

Wet Landfill Engineering and Landfill Gas Recovery

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May 7, 2007



Outline

- Landfills and Landfill Gas
- Wet Landfilling
- Geotechnical Challenges



Landfills

- Landfill Construction
- Landfill Gas
- Landfill Gas to Energy



Landfills

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- Landfill Gas
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Excavation



Soil Liner Construction



Synthetic Liner Installation



Drainage System Construction



Waste Placement



Final Cover



Final Cover

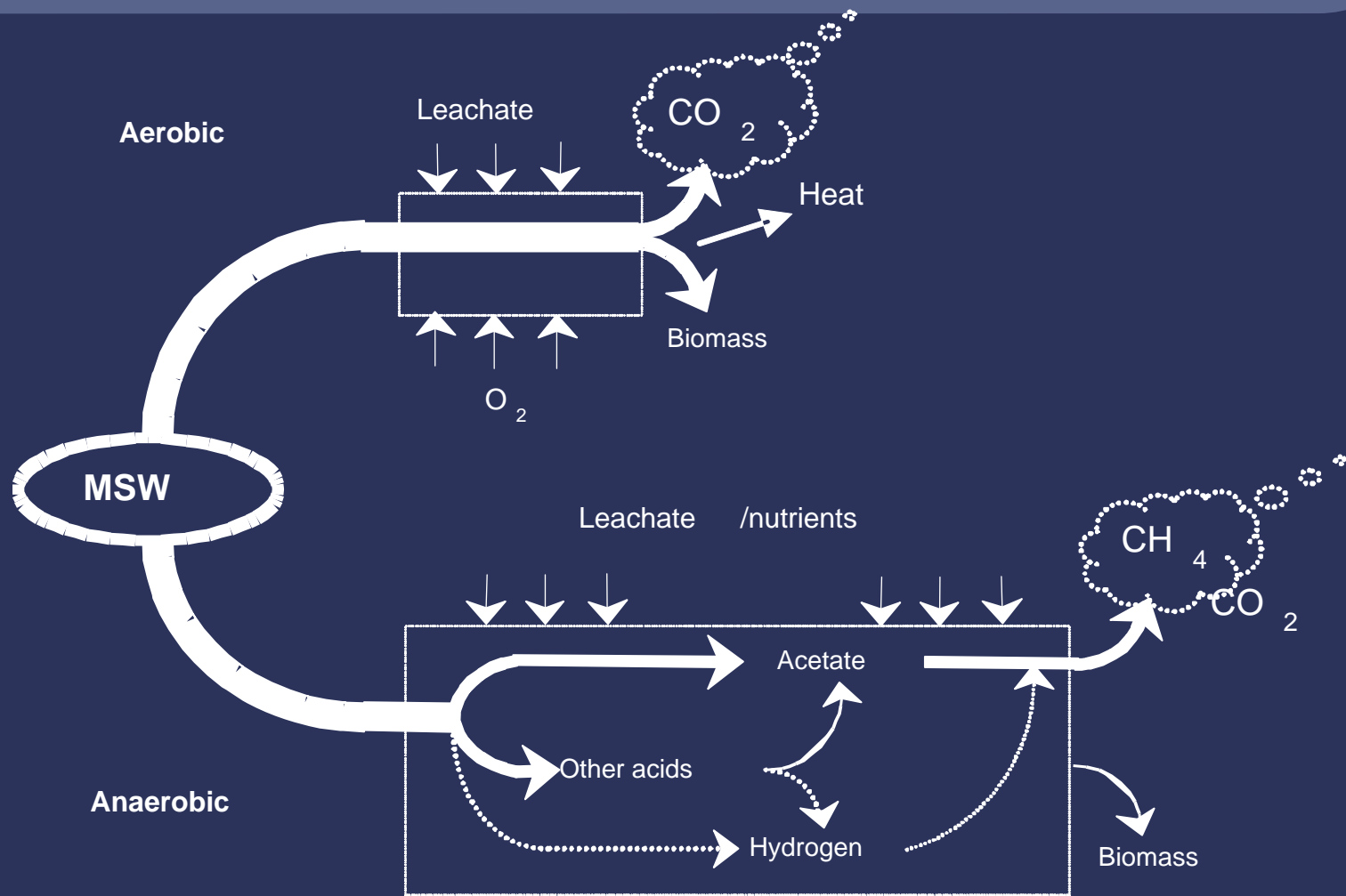


Landfills

- Landfill Construction
- Landfill Gas
- Landfill Gas to Energy



Biological Decomposition





LFG

LFG

LFG

LFG

LFG

LFG Collection



LFG Flare



Landfills

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Landfill Gas Electric Generator

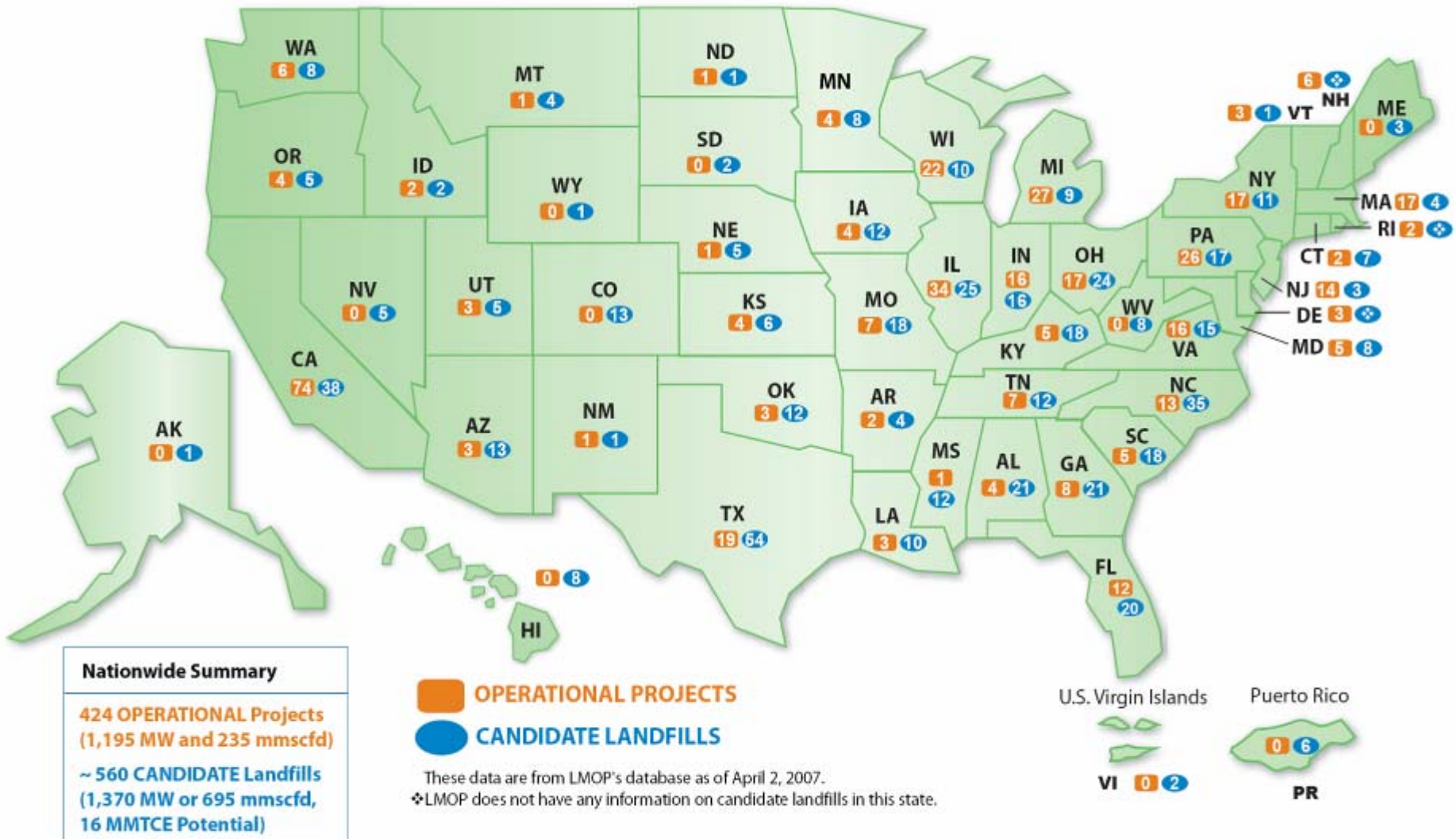


Electricity Generation (EPA LMOP)

- At least 400 operational projects in 40 states supplying:
 - **9 billion kilowatt hours** of electricity and 74 billion cubic feet of landfill gas to direct-use applications in 2005
- Estimated **Annual Environmental Benefits**:
 - Planting nearly 19,000,000 acres of forest, or
 - Preventing the use of over **160,000,000 barrels of oil**, or
 - Removing emissions equivalent to over **13,000,000 vehicles**, and
 - Powering over **725,000 homes** and heating nearly **1,200,000 homes**.

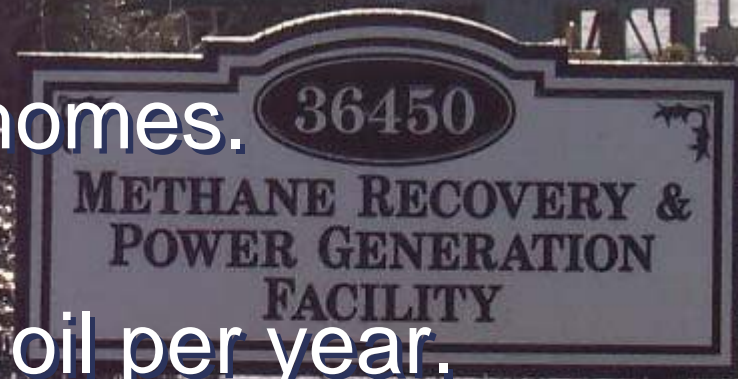


Landfill GTE Development by State



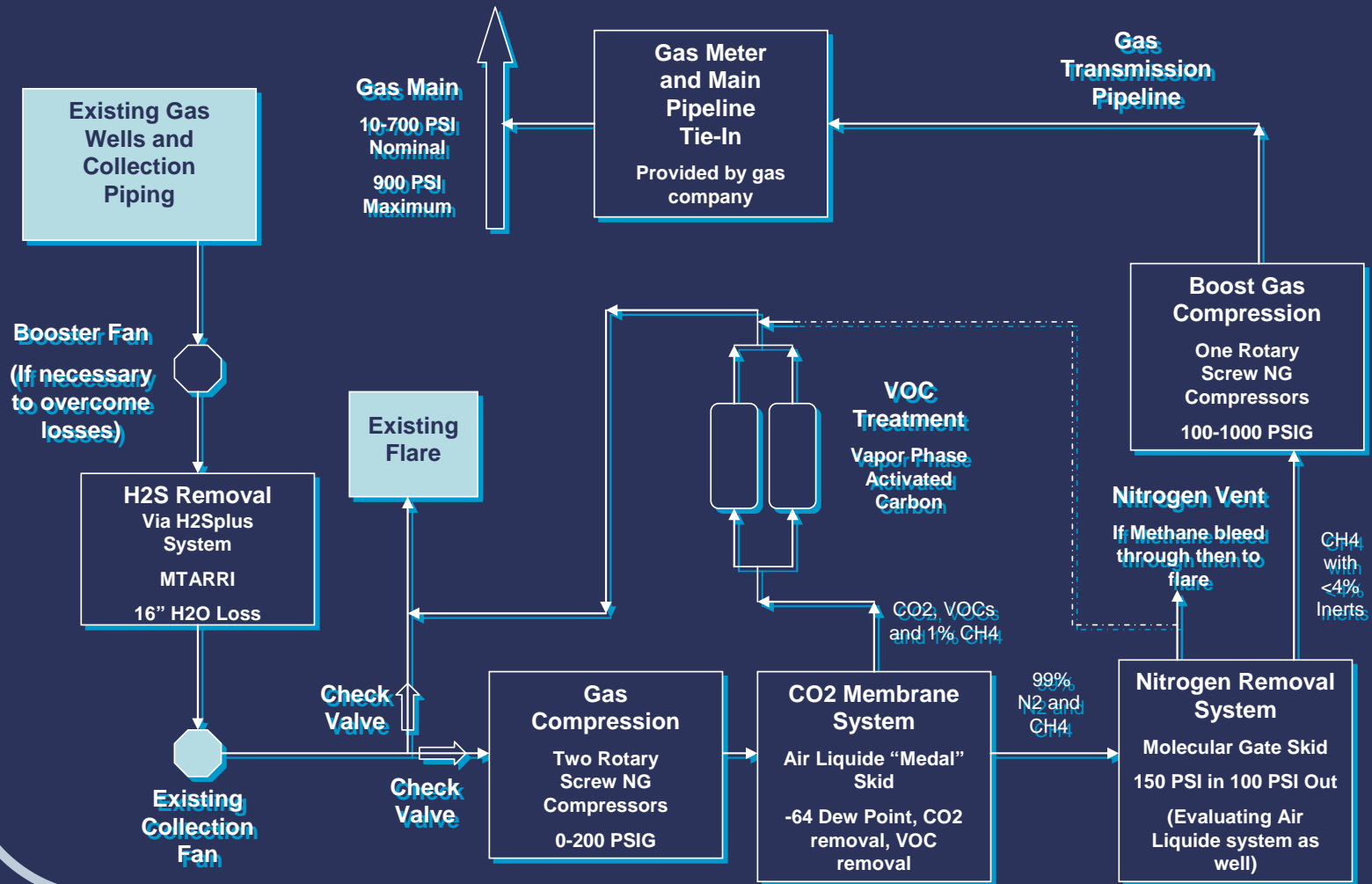
Landfill Gas to Energy

- Pine Tree Acres Generates 5,600 kW.
- Enough to power 5,000 homes.
- Equals 98,000 barrels of oil per year.



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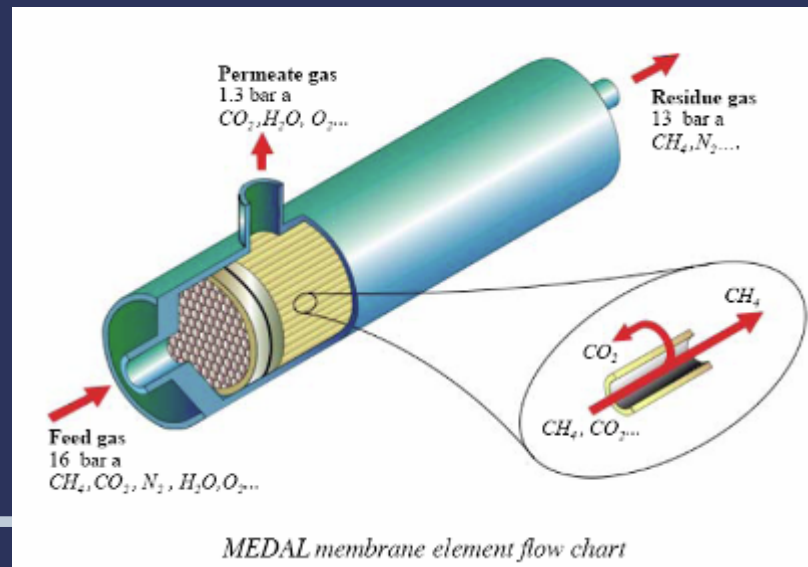
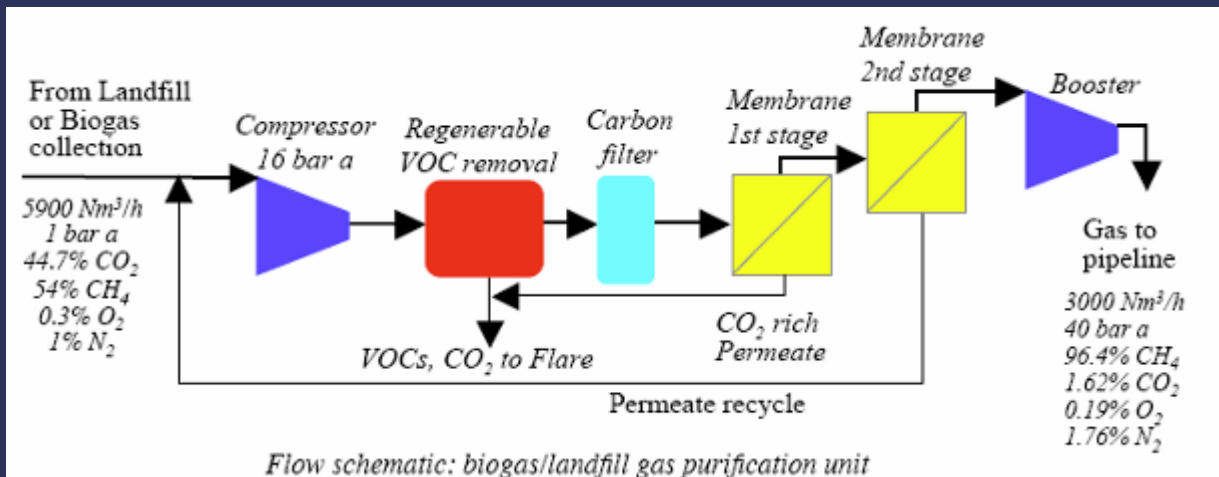
High BTU Gas Purification



Hydrogen Sulfide Removal



Carbon Dioxide Removal



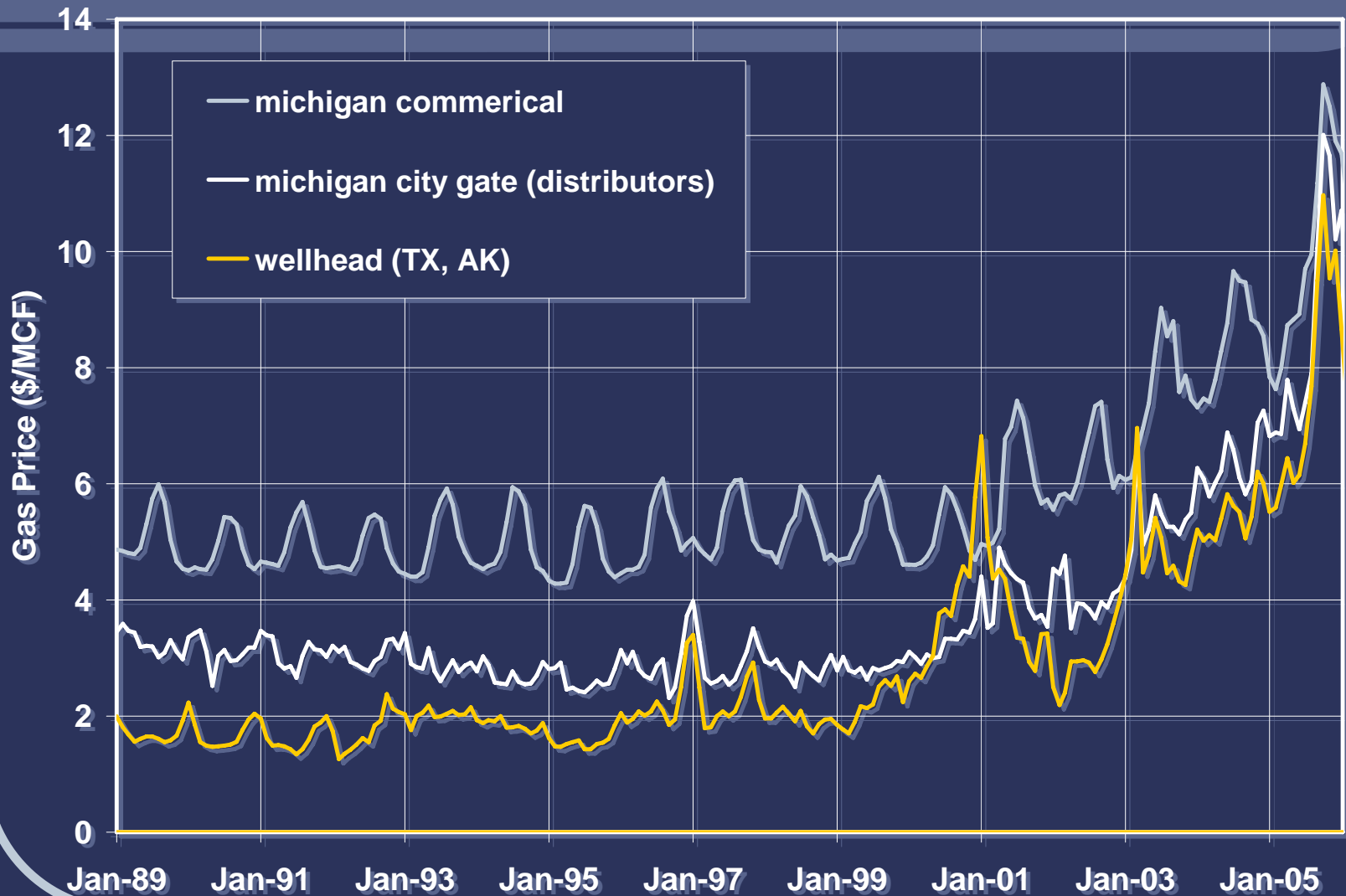
Carbon Dioxide Removal



Nitrogen Removal (Molecular Gate)



Gas Price History



Biological Methane Potential (BMP)

- **1** ton of MSW produces **3,000** cubic feet (**85 m³**) of methane (\$18~\$27)
- Bioreactors accelerate the process
- LFG can be processed in economically feasible quantities

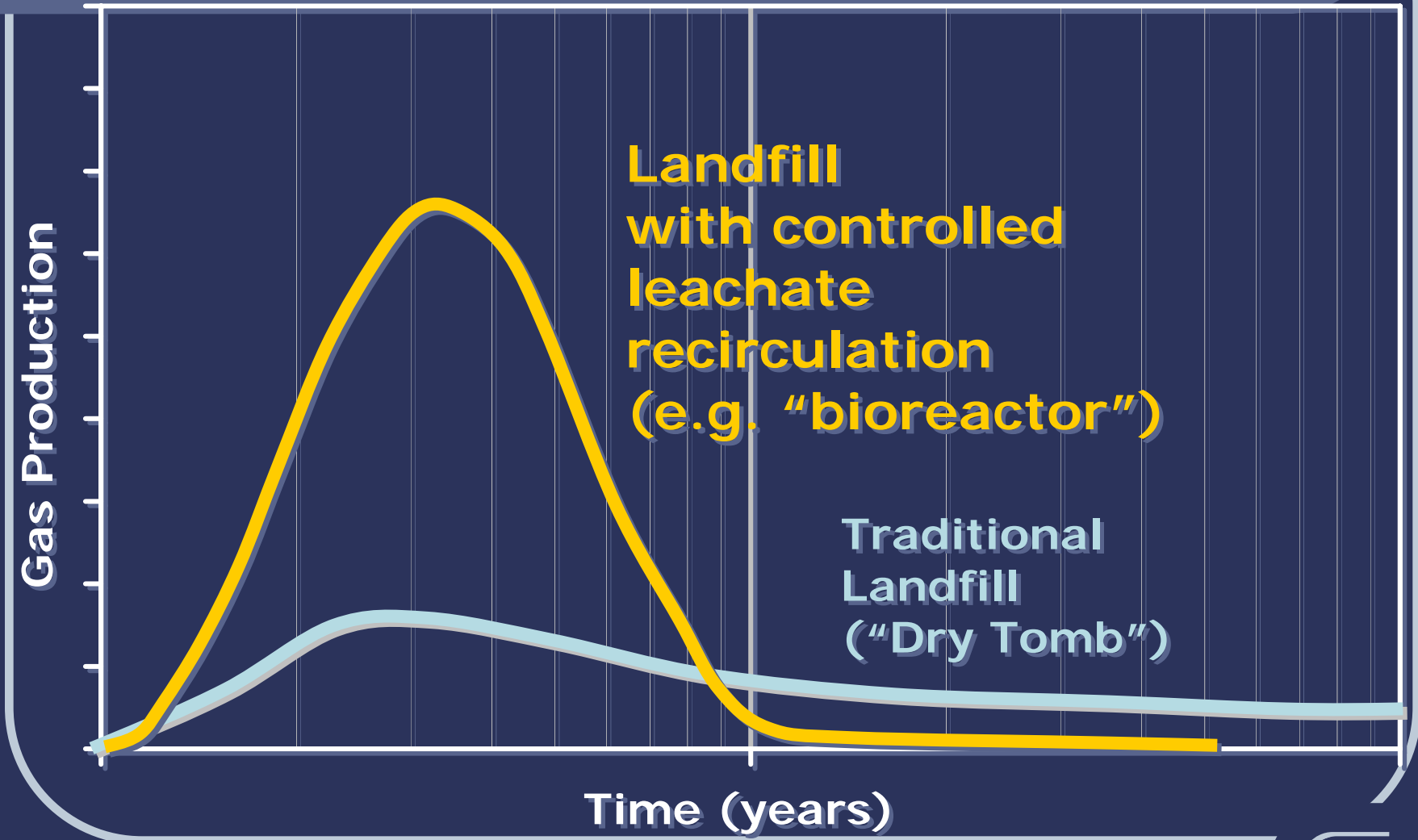


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Landfill Gas Production



Factors Influencing LFG Production

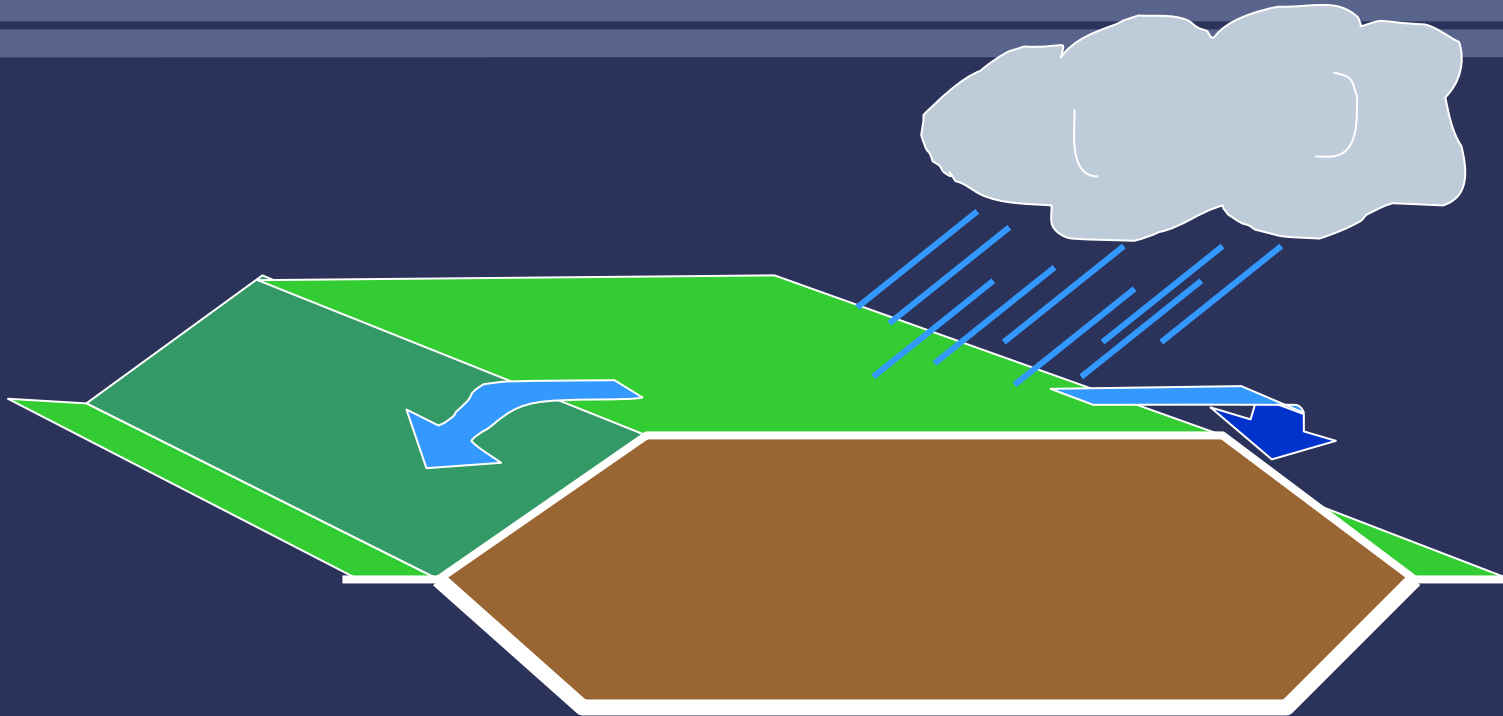
- Moisture
- Temperature
- pH-level
- Nutrients

Note:

- *Leachate recirculation allows for control of moisture*
- *Bioreactor operation will allow for optimal temperature control*



“Dry Tomb Landfill”



- waste sealed from moisture
- indefinite timeframe for decomposition/gas generation



“Dry Tomb Landfill”



Fall 1998

Test Cell # 2 (Dry)

Chicken Leg

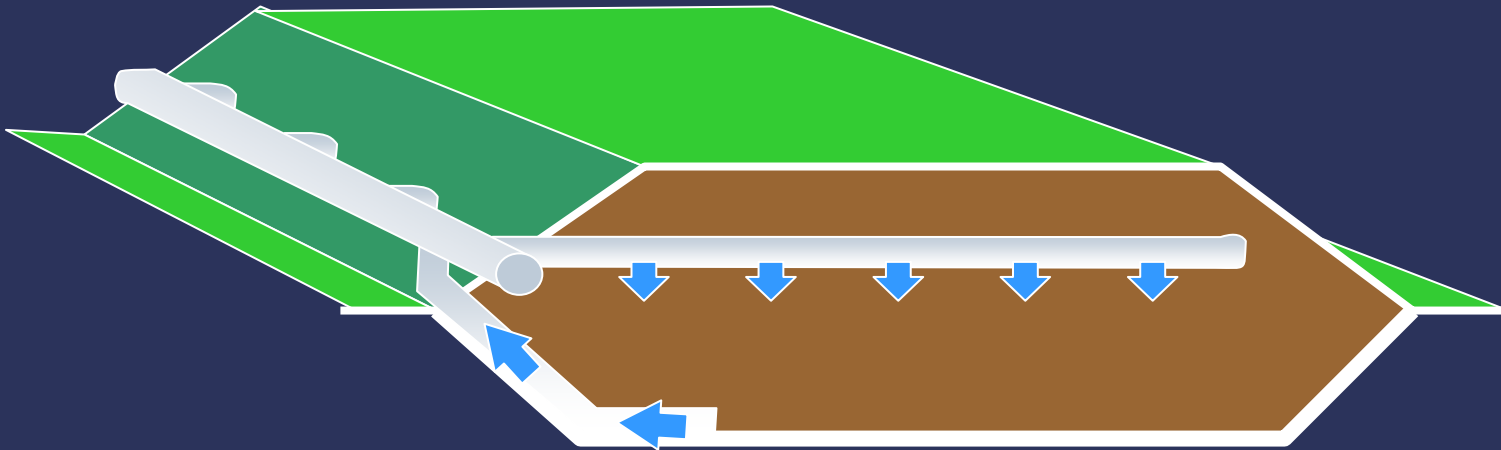


Chicken Leg



8 years in a “dry” landfill

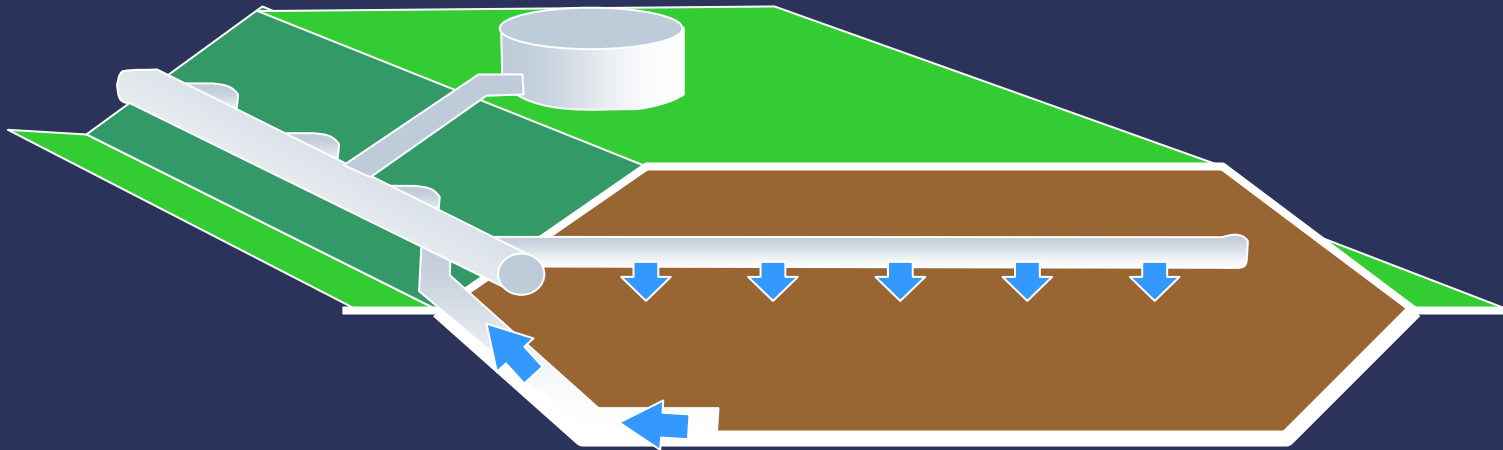
Leachate Recirculation



- controlled reintroduction of collected leachate
- accelerated decomposition/gas production



Bioreactor Landfill



- controlled reintroduction of collected leachate/other liquids/air
- maximum decomposition/gas production



Wet / Bioreactor Landfill

● Basic Requirements

- Microorganisms: balanced and developed community
- Food – organic fraction in MSW
- Water
- (Oxygen for aerobic process)
- Suitable chemical conditions
 - pH: 6 – 9
 - Non inhibitors

- **Leachate recirculation**
- **Minimum (or no) performance monitoring**
- **No optimization**

● Optimization Requirements

- Optimal moisture level
- Temperature: 30 – 50 °C (86 – 120 F)
- Nutrients – phosphate, ammonia, and trace metals: Copper, Cobalt, others

Optimized Bioreactor Operation



Geotechnical Challenges

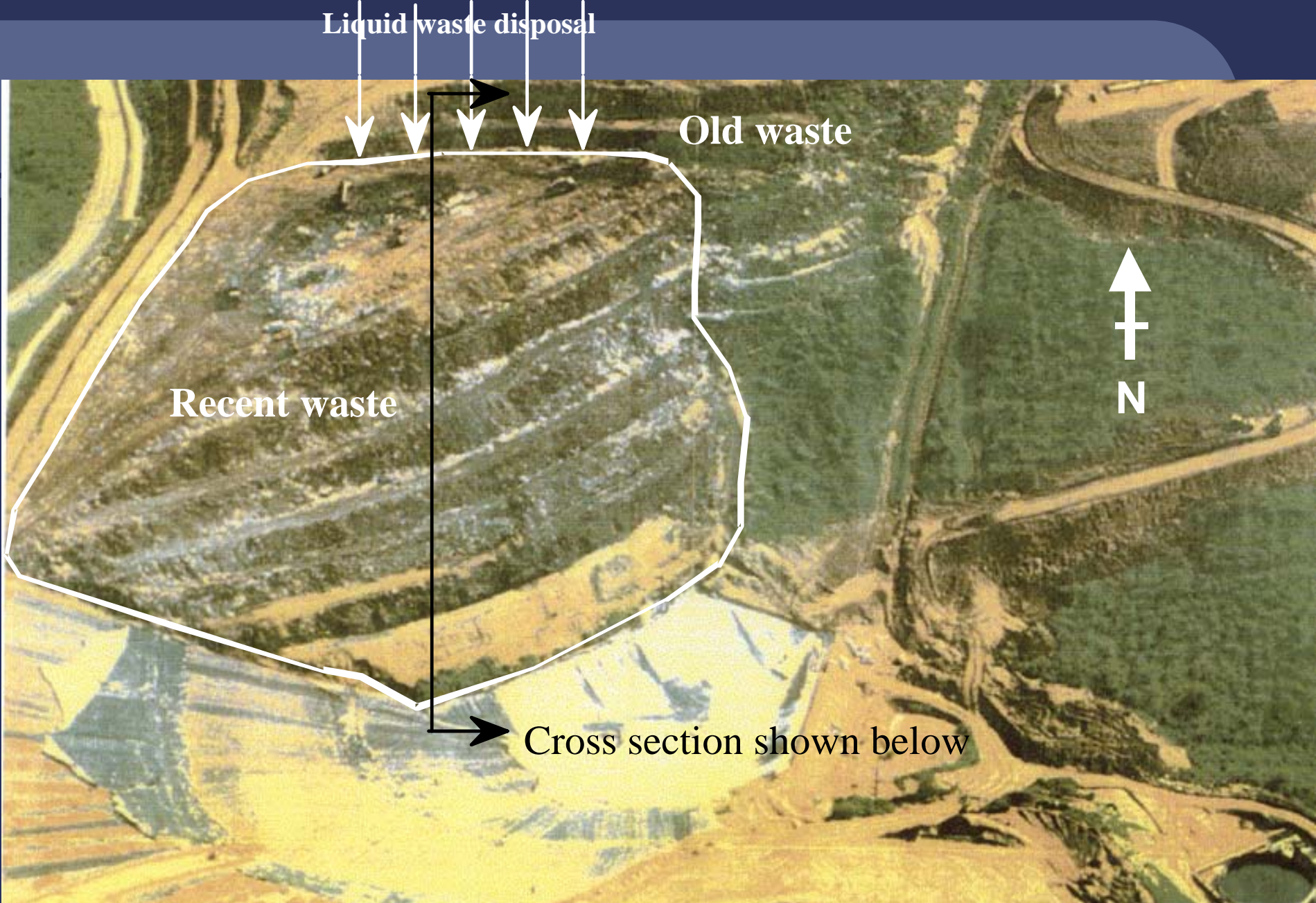
- Waste Mass Stability
- Flow Through Heterogeneous Media
- Performance Monitoring



Geotechnical Challenges

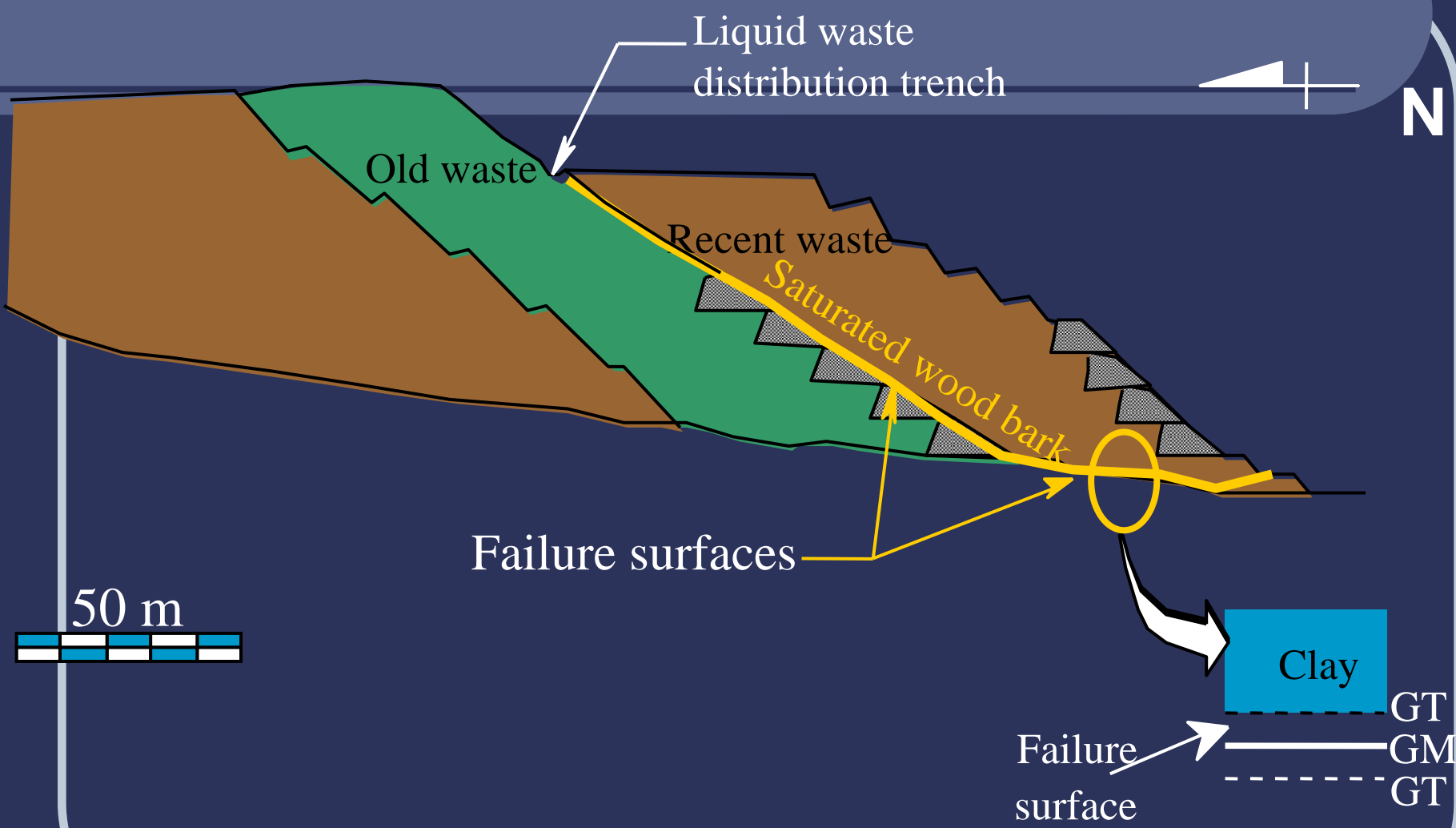
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Aerial photograph taken shortly before failure



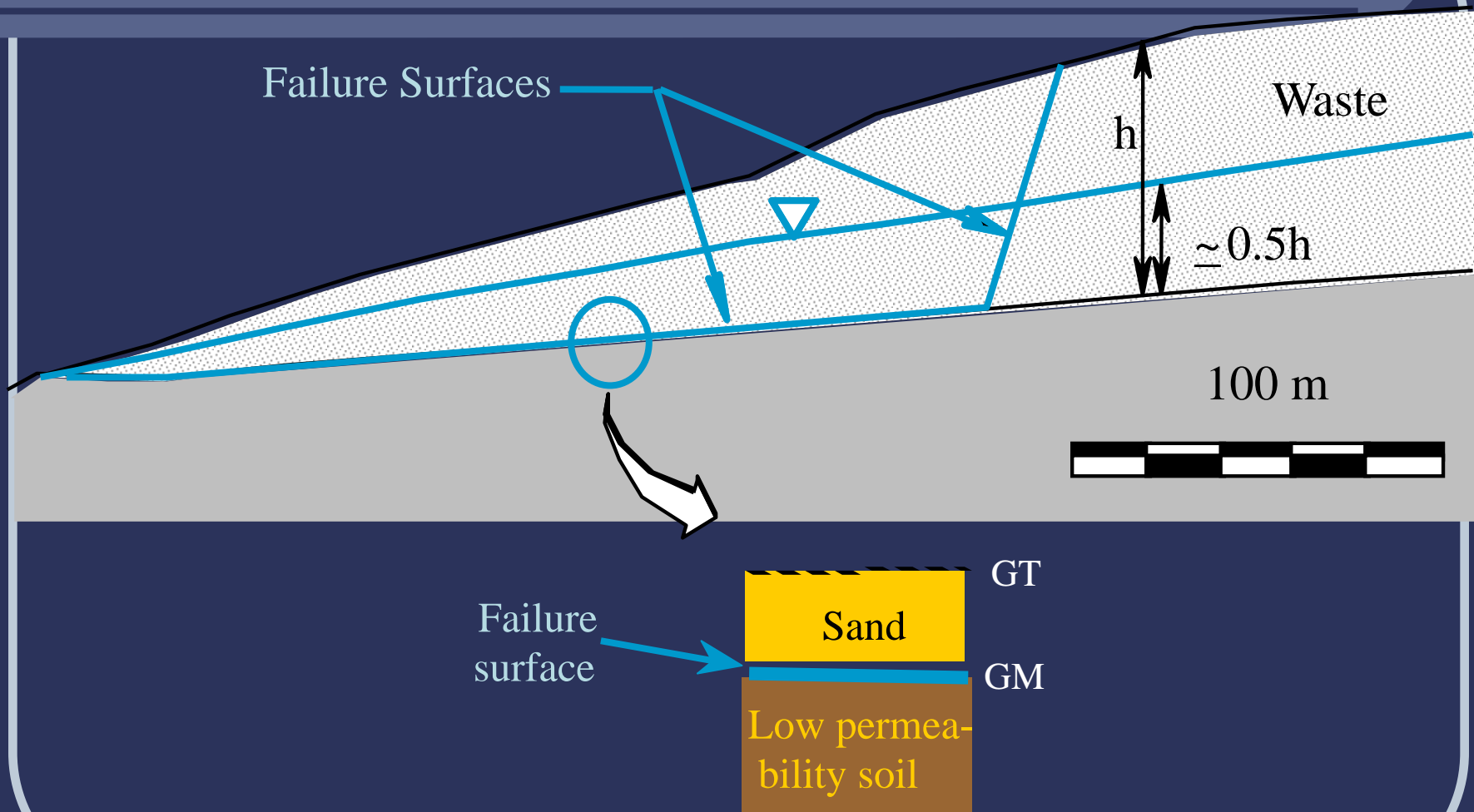


Critical 2-D cross Section









Critical 2-D cross section with estimated leachate level prior to failure





'96 5 24



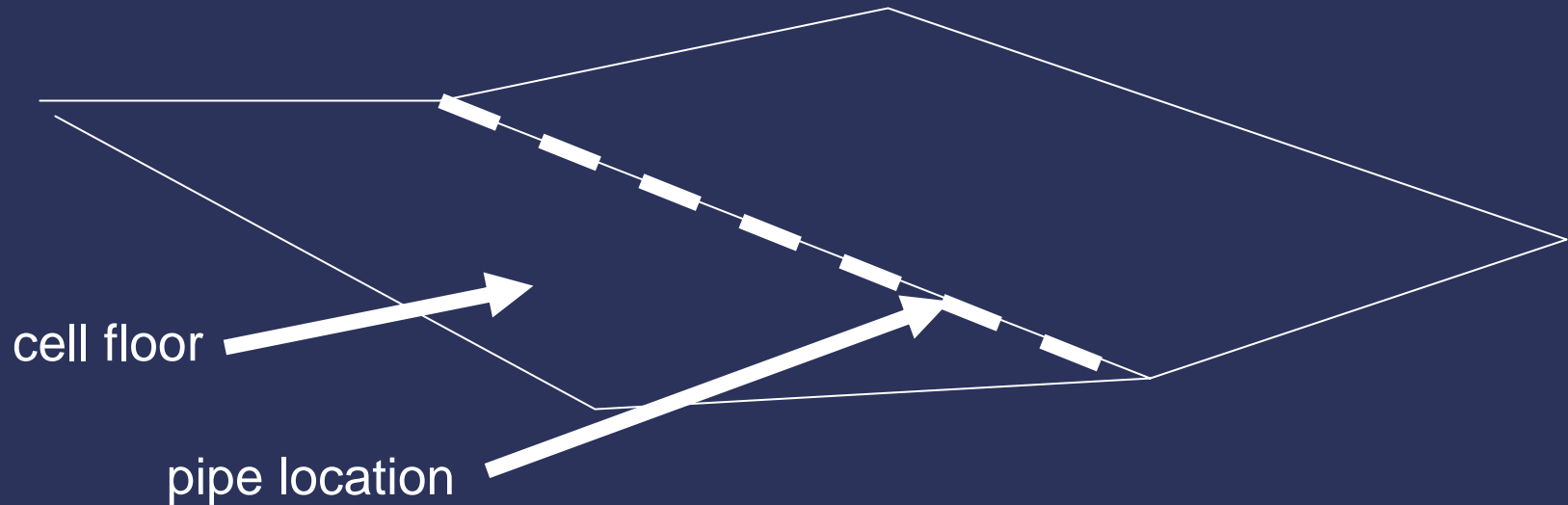




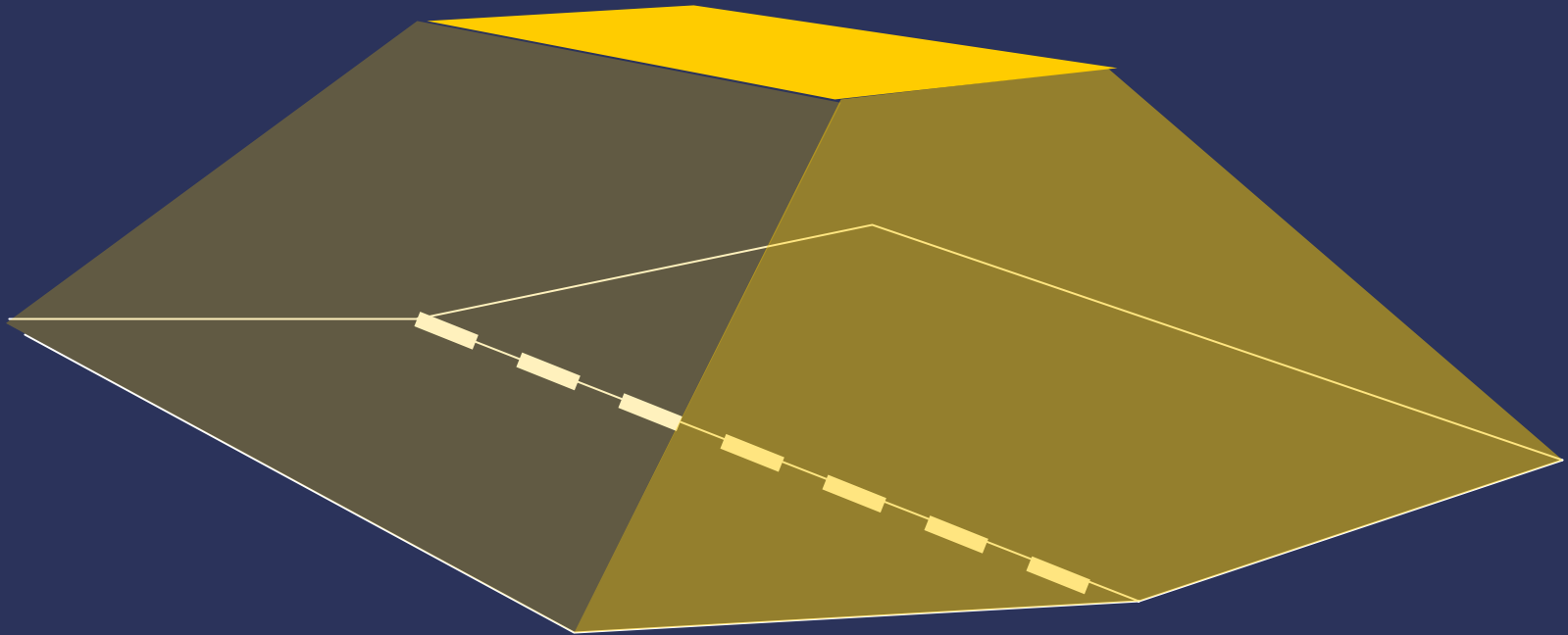
HDPE Leachate Collection Pipe



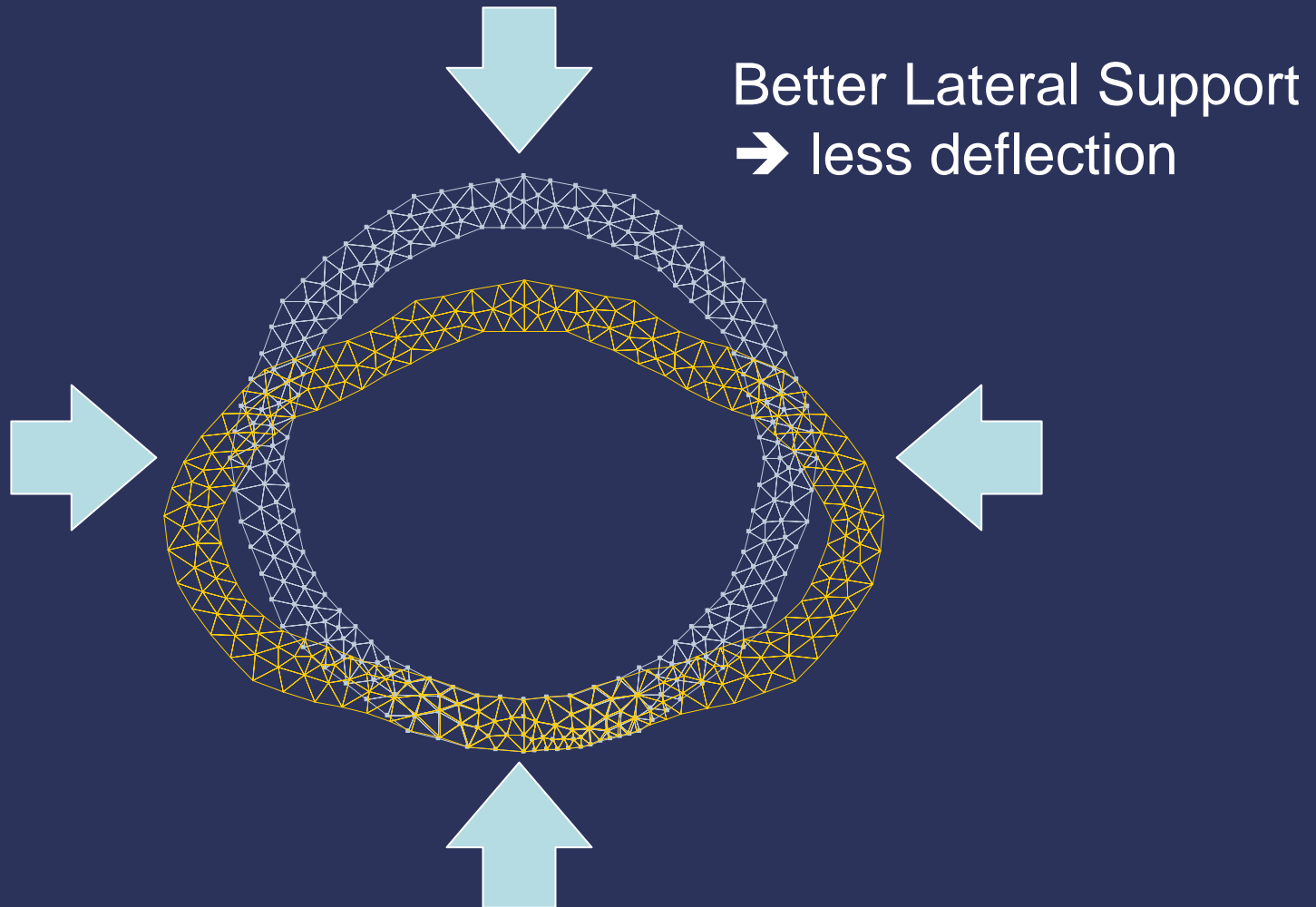
Leachate Collection Pipe



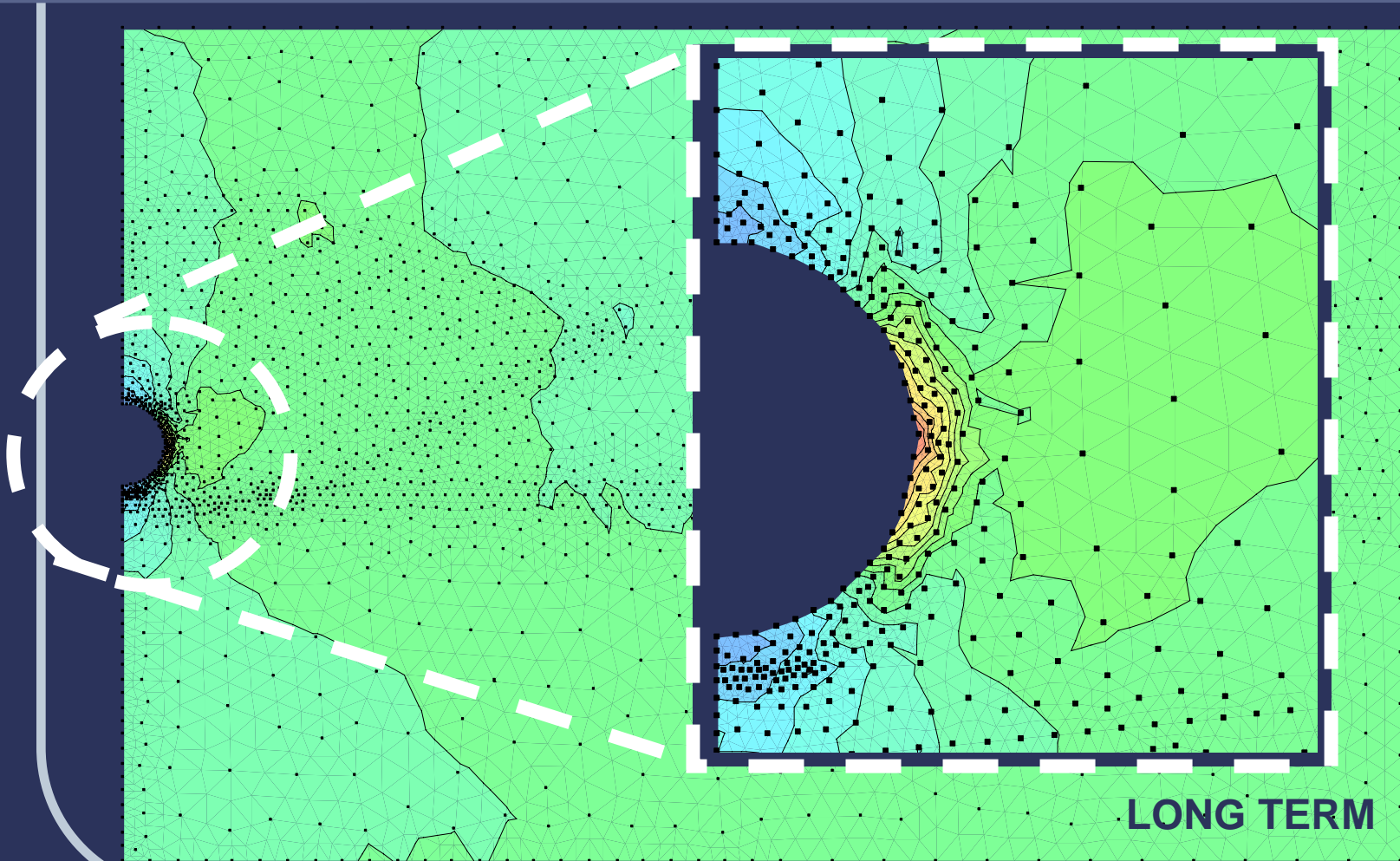
Leachate Collection Pipe

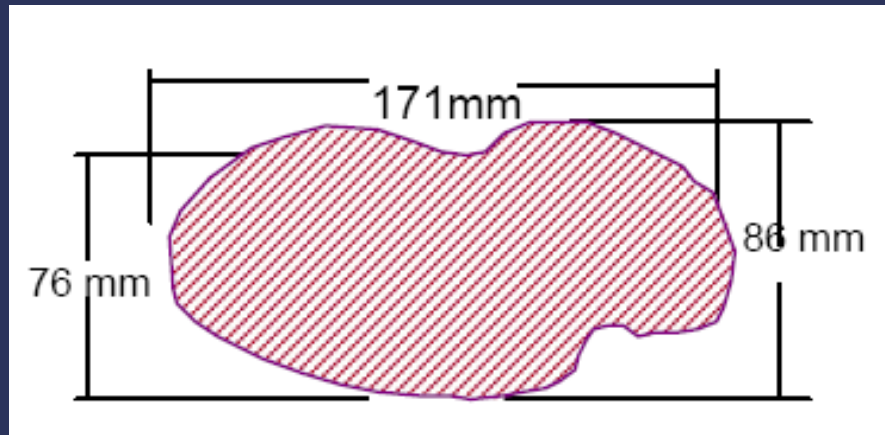
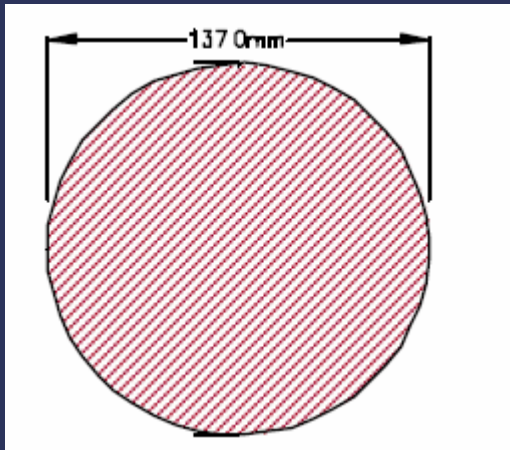


Pipe Load/Deflection



Vertical Stress Under Load



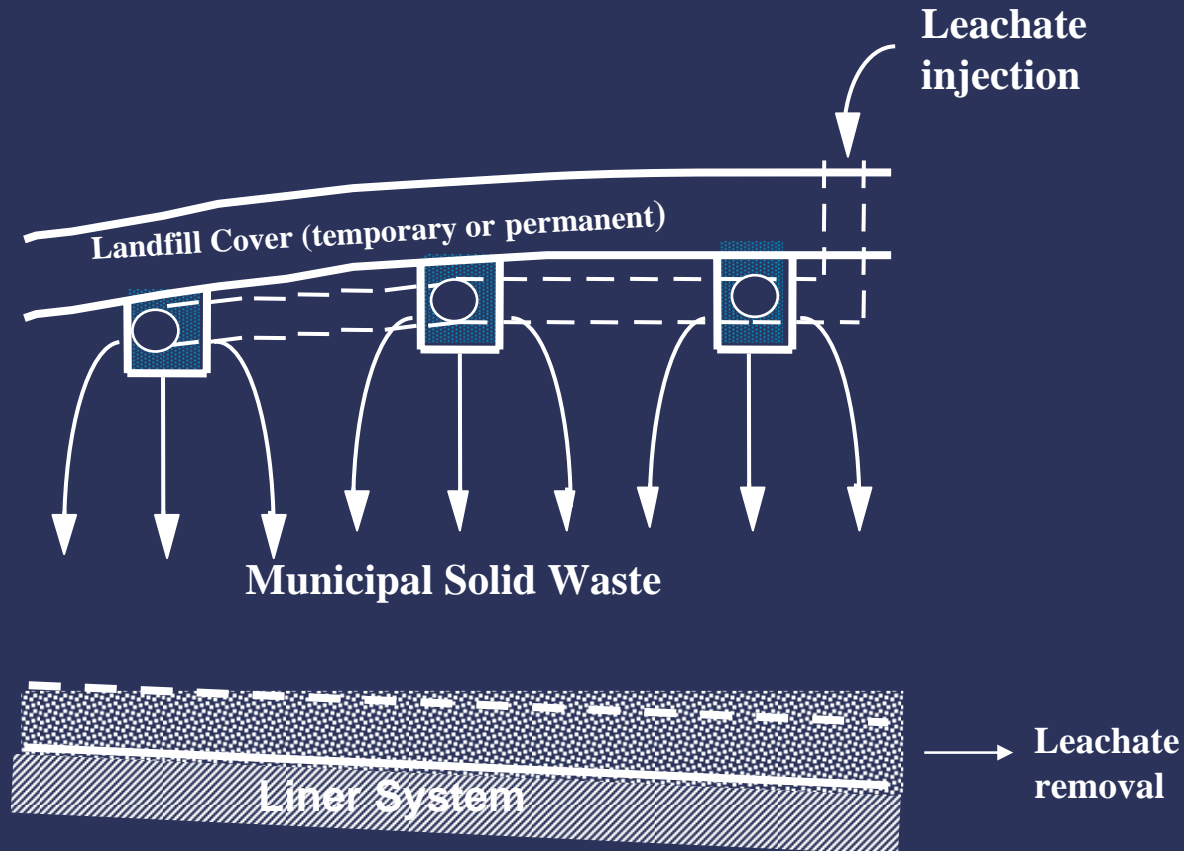


Geotechnical Challenges

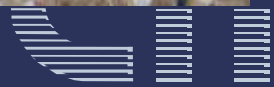
- Waste Mass Stability
- Flow Through Heterogeneous Media
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Flow Through MSW







Geotechnical Challenges

- Waste Mass Stability
- Flow Through Heterogeneous Media
- Performance Monitoring



Monitoring Devices



Monitoring Devices

Moisture and Temperature Probe



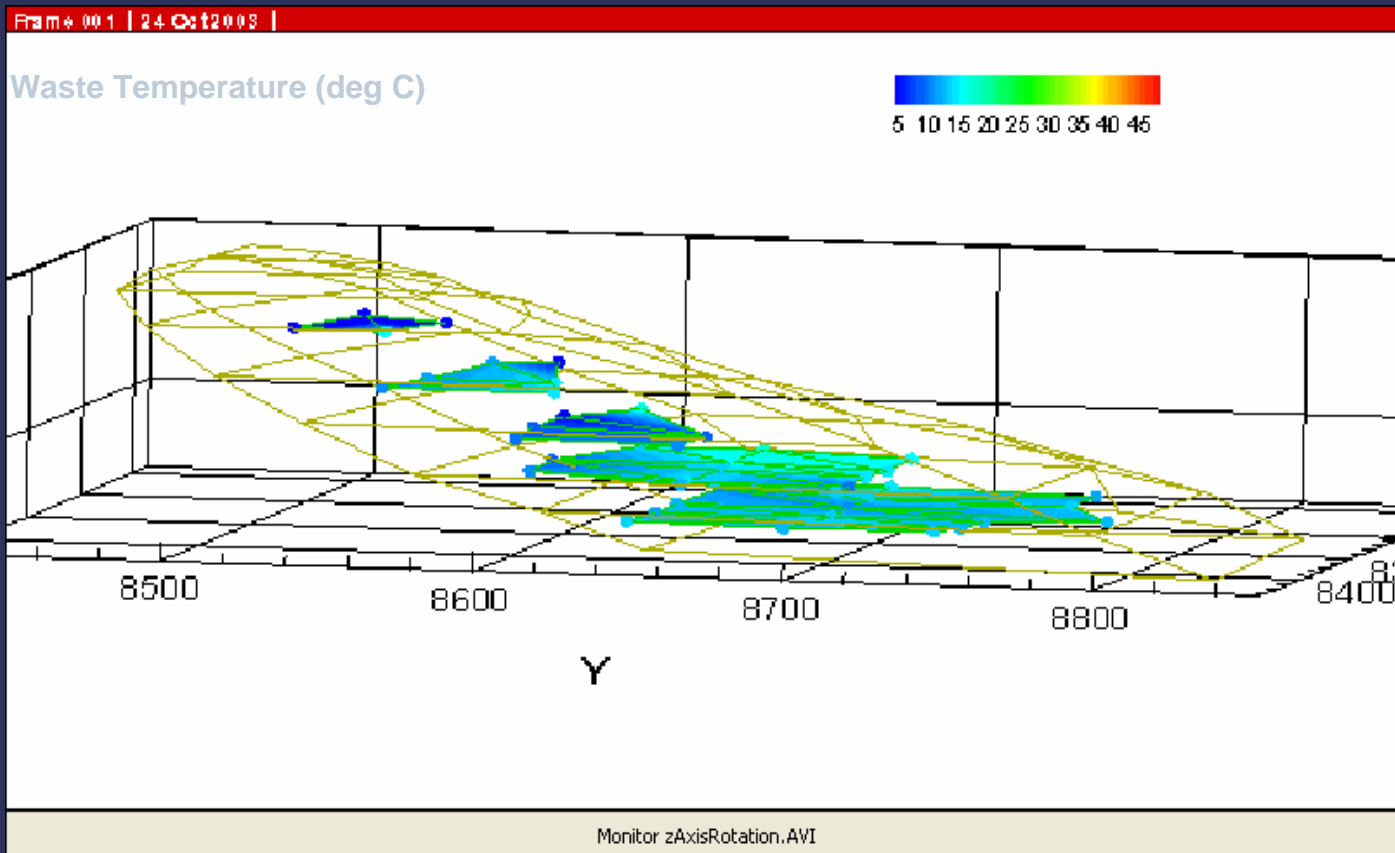
Leachate Basket



Gas Port

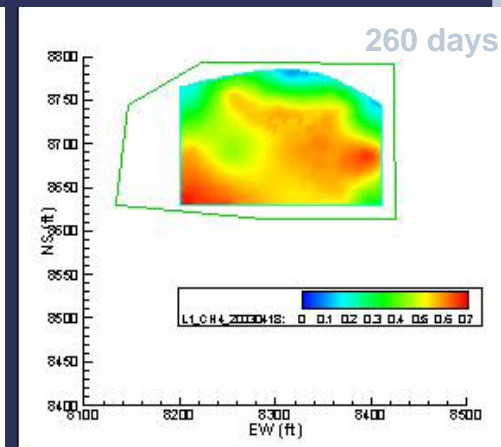
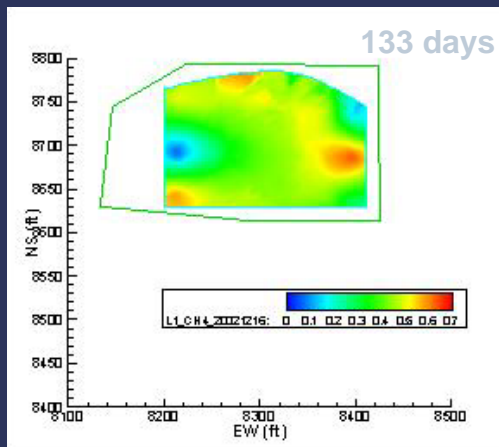
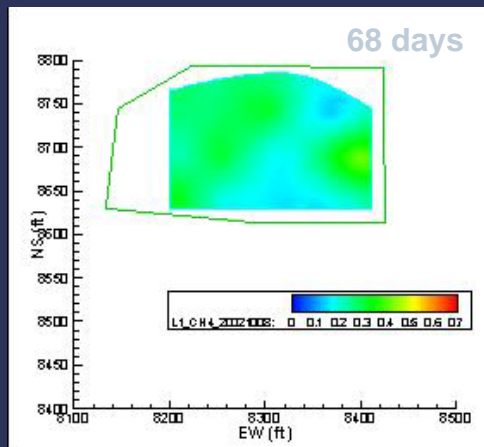


Harrison, MI Bioreactor

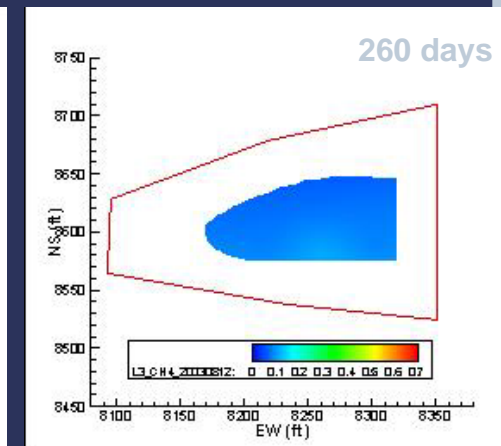
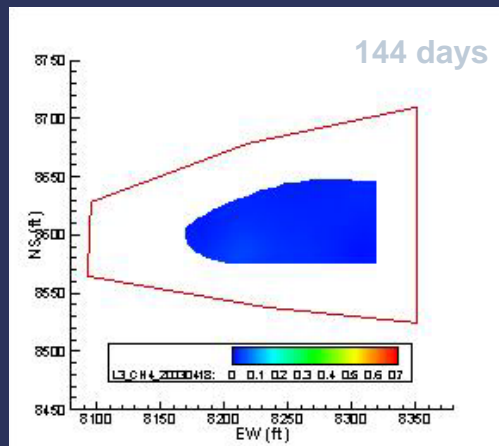
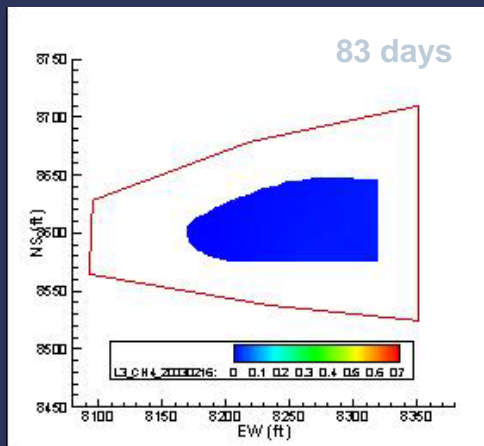


Methane Concentration

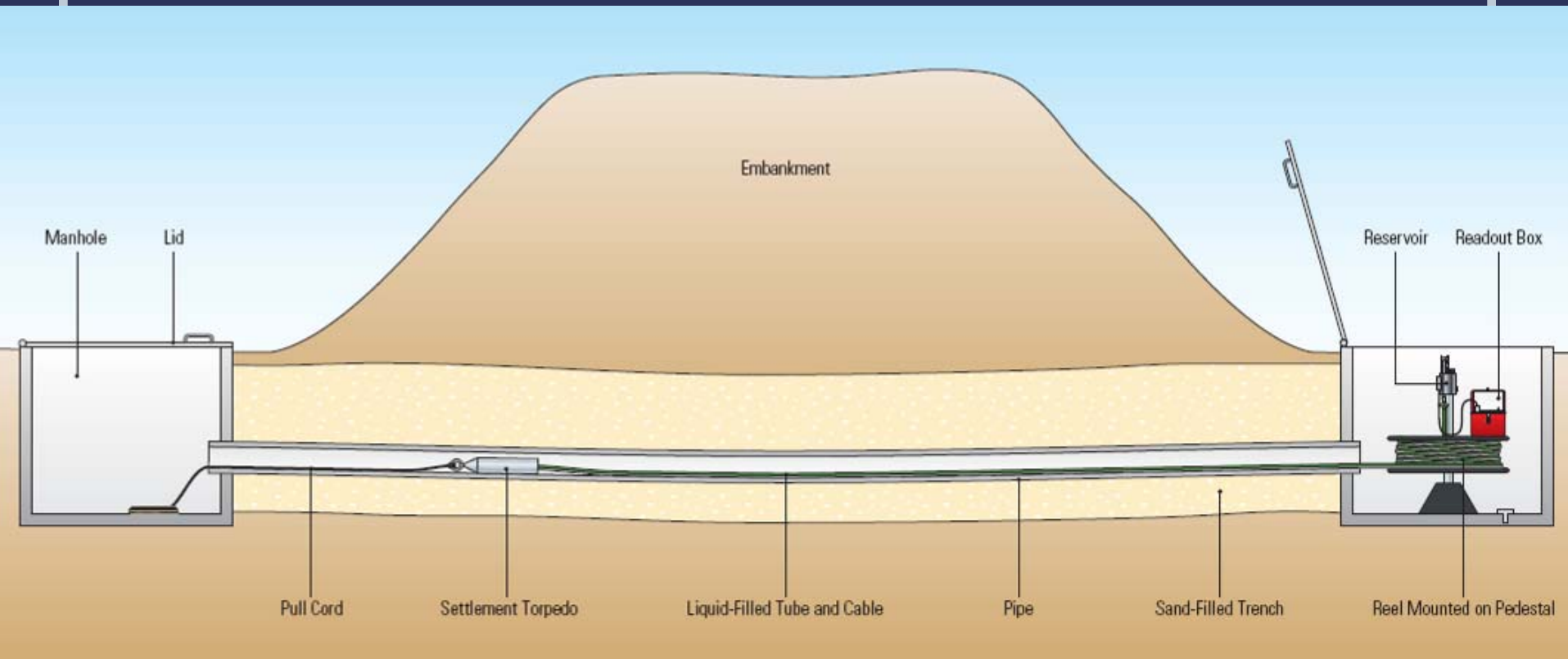
LIFT 1



LIFT 3



Settlement Profiler

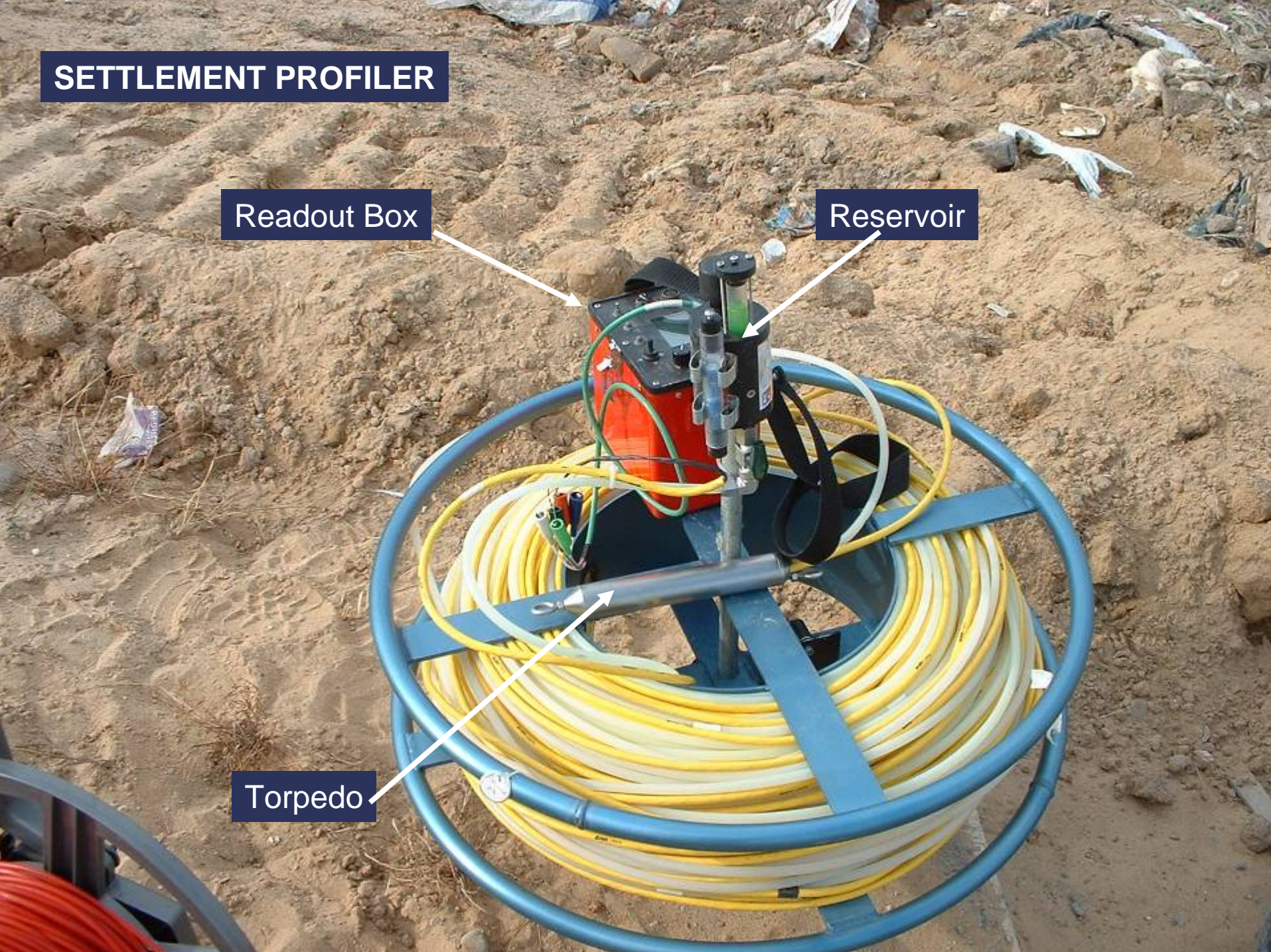


SETTLEMENT PROFILER

Readout Box

Reservoir

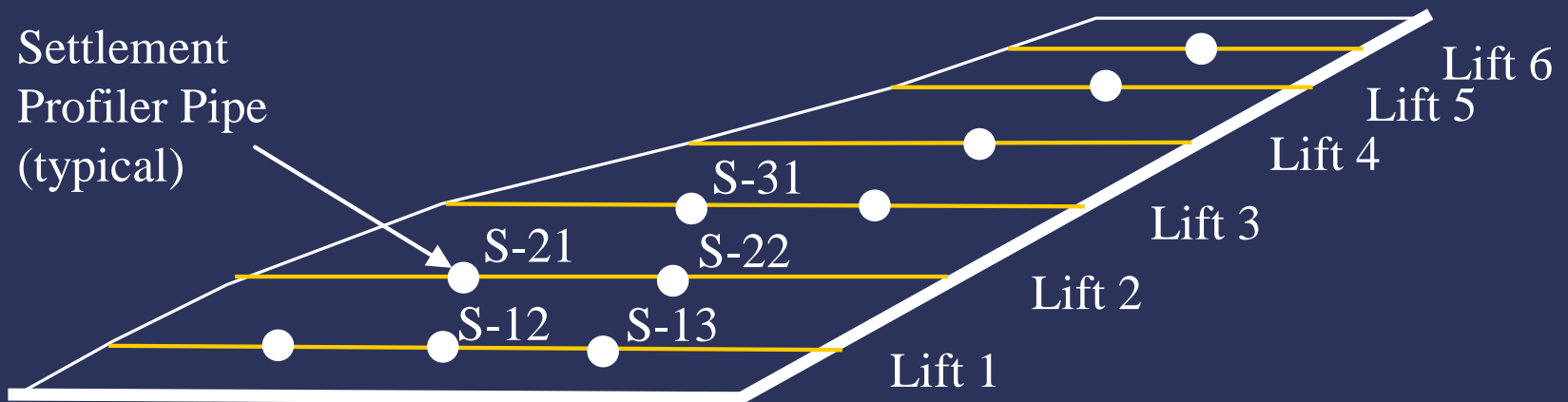
Torpedo



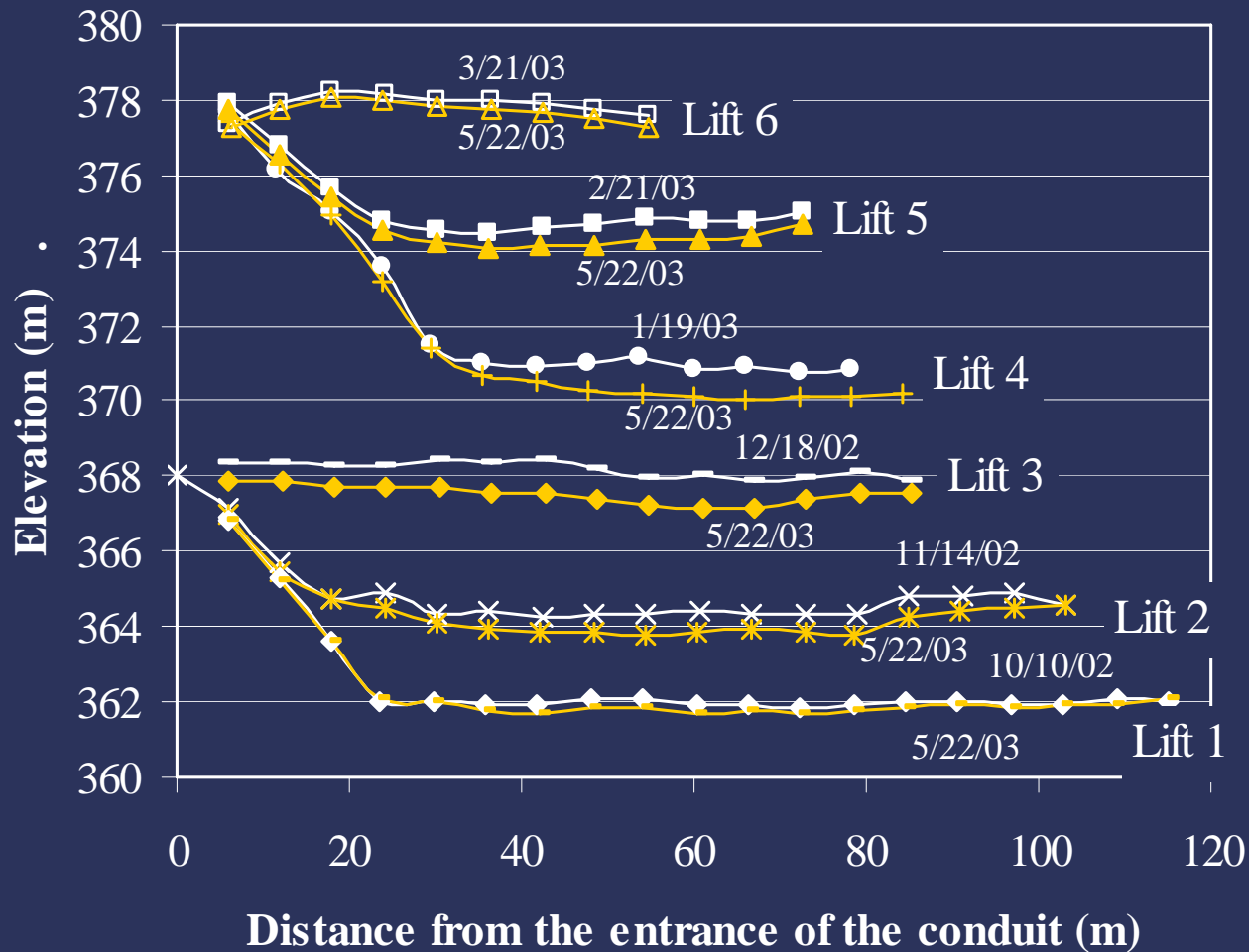
Profiler Conduit Installation



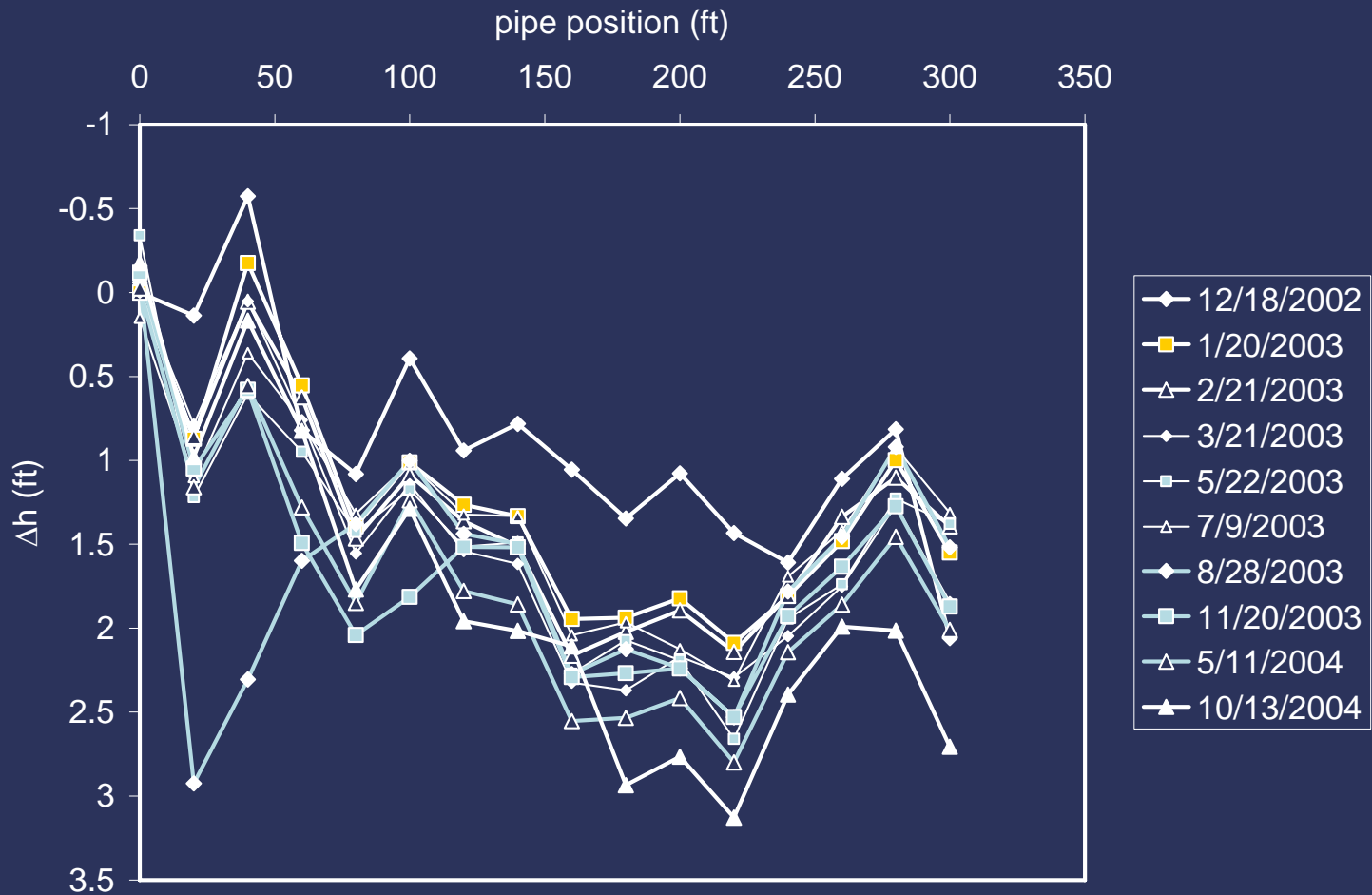
Profiler Conduit Installation



Profiler Measurements



Measured Settlement – 2 yrs.



Summary

- LFG is a significant energy resource
- Wet landfill technology can increase access to this resource
- Geotechnical Engineering is key to the safe recovery of LFG

