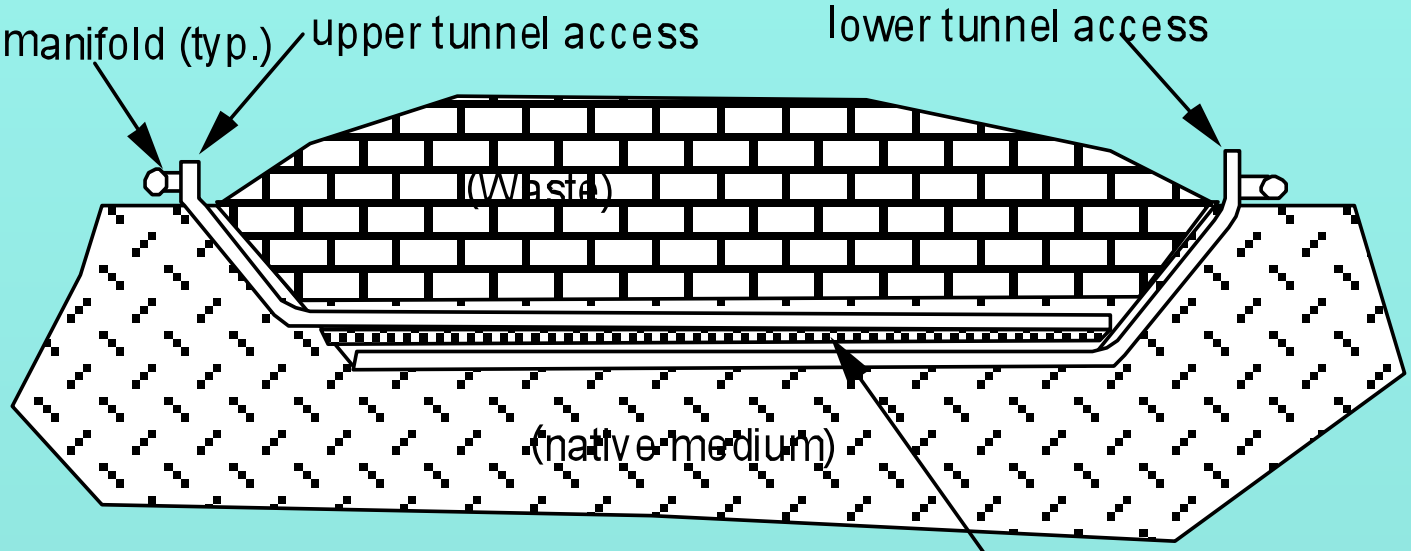
A candidate design is described hereafter.

The geometry is:



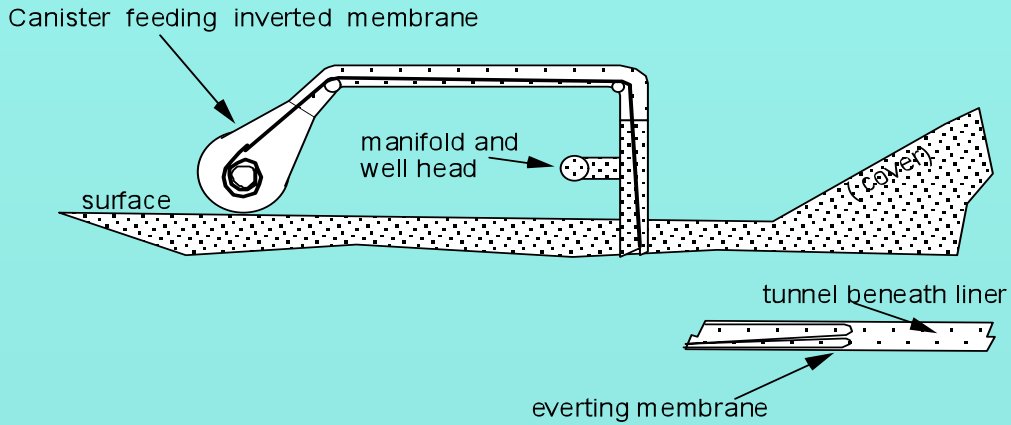
Air Flow in Permeable Bed (side view)

The end view

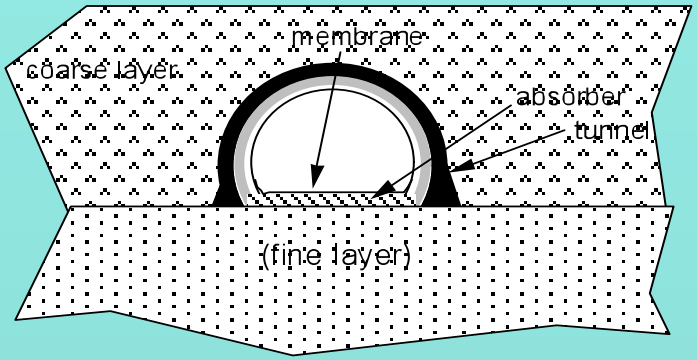


END VIEW
(not to scale)

The means of tunnel access is called SEAMIST



Tunnel Cross section



The system function serves the remedy as well as monitoring

- extract pore gas from the permeable bed to cheaply monitor for vapor leaks
- tow logging tools in the tunnels to assess moisture changes, resistance changes, radiation sources, chemical vapors,....
- install an absorbent liner in each tunnel to wick up a sample of any wet spots; measure the length of the wet spot and its composition in each tunnel

system function (cont.)

- install other instruments as they are developed
- If necessary,
  - extract a heated air flow to dry up small leachate leaks
  - freeze other leachate leaks
  - inject grout or other sealants in the upper coarse layer to seal sections known to be leaking
- monitor the lower tunnels for evidence of leakage before and after a remedy.

A summary of the system attributes:

- monitors the entire plane beneath the landfill
- requires few samples to prove the null result
- allows the location and sampling of a leak
- measures the total flux and not just the presence of the leak
- is highly redundant to assure a high reliability
- allows measurement resolution in excess of today's judgement of the requirement. i.e., not the minimal set.

Attributes (cont.)

- allows the procedure and measurement resolution to be adjusted on the basis of the measurement results
- is not too expensive in installation and does not penetrate the cover
- is independent of the gauge reliability or the current state of the art. (can use instruments yet to be developed)

Attributes (cont.)

- is independent of the local geologic site characteristics
- serves as a barrier to the leakage from the pit
- performs the remedy, or aids the remedy of the leak prior to any significant contamination of the vadose zone

Why not monitor the cover for leakage?

It is so much easier to repair the cover than to remedy a leachate leak.

So, it is relatively easy to do much better than has been done.

Thanks for the time to share these concepts. I invite you to improve on them.