

# Innovative Design Approach for Mitigating Landfill Gas: A Landfill Post-Closure Mixed-Use Development Case Study

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# Outline

- Site Background
- Pilot Testing
- Pneumatic Modeling
- Design Considerations
- Landfill Gas Mitigation Strategy
- Conceptual Design

# Site Background

- Landfill operated from 1960s to 1990s
- Accepted 5.5 millions tons of refuse over 240 acres





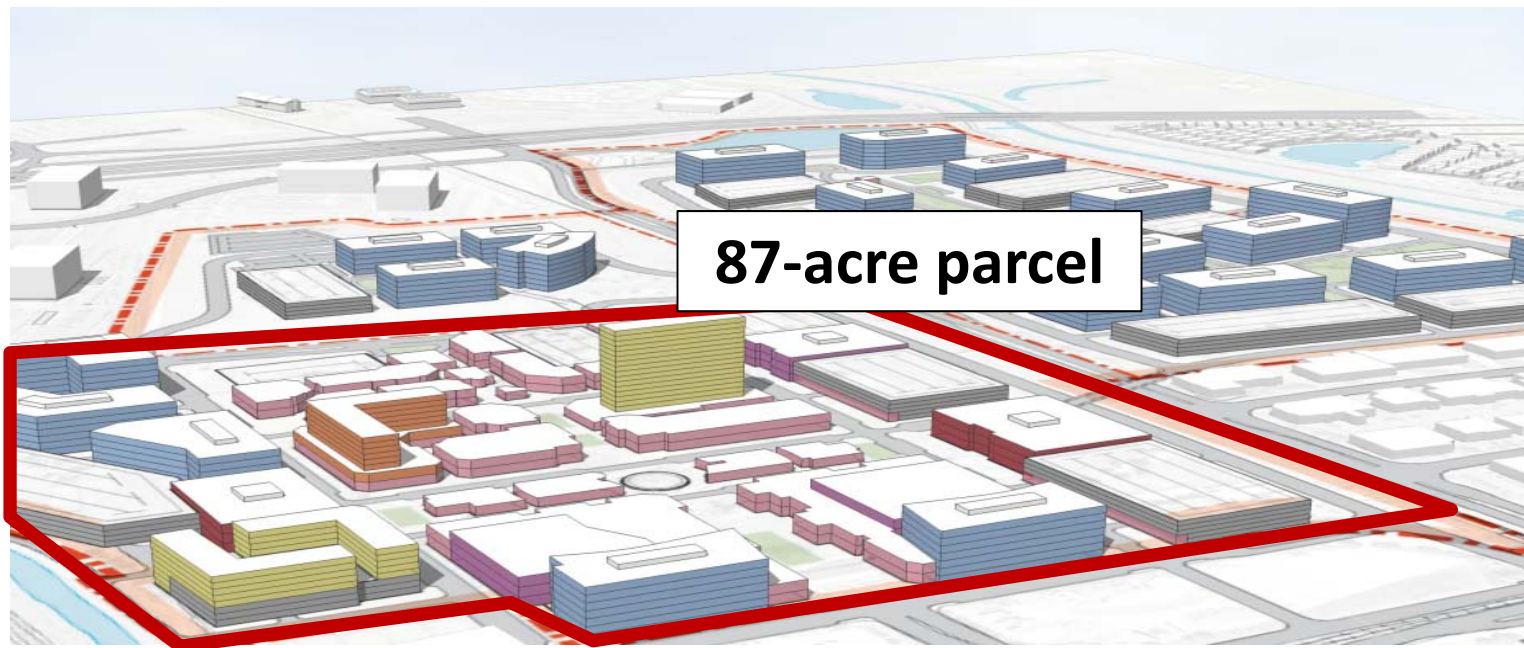
# Site Background

- Mixed-use Development Mega Project
  - Largest private development project in Silicon Valley's history
- Environmental and Geotechnical Challenges
  - Landfill gas and VOCs mitigation
  - Design for significant settlement and seismic risks
  - Construction to safely operate during phased development
- Concentrations of methane up to 50% by volume (10 X LEL)



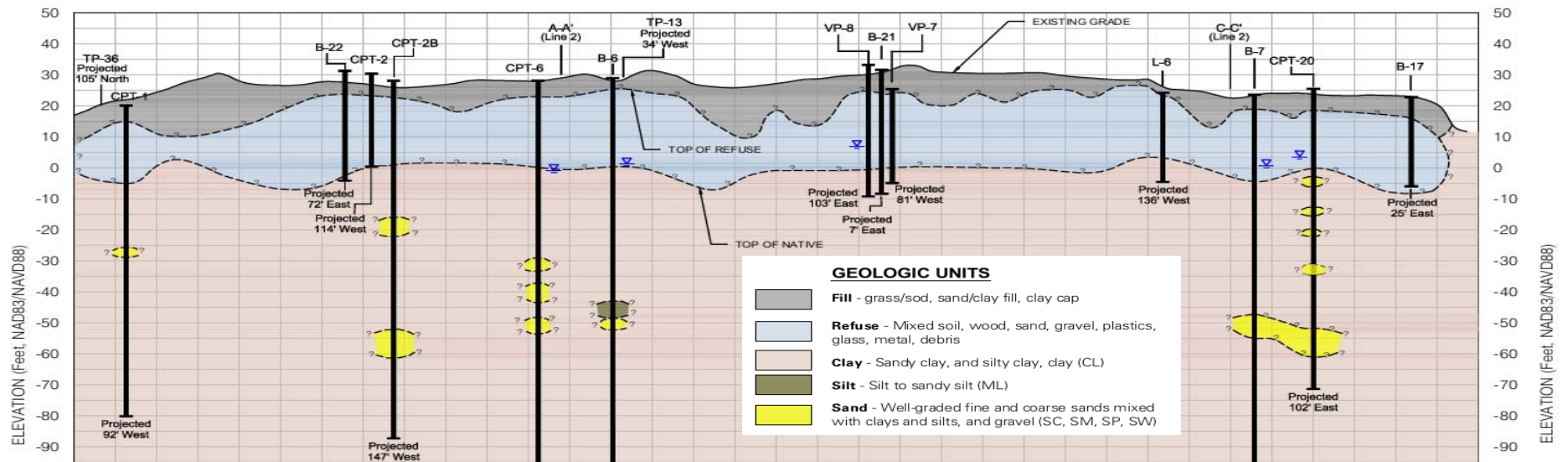
# Site Background

- Proposed multi-building, mixed-use development





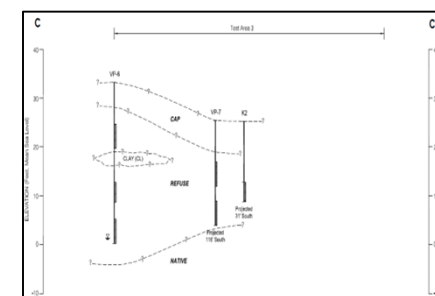
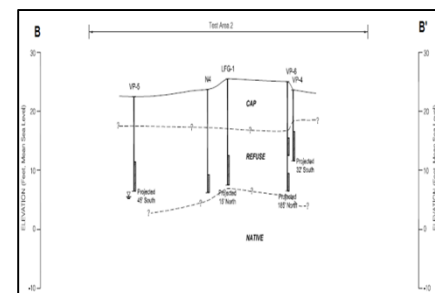
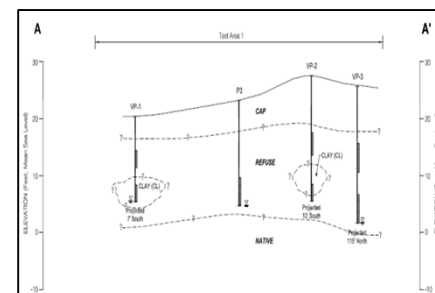
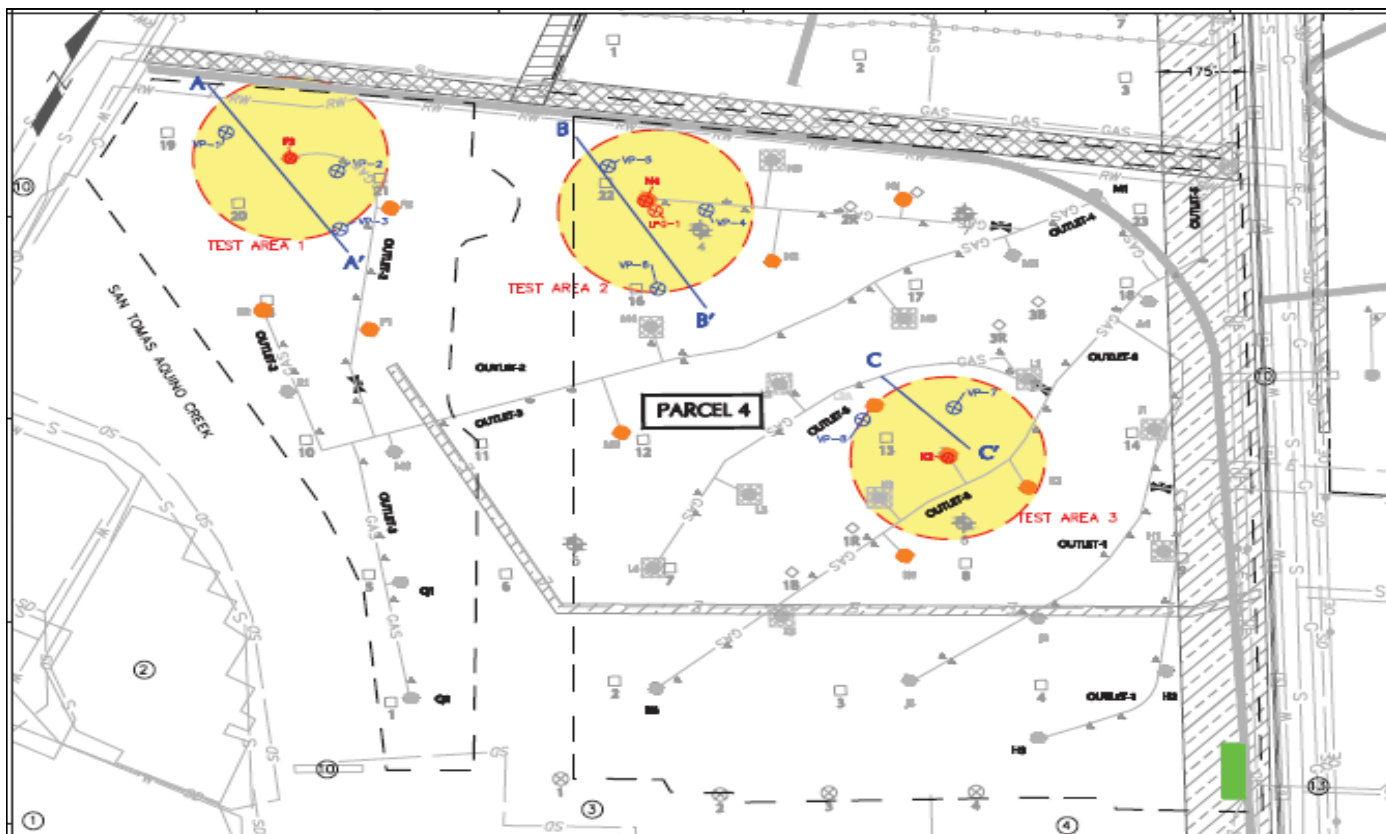
# Geologic Section



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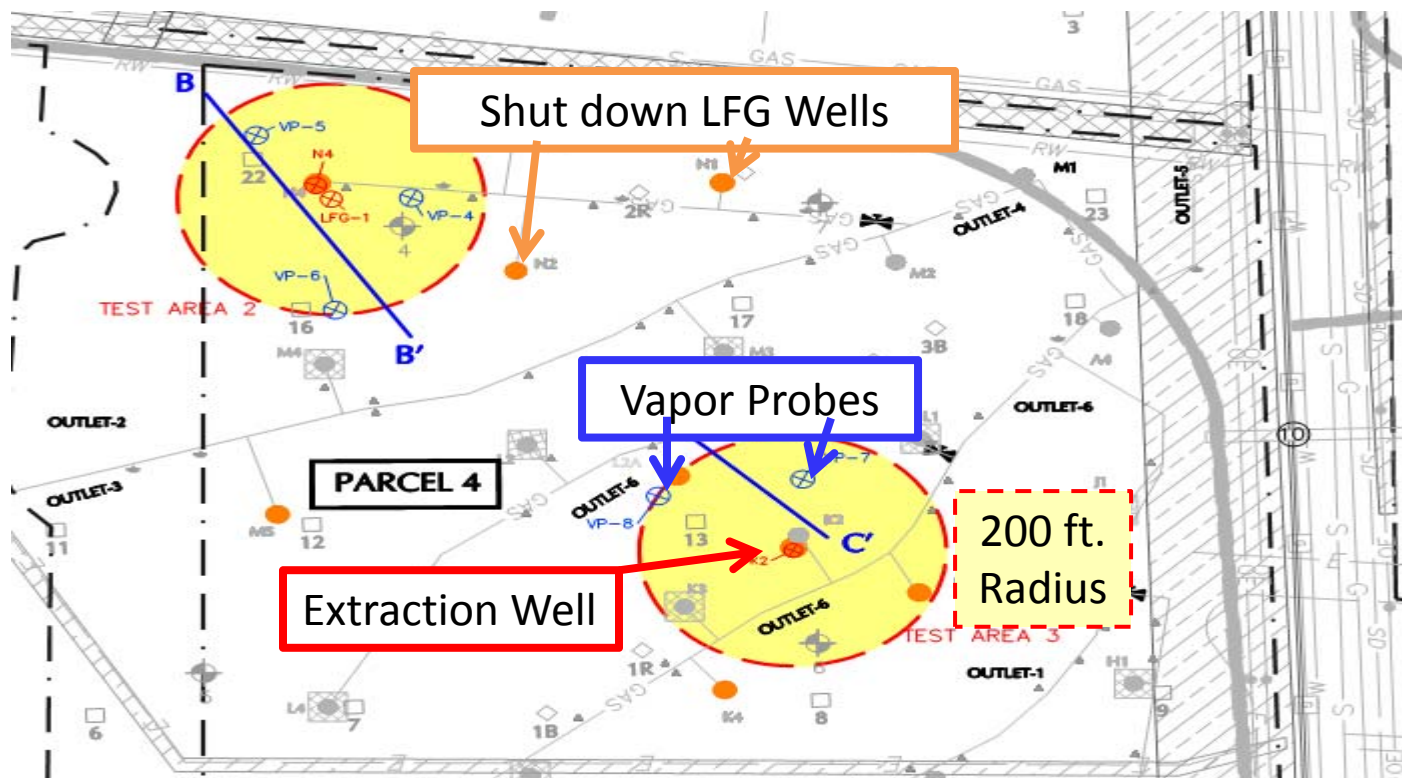
# Pilot Test



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# Pilot Test





# Pilot Test

## Testing Types:

- Baseline
- Isolated
- Anisotropy
- Rebound

## Parameters of Interest:

- Extraction Flow Rate
- Vacuum Propagation
- LFG Quality



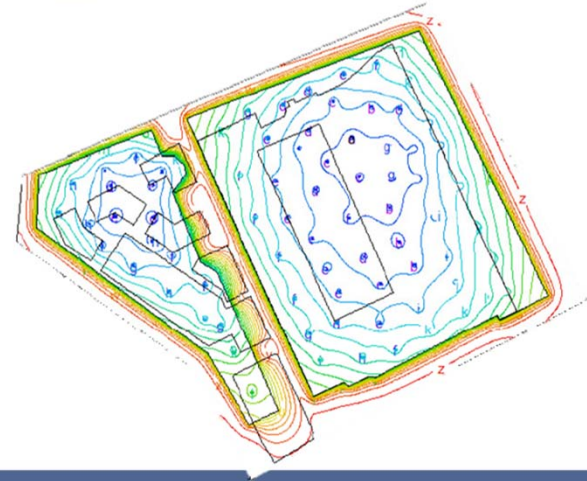
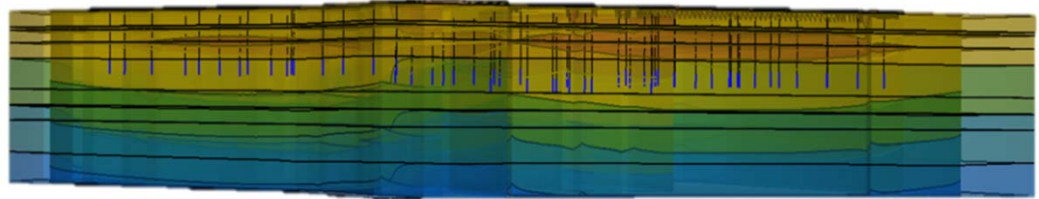
# Pilot Test



# Pneumatic Modeling

## WHY DO IT?

- Determine Existing Conditions
- Simulate Proposed Conditions
  - Structural Elements
  - Refuse Settlement
  - LFG Generation Rate
- Better Predict System Performance
- Cost-Effective and Reliable Remediation Systems
- **Saves Time and Money!**





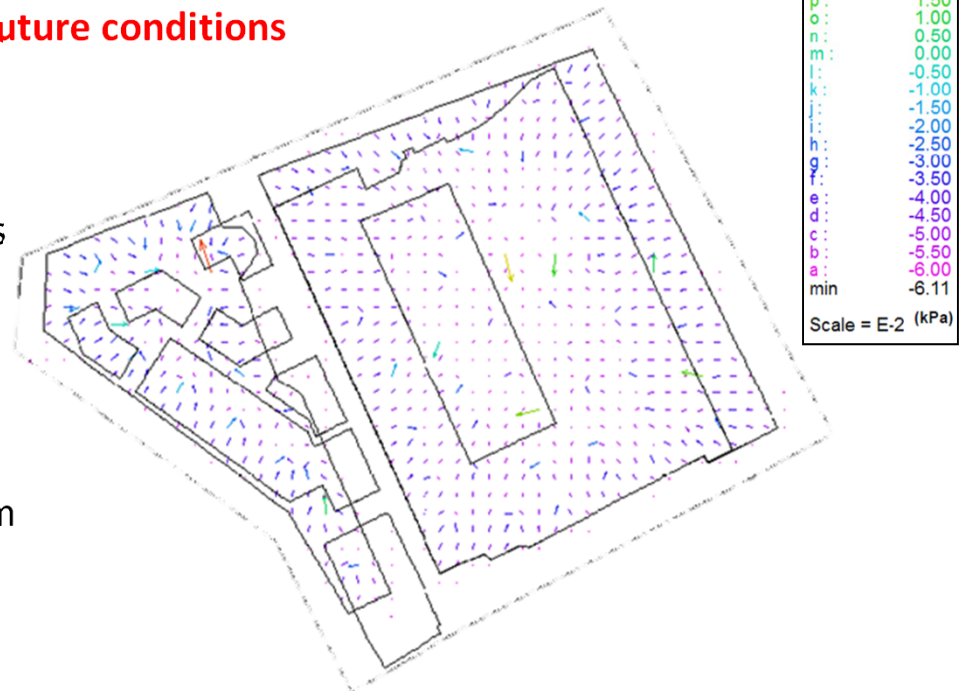
# Pneumatic Modeling

## OBJECTIVE:

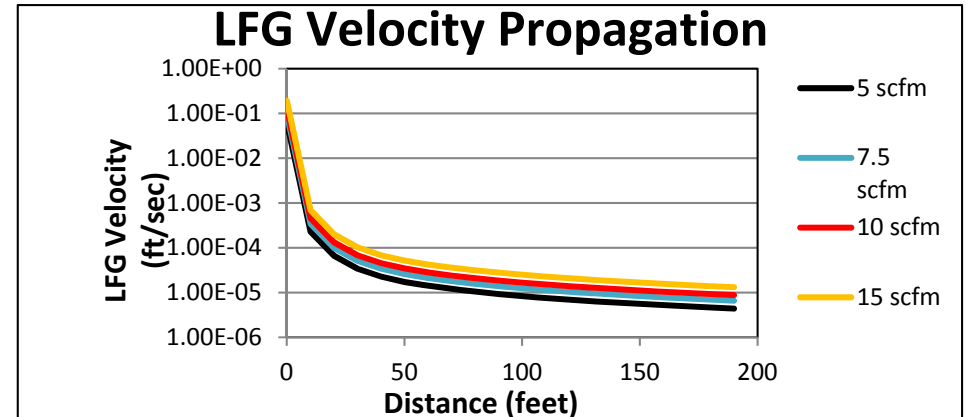
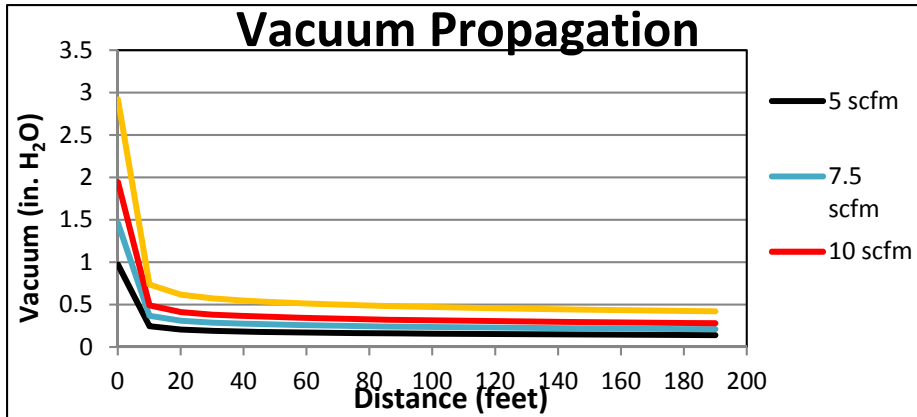
**Predict system performance under current and future conditions**

## Model Outputs:

- Radius of Influence
- Number and Spacing of LFG Extraction Wells
- Anisotropic Conditions
- Air Intrinsic Permeability
- Vacuum Propagation
- Pore Volume Exchanges
- Design LFG extraction flow rates and vacuum
- Balance LFG extraction with LFG generation



# Pneumatic Modeling



### Air Intrinsic Permeability Estimation:

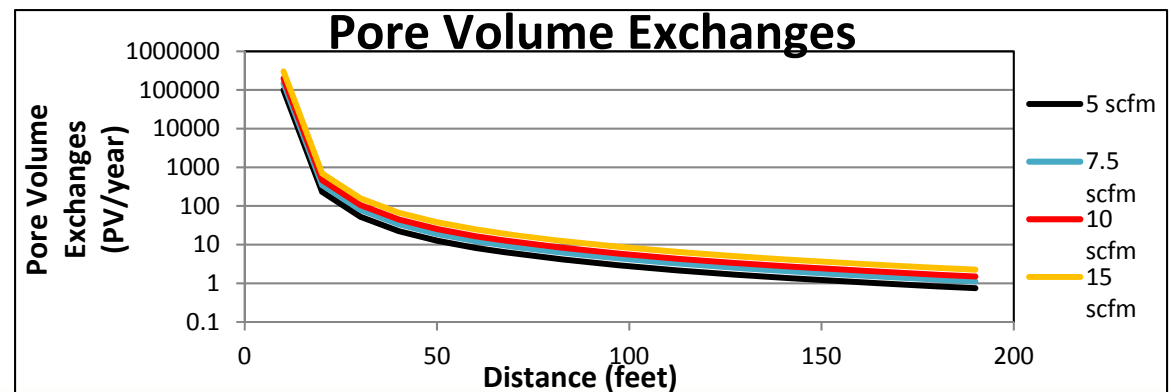
$K_R = 8.08E-07$  cm<sup>2</sup> – Refuse, Lateral Direction

$K_Z = 2.18E-07$  cm<sup>2</sup> – Refuse, Vertical Direction

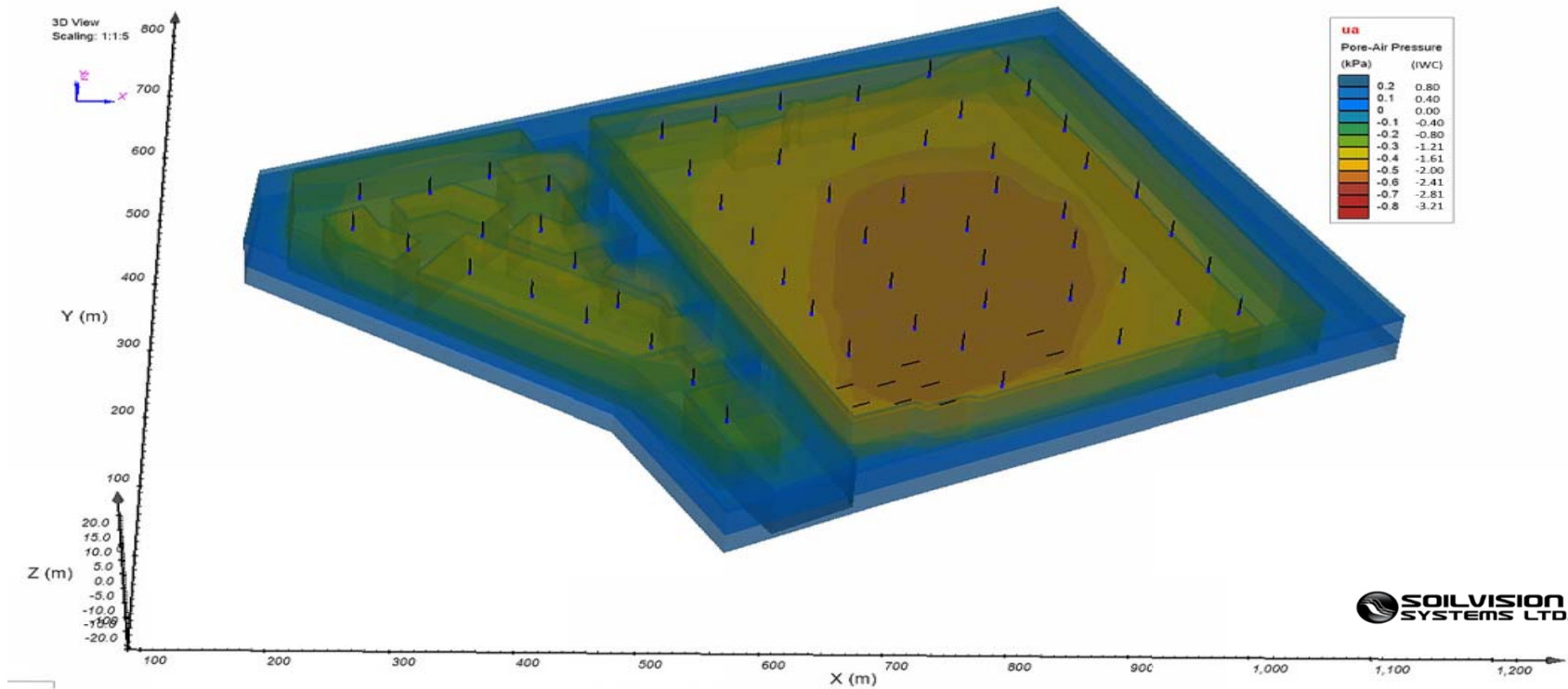
$K_C = 4.67E-11$  cm<sup>2</sup> – Upper Clay Cap

$K_N = 9.67E-09$  cm<sup>2</sup> – Underlying Native Soil

(MDFIT™ M. Marley)



# Pneumatic Modeling

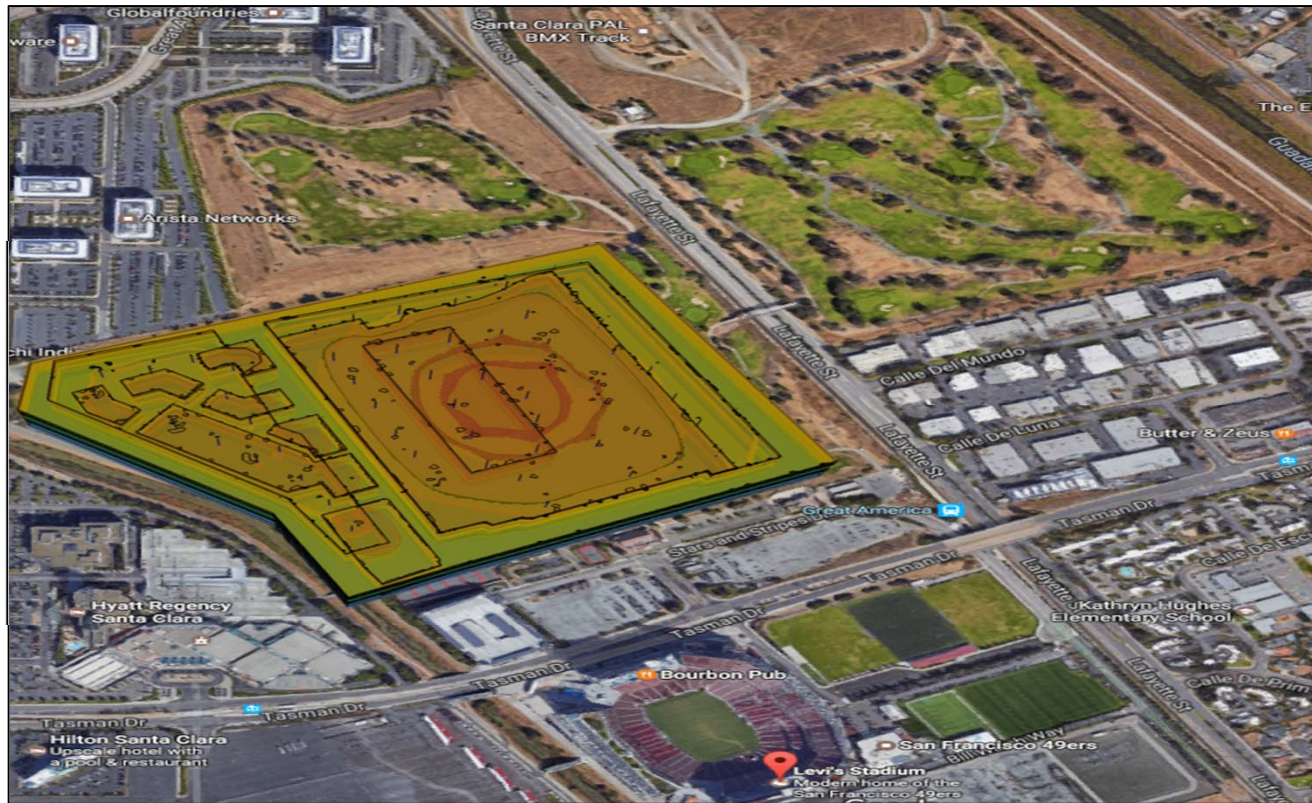


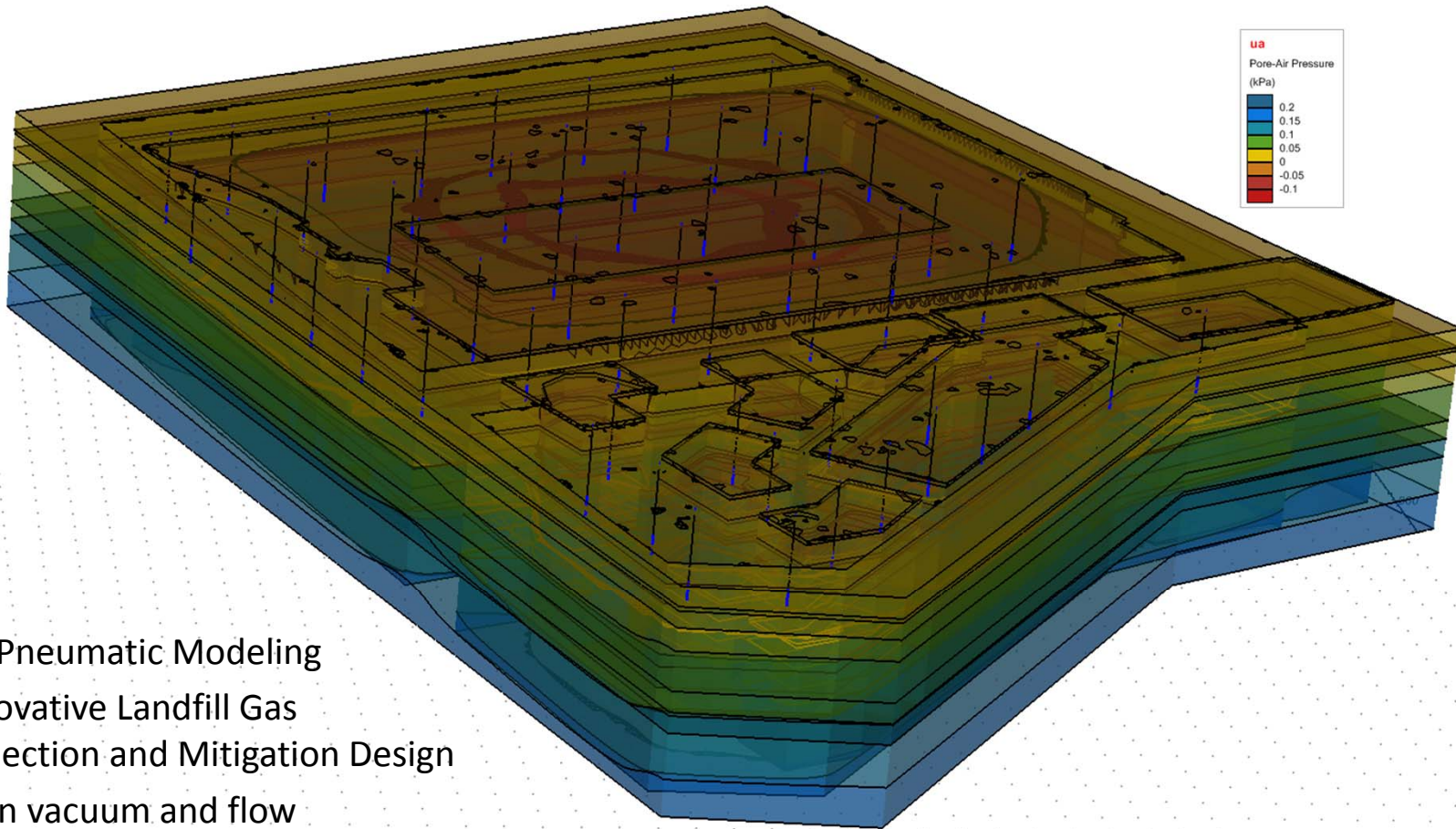
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# Pneumatic Modeling





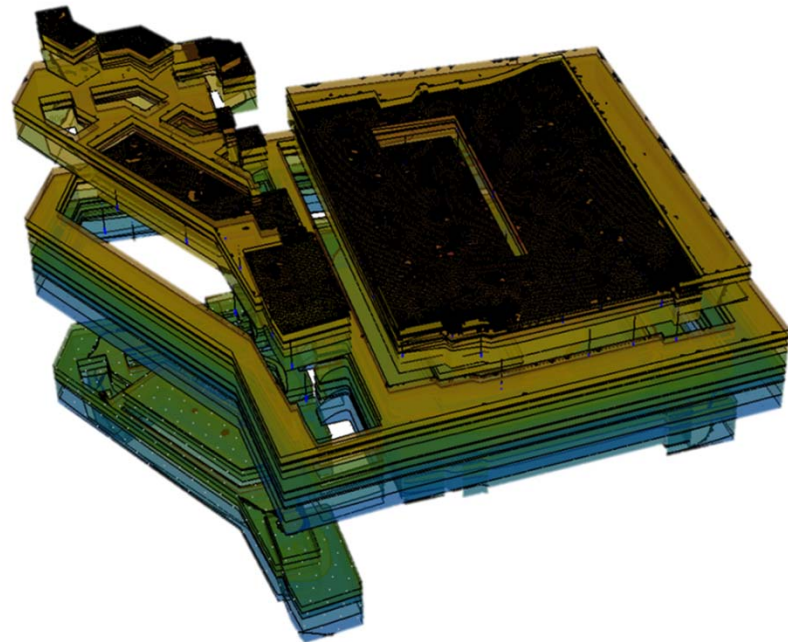
- 3D Pneumatic Modeling
- Innovative Landfill Gas Collection and Mitigation Design
- Even vacuum and flow distribution



# Modeling Sensitivity Analyses

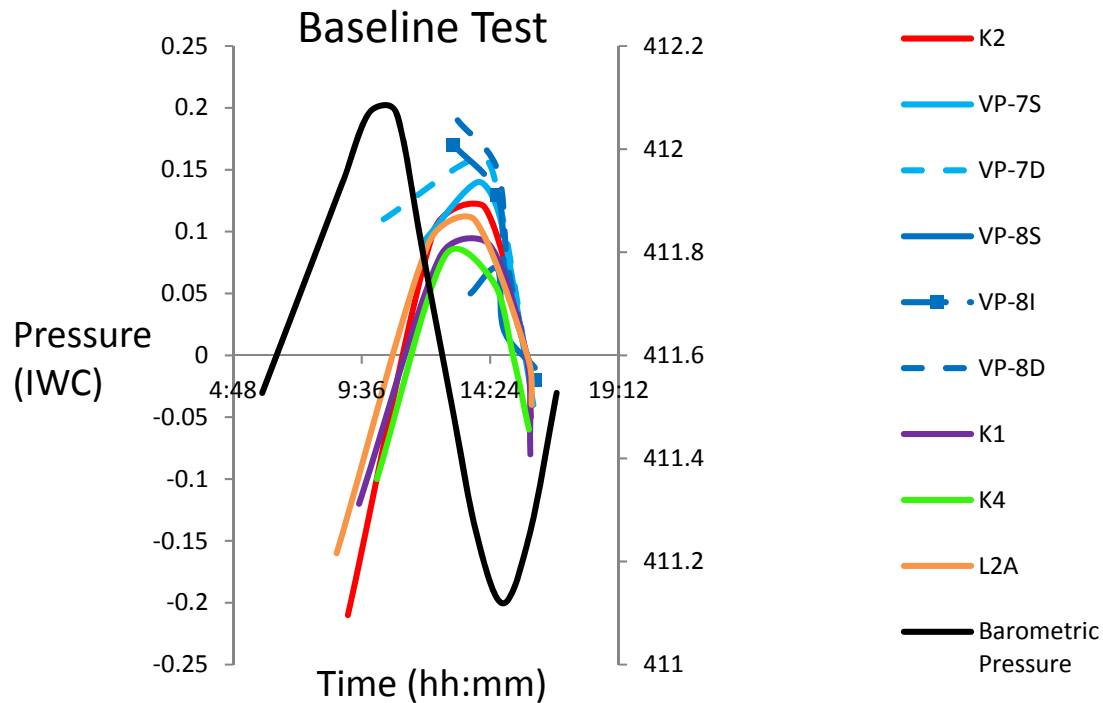
## KEY MODELING CONSIDERATIONS:

- Refuse Settlement
- Seismic Activity
- **Barometric Pressure Fluctuations**
- Under Slab Void Space
- Reduced LFG Generation Rates
- Proposed Development Features
- Moisture Content
- **Screen Length**
- Oxygen Intrusion



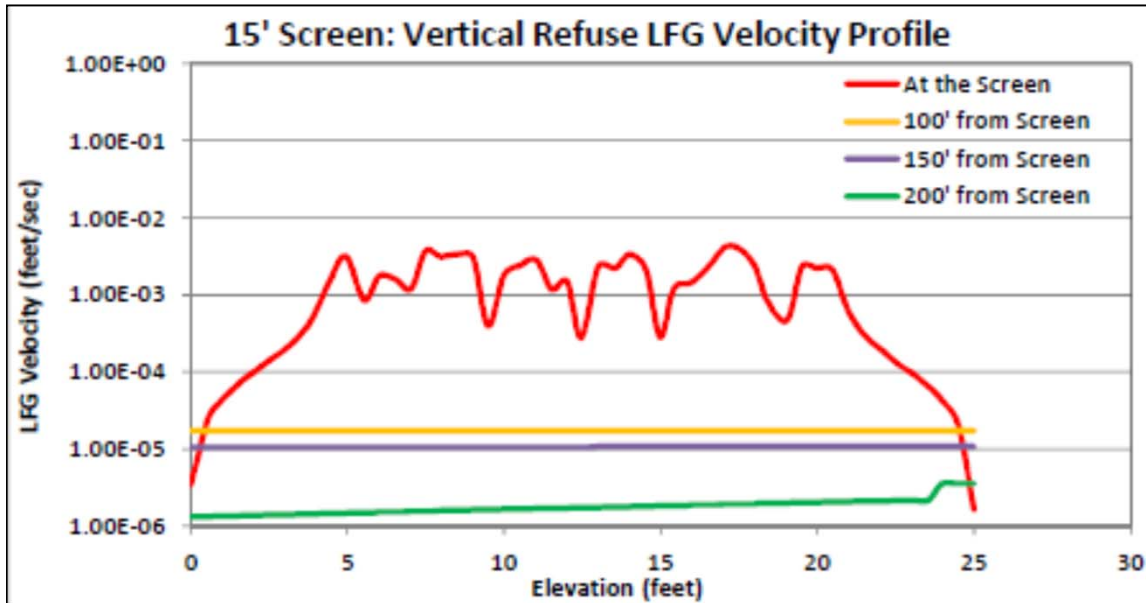


# Barometric Pressure Influence

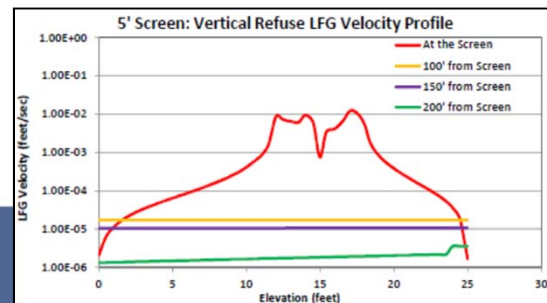
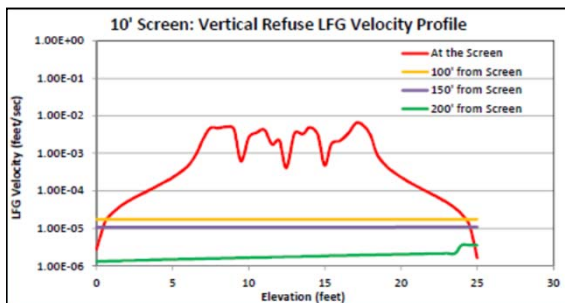


Increase in atmospheric pressure = increased vacuum influence  
Faster  $\Delta$  atmospheric pressure = greater  $\Delta$  vacuum influence  
Greater distance/lower flow = slower equilibrium  
Minimum LFG Velocity  $\sim 1.57E-5$  ft./sec

# Screen Length Influence



More uniform vertical distribution with longer screens  
Relatively thin unsaturated refuse layer =  
shorter screens better to reduce air intrusion

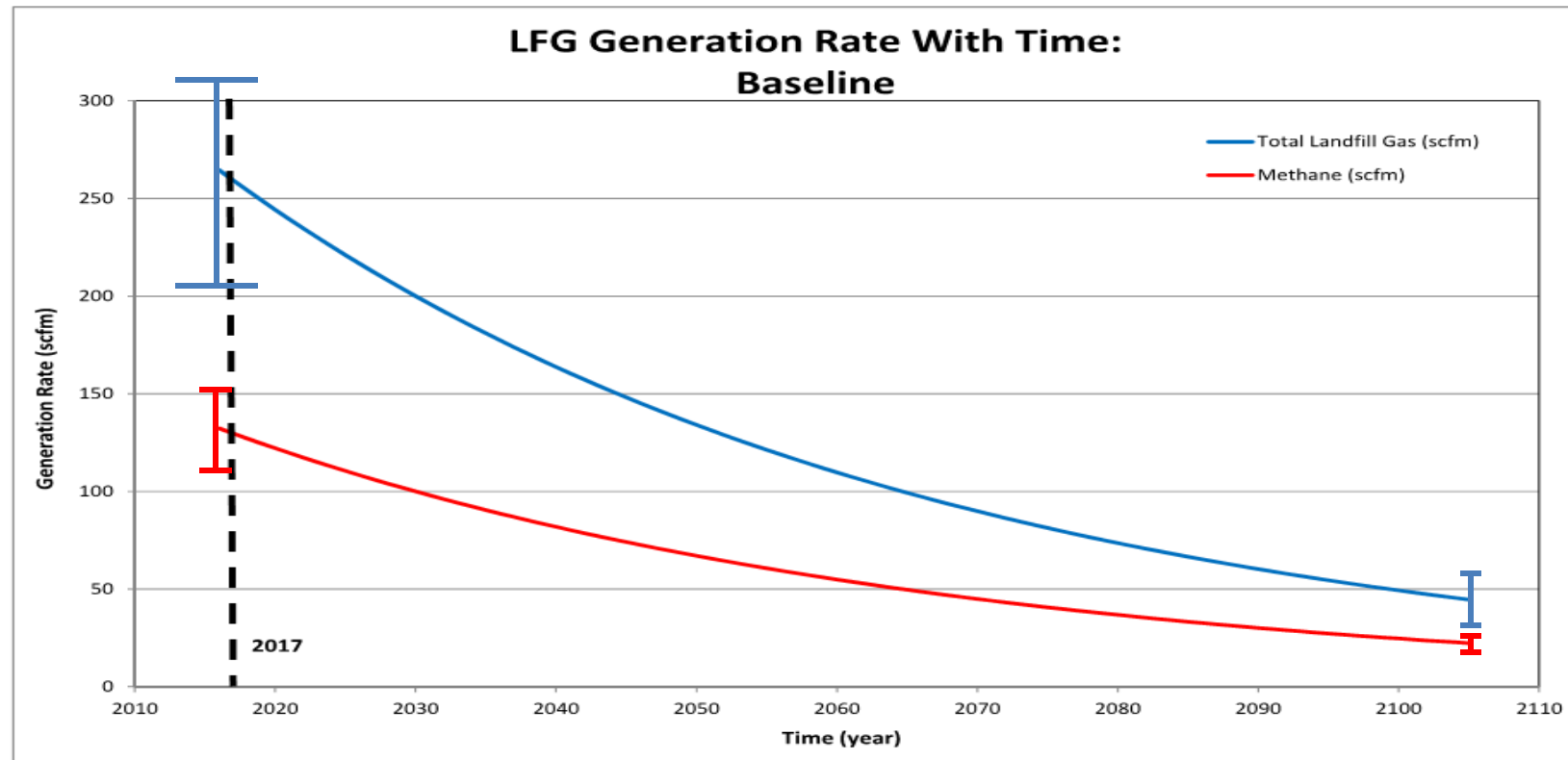


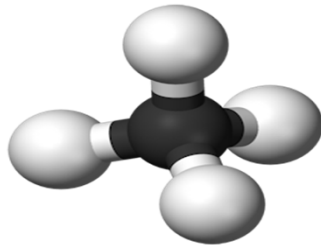
# Key Design Considerations

- LFG Generation Rate
- Fire Hazards
- Seismic Hazards
- Refuse Settlement
- Development of Void Space Under Slab
- Corrosivity



# LFG Generation Rate



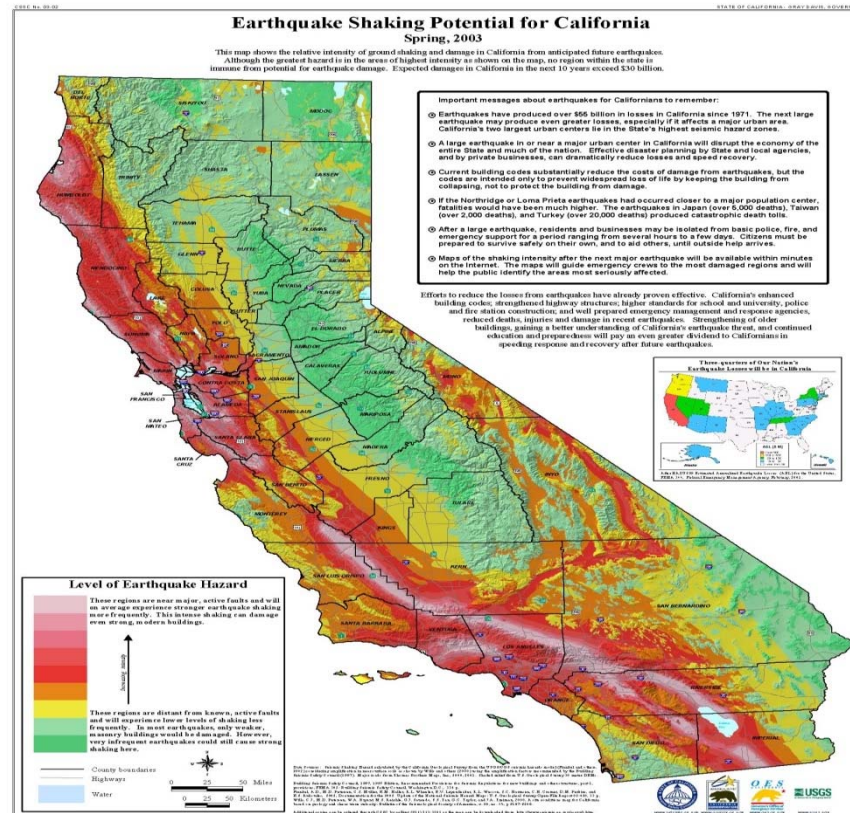


# Fire Hazards

- Methane is colorless and odorless
- Methane Lower Explosive Limit [LEL] (5% by volume)
- LFG Methane Content at the Site (40-50% by volume)
- 1.25% by volume Methane = 25% LEL (Triggers Active Venting Requirements)

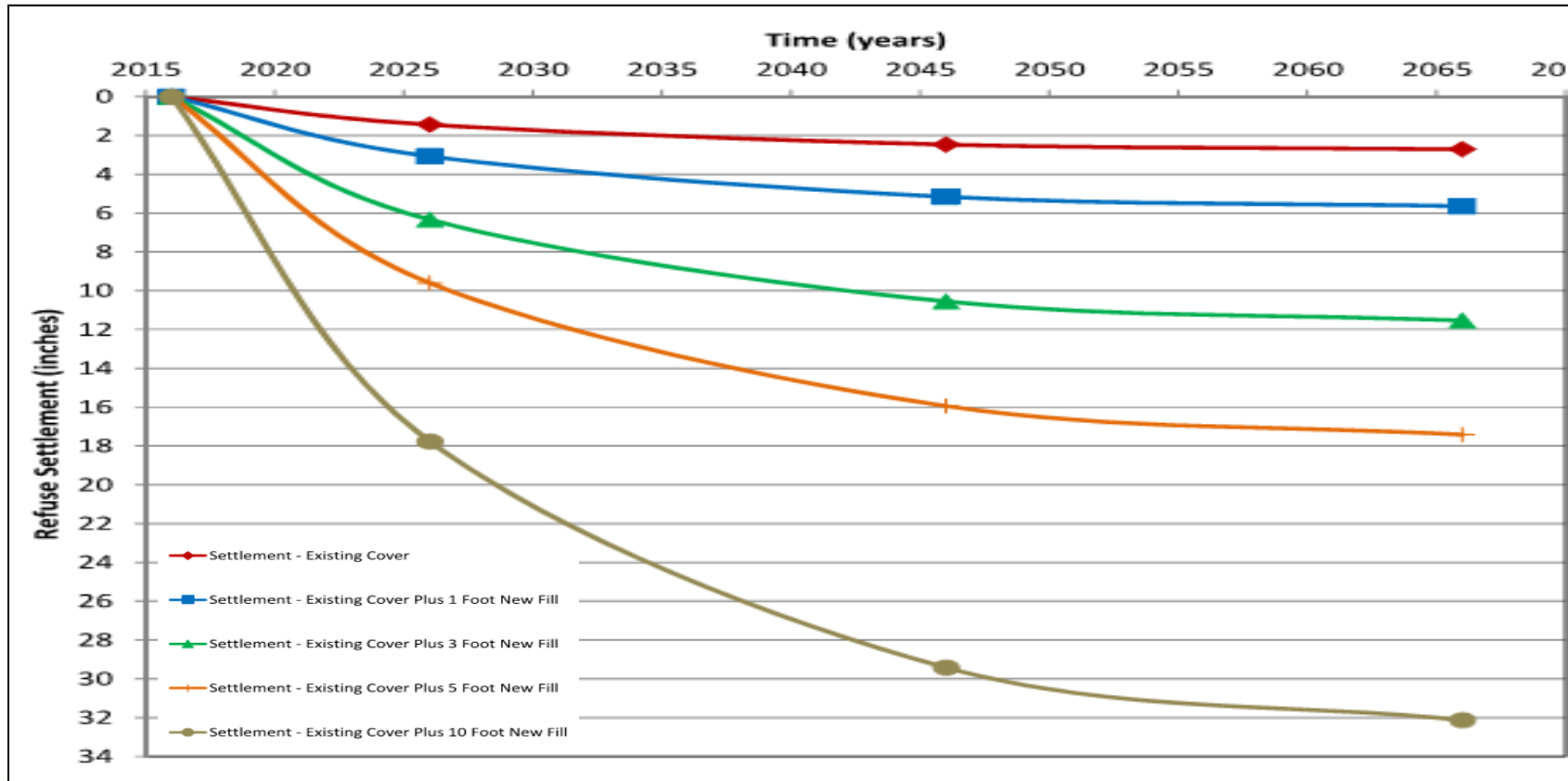


# Seismic Hazards

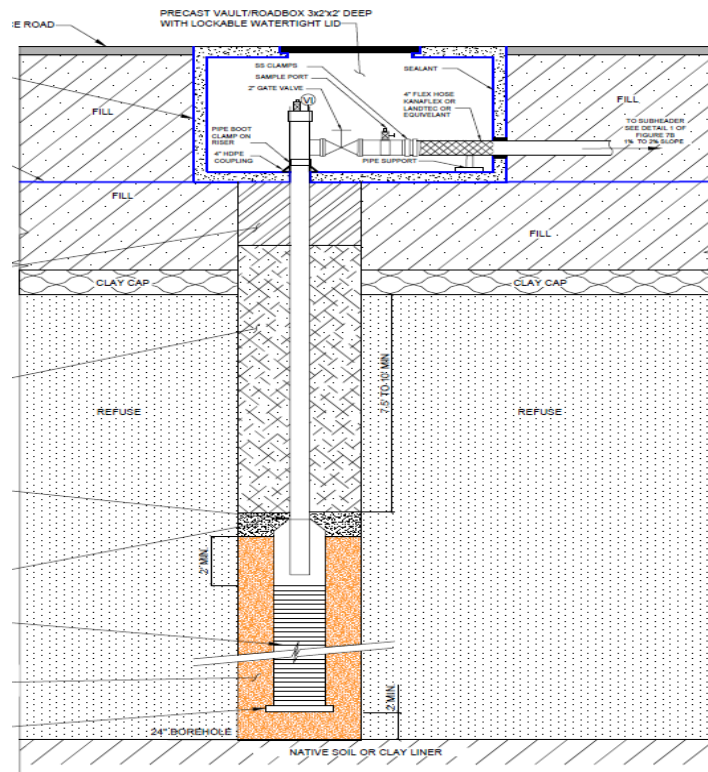




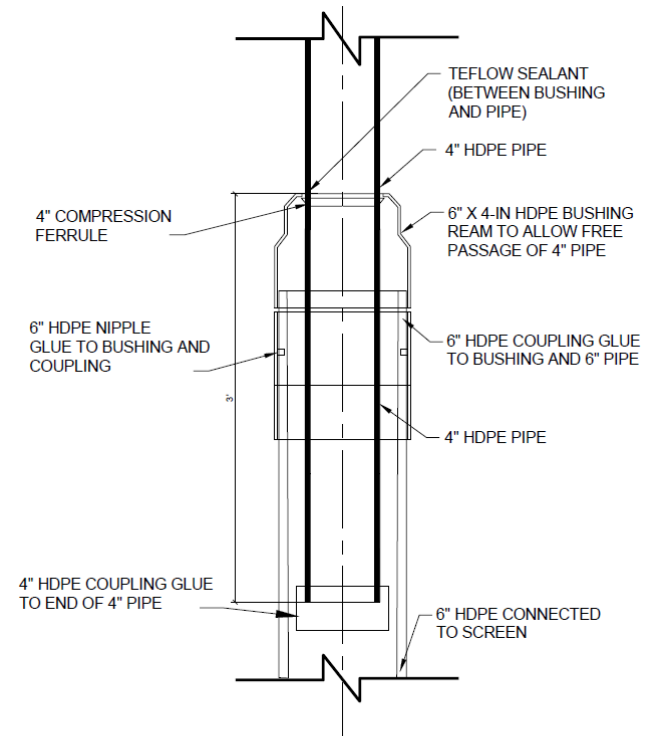
# Settlement



# Settlement...

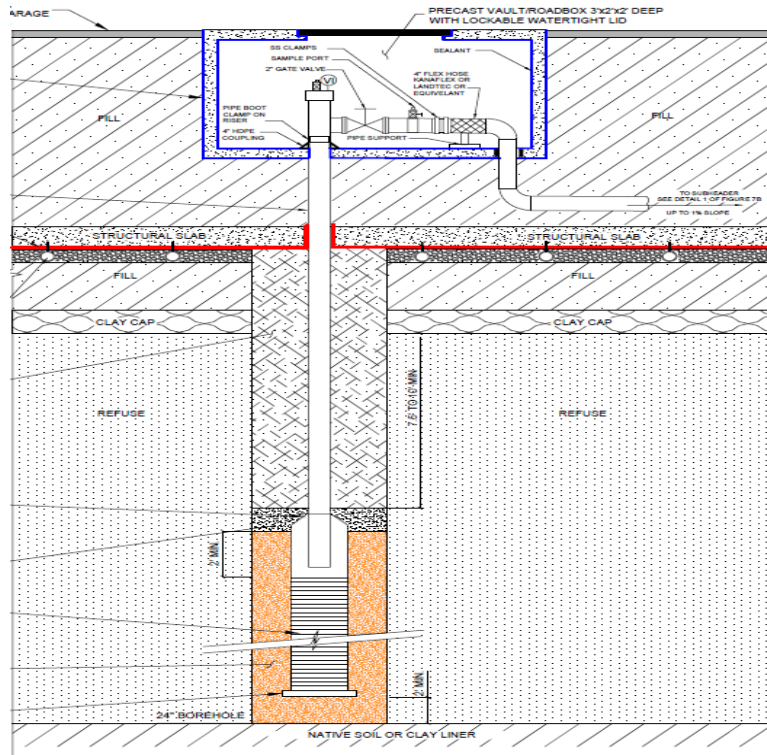


## LFG Collection Wells Outside the Structural Platform Area

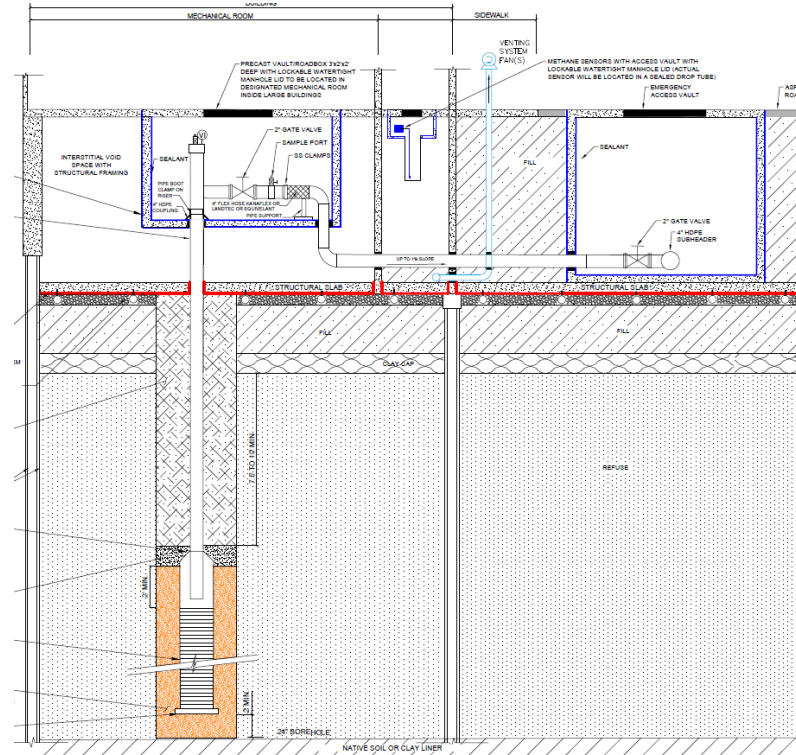


⑤ HDPE SLIP JOINT DETAIL - TELESCOPING WELL  
(NOT TO SCALE)

# Settlement...



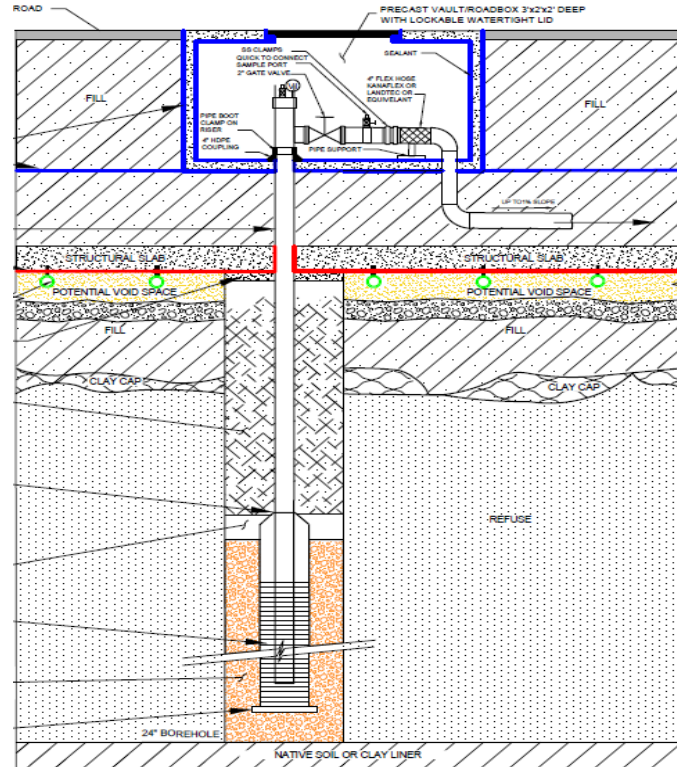
**LFG Collection Wells Within the Structural Platform Area  
Outside the Building Footprints**



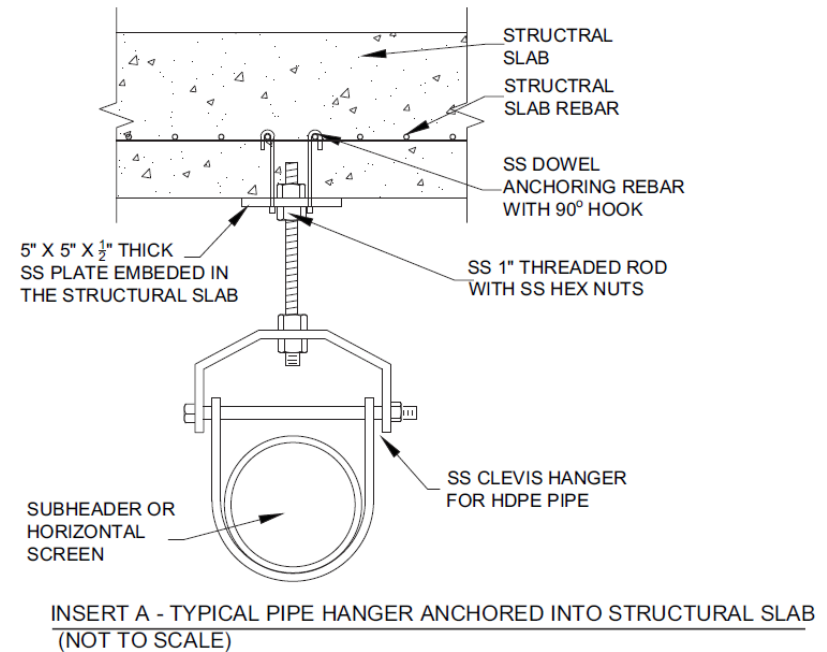
**LFG Collection Wells Within the Structural Platform Area  
Inside the Building Footprints**



# Void Space LFG Control



Proposed Cell-Crete Liquid Concrete Injection



# Corrosivity

- Sulfur-based gases (hydrogen sulfide) are microbially converted to sulfuric acid ( $\text{H}_2\text{SO}_4$ ).
- Low pH
- Hydrogen sulfide and Fe results in the formation of iron sulfide film.
- Construction Materials Selection
  - HDPE
  - PVC
  - Stainless Steel
  - Corrosion Resistant Coatings



# Design Summary

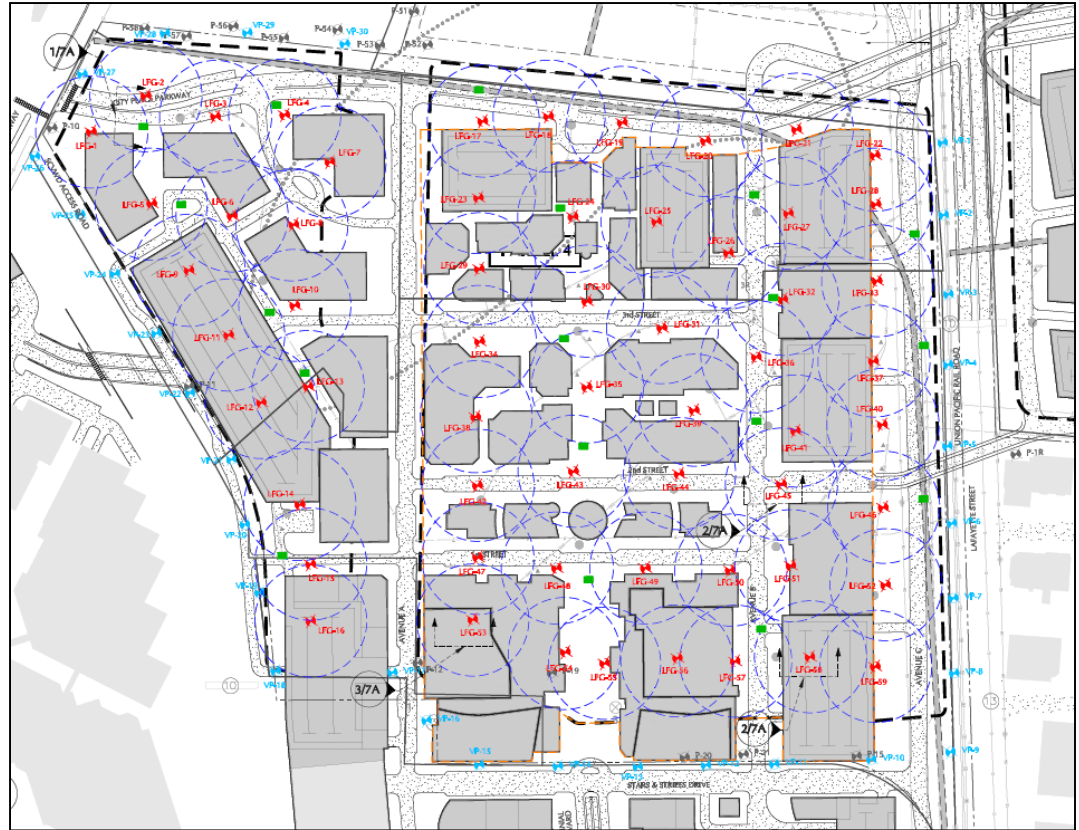
- LFG collection wells
  - 59 telescoping vertical wells

*100 to 150 feet radius of influence*

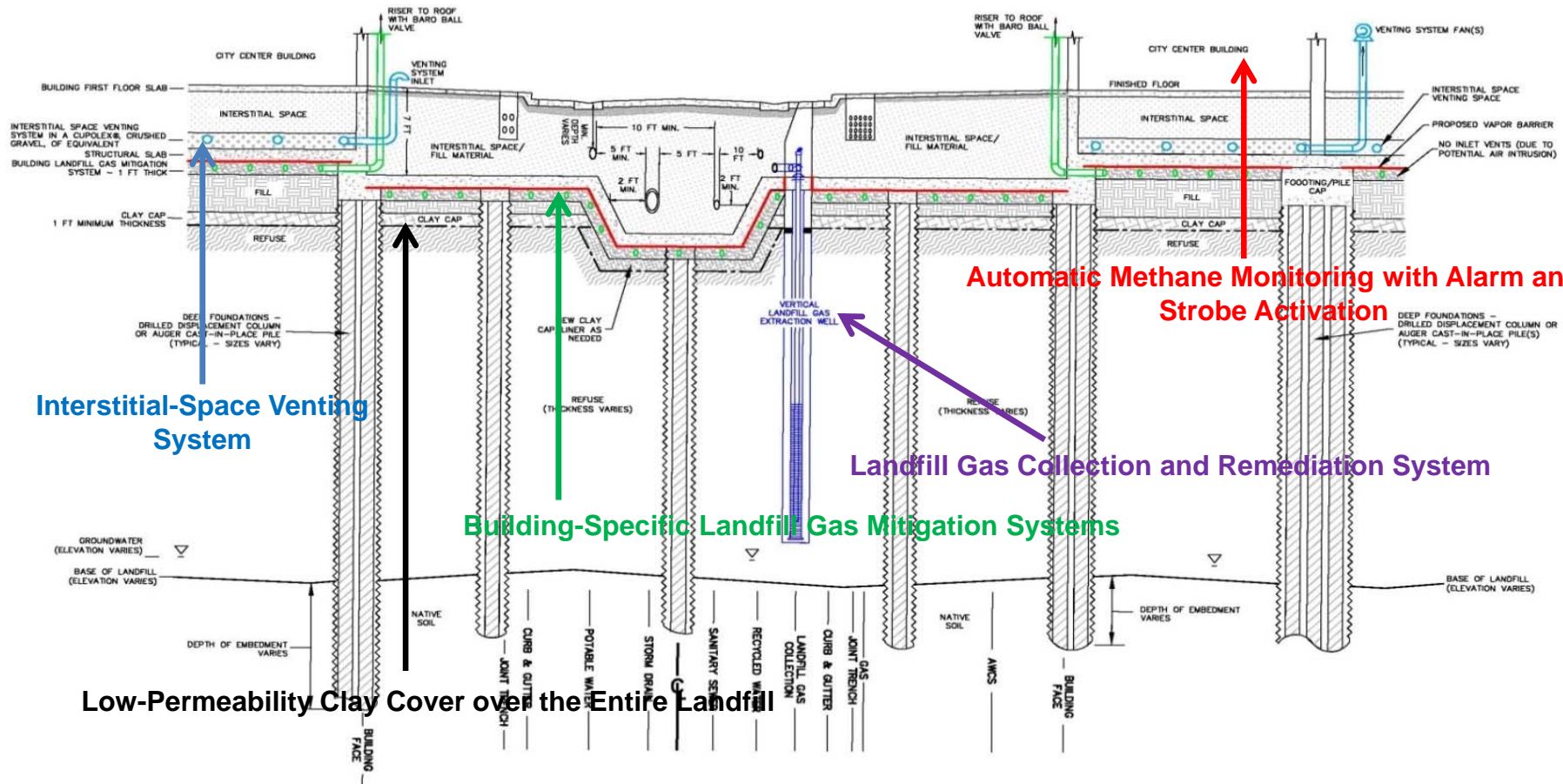
*0.75 – 4.25 scfm flow*

*0.05 – 3 in WC vacuum at well*

- Fully Explosion-Proof Blower(s)
- Enclosed Flare and Micro-Turbines
- Condensate Knockout Pots

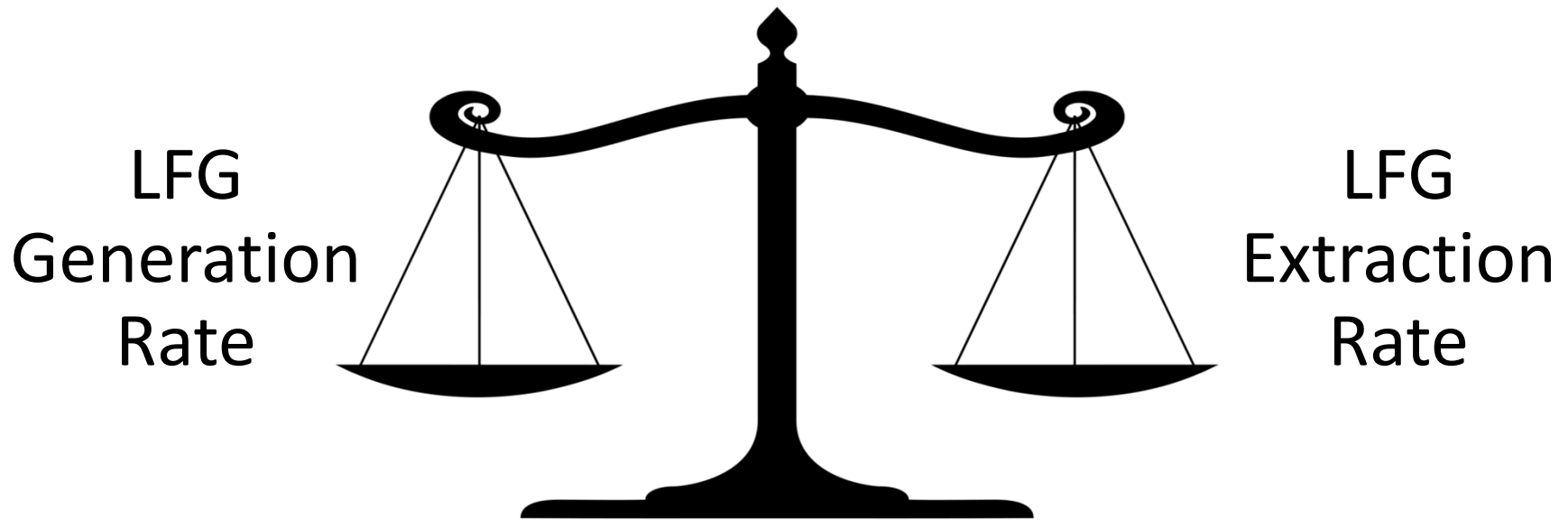


# Structural Platform

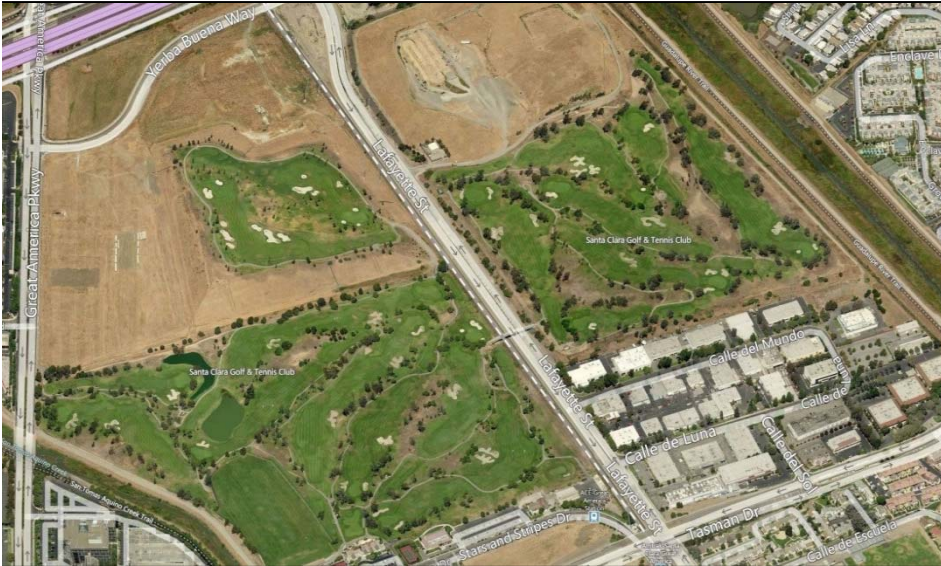




# Operations Strategy



# Project Status

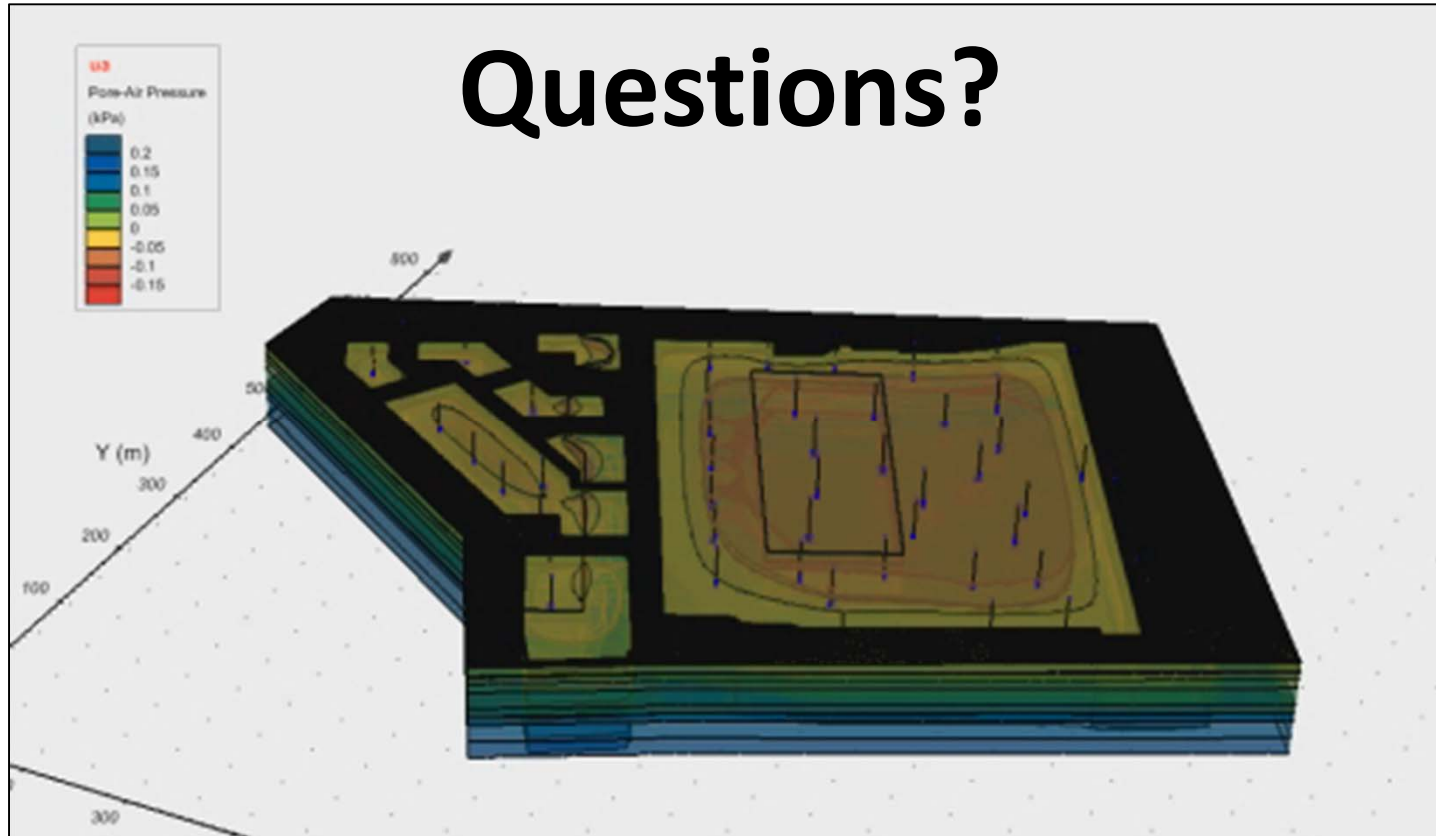


**Current Land Use**



**Planned Future Development**

# Questions?



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