

Effect of Perched Water Conditions in MSW Landfills: Considerations for Landfill Operators

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Motivation

- At last year's landfill symposium, several presentations and audience comments described the issue of *saturated* waste layers in the deeper parts of landfills.
- The presence and cause of these *saturated* layers can be interpreted differently.
- The question that we asked: “what should one expect?”

Consider a MSW Landfill

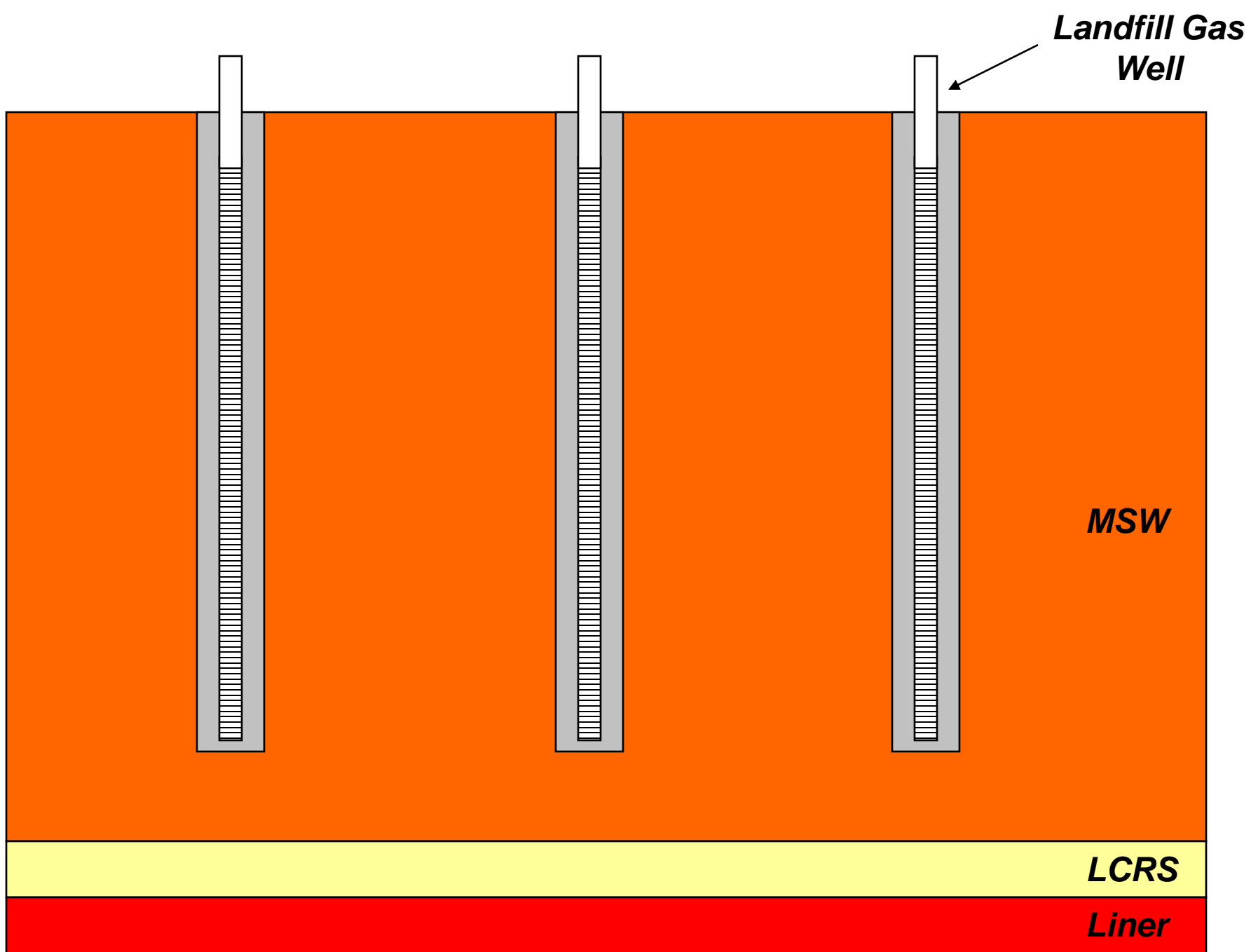


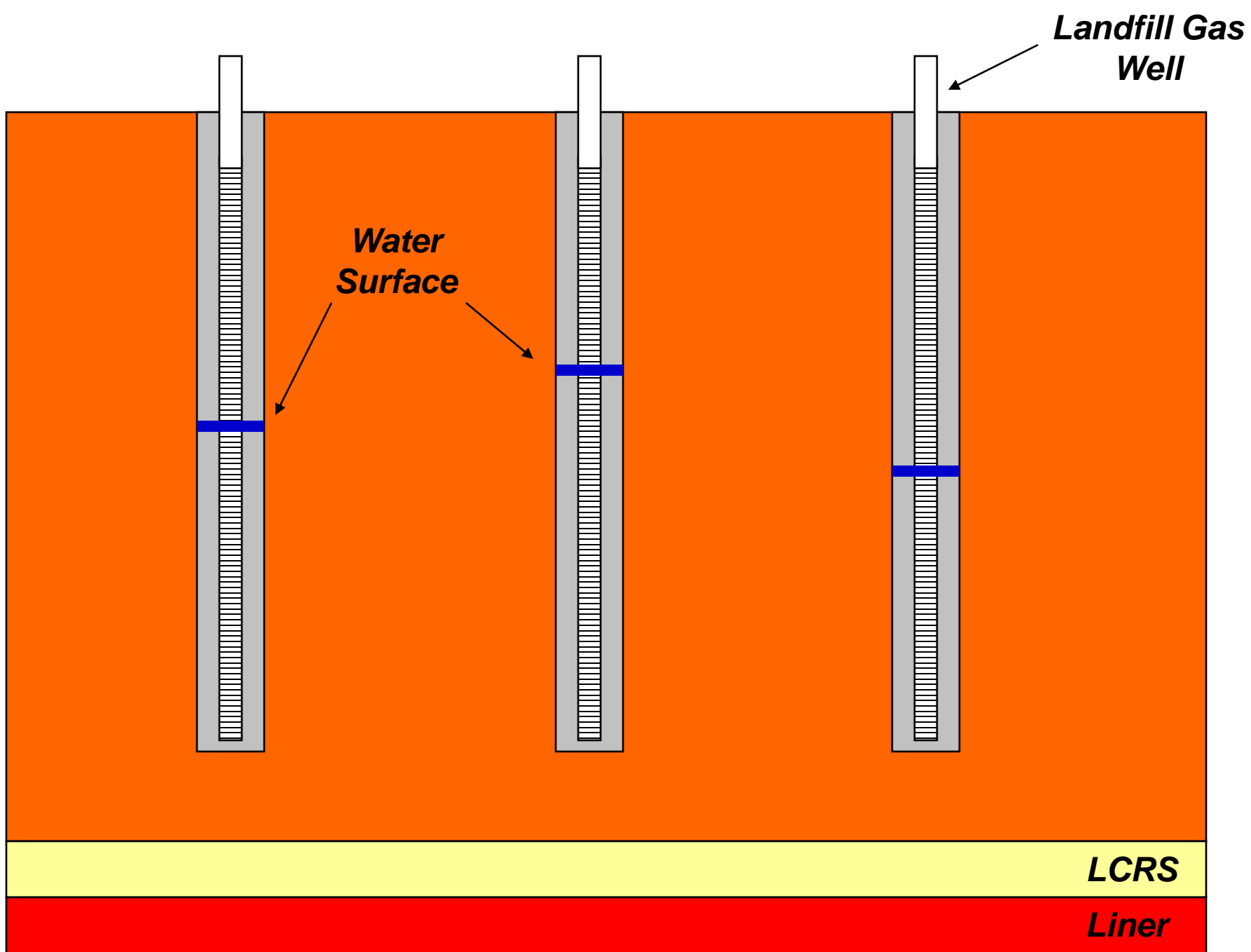
Install Gas Wells



Consider a MSW Landfill







Implications of Perched Water

- Problems with gas recovery?
- Slope stability concerns?
- Leachate collection system problems?
- Future side slope seepage issues?



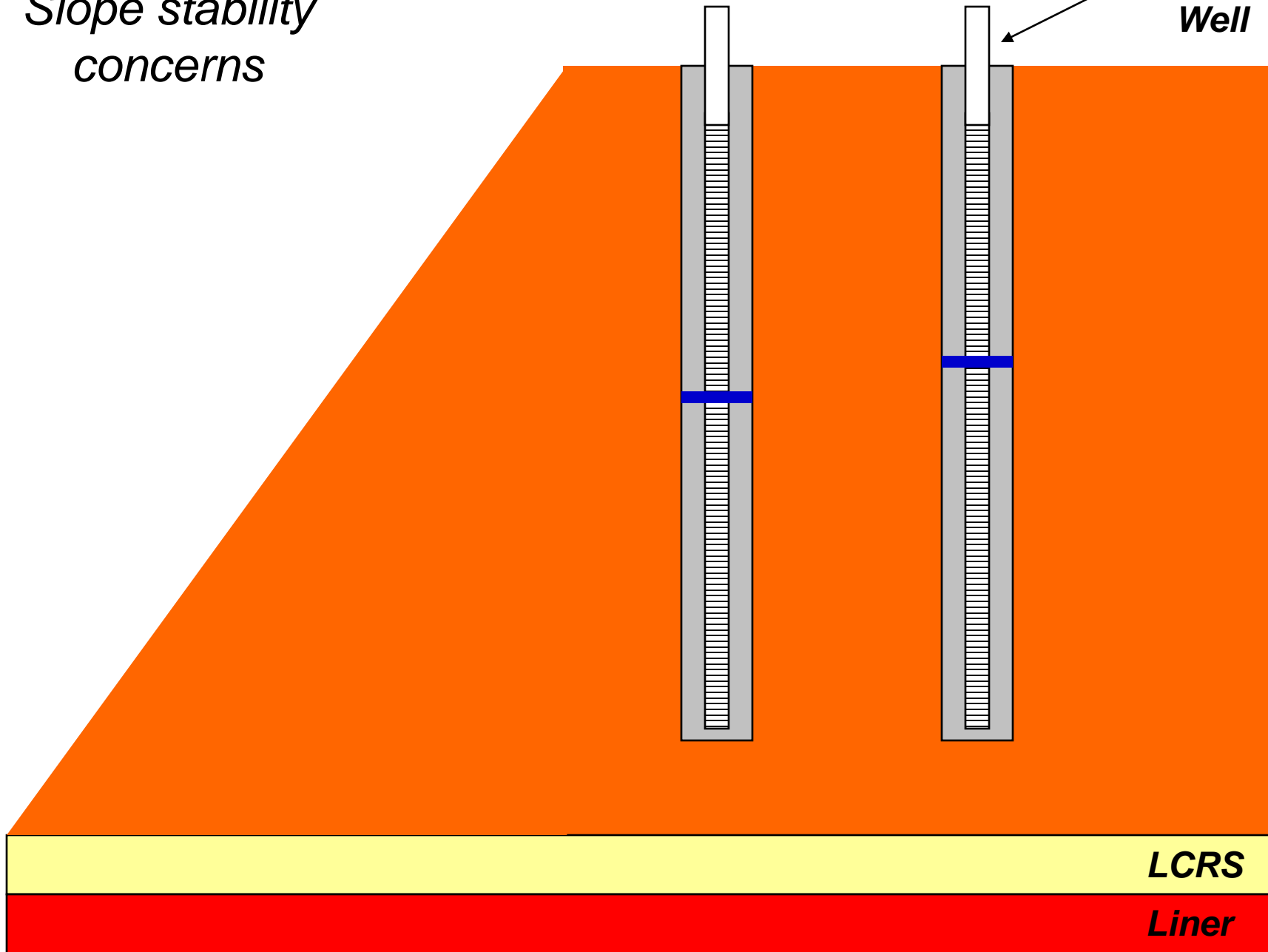
Landfill gas well equipped with liquid pumping system

*Pump repair
and maintenance*



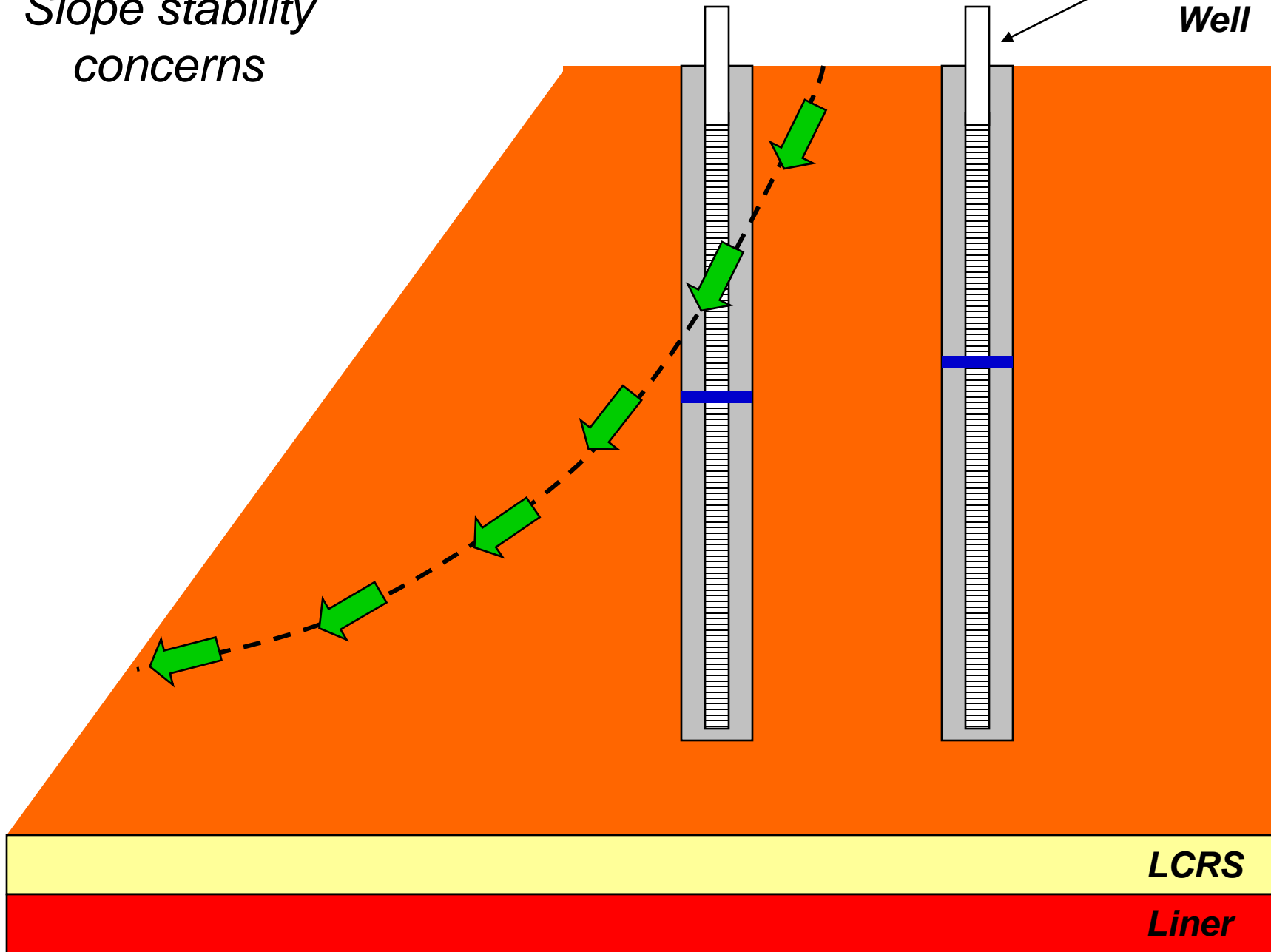
*Slope stability
concerns*

**Landfill Gas
Well**



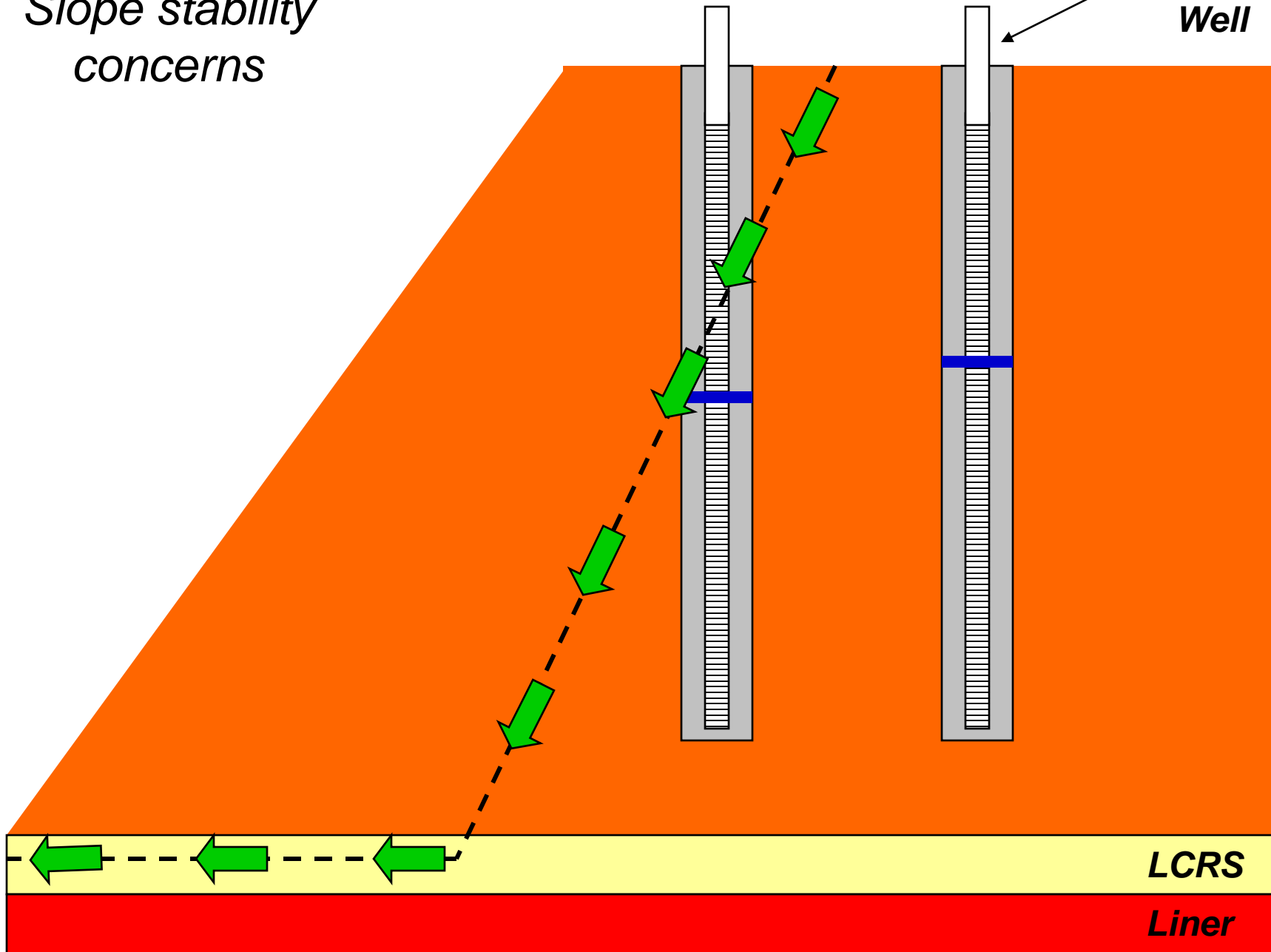
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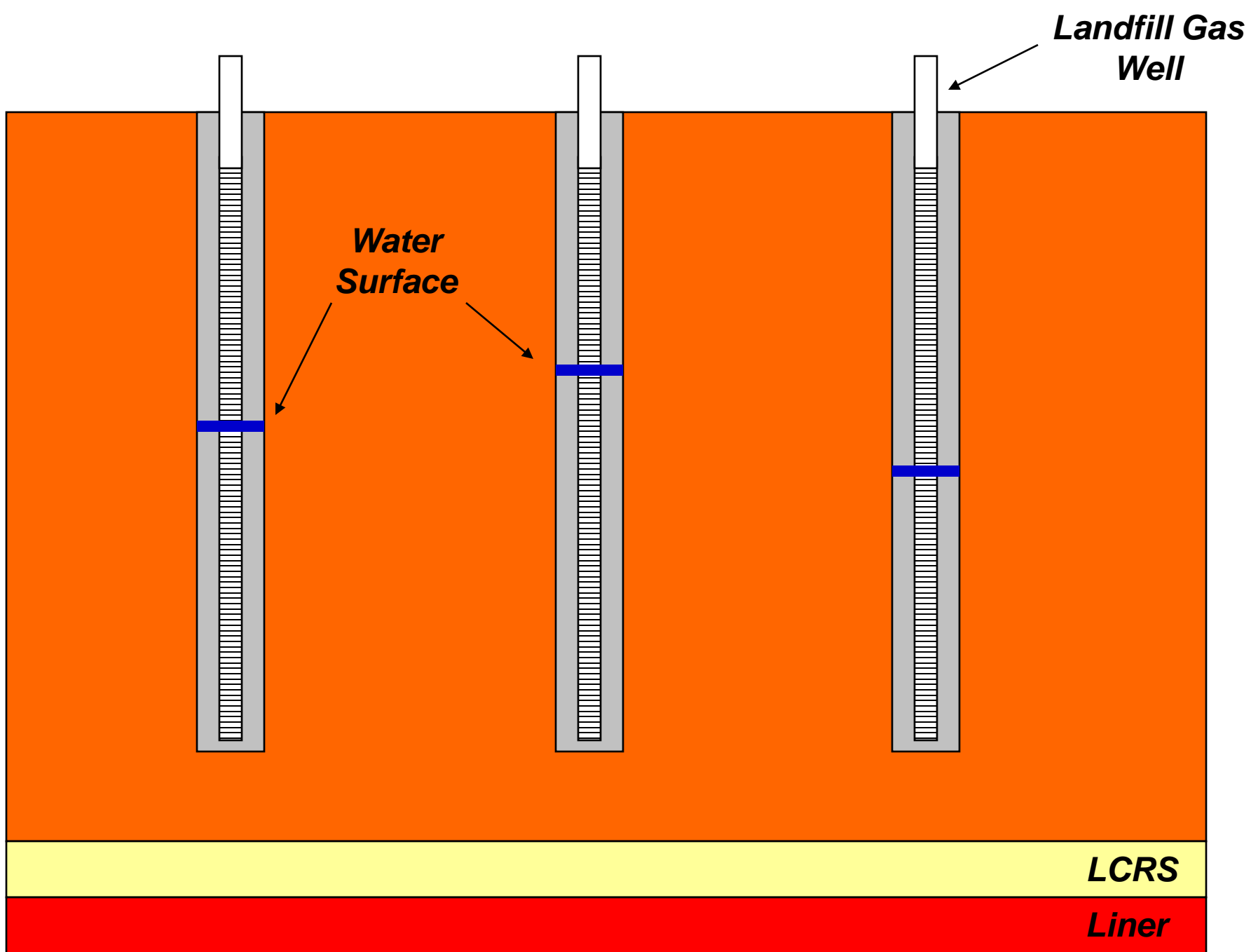


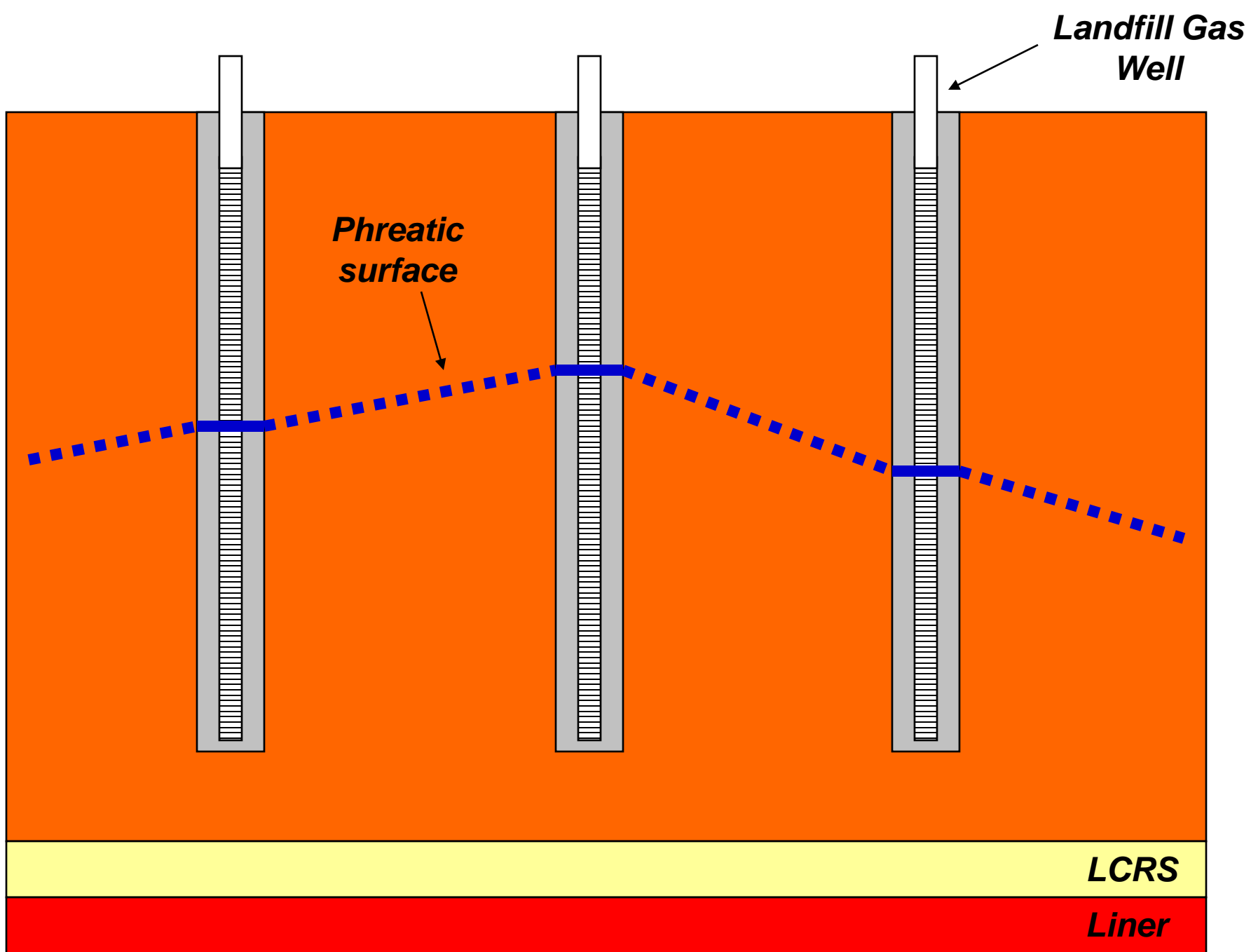
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**Landfill Gas
Well**

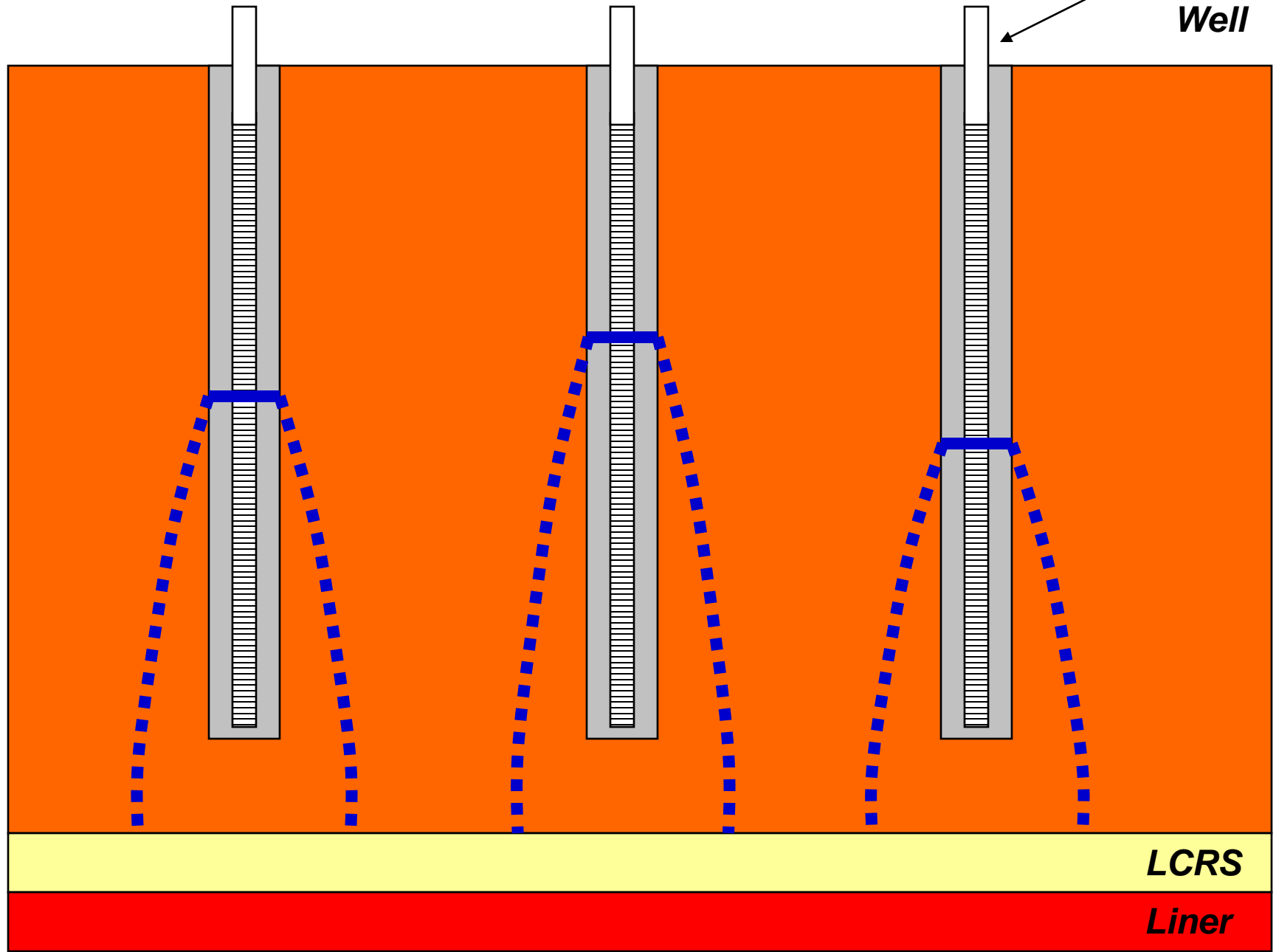


The implications of the perched liquids depend on their true nature within the landfill



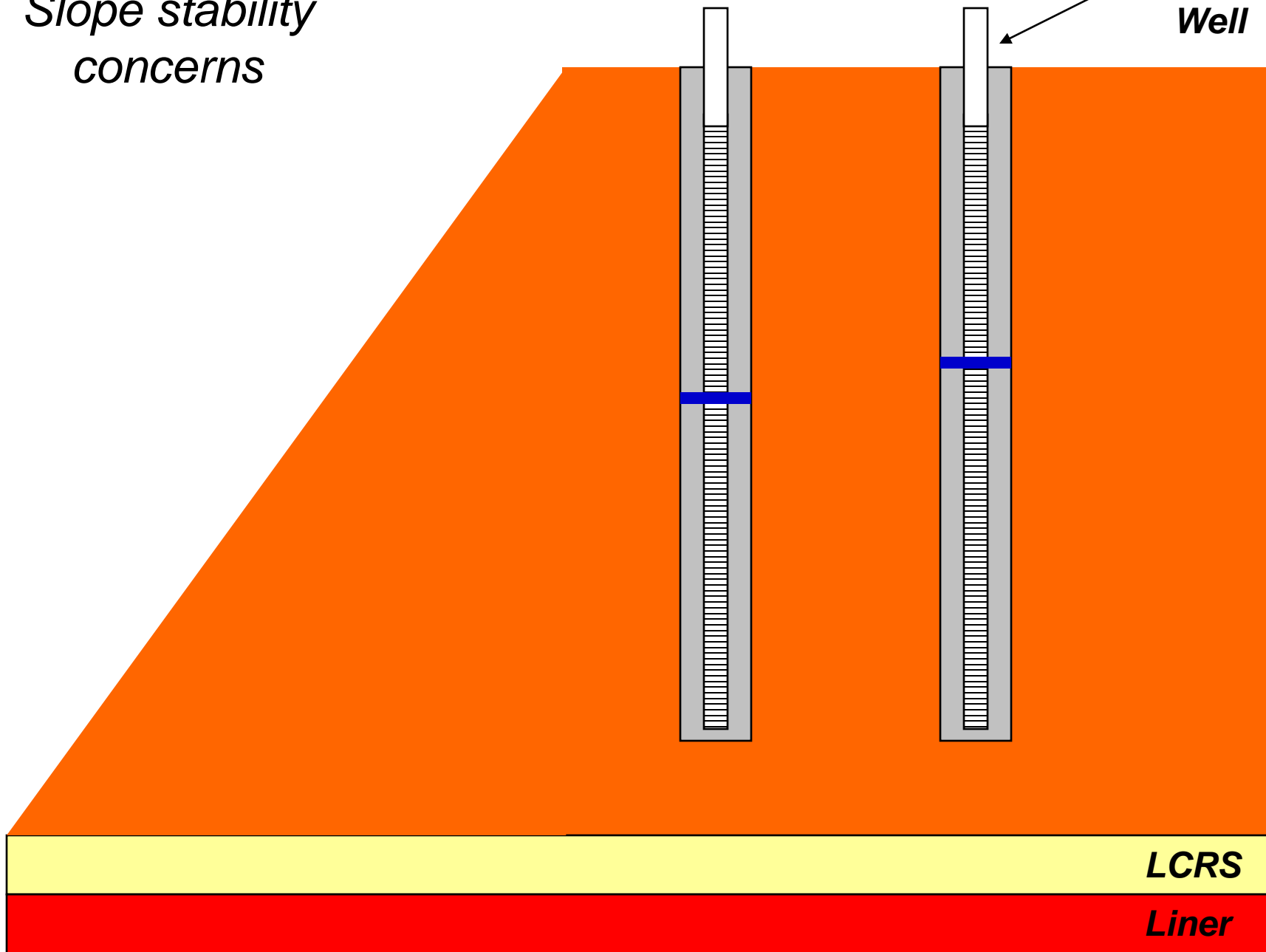


Landfill Gas Well



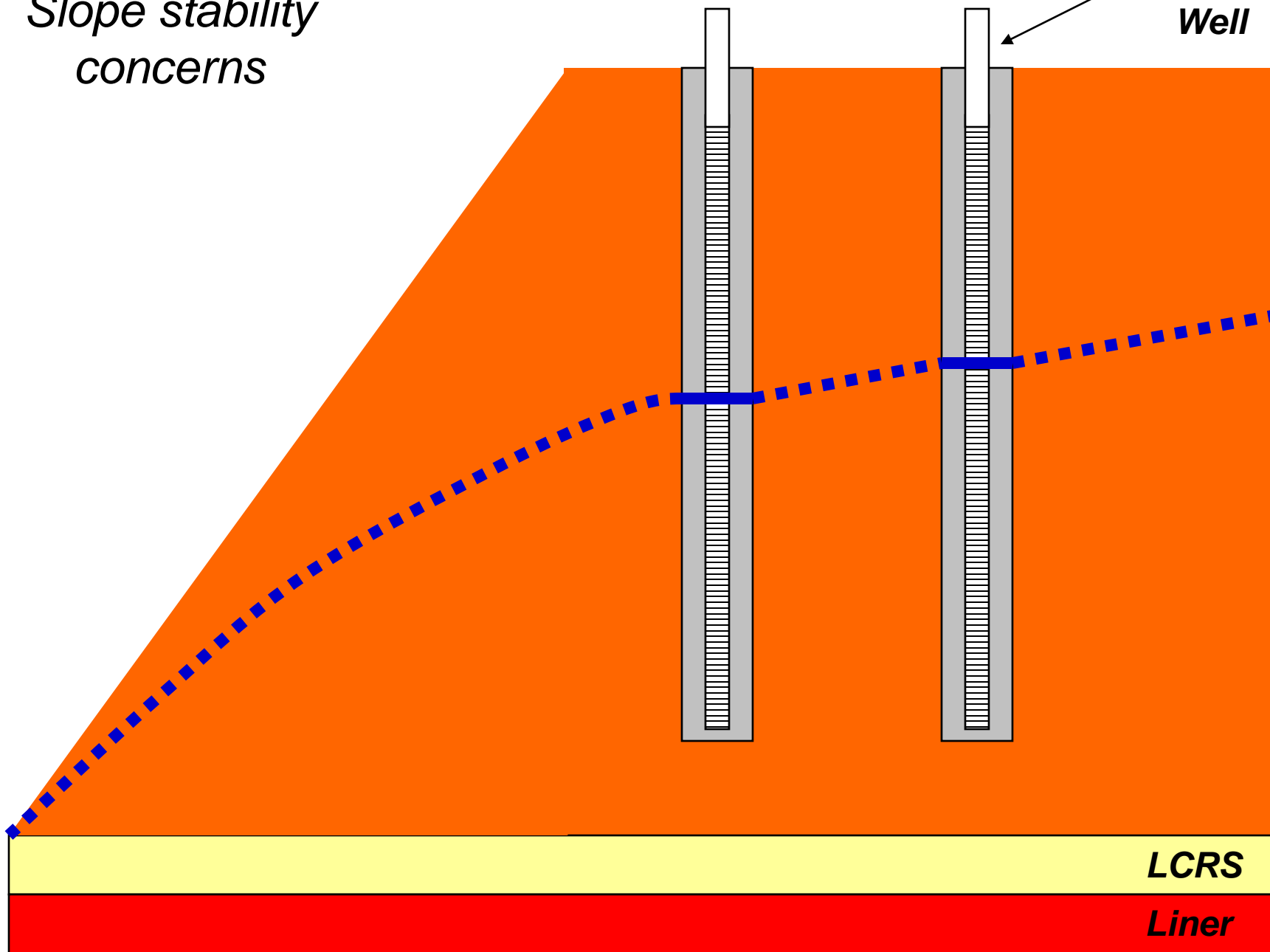
*Slope stability
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**Landfill Gas
Well**



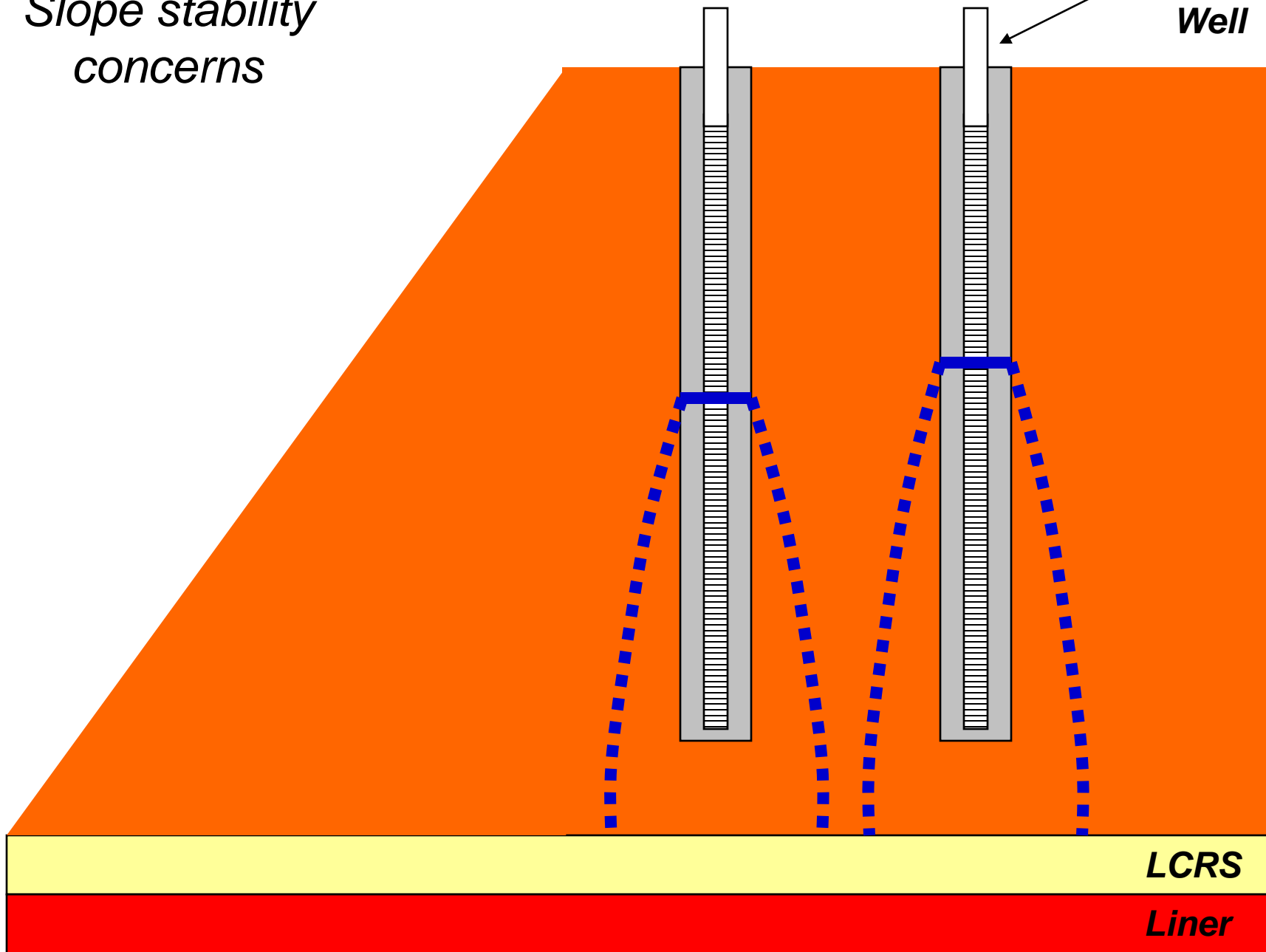
*Slope stability
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**Landfill Gas
Well**



*Slope stability
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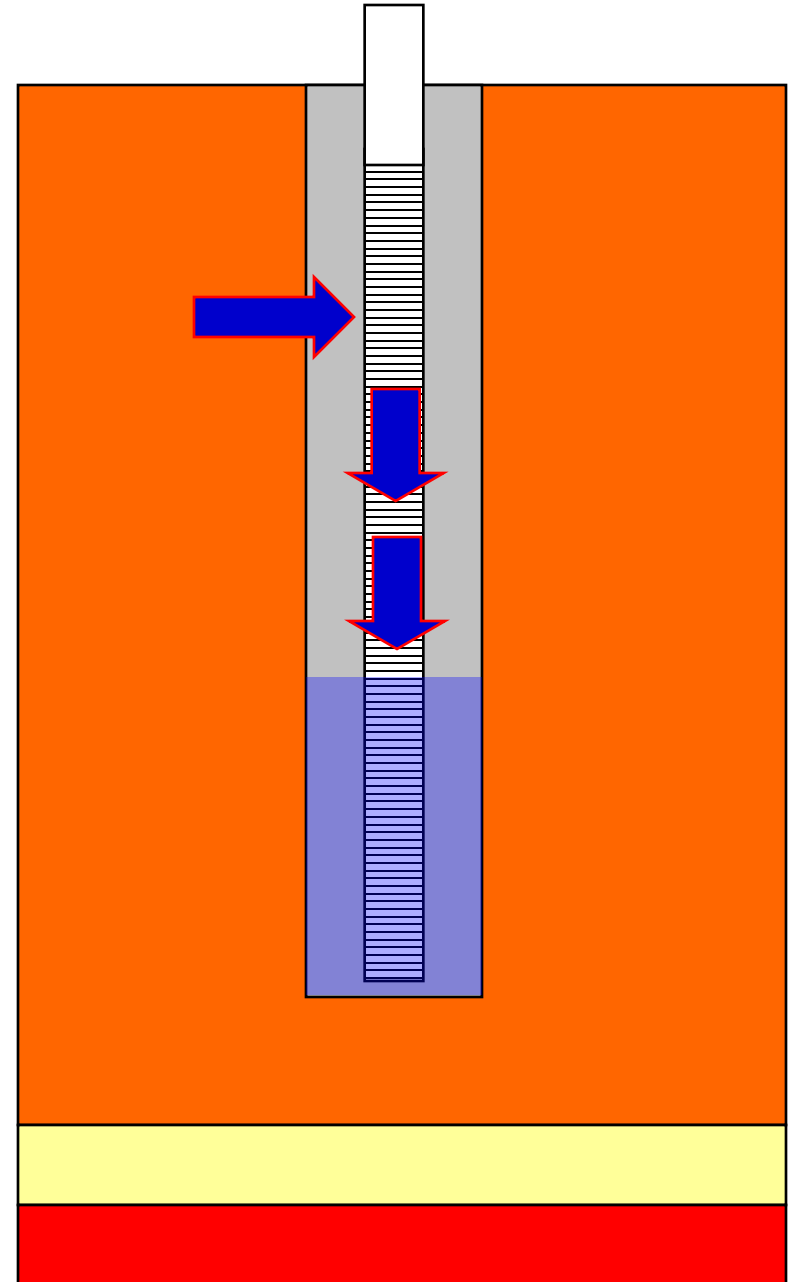
**Landfill Gas
Well**

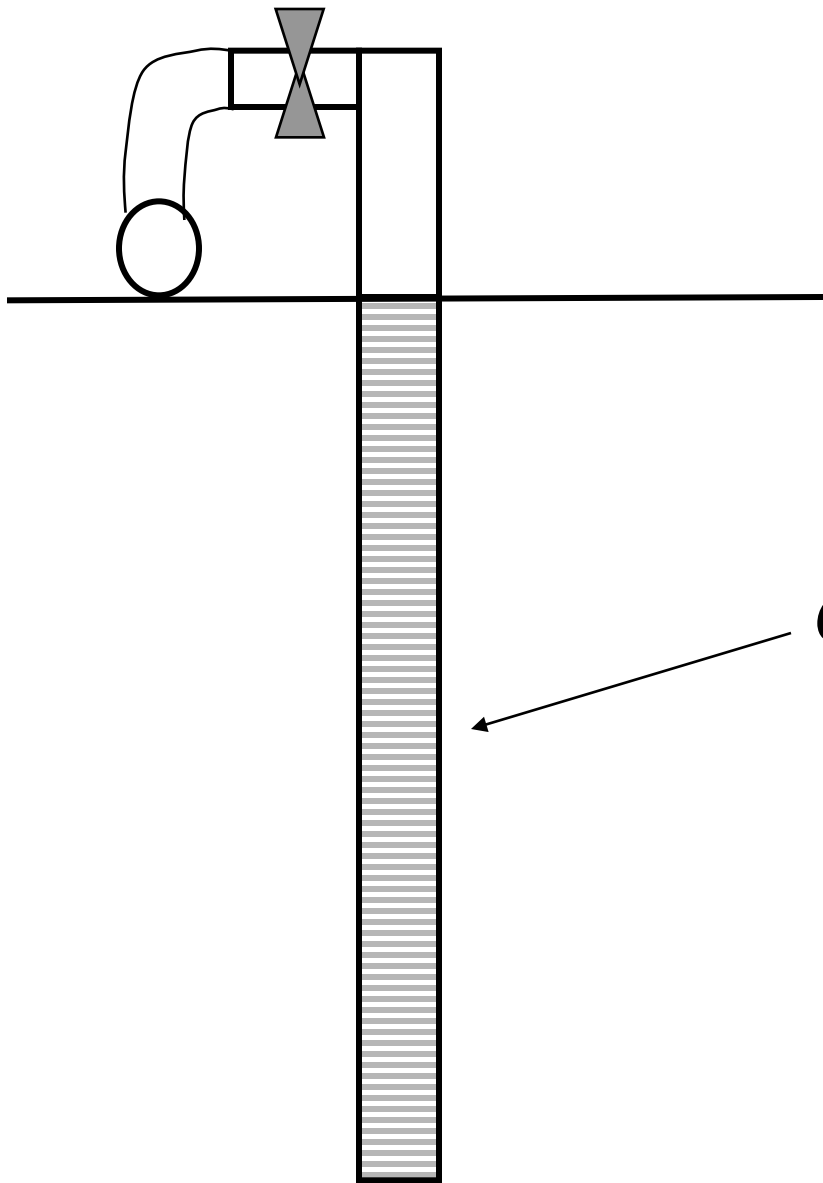


*Let's examine
the scenario where only
waste around
the well is saturated*

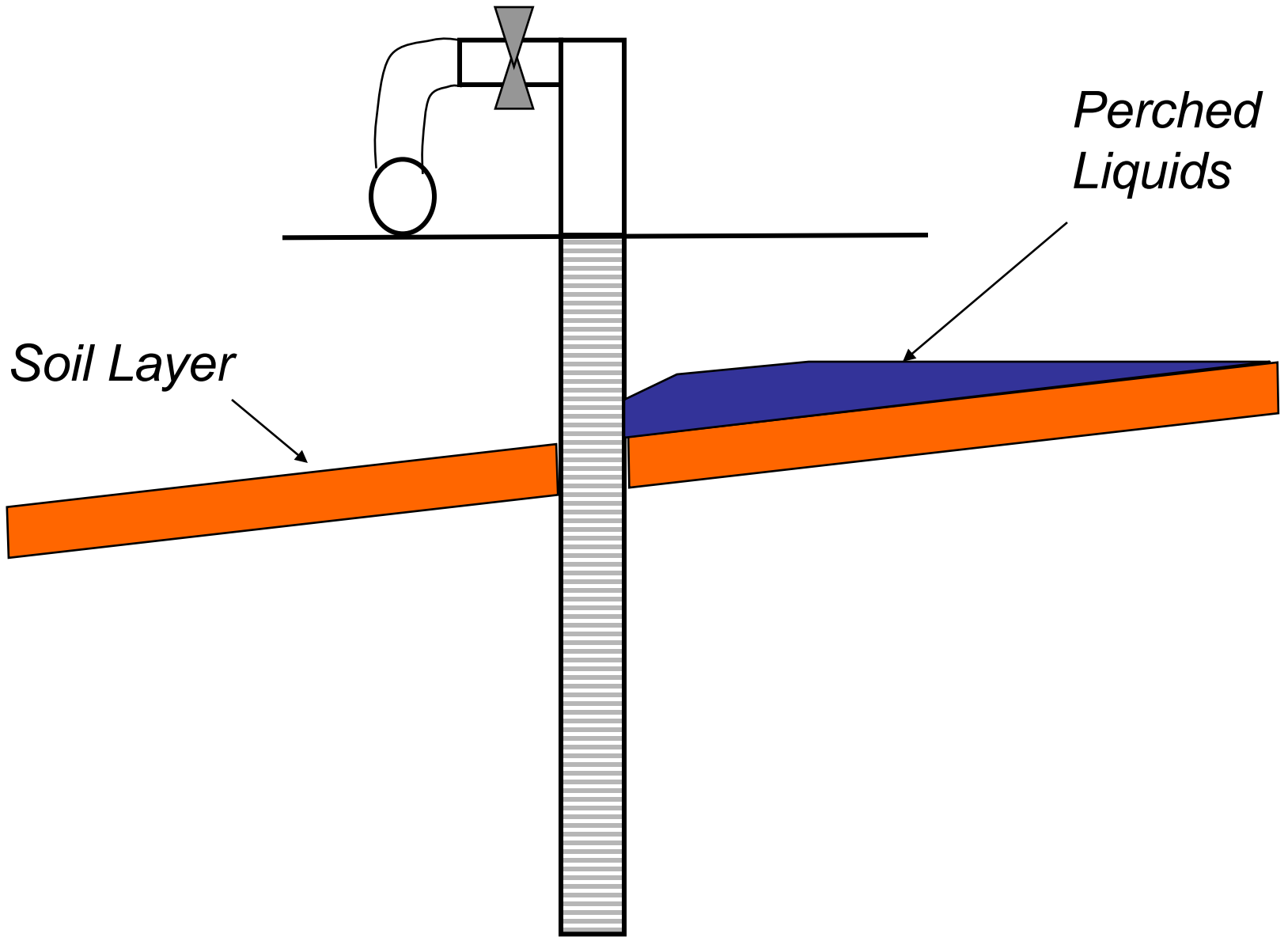
Some source of water is added to the well at a rate greater that it can drain out. Possible sources:

- Gas condensate
- Perched zones of leachate in the landfill
- Short circuiting from liquids addition



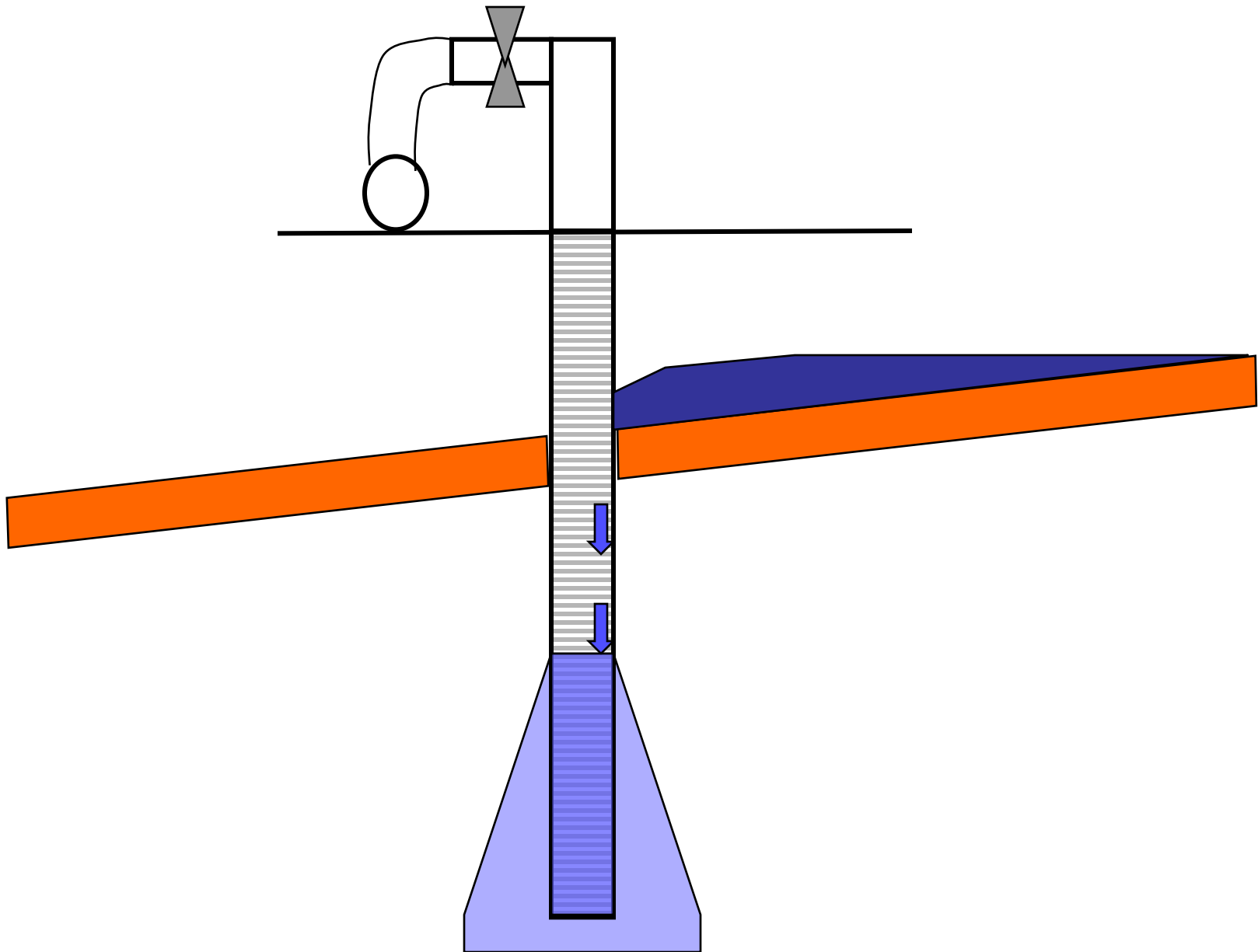


Gas Well

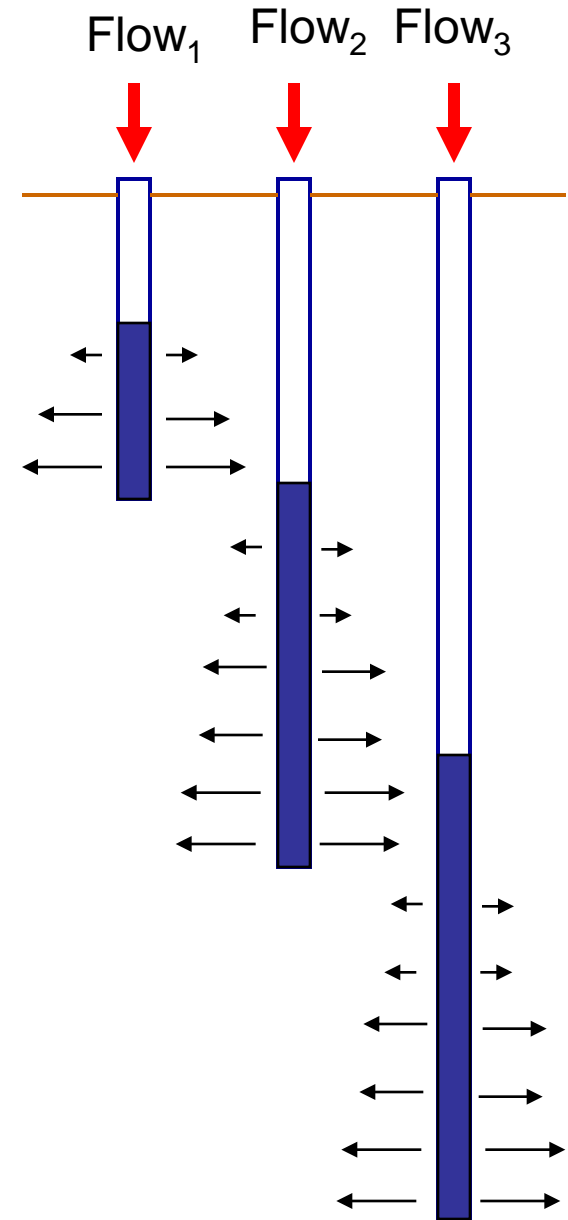


Soil Layer

Perched Liquids



Vertical Injection Wells at New River Regional Landfill

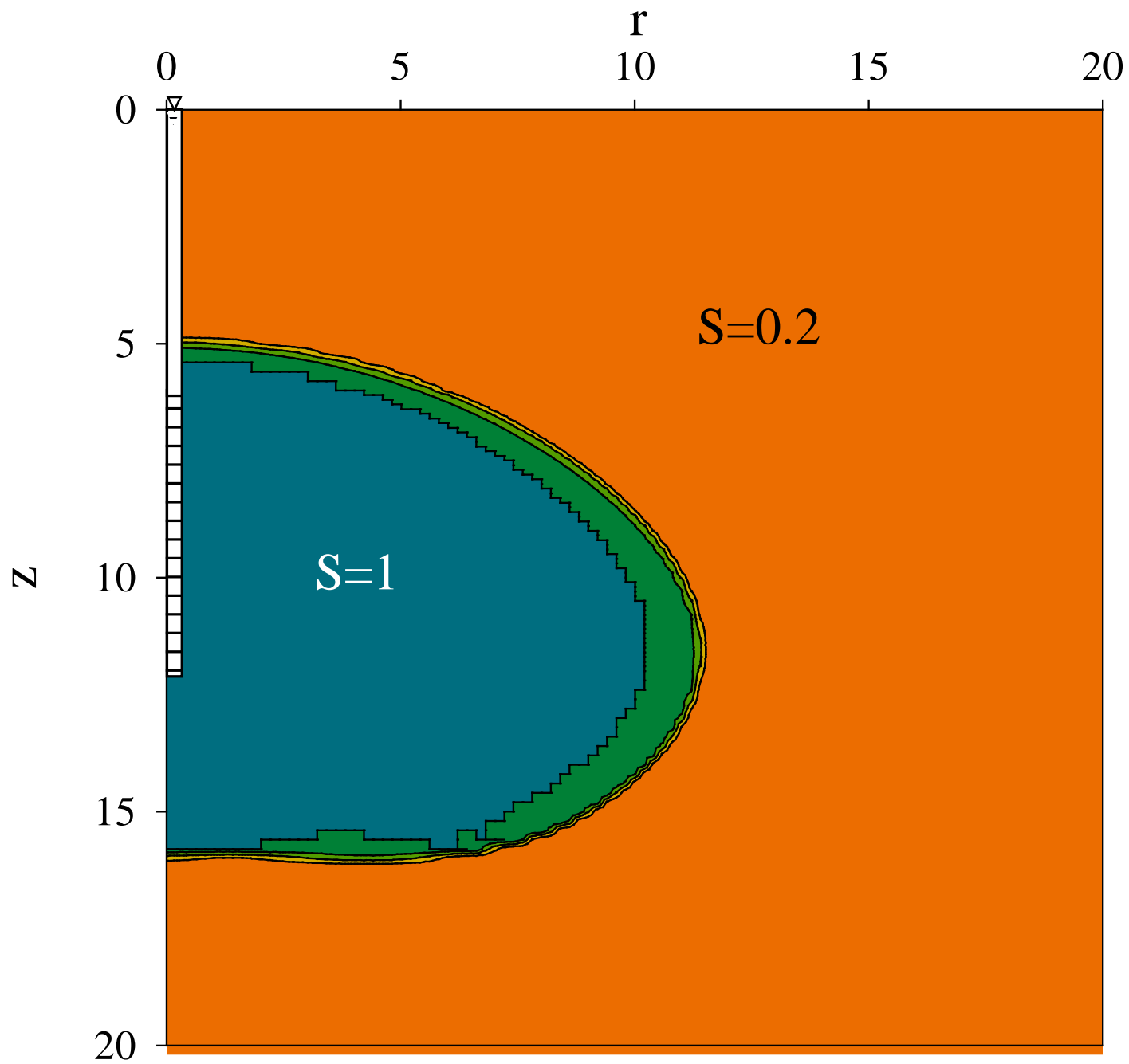


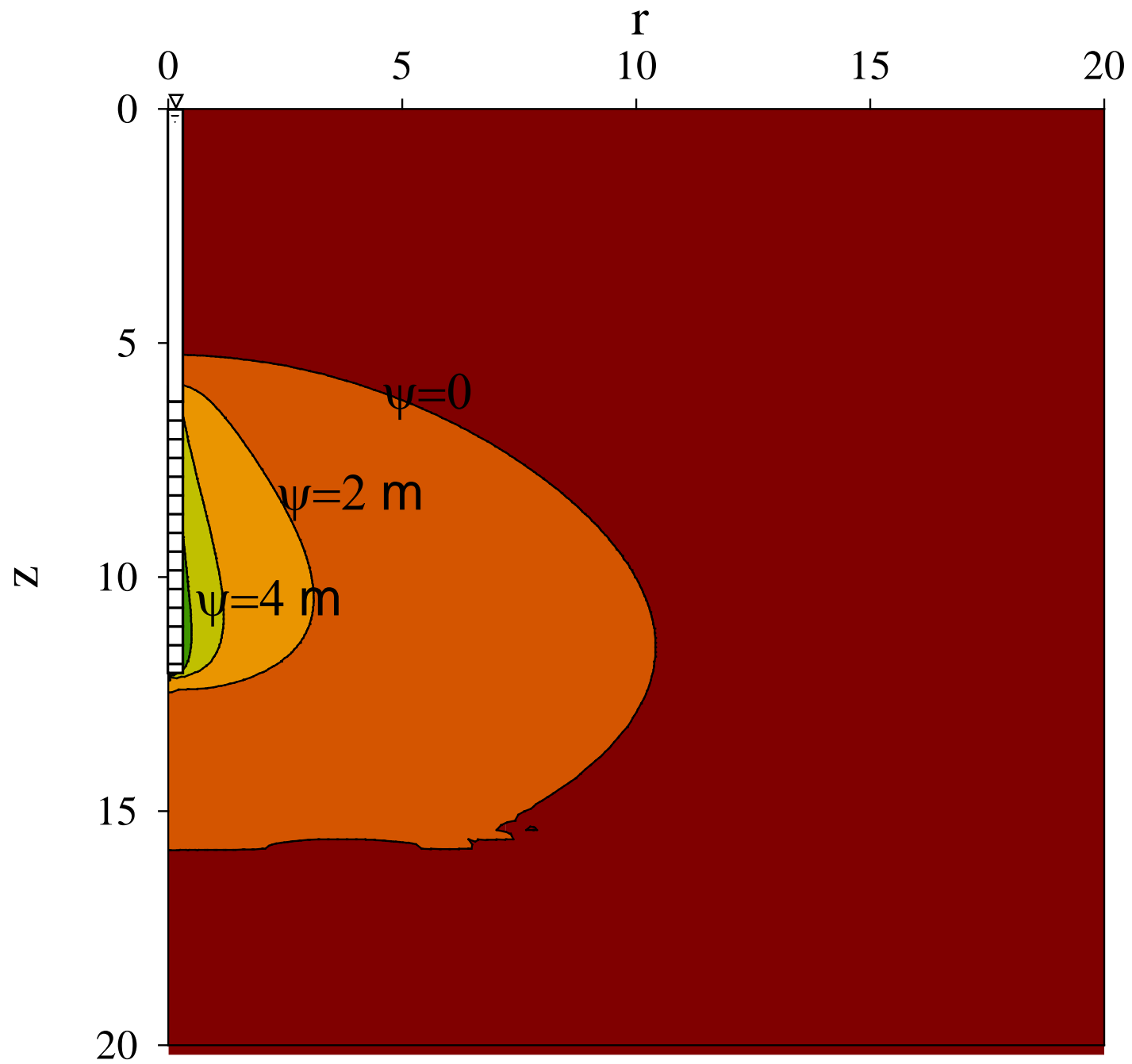


Modified Version of Richard's Equation

$$K_r \frac{\partial}{\partial r} \left(k \frac{\partial \psi}{\partial r} \right) + \frac{kK_r}{r} \frac{\partial \psi}{\partial r} + K_z \frac{\partial}{\partial z} \left(k \frac{\partial \psi}{\partial z} + k \right) =$$
$$= C(\psi) \frac{\partial \psi}{\partial t} + S_s \frac{\partial \psi}{\partial t}$$

Richard's equation was solved using a USGS program called SUTRA





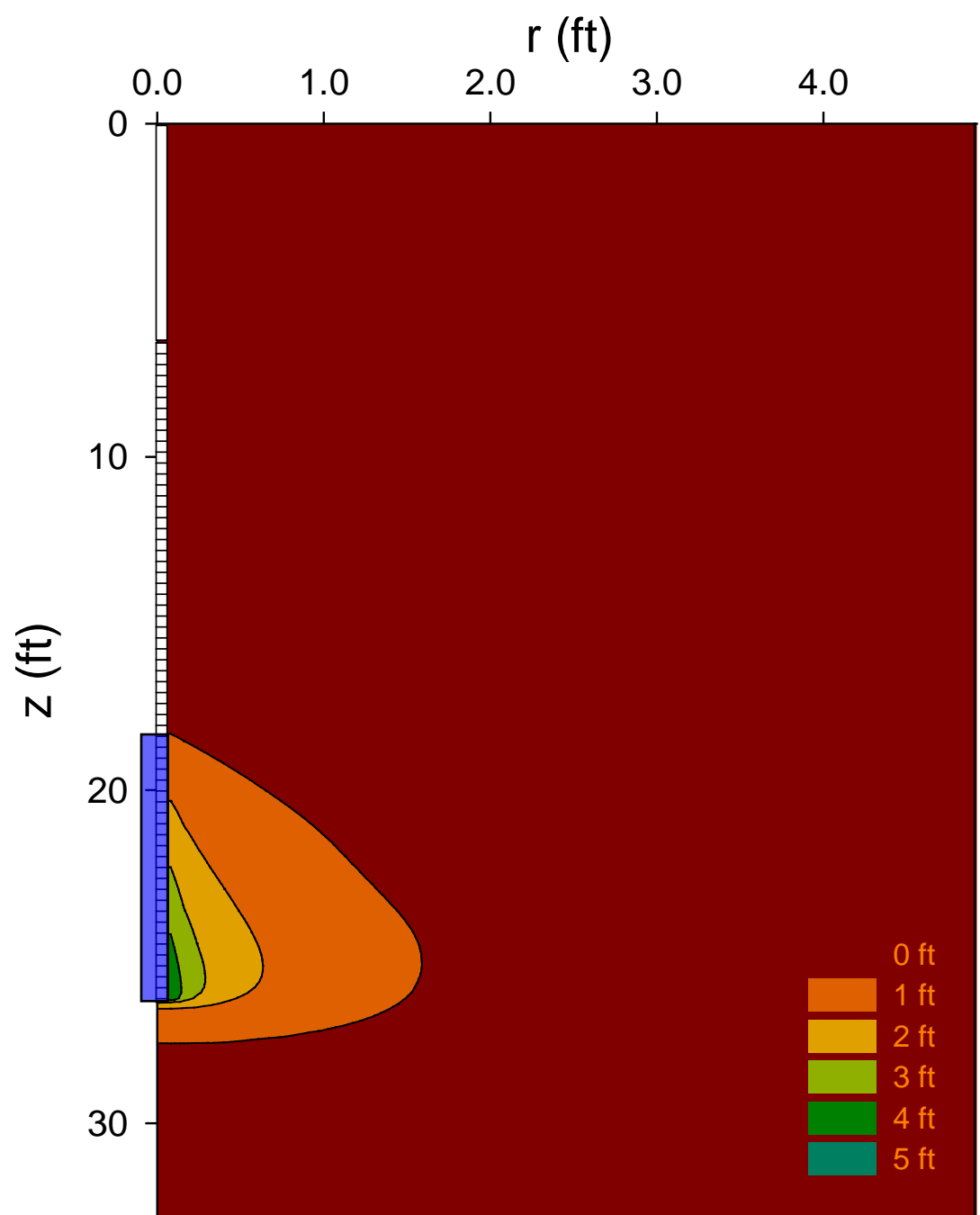
Simulation Parameters

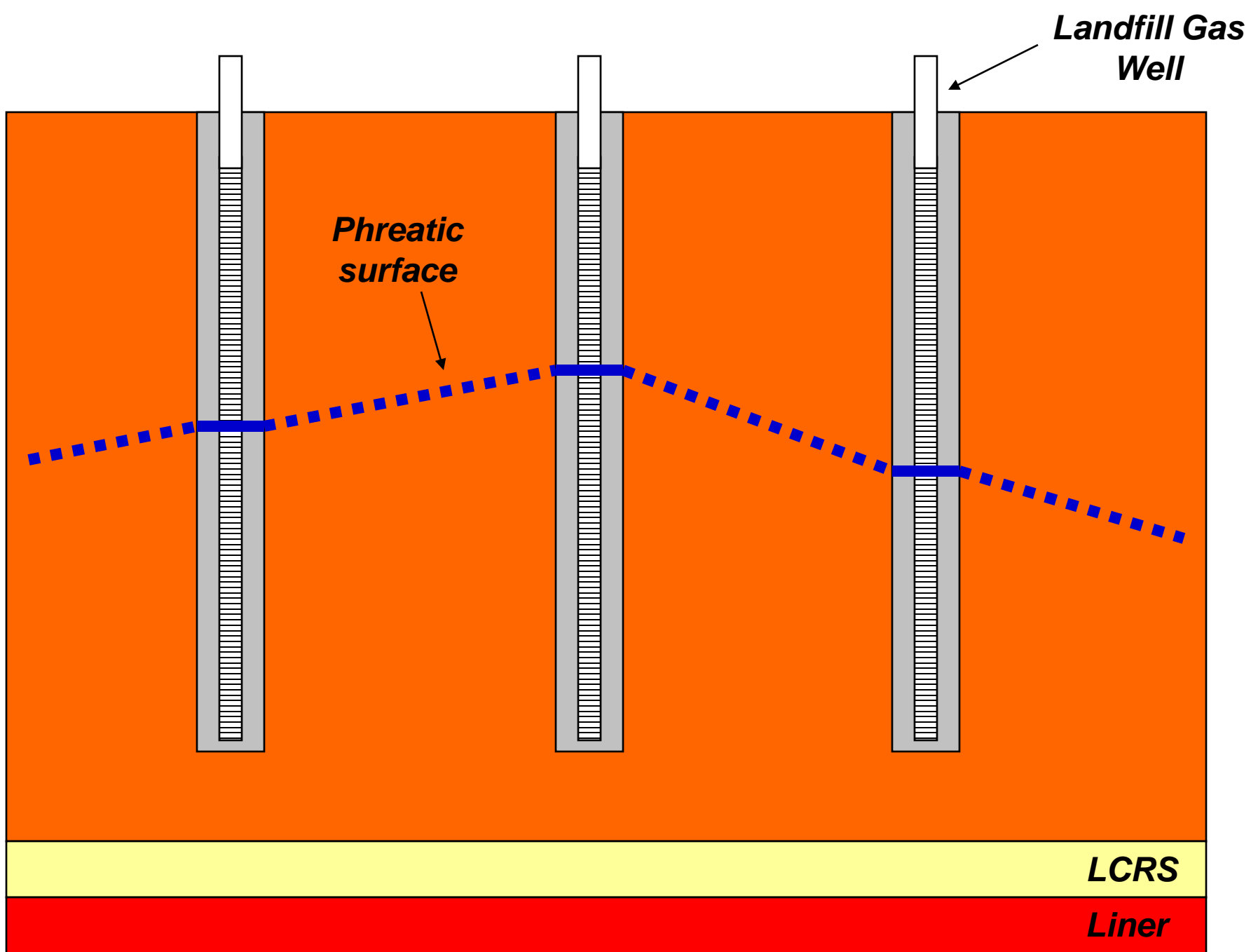
$K = 10^{-5}$ cm/sec

$Q = 17$ gallons/day

Duration of
Moisture Addition =
10 days

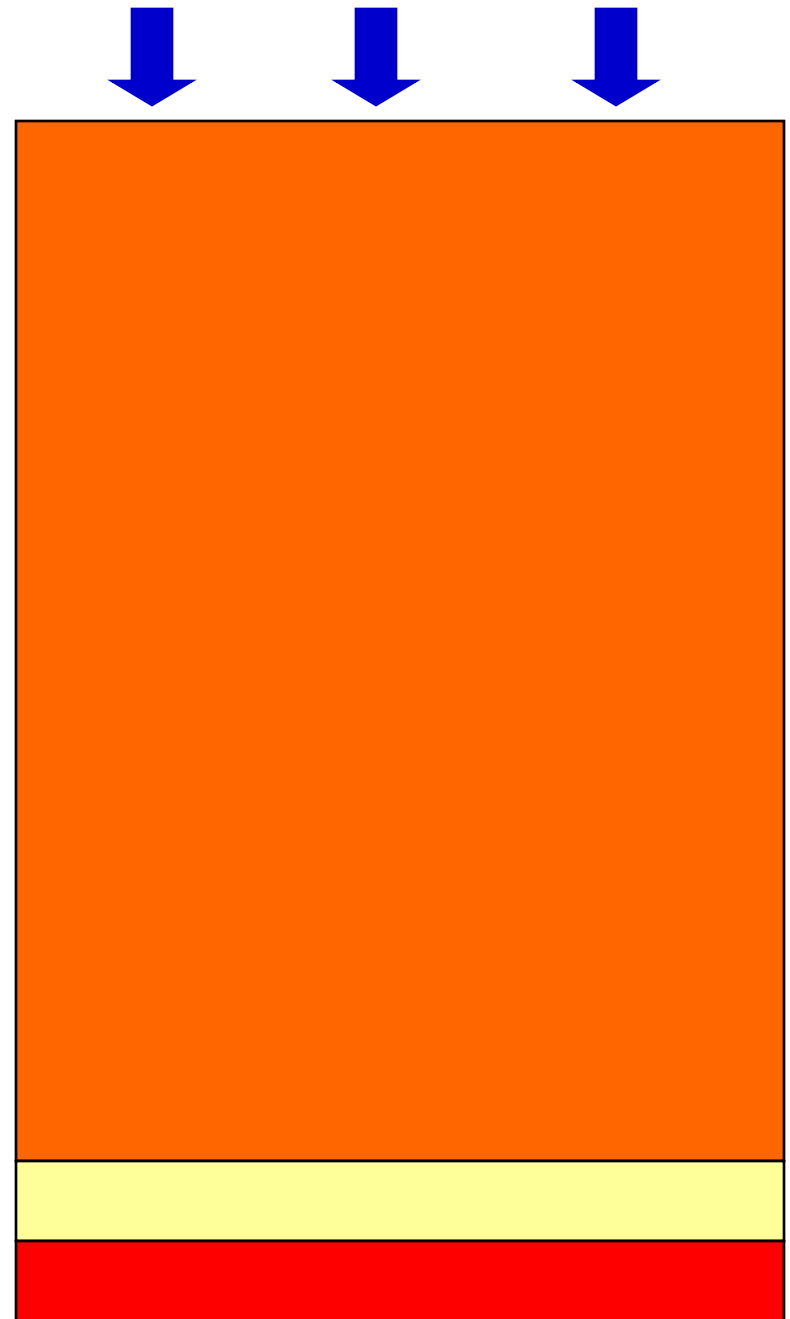
Head in the well ~
8 ft





*Let's examine
the scenario where saturated
conditions will develop in the
landfill even if barrier layers are
not present*

- If the liquids are added to the landfill at a rate greater than the hydraulic conductivity, saturated conditions will result



Consider a Liquids Infiltration Pond

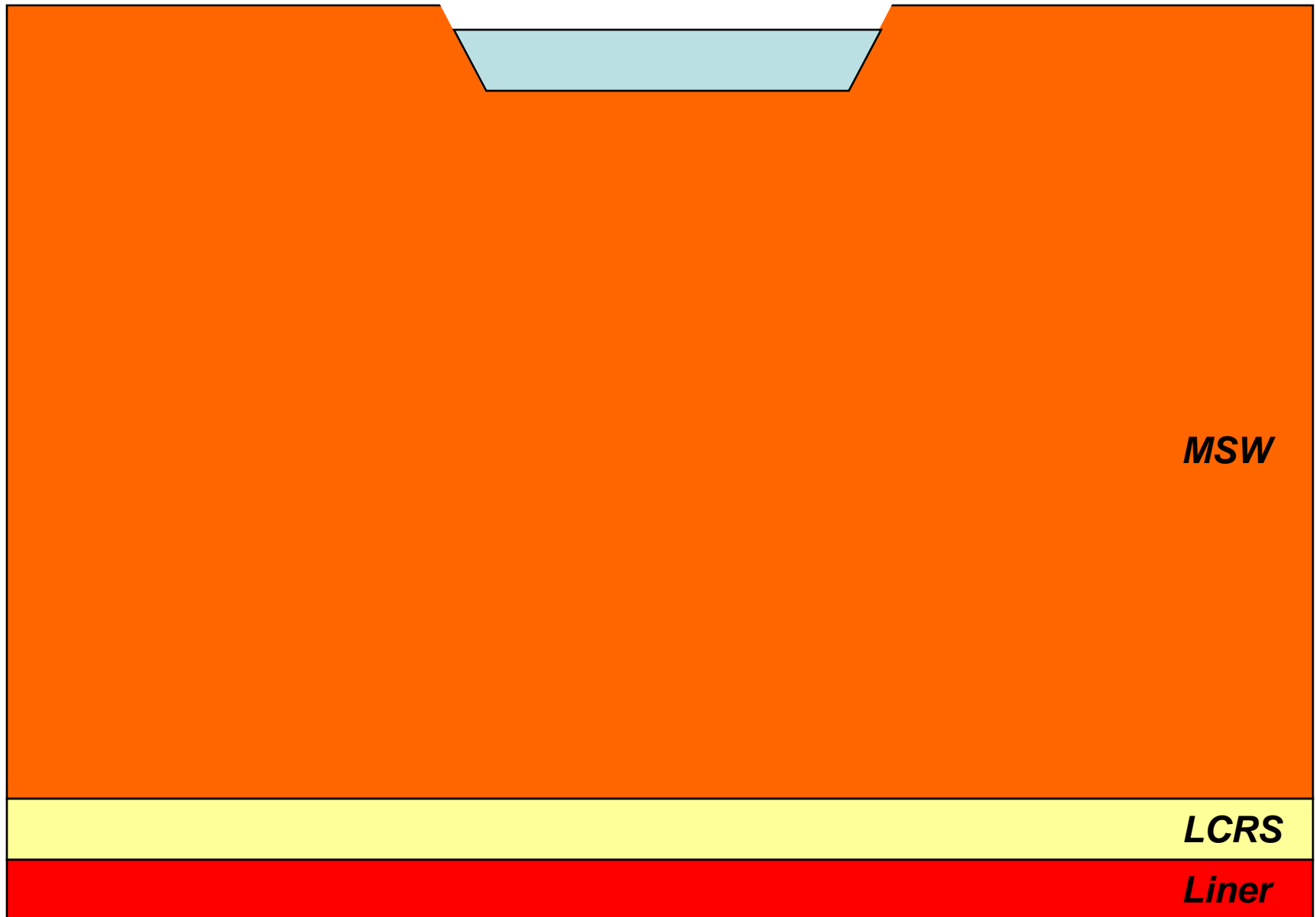
- The waste underneath the pond will become saturated
- In the absence of cover soil layers, a saturated zone will extend to the leachate collection system



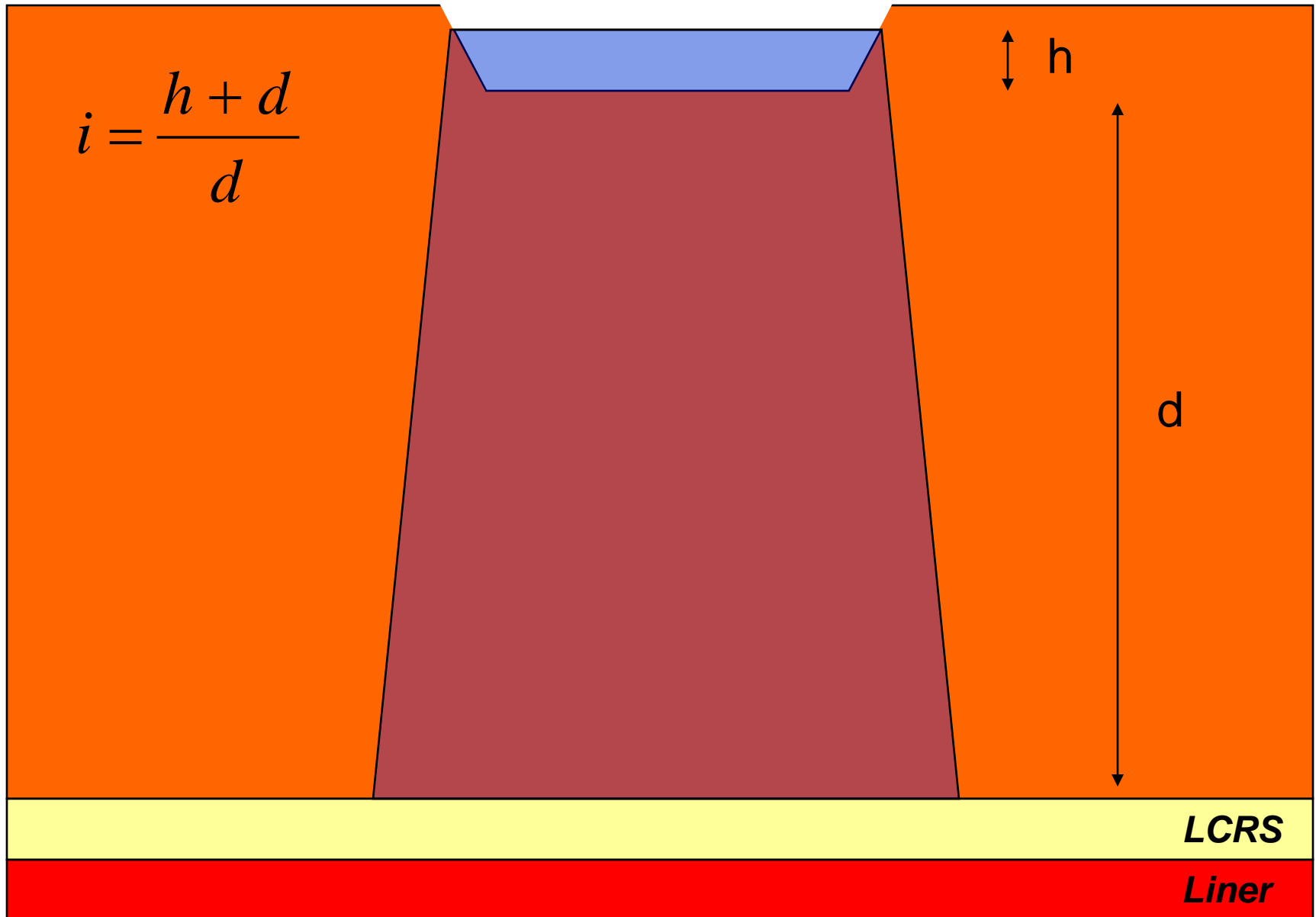
Consider a MSW Landfill with an Infiltration Pond



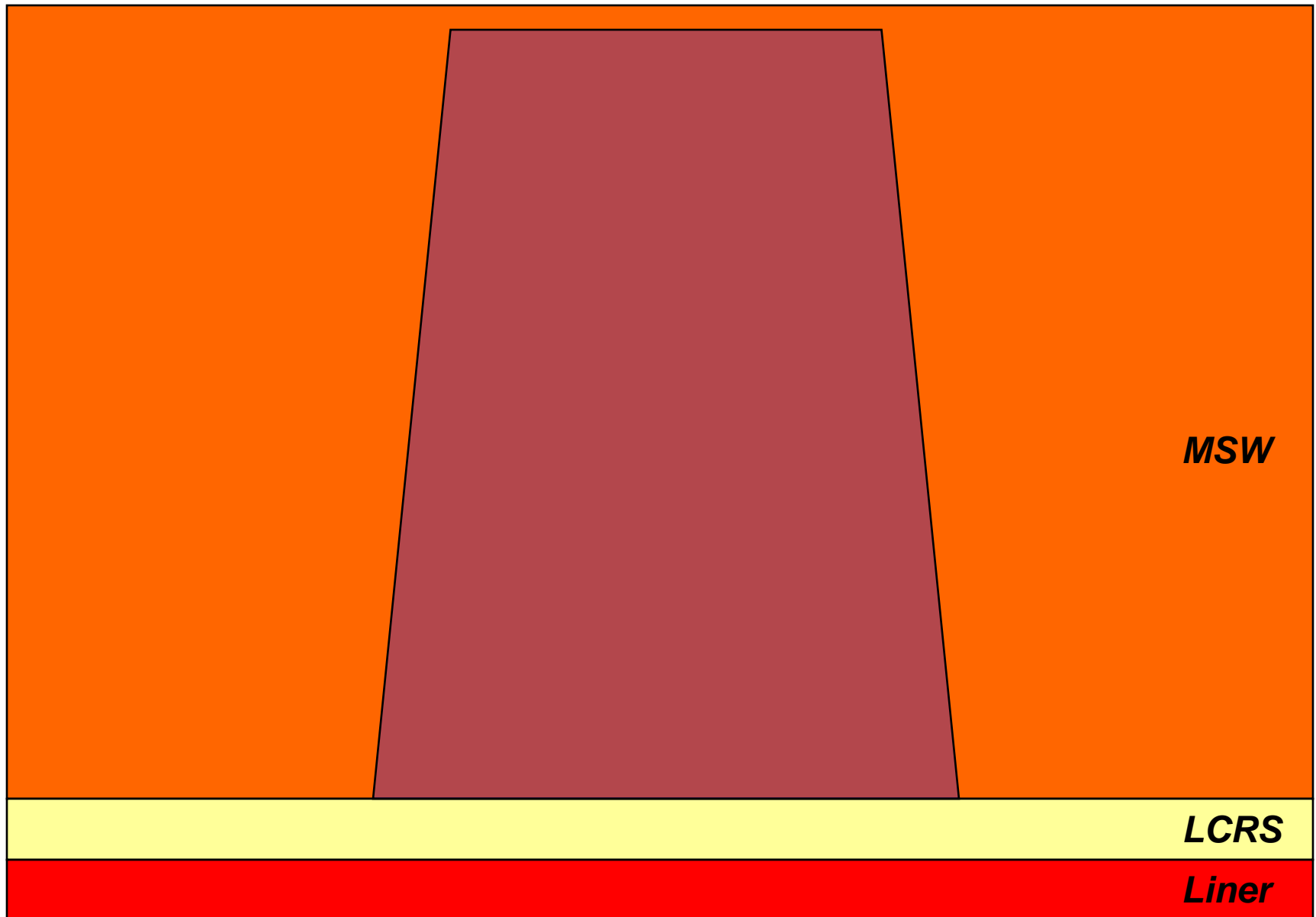
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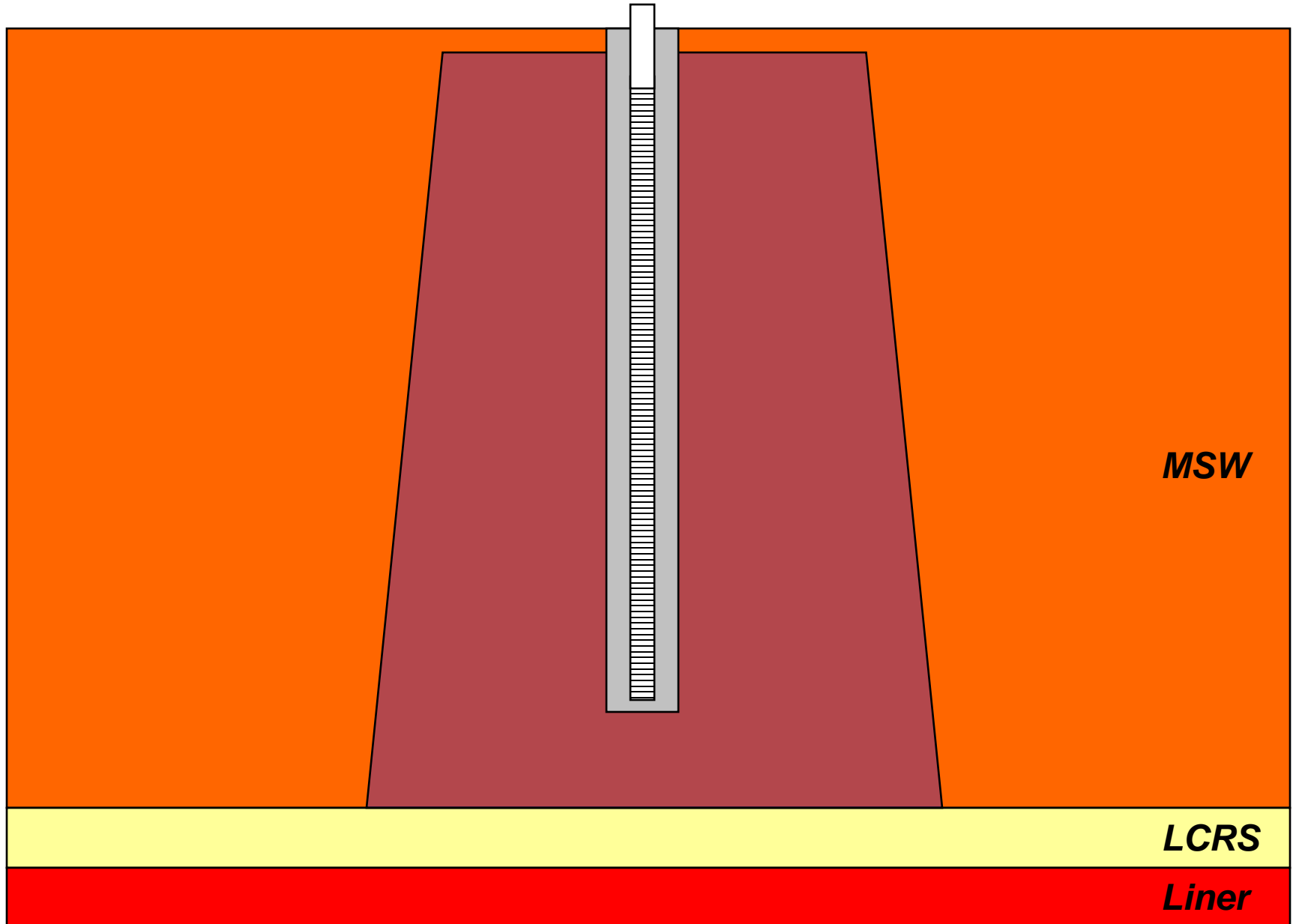
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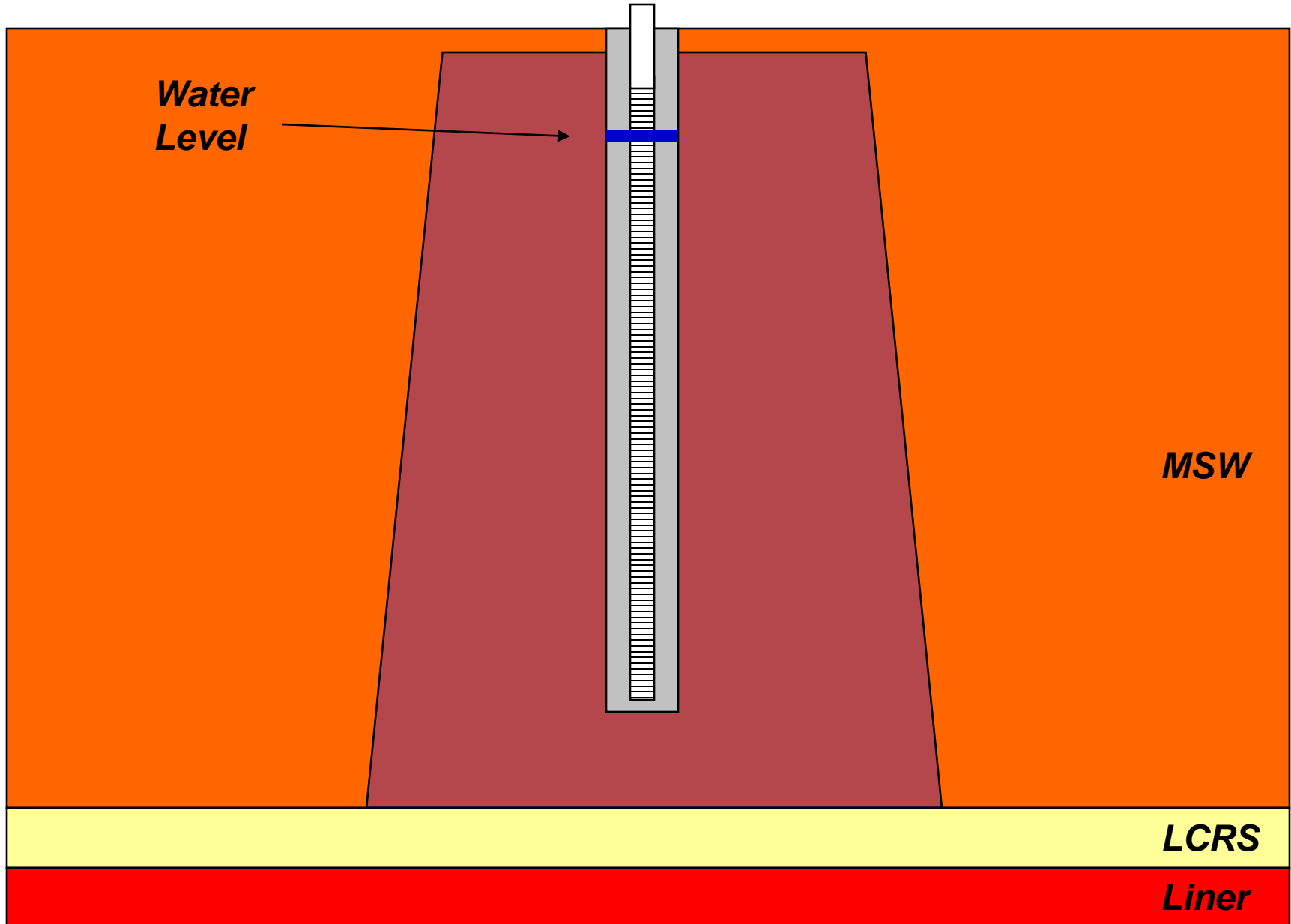
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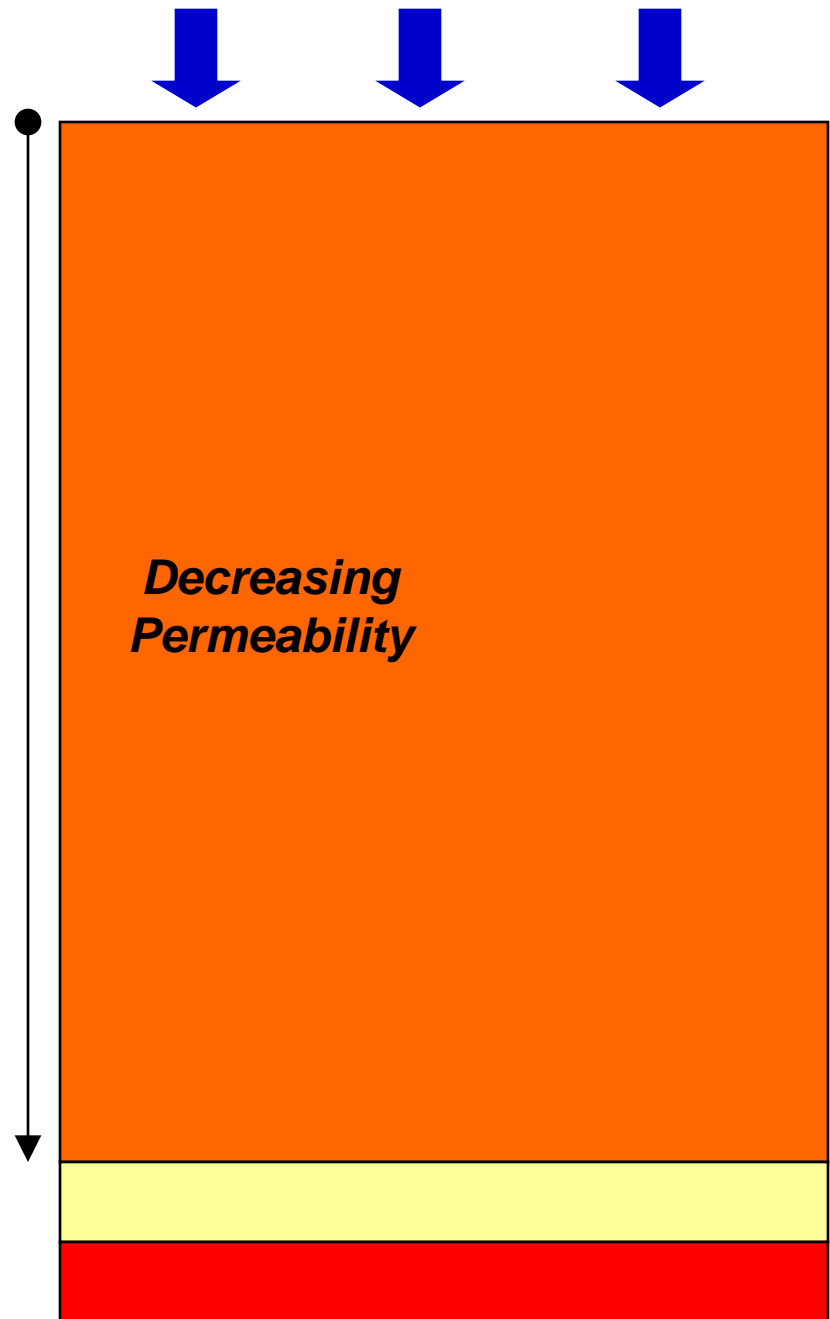


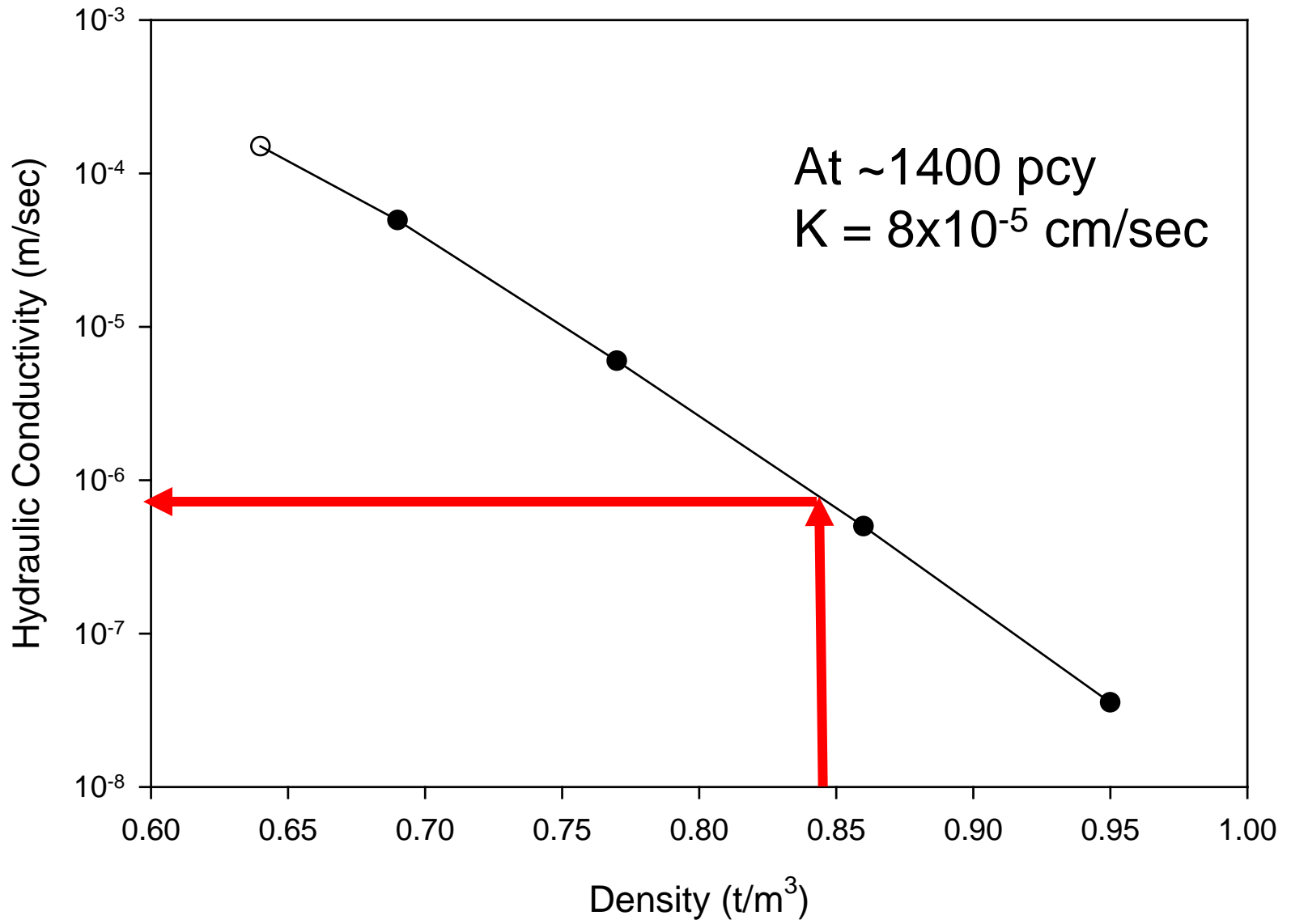
Consider a MSW Landfill with an Infiltration Pond



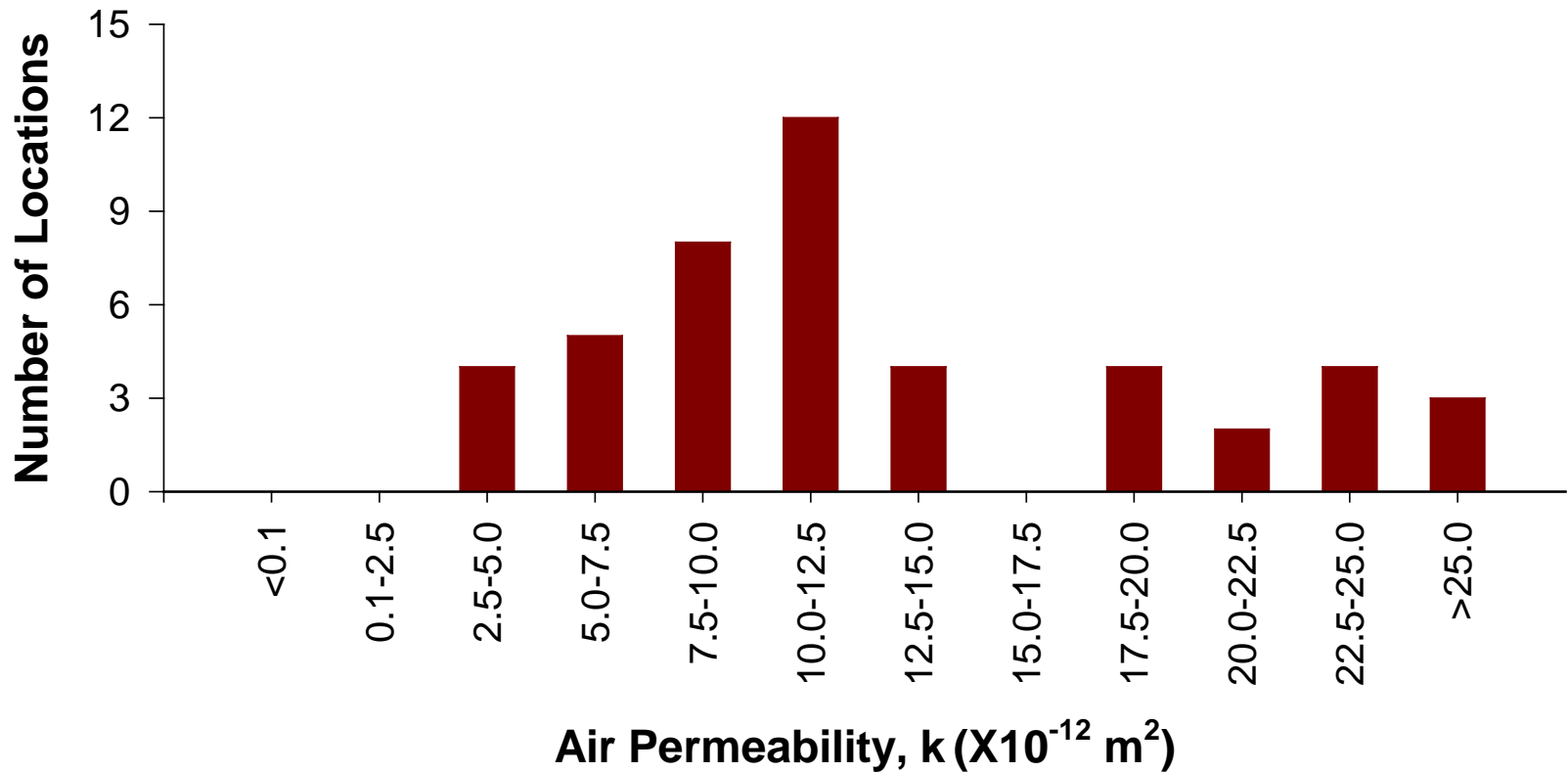
Can saturated conditions develop if the liquids are added at a rate less than the permeability of the waste?

- Yes, if the permeability of the waste is reduced with depth

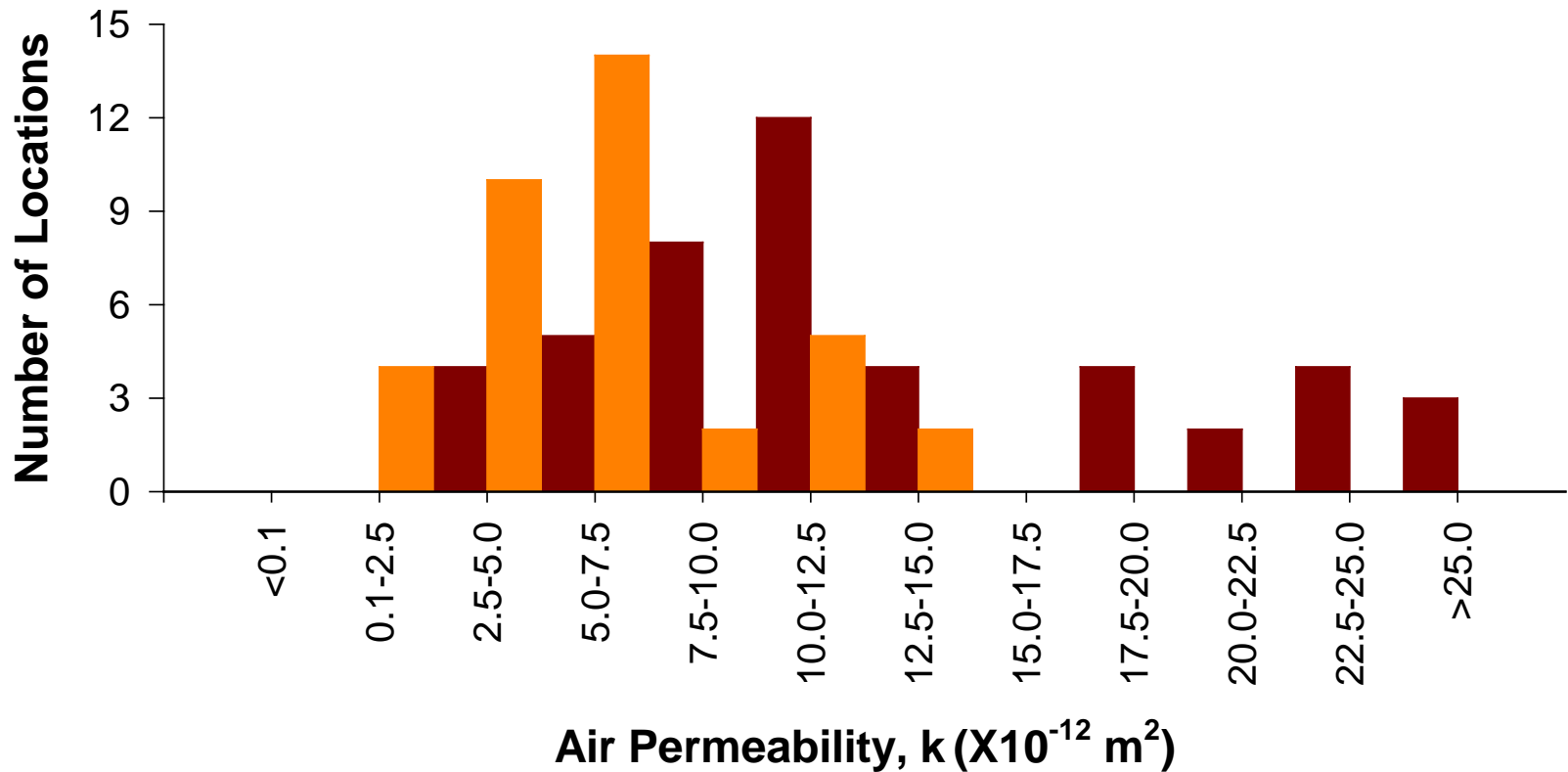




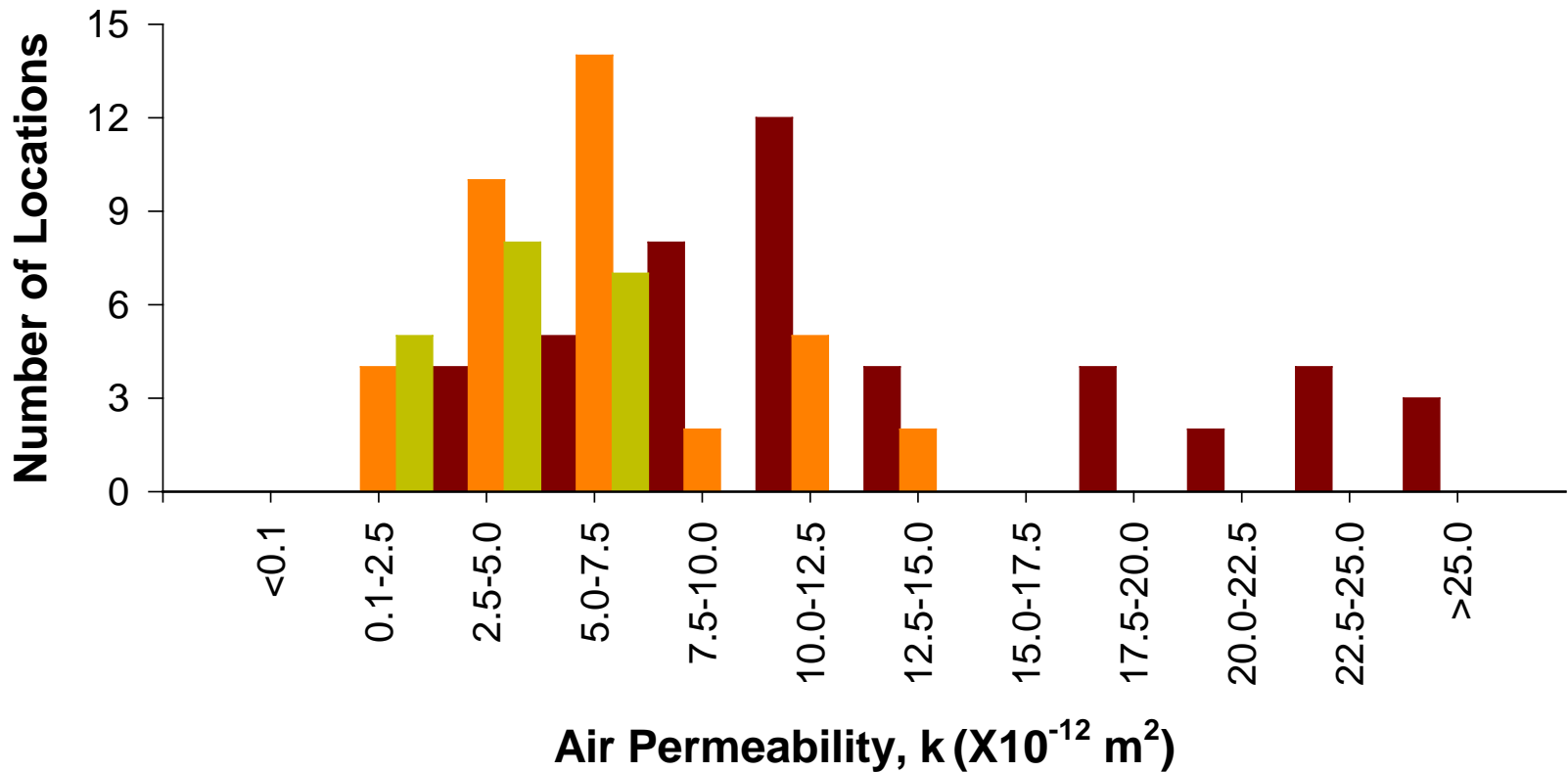
Air permeability of waste at NRRL at different depths

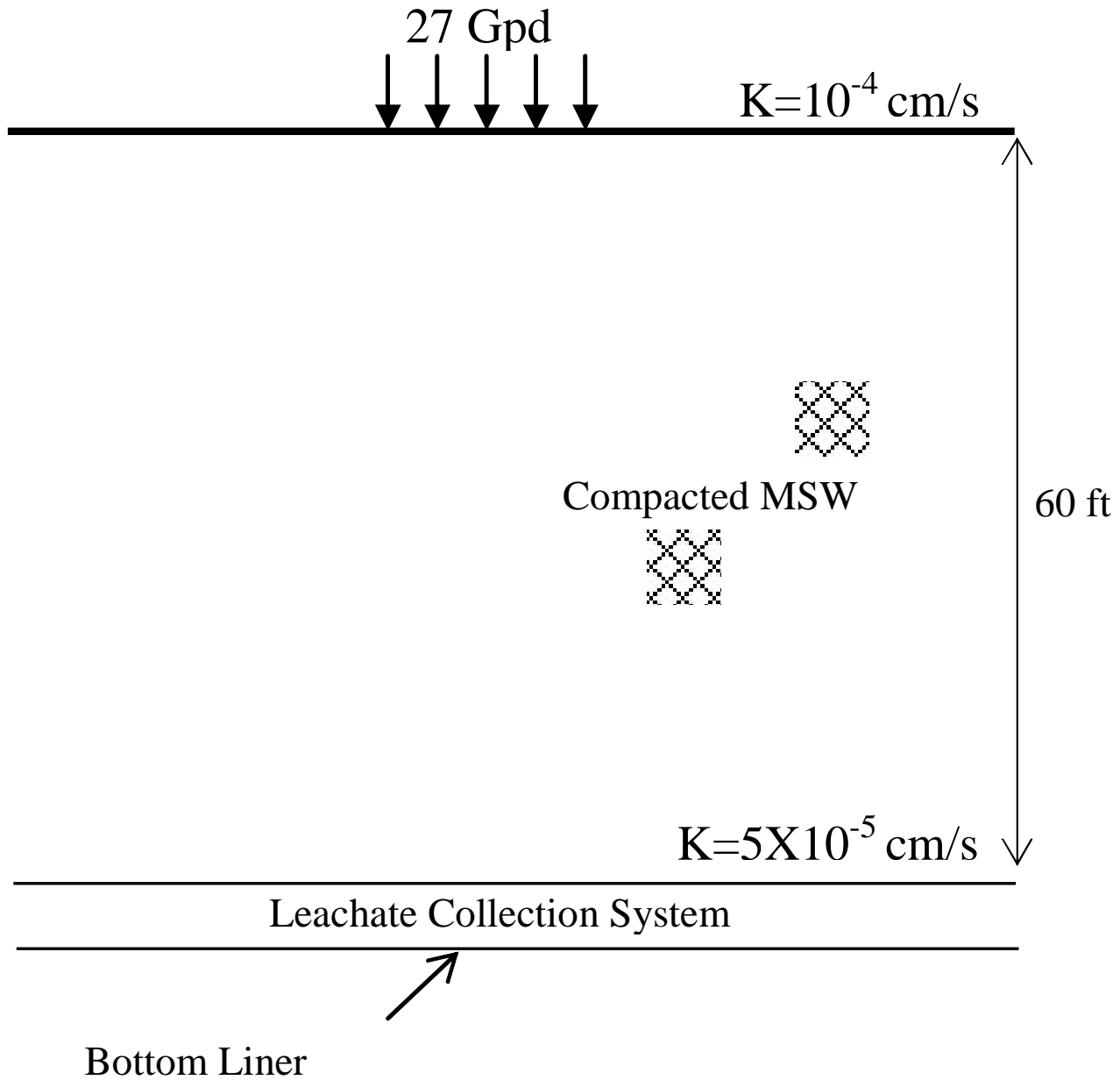


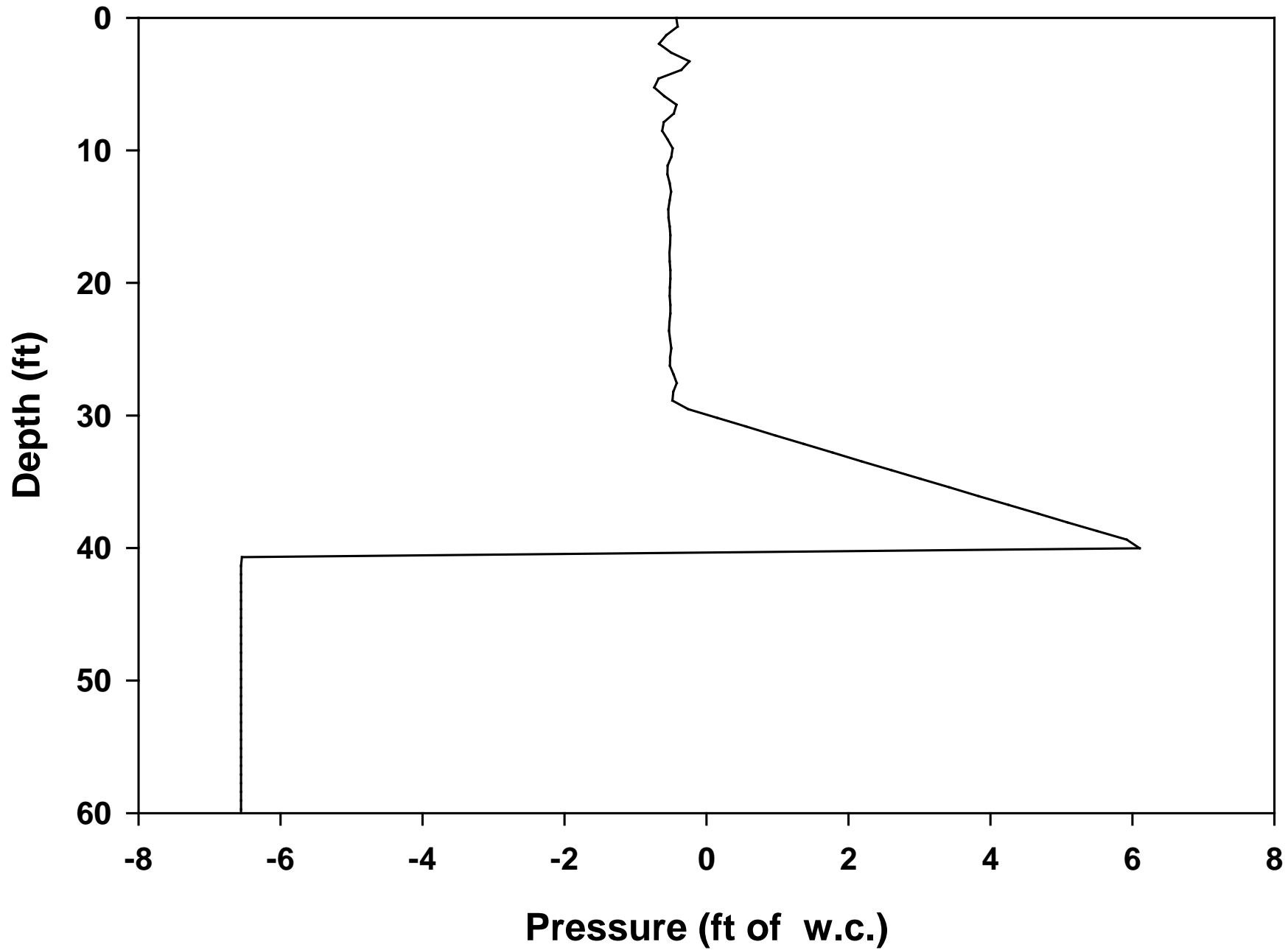
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Air permeability of waste at NRRL at different depths







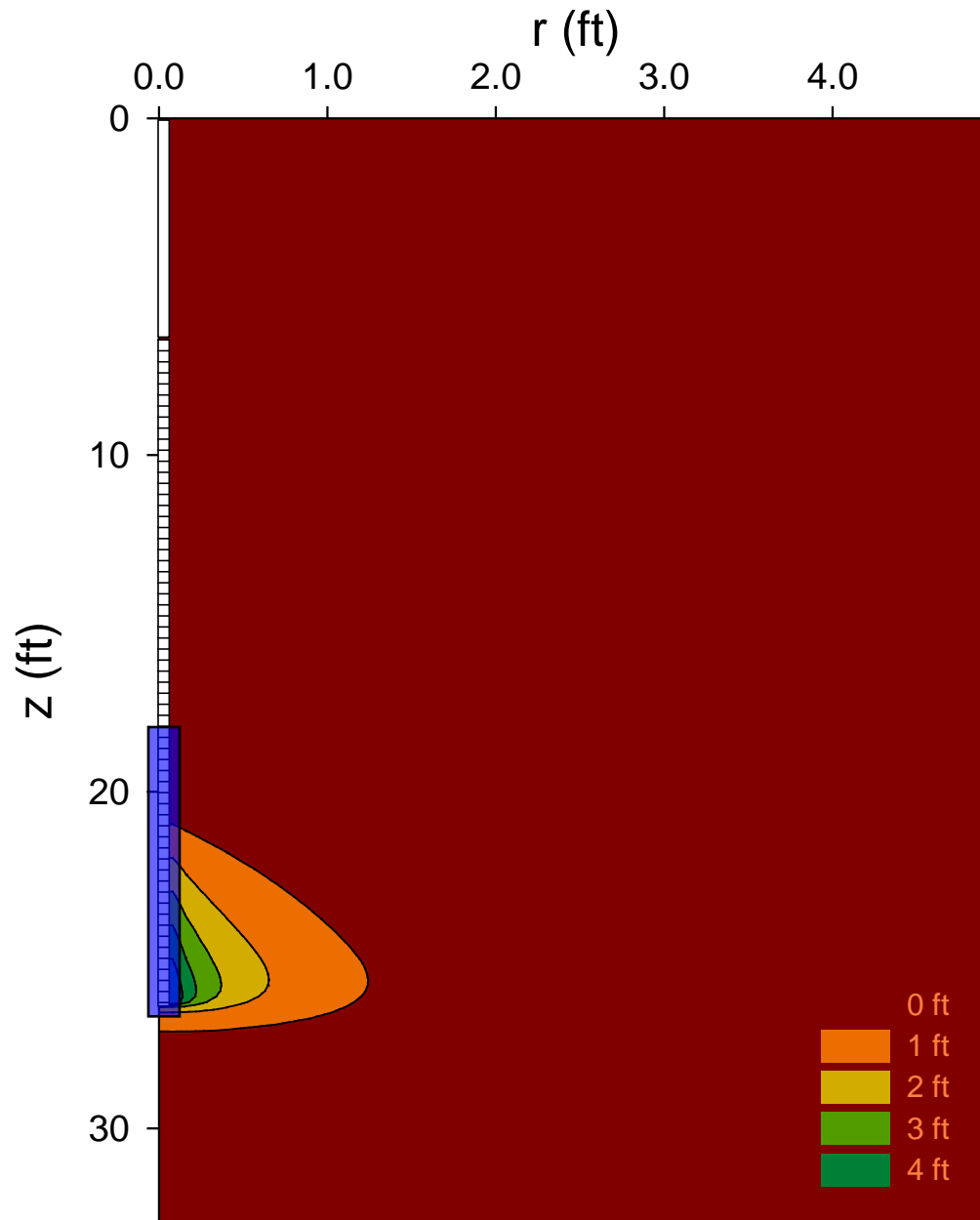
Simulation Parameters

Decreasing $K = 10^{-5}$
cm/sec (top) to 5×10^{-6}
cm/sec (bottom at 60 ft
deep)

$Q = 8.5$ gallons/day

Duration of Moisture
Addition = 10 days

Head in the well ~ 5 ft



Review

- The existence of standing liquids in gas wells in landfills does not necessarily result from a phreatic liquid surface in the landfill.
- Liquids added to wells as a result of perched layers in the landfill, gas condensate or other sources can result in relatively large depths of water in the well.

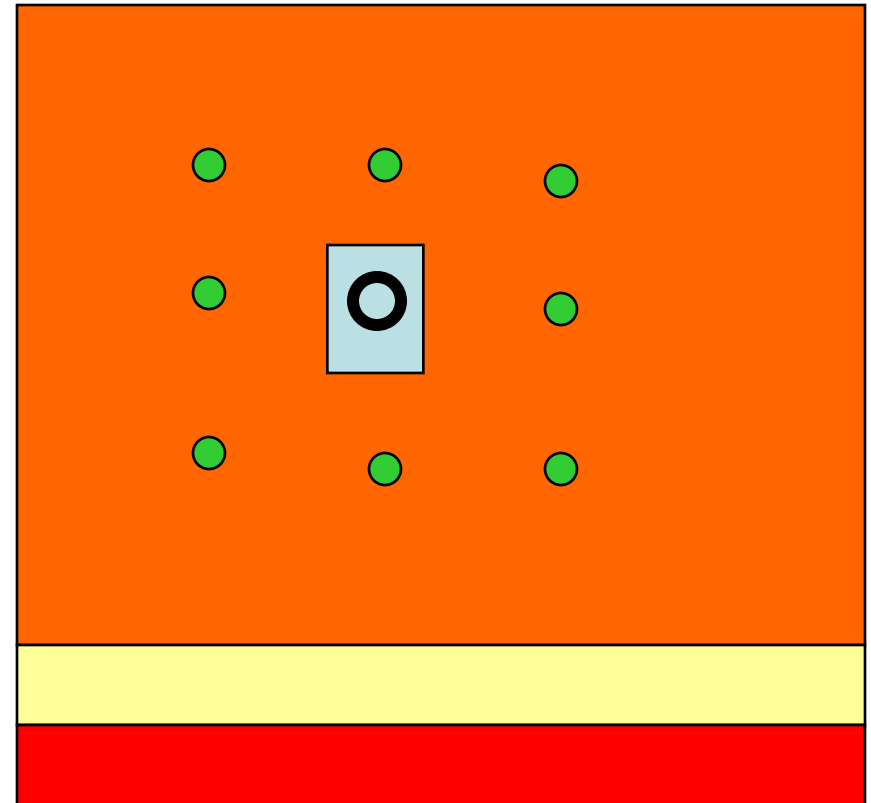
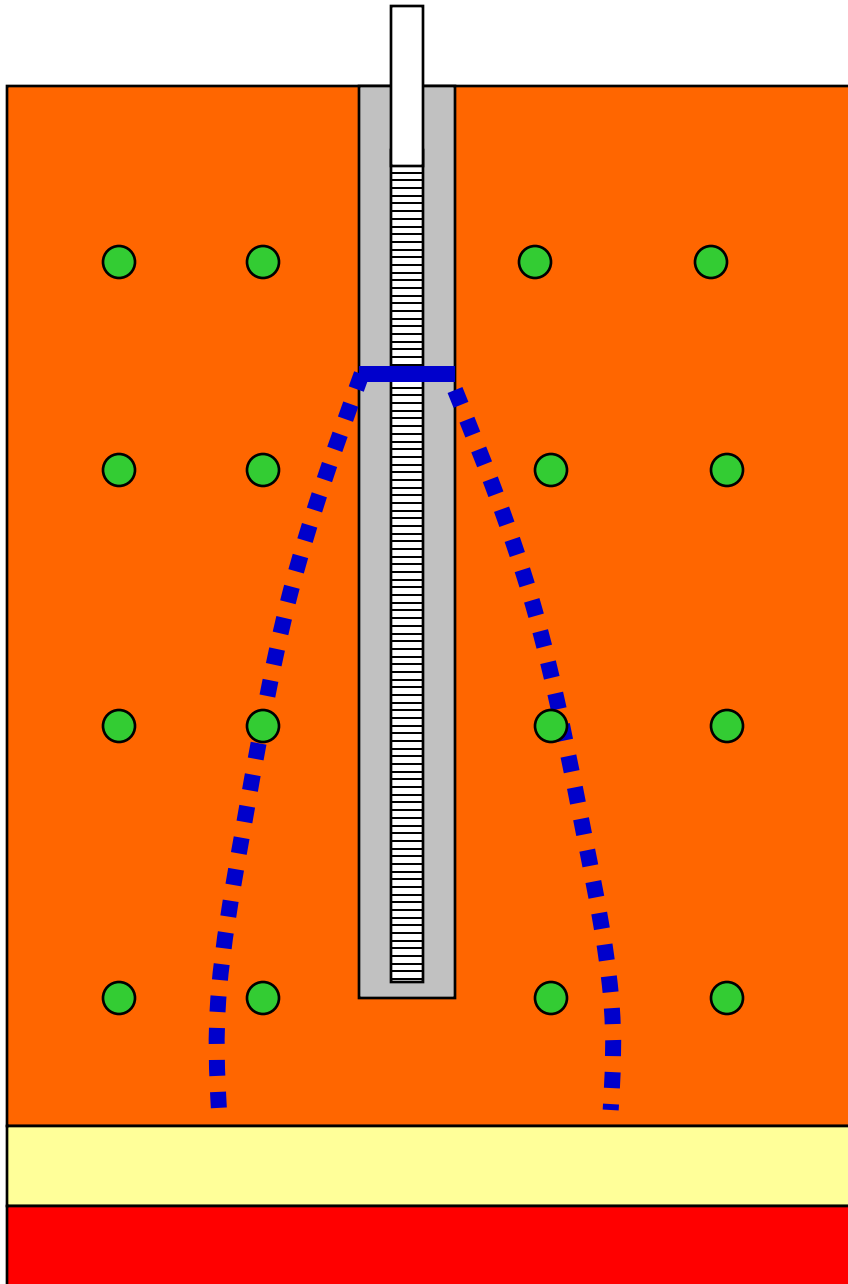
Review

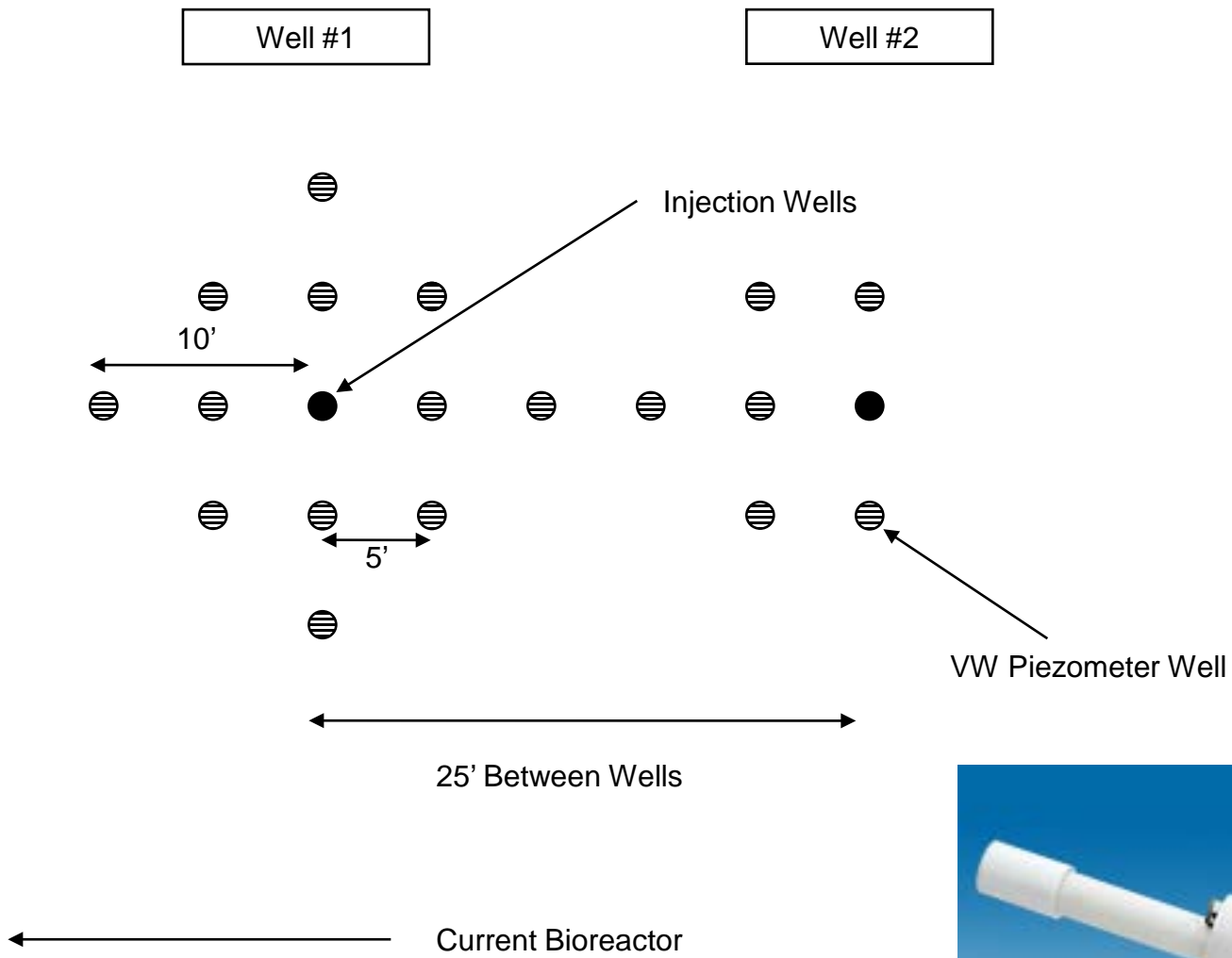
- The decreasing permeability of landfilled waste with depth should have impact.
- Saturated waste conditions may be present, but the pressure of this water may not be accurately reflected by the depth of water that would be measured if a well was installed.
- At large liquid addition rates, saturated conditions in deeper layers may develop.

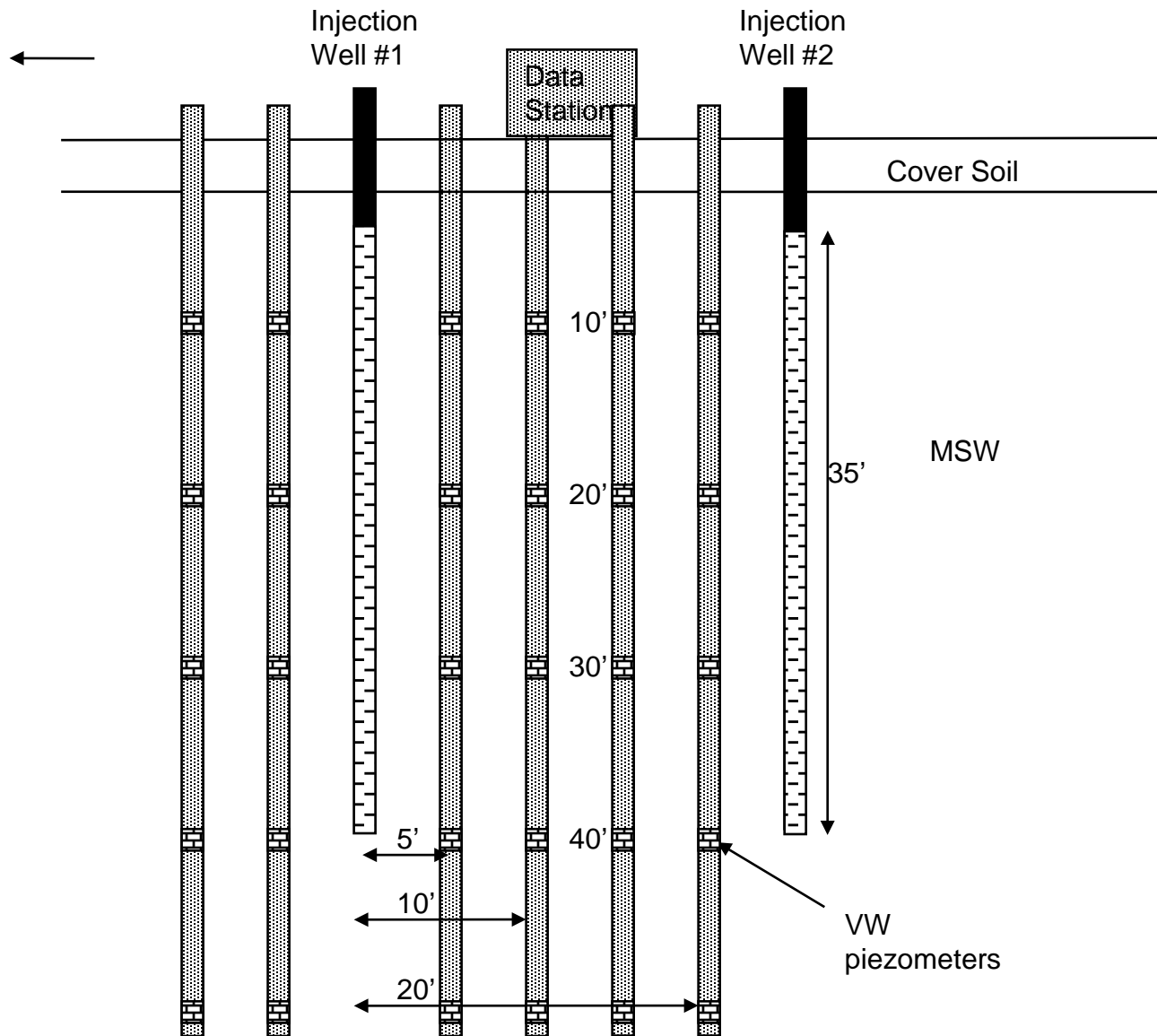
Implications

- The presence of liquids in gas wells in “dry” landfills should not automatically assumed to represent a phreatic surface.
- In “wet” landfills, the liquid levels in wells may result from both situations.
- When evaluating slope stability, careful thought must be given to the pressures that truly occur.
- Leachate collection systems need to be designed and operated correctly.

New Experiment in Florida
Bury piezometers in waste
vertical well and horizontal trench







Contact Info

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